ANALYSIS OF INSURANCE COMPANIES' PERFORMANCE, CAPITAL STRUCTURE AND SOUNDNESS: EVIDENCE FROM THE U.K. MARKET

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I hereby declare that this thesis has not been and will not be, submitted in whole or in part to another University for the award of any other degree.

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Analysis of Insurance Companies' Performance Capital Structure and Soundness: Evidence from The U.K. Market

Abstract

Since the UK insurance industry could be regarded as an essential contributor in both international and domestic economic strength, it is worth to gain the insights within the performance of the UK insurance industry and get acknowledged of how different internal or external factors might influence its behaviours.

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CHAPTER 0: Introduction

Section 0.1 The Importance of the Insurance Industry

The financial system plays a vital role in a nation's financial and economic development. One of its basic functions – of providing financing to promote real economic growth in a situation of instability – is not easy to execute. Therefore, it is helpful to investigate the health of the various sub-components, *e.g.* the insurance or banking sectors, in the system in order to understand its overall stability.

There is a notable link between an economy's financial development and insurance market growth, see, Outreville (1990, 1996), Ward and Zurbruegg (2000), Kugler and Ofoghi (2005), Lee, Lin, Zeng (2016). Both economy and financial development involve the protection of a population's properties against unexpected events, which are hard to avoid and may lead to further losses. For this reason, the insurance concept was developed.

From an insurer's perspective, different products are targeted to different customers, and the features of different products are accordingly varied. However, these products are based on all three principal services in general: (1) risk pooling and risk bearing; (2) real services relating to insured losses; and (3) financial intermediation. Acting as a risk-bearer, the insurer provides a range of financial products to clients in exchange for premiums. Insurers collect premiums from the pool of policyholders and redistribute most of the funds to those policyholders who suffer losses. This means that the risk of losses is spread across the pool. Also, the insurers facilitate financial development and stability by monitoring and supporting risk-taking activities. In any event, the primary functions of an insurer is to serve as an essential post-loss financing mechanisms for individual or corporations by transferring downside risks through insurance (Froot, Scharfstein and Stein, 1993; Zou, Adams and Buckle, 2003). With this protection, corporations can expand their business and therefore contribute to economic development. Insurers also contribute to economic growth by acting as intermediaries, which allows them to collect premiums and invest them in capital markets to generate further investment-related income.

Moreover, insurance companies are closely connected to different individuals, business units and other financial institutions. Hasman (2012) and Acemoglu, Ozdaglar and Tahbaz-Salehi (2013) state that interlinkages among financial institutions have important implications for risk contagion, as they can amplify negative effects. Billio *et* *al.* (2010) also found that the level of systemic risk in insurance industries increased as they revealed that banks, insurance companies, hedge funds and brokers had become highly interrelated and illiquid. In addition, the potential impacts of insurers on the other financial institutions are also significant. Both Mirzaei and Moore (2014) and Clerides, Delis and Kokas (2015) draw attention to the fact that the growth of the insurance industry may have significant impacts on market structure in banking.

The 2007 – 2009 financial crisis can be regarded as one example of how interlinkages and the financial distress of insurance firms may reduce financial system stability. An early collapse in the cycle was not caused by the default of a bank, but rather by the near-breakdown of an insurance company (American International Group, AIG). Just like a 'bank run', the default of a large insurer with extensive interconnections with other financial institutions could trigger a shock to the real economy. The AIG case led economists, academics and regulators to consider the possibility of insurers becoming systemically important and thereby make an effort to identify the systemically important financial institutions (SIFIs) and enact rigorous regulations for financial institutions. A study by Acharya *et al.* (2009) generates the first evidence to confirm the contribution of large US insurers to systemic risk after the collapse of Lehman Brothers.

More recent reports on the potential systemic relevance of insurers have argued that some insurers could contribute to the instability of the global financial system if they are to offer functions similar to those of banks (Geneva Association, 2010; IAIS, 2013). Weiß and Mühlnickel (2014) also confirm that several insurers do contribute significantly to the instability of the US financial system during the crisis period, and that firm size is a contributory factor to systemic risk. Their results also indicate that those insurance companies also had a significant impact on financial fragility. Cummins and Weiss (2014) further confirm that insurer's non-core activities (such as financial guarantees and derivatives trading) and high degrees of interconnected growth are the primary sources of systemic relevance. Overall, the contribution of an insurer to systemic risk can be driven by a persistent risk raised from its underwriting and investment strategies. Therefore, insurers not only have high systemic risk exposure but also contribute riskiness back to the financial system.

On the other hand, we can also expect insurers with more rigorous risk governance to stabilise the financial system in times of crisis. Das, Davies and Podpiera (2003), Rothstein (2011), Lee and Chang (2015) and Lee, Lin and Zeng (2016) all suggest a (healthy and well-developed) insurance industry might improve financial stability. The International Monetary Fund (IMF) (2016) also suggested that the insurance industry per se warrants particular attention, as it contributes to the high systemic relevance in the overall economy. Then, as one of the key players in this interconnected network, the insurance industry should be investigated. In specific, three vital elements – performance, capital structure and soundness (stability) – are examined in this research.

Section 0.2-Why Choose the UK Insurance Market?

Existing studies on the insurance sector use different approaches to achieve varied research purposes, with the bulk of analyses focusing on the US market and the unitary EU market by pooling member countries together. Eling and Jia (2018) state that variations of the business and regulatory culture within different nations in the EU could provide a persuasive context to analyse the insurance sector's soundness. Burchell and Hughes (2006), Adams and Jiang (2016) and Eling and Jia (2018) also reveal that the UK market would be a good research subject to analyse an insurer's failure due to its cultural factor.[1]

Moreover, in contrast to the multi-state-based supervision framework in the US market, the UK market has a unitary regulatory regime. For example, some states in the US impose restrictions on premium setting - but this is not the case in the UK, and this difference is important in terms of underwriting strategies. Another main difference between the UK and the US insurance sector is the number of publicly listed firms. Only a small number of UK insurers are listed, but one-third of insurers are listed in the US. This means that external corporate control is less likely to be an effective governance mechanism in the UK insurance market (Adams and Jiang, 2016).

As a uniform supervision framework is shared across EU markets, by studying the UK insurance market, we can make comparisons to other markets in the EU. Different features are associated with different markets: for instance, compared with the UK, the German market is highly regulated. Bikker and Gorter (2008) introduce the concept that the financial reforms (e.g. the 1994 deregulation) have limited impact on traditionally less

[1] The business and regulatory culture in the United Kingdom has a feature that allows firms to exit more freely than they can in other EU countries. As a result, more failure cases exist in the UK (Burchell and Hughes, 2006; Eling and Jia, 2018), notably the failure of Equitable Life and Independent Insurance Plc. in the early 2000s.

regulated countries, such as the UK.

In general, the UK insurance industry is an important contributor to economic growth both in the country itself and worldwide, and is ranked as the largest across the EU and the third largest in the world (Association of British Insurers, 2014). Moreover, the UK insurance sector makes £1.9 trillion in investments and pays nearly £12 billion in taxes to the government per year (Association of British Insurers, 2016). It also contributes £35 billion per annum to the UK economy (Office for National Statistics, 2015). The contributions from insurers to the UK economy are significant.

The UK market has its own specific features and research contributions. However, not many studies have focused on the unitary UK market. Therefore, this research is focused on the UK market only, although the results that are gained can be used to make further comparisons to other markets.

Section 0.3 The Development of the Current Research

This research first looks at performance which is the insurer's primary concern, because it acts a prelude to the analysis of other research topics, such as the insurer's financial stability. Performance is the basic outcome of an insurer's operational activities, but it can also be a fundamental source of a firm's soundness. Eling and Jia (2018) stated that efficiency (performance measurement) could be defined as a candidate of failure indicators as they believed that inefficient firms would fail to maintain operations in the market due to external pressure. Thus, by defining insurers' performance, two questions can be answered: (1) How well is the firm being operated? and (2) How has the market evolved over time? In order to obtain a more comprehensive and accurate overview of insurers' performance, the results encompass various aspects, which are generally covered in three areas: (1) different performance indicators - efficiency and productivity; (2) types of insurers - life, non-life and composite insurers; (3) types of ownership - stocks and mutual insurers. The results are presented in Chapter 1.

Further, it is worth determining the driving forces of insurers' performance. As in line with the requirement of the Solvency II framework, the foundation of the insurer's advanced management is detecting and identifying (quantitatively and qualitatively) the existence of risks,[1] and then to manage these accepted risks. For example, pricing risk, which is one of the underwriting risks, represents the uncertainty that costs and claim payments will not coincide with the premiums received. Thus, one effective conduct is to maintain an adequate level of capital (Jakov and Žaja, 2014). In addition, insurers are exposed to various underwriting risks in the first place because uncertainties always occur from the business activities, and they are hard to predict. In other words, underwriting risks originated from insurers' business strategies. These fundamental strategies will further impact insurers' other activities, such as investment strategies and risk management activities. Then, Chapter 2 reveals the influences of insurers' risk takings and risk management practices on the performance, as these are the fundamental factors that insurers need to consider.

In the aftermath of the recent global financial crisis, insurers' risk-taking behaviours and risk management tactics are essential issues of concern for regulators and policyholders, as well as for the shareholders and managers of insurance firms. The primary objective of the solvency framework is to ensure that insurance companies hold enough capital to enhance an insurer's financial health. Harrington (2009) also states that insurers must fulfil the rigorous capital requirements in order to limit their potential to destabilise the system. Capital thus act not only as a loss cushion but also as a barrier to prevent insurers from taking excessive risks from their underwriting and investment practices. More specifically, insurers could choose to accept an excessive amount of risk in exchange for a higher level of incentive. In the absence of an external guarantee (e.g. a national insurance guarantee scheme), the insurers could then choose to transfer the risk to policyholders unilaterally via a higher premium level. This is referred to as a reverse moral hazard. As a result, this would reduce the insurer's competitiveness in the market. Accordingly, to main the firm's competitiveness, it could raise external capital as an optimal solution, but there are costs of capital. Therefore, the insurer needs to make a trade-off between incentives gained from excessive risk taking and cost spending on raising additional capital. As the capital provides these critical functions to ensure a firm's financial health, it is important to reveal the impacts of potential factors on insurers'

[1] Risks can be classified in several ways. Under solvency II, the main categories within this classification include underwriting risk, market risk, credit risk, operational risk and liquidity risk. Different risks may adversely affect the operation of the insurer, and it can lead to disturbances in achieving an insurer's goals. The worst case would be that the insurer is not able to meet its obligation, and thereby becomes insolvent. Underwriting risk represents the possibility of failing to meet future liability due to incorrect pricing and an inappropriate business scope.

capital structures. Specifically, the results from this research reveal that the insurers past leverage level, retained earnings, business volatilities and the use of reinsurance are all relevant factors that influence insurers' capital structure'. Chapter 3 presents the detail of relevant investigations.

The role of the insurance sector in maintaining the stability and sustainability of the financial system, facilitating business growth and creating wealth is well established, as discussed. Thus, it is important to ensure that the insurers maintain the ability to meet their obligations, thereby further enhancing their soundness. The impact of an insurer becoming insolvent can be extensive, as it acts as the ultimate carrier of risks. To be specific, the insurer's financial ability to continually meet the promised obligations is essential for policyholders/clients, as they pay premiums long before receiving any claim/benefit payments. Thus, for the purpose of identifying early warning signs of insurer instability, it is important to determine some particular driving factors on insurers' financial health.[1] More specifically, insurer's performance, risk takings (*i.e.* leverage and liquidity) and management practices (*i.e.* the use of reinsurance) all contribute significantly to the insurer's stability, as discussed in Chapter 4.

This thesis mainly contributes to ongoing discussions on insurers' performance (Fenn *et al.*, 2008; Bikker, 2016; Eling and Schaper, 2017), capital structure (Campello, 2003; Shiu, 2011; Altuntas, Berry-Stölzle and Wende, 2015) and financial soundness (Cummins, Rubio-Misas and Vencappa, 2017); meanwhile, some particular internal driving forces, which are related to each of the already mentioned elements, are defined. We also consider the influence of external pressures on the discussed relationships, *i.e.* the market structure (Canton *et al.*, 2005; Dam, Escrihuela-Villar and Sánchez-Pagés, 2015) and the underwriting cycle (Elango, 2009; Ren *et al.*, 2011).

Regarding market structure, direct cross-border selling was not allowed among national markets in the EU before 1994, and limited competition therefore occurred in the single market. After the introduction of deregulation, insurance companies were able to use a single license to operate throughout the European market, as the barriers to entry

[1] For example, Brockett *et al.* (1994), Hsiao and Whang (2009) and Eling and Jia (2018) demonstrated various financial insolvency prediction models for the insurance industry. Meanwhile, a large volume of studies have been conducted to determine the impacts of different factors on insurers' financial health, see, Shiu (2005), Trufin, Albrecher and Denuit (2009), Cheng, Elyasiani and Jia (2011), Dutang, Albrecher and Loisel (2013) and Cummins, Rubio-Misas and Vencappa (2017).

into the other countries were removed. The initial objective of this deregulation was to gain market efficiency and enhance productivity by imposing competition[1]. Eling and Schaper (2017) reveal that different external environmental factors have significant impacts on insurers' efficiency. After years of adopting the financial reforms (1994 deregulation, 2007 reinsurance directive), it is necessary to analyse dynamic changes in the market structure (e.g. competition or others) and its potential impact on insurers practices, as this should be considered in policymaking. And Pandey (2004) further confirm that there is a cubic relationship between market structure and capital structure. Thus, market structure is considered as one of the key variables in Chapter 3.

The underwriting cycle, is another external factor, is one of the key variables in Chapter 4. The existence of it has directly impacted insurers' practices, such as pricing strategies, and revenue and profit generations, in the general insurance market (Cummins and Outreville, 1987; Eling and Luhnen, 2009; Zhang and Tang, 2012; Jakov and Žaja, 2014). The causes of the appearance of the underwriting cycle have been well discussed from different perspectives, see studies from Winter (1991), Cagle and Harrington (1995), Grace and Hotchkiss (1995), Cummins and Danzon (1997), Lamm-tennant and Weiss (1997), Meier (2006b, 2006a), and Meier and Outreville (2006).[2] Simmons and Cross (1986), Jones and Ren (2006) and Jakov and Žaja (2014) further suggest that this cycle indirectly influences the general insurers' risk-taking behaviours and their solvency situation. Therefore, mainly in Chapter 4, the impact of this cyclical pattern on insurers' stability will be discussed.

Section 0.4 Contributions to the extant literature

Summarily, we contribute to the extant literature in the following respects:

1. The UK insurance industry can be categorised as one of the most advanced markets from the perspective of participation and supervision. Therefore, it is both beneficial and necessary to research the UK insurance market, in order to provide a clear standard and a potential benchmark to its counterparts; for example, emerging countries (e.g., China).

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[1] Studies related to the financial liberalization, competition and their impacts on financial industries (banks and insurers), see, Barros (1996), Boonyasai, Grace and Skipper (2002), Turk Ariss (2008), Lin, Officer and Zou (2011), Delis (2012), Alhassan and Biekpe (2017) and Goetz (2018).

[2] Harrington (2004) and Meier (2006a) both provided good reviews on the explanation of the causes of the underwriting cycle. However, the causes of the cycle are not the priority, as the primary aim is to reveal its impact on insurers' stability in this research.

Based on this point, the first contribution is to provide a relatively comprehensive analysis that investigates domestic insurers' performance and risk-related activities (both risk-taking and risk management).

2. In comparison to previous, related UK studies, the sample used in this research can be considered the largest, and its acquired data are also the most recent and the second widest in coverage regarding time.[1]

3. It is the first and most comprehensive study to investigate the UK insurer's performance. Chapter 1 encompass various aspects, which are generally covered in three areas: (1) different performance indicators - efficiency and productivity; (2) types of insurers - life, non-life and composite insurers; (3) types of ownership - stocks and mutual insurers.

4. Chapter 2 is the first study to consider the interaction effects between different insurers' risk-taking behaviours and risk management activities on performance. It is worth to determine such impacts, because of the fact that insurers' risk-taking behaviours and risk management activities are often jointly considered.

5. The main contribution of Chapter 3 is to determine how market structure affects UK insurers' capital structure directly and indirectly—for example, considering the individual effect of market structure and its interactions with firm-specific characteristics on the UK insurance market's capital structure. Because, such relationship is ambiguous.

6. Chapter 4 contributes to the literature by incorporating the influence of the underwriting cycle on an insurer's financial soundness (stability or risk-taking behaviour), including the interaction term between both internal and underwriting cycle in consideration of their joint effects. Because, such relationship is ambiguous.

As a background for the following chapters, this chapter presents a brief overview of the reasons why the insurance sector, especially the UK insurance sector, was selected as the research target, and roughly introduces some of the key concepts discussed in this

[1] According to my best knowledge, the insolvency study undertaken by Caporale, Cerrato and Zhang (2017) was based on data from 1985 to 2015 - the widest coverage in terms of time.

thesis. The remainder of this thesis is organised as follows. As the foundation of the research, in Chapter 1, the performance of UK insurers is determined by using efficiency and productivity analysis. Then, Chapter 2 reveals the driving forces behind UK insurers' performance from two perspectives: risk-taking and risk-management activities. Chapter 3 investigates insurers' capital structure, paying particular attention to the influence of market structure. Chapter 4 determines the influence of performance and risk-related practices on insurers' soundness (stability), with a consideration of the impact of the underwriting cycle. Finally, the conclusions of the thesis are presented in Chapter 5.

CHAPTER 1: Analysing Insurer’s Performance in the UK Market: Using Stochastic Frontier Analysis to Estimate Efficiency and Productivity

Abstract

The UK insurance industry could be regarded as an essential contributor to both domestic and international economic strength, but it also plays an important role in the financial system. Therefore, investigating this market from different perspectives is a worthwhile pursuit. The purpose of this chapter is to provide an overview of insurers’ performance in the U.K. insurance market from 1996 to 2017. Efficiencies and productivities, both performance indicators, are introduced and used to measure the performance of UK insurers in the chapter. These indicators are also treated as one of the basic variables for further analysis, which is related to different insurers’ behaviours.

The result first shows that no significant improvements in both cost and profit efficiencies from the past 20 years. On average, there are chances for insurers to improve their performance: about 40% for cost efficiency and 70% for profit efficiency. Besides, there is evidence to show that the insurer’s cost efficiency are higher than its profit efficiency. Regarding the cost-scale efficiency, the year of 2010 is a “break-even” point, as the entire market (except the life insurers) starts to operate at an opposite condition since that. Overall speaking, UK insurers (except the life insurers) suffer productivity declines over time.

Section 1.1 Introduction

1.1.1 Introduction: The U.K. Insurance Market

In contemporary society, the UK insurance industry has become an important contributor to economic growth in both at home and abroad. It is ranked as the largest such market across the EU, and the third largest in the world, with generating 24% of total EU premium income, with a contribution of £25bn to the UK GDP as well as, more than 314,400 job opportunities in the domestic market (Association of British Insurers, 2014).

As the UK insurance industry has undergone regulatory reforms since the early 1990s, an analysis of its past and present performance was warranted. Insight in this respect could provide a comparative benchmark to its counterparts over time and a clear foundation for further analysis on how different internal or external factors might influence a firm's behaviours, such as risk taking and risk management.

1.1.2 Introduction: Performance Measurements

Performance can be treated as an outcome of business activities, but it can also be seen as fundamental to a firm's soundness. Eling and Jia (2018) point out that performance (e.g., efficiency) could be defined as a candidate of failure indicators because they believe that underperforming firms would fail to maintain operation in the market due to external pressure (*e.g.* competition). Giroud and Mueller (2010) state that well-performing insurers would gain an advantage from acquiring market knowledge, establishing distribution networks and appropriating existing customer networks. Therefore, by analysing a firm's performance, two questions can be answered: (1) How well is the firm being operated? and (2) What can be achieved from the firm's performance?

There are two types of performance measurement: ratio-type analysis (*e.g.* the solvency margin, expenses and claims ratios, the return on invested assets, *etc.*) and modern frontier efficiency analysis (e.g. data envelopment analysis or stochastic frontier analysis). Although some researchers use ratio-type analyses in testing the performance of insurance companies - for example, return on asset, return on equity, underwriting profit ratio and expenses ratio[1], see, Chen and Wong (2004), Shiu (2004), Leverty and Grace

[1] Return on asset (ROA) shows the profit earned per unit of asset and reflects the firm's ability to generate profit from its asset holding. Return on equity (ROE) reflects the ability of the firm to generate profit with the amount that shareholders have invested, and it relates to financing decisions. The underwriting profit

(2010), Fields, Gupta and Prakash (2012) and Tan (2016) - some problems appear in association with a simplistic multiple-ratios analysis (Diacon, Starkey and O'Brien, 2002).[1]

Modern frontier efficiency analysis, which has become a popular performance measurement over the last 20 years, can create a framework for analysing companies, which are not totally efficient (Farrell, 1957). A frontier is a component of the frontier set, in which firms utilise a minimum range of inputs to produce a given level of contemporaneous outputs; therefore, it is a modern approach to benchmarking. It has been further pointed out by Diacon, Starkey and O'Brien (2002) that the limitations of using a simple ratio-type analysis can be avoided by applying efficiency methodologies in two steps: first, confirm the frontier, which could represent the best performance achievable by applying current production technology; second, identify the efficiency of the object, which could be measured by benchmarking the object against the nearest 'frontier' company. An increasing number of studies are using efficiency as their performance indicators, see overview from Eling and Luhnen (2010b) and Cummins and Weiss (2011).

Furthermore, efficiency analysis is focused more on economic than accounting performance, and it could help to avoid potentially confounding effects originating from differences in firms' adoption of financial reporting schemes of annual income and their accounting items (Hardwick, Adams and Zou, 2011). For this reason, the tangible implications for insurance economics can be studied and identified after applying modern frontier efficiency methodologies (Cummins and Weiss, 2011).

Worldwide, studies of firm's efficiency have been conducted due to a strong fascination with insurers' performance and related activities (Eling and Luhnen, 2010a). This measurement could be regarded as a critical indicator, one which could help stakeholders

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ratio for nonlife insurers, which is 1- Pure Loss ratio – Expense ratio, is positively related to performance; and the expense ratio is negative related to performance for life insurers.

[1] (Diacon, Starkey and O'Brien, 2002) summarised the limitations as followed: (1) Since it is impossible to find out a company, which is pointed by all ratios, it is not achievable for identifying the best practice frontier. (2) If some of the ratios conflict with each other, it might be difficult to make further determinations in advance on deciding which ratio could be regarded as the key indicator to compare efficiency or performance. (3) Since the basic rule of 'like-for-like' should be properly applied for making performance comparisons, underperforming companies could be identified, this is because underperforming companies are inferior to their competitors. Simple ratio comparison is hard to achieve this purpose. (4) It is not possible to allow companies to identify the backup source (reasons) of any inefficiency from traditional measures.

to gain an overview of the insurance company's position at the industry level. This could in turn provide clearer and more solid guidelines for taking further actions to minimise (maximise) the cost (profit) from an operational perspective (Farrell, 1957). Doing so could ultimately directly predict a firm's and a stakeholder's value in both the short and long term (Bikker & van Leuvensteijn, 2008).

Although insurers and regulators have paid a great deal of attention to insurer's efficiency, only about 100 empirical studies on the topic have been studied thus far.[1] Within these studies, two types of methodologies have been frequently employed: econometric approaches and mathematical programming approaches. More specifically, about 60 studies utilised a non-parametric approach (Data Envelopment Analysis), while the other 40 used a parametric approach (Stochastic Frontier Analysis). Besides, efficiency is also used for testing different economic hypotheses, and various implications have been involved in efficiency studies across different countries, mainly in the US and the unitary EU market. Most of these studies focus on the the level of efficiency, its evolution over time, and its implications on various corporate governance issues – for example, firm's ownership structure, regulation changes, distribution system, financial and risk management, and capital utilization and others. By studying the relationship between the internal or external factors,and efficiency, both managers and regulators would receive a guidance on appropriate responses to problems and managerial issues at a firm or industry level.

Performance is not only one of the insurer's operational outcome, but also a potential indicator of an insurer's financial health (Eling and Jia, 2018). By providing a comprehensive study on the U.K. insurers' performance, two main questions can be answered: (1) How well is the firm being operated? and (2) How has the market evolved over time?

Financial services industries, such as banking, have been studied extensively. Regarding insurance, although the insurance sector has recently received more attention and relevant studies have become more popular than ever since the recent financial crisis, more comprehensive studies are still lacking. The chapter mainly several contributes to

[1] Eling and Luhnen (2010b, 2010a) and Cummins and Weiss (2011) provide detailed reviews on efficiency studies.

ongoing discussions on insurer's performance (e.g., Eling and Luhnen, 2010a; Eling and Luhnen, 2010b; Bertoni and Croce, 2011).

First, the U.K. insurance industry is an important contributor to economic growth both in the country itself and worldwide, and is ranked as the largest across the EU and the third-largest in the world. However, in contrast to the number of studies related to the US market or the EU market, the number of studies that focus on the U.K. market is relatively low. Therefore, it is essential to fill the gap and draw a picture of this important market. Second, it is the first and most comprehensive study to investigate the U.K. insurance market. In order to obtain a more accurate overview of insurers' performance, this chapter encompasses various aspects, which are generally covered in three areas: (1) different performance indicators - efficiency and productivity; (2) types of insurers - life, non-life and composite insurers; (3) types of ownership - stocks and mutual insurers. On the other hand, most of the extant performance studies only focused cost efficiency in one business market (either life or non-life), and even fewer studies attempted to analysis productivity growth and its decomposed components for the insurance sector. Third, in comparison to other performance studies related to the U.K. market, the sample used in this chapter can be considered the largest, and its acquired data are also the most recent and the widest in coverage regarding time. Fourth, this chapter also serves as a prelude for other studies presented in this thesis which have focused on analysing the driving factors of insurer's performance, capital structure and stability.

Therefore, it is first to provide a detailed description of the principal methodologies that have been adopted to measure efficiency and productivity[1]. Then, detecting cost and profit efficiencies[2] with consideration of different types of businesses and ownership structures; at the same time, productivity and its components are also assessed. However, no expectations or hypothesis will be made in this chapter because the main purpose is to reveal the feature of the U.K. insurers' performance.

This chapter is organised as follows. Section 2 provides a brief review of the literature pertaining to the U.K. insurers' efficiency and productivity. Methodological issues and

[1] Discussions on how to choose inputs, outputs and prices are also provided

[2] Estimating both cost and profit efficiencies is essential, because cost efficiency only captures information from the input side, whereas the profit maximised as the initial goal of management contains information from both input and output sides.

sample descriptions are discussed in Section 3. Next, in Section 4, the estimated efficiency scores, as well as productivity are presented. Finally, the main conclusion is summarised in Section 5.

Section 1.2 Literature Review

1.2.1 Literature Review on Efficiency (Performance) Research

According to Eling and Luhnen (2010b), the term ‘frontier efficiency’ (which is also called frontier analysis) refers to a result/score generated by utilising ‘frontier efficiency measurement techniques’ that test whether the performance of a corporation could be measured as the relative ‘best practice’ frontier in comparison with the most efficient competitors in the industry. More specifically, Donni and Fecher (1997) claim that a more accurate interpretation of efficiency analysis is not being attributed only based on the parameters of input and output, but also in line with an additional frontier set, named as the production set, which could be described as ‘a point lying on the frontier is characteristically one that corresponds to the maximum achievable quantity of output for any given level of input, or also to the minimum required quantity of input for any given level of output’ (Page 525).

Also as pointed out by Eling and Luhnen (2010b), such an analysis generally encompasses two main approaches: an econometric approach and a mathematical programming approach. Whereas econometric approaches are subject to the process of specifying a corporation’s capacity of production, cost, revenue (or profit) with a specific shape, and then generating assumptions about the distributions of inefficiency and error terms. On the other hand, mathematical programming approaches focus on measuring the relationship between produced outputs and inputs (assigned resources) by utilizing linear programming method (e.g., Data Envelopment Analysis), without involving distribution assumptions, and without separating inefficiency terms and error terms (Eling and Luhnen, 2010b).

In the last 20 years, studies of frontier efficiency analysis have ‘dramatically increased’, from only eight up to 1997 (Berger and Humphrey, 1997), and 21 by 2000 (Berger *et al.*, 2000); yet more than 95 studies in insurance industry were conducted 2010 (Eling and Luhnen, 2010b).

Broadly speaking, in the early period, the orientation of frontier efficiency analysis, in terms of examining insurance corporations' operational efficiency, was more on the results of output efficiency and its counterparts (such as methodological and analytical targets), an emphasis observable in studies of international corporations, *e.g*. Rai (1996). Moreover, by conducting 'output-focusing' orientated studies, Fields and Murphy (1989) and Grace and Timme (1992) demonstrated the clear tendency towards economies of scale in small and medium enterprises and diseconomies of scale in large enterprises in the US insurance market. Furthermore, apart from large firms, which hold 90% efficiency levels (Cummins and Weiss, 1993), low efficiency in operating capacities across US insurance firms have also been identified from Gardner and Grace (1993) and Yuengert (1993). In addition, in Gardner and Grace (1993)'s study, a positive linkage between efficiency and improvement technology, while no linkage between efficiency and form of corporate ownership.

It was only in recent years that, efficiency studies include two additional features:

1. The studies and results of frontier efficiency generally covered all major lines of business in a wide range of countries, e.g., intercountry comparison studies.[1]
2. Applied implication fields, in terms of factor influencing efficiency, have also been intensely refined and developed. Some new topics, such as distribution system, organization form and corporate governance issues, regulation changes, market structure and risk management-related investigations, have also been developed. [2]

According to Eling and Luhnen (2010b) survey, until now, different fields of applied implications, were involved in efficiency studies carried out worldwide and were included in more than 100 studies. It should be noted that the efficiency findings, which were subject to investigation under the same economic issue, varied as a result of differences of time horizon, country, line of business and the methodologies employed (Eling and Luhnen, 2010b). A summary of some selected findings, which were well studied in various popular implication fields, is presented in Appendix 1. And the UK relevant studies are reviewed in the next section.

[1] Appendix 1 shows a brief review of relevant studies of the topics on intercountry comparisons.
[2] Appendix 1 shows a brief review of relevant studies of the topics on distribution system, organization form and corporate governance issues, regulation changes.

1.2.2 Literature Review on Efficiency in the UK Insurance Market

Regarding studies of frontier efficiency in the UK insurance industry, although numerous UK-related investigations have been carried out, most only focus on comparing the UK efficiency figure with those of other countries, e.g. Rees and Kessner (1999) and Hussels and Ward (2007). Therefore, their approaches are aimed at tackling their research problems for an aggregated market than at presenting a comprehensive investigation of the UK single market. Even though several (around 10 studies) UK-based frontier efficiency studies have been published by now, the lack of a decent investigation into some specific applications (*e.g.* risk management, market structure, *etc.*) remains a persistent issue. In order to fill these research gaps accurately, as well as to test for consistency between the findings for the UK and those of previous studies, it is necessary to review previous UK-related frontier efficiency studies in this chapter.

As mentioned earlier, under the topic of the impact of distribution on efficiency, Berger, Cummins and Weiss (1997) developed two hypotheses: the product-quality hypothesis and the market imperfection hypothesis. The product-quality hypothesis was investigated by Ward (2002), while the market imperfection hypothesis was further discussed within a UK insurance study undertaken by Klumpes (2004).

Ward (2002) analyse 44 UK life insurance companies from 1990 to 1997, by using SFA to estimate three types of efficiency, with his findings illustrating that the average cost efficiency is 76.3%, which is comparable to the 70% figure presented by Hardwick (1997) in the 1989-1993 period. Additionally, the UK life insurance market is expressed as being low revenue inefficient with a high level of profit inefficiency. A difference across various channels is found for cost efficiency, but it is not sufficient to clearly support the product-quality hypothesis, as no significant relationship between the choice of distribution channels and the level of profit (and revenue efficiency). However, the product-quality hypothesis is achieved when testing an independent channel associated with mutual companies and the selling of complex products.

Klumpes (2004) provides another similar study under both hypotheses for UK insurers, but with a slightly different period, in which profit and cost efficiency functions are utilised to assess the performances of 40 life companies in the 1994-1999 period. The result of his study contrasts with those obtained by Berger, Cummins and Weiss (1997), who support the product-quality hypothesis. Klumpes (2004) find strong support for the market imperfection hypothesis in contrast to its counterpart (the product-quality hypothesis).

Rai’s (1996) research could be regarded as one of the earliest UK-related studies, in which a comparison of cost efficiency between the UK and other EU countries in the 1988–1992 period was performed. Moreover, this study could be considered one of the most constructive in its hypothesis that the efficiency of insurers could be various, depending on a firm’s size and other macro factors (i.e. country-specific). It is worthy of noting that the UK’s X-efficiency was ranked at the lowest stage in comparison to other markets, such as Finland’s and France’s, indicating that the competitive advantages of UK insurers have remained relatively low, a finding consistent with Hardwick’s (1997) suggestions.

Hardwick (1997) measured the cost inefficiency among UK life insurers only. Within his study, 54 life-insurers from 1989 to 1993 are tested, and an estimated flexible form stochastic cost frontier was applied in measuring the ‘scale’, ‘economic’ and ‘total’ inefficiency for different size groups within the sample Hardwick (1997). His study revealed the following findings: (1) high inefficiency in the UK life market, which was in line with Rai (1996); (2) a significant positive scale of economies; (3) larger life insurers are more efficient; (4) London-based stock companies were economically inefficient; and (5) competition from EU countries (from one single EU market) was not yet a threat to the domestic market.

However, in another UK-related study, Donni and Fecher (1997) compare the UK with the other 14 OECD countries over the 1983-1991 period, and arguing that the level of both technical efficiency and productivity in the UK remain in a leading position. (Bertoni and Croce (2011) investigate life insurance companies operating in five EU countries from 1997–2004, finding that the UK insurance has the lowest local efficiency score, and that this local score is higher than the UK’s global efficiency score and the EU’s average score. This also indicated that the UK’s efficient firms dominate those in other markets. However, by comparing their scale efficiency scores, Bertoni and Croce (2011) documented that UK insurers were operating in a decreasing return to scale because the lowest scale inefficiency was found in the group with the largest firms.

There are several potential reasons for such controversial results: (1) the involved countries and the time periods are different; (2) the methodologies used to determine efficiency are different, with DEA applied in Donni and Fecher (1997)'s case, whereas both Rai (1996) and Hardwick (1997) used SFA; and (3) Donni and Fecher (1997)'s research, which is focused on explaining the shift of the product frontier, could be reflected by monitoring technological progress; whereas the the others concentrate on explaining the different factors among different countries regarding efficiency.

Later, a mixed results from both Rai (1996) and Donni and Fecher (1997)'s are confirmed by Diacon, Starkey and O'Brien (2002), who focus on detecting three different types of efficiencies (scale efficiency, technical efficiency and mix efficiency) for European long-term insurers between 1996 and 1999. They suggested that a requirement of reducing the operating cost among the UK's long-term insurers by 19.6% (related to the European frontier in 1996), 16.9% in 1997, 12.9% in 1998, and 14.3% in 1999 was recommended. As a result, the highest average levels of technical efficiency could be detected in the UK market, a finding consistent with Donni and Fecher (1997), but a particularly lower level of mix and scale efficiency also appear among UK insurers, which confirmed by Rai's (1996) hypothesis.

Diacon, Starkey and O'Brien's (2002) study was an extension of those by Rai (1996), Donni and Fecher (1997) and Katrishen and Scordis (1998) and is aimed at testing whether a firm's risks could explain the difference in efficiency among firms, sizes and organisational forms. To be more specific, an increase in the solvency ratio is associated with higher technical efficiency. Mutual firms have a higher level of technical efficiency than stock firms, but a lower level of mix efficiency. There seems to be little relationship between liquidity and efficiencies, and profitability has a significantly positive influence on scale one but a negative impact on mix one. A high proportion of reinsurance is also associated with lower mix efficiency. Moreover, the most efficient UK insurers are those that have businesses in specific target market sectors (e.g., merchant banks, investment houses or specialized in doing group pensions business).

As suggested by Rai (1996), companies with higher X-inefficiency may have a competitive disadvantage, under the circumstances of deregulation in 1994. Base on this point, Hussels and Ward (2007) further analyse the impact of deregulation on the dynamic development of efficiency in the UK and German life insurance markets. The authors assume that by allowing EU insurance firms to operate freely across the EU zone, the highly regulated German insurance industry was expected to carry a greater enhancement in post-deregulation efficiency in comparison to the UK insurance industry. However, the statistics do not sufficiently verify this assumption from two perspectives: On the one hand, there is scant of evidence to indicate a strong cause-effect relationship between deregulation and efficiency enhancement (only a modest level) - for example, overall cost efficiency declined over the period from 1991 to 2002, only showing some improvement post 1995 in the UK.[1] On the other hand, when individual efficiency scores are compared, it is revealed that the UK's score is higher than that of its counterpart's[2]; yet, when joint efficiency scores (aggregated two markets) are compared, Germany's score is closer to the frontier level than that of the UK.

Again, under the environment of a single European insurance market, stemming from deregulation, Fenn *et al.* (2008) and Kasman and Turgutlu (2011) make further UK-related comparisons, which are focused on detecting cost-efficiency and scale economies within the single European insurance market. Throughout the study by Fenn *et al.* (2008), the authors utilise a stochastic frontier methodology in modelling efficiency in the 1995 – 2001 period, and estimations for different businesses are considered. The results indicated that businesses in non-life and composite sectors are relatively stable in cost efficiency among firms in the 1995 – 2001 period. However, according to Fenn *et al.* (2008), cost efficiency is declined, especially in the 1997-2000 period, for those firms in the life insurance sector. To be specific, the UK insurers carry an average score of 0.776 in the life sector from 1995 to 2001 (which declined from 0.8000 in 1995 to 0.759 in 1999); in comparison to this, the average score of 0.944 appeared in the non-life sector; whereas the score of composited insurers is around 0.988 (Fenn *et al.*, 2008). In addition, the authors also point out the relatively low level of efficiency in Germany, the UK and France, with a high level of concentration of M&A.[3] However, the scale of economies still exists due to consolidation. Also, by studying the impact of business environment

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[1] Hussels and Ward (2007) stated that the firm could be expected to reduce its cost by 35%, as the average cost efficiency was around 65% in the UK market. The results are similar to those of Hardwick (1997), Diacon, Starkey and O'Brien (2002) and Ward (2002).

[2] When comparing the efficiency scores with other countries, the authors found that the score in the UK was much higher than in the Spanish (Cummins and Rubio-Misas, 2006) and German industry (Mahlberg and Url, 2000) industries.

[3] The supporting evidence can be found in Table 1 and Table 2 in Cummins and Weiss (2004).

factors on insurers' efficiency, no significant efficiency differences are found in the UK (Eling and Schaper, 2017).

Kasman and Turgutlu (2011) study efficiency for EU-15s from 1995 to 2005. Their results show that the UK average inefficiency score is 0.083, which indicates that insurers could improve their cost efficiency by 8.3%. During this period, the fluctuation could be regarded as the feature of estimated cost inefficiency, with an increasing trend from 1995 (of 5.6%) to 2002 (of 11.2%), and a decreasing trend from 2002 (of 11.2%) to 2005 (of 9.8%) in the UK market. The authors also point out that the higher cost inefficiency generally appears within those large size firms, than other smaller size groups, and this result is also consistent those of with Fenn *et al.* (2008) and Cummins, Tennyson and Weiss (1999) in the case of the US market, but contradicts to the market evidence from Spain, see, Cummins and Rubio-Misas (2006).

Hardwick, Adams and Zou (2011) and Bahloul, Hachicha and Bouri (2013) also argue that corporate governance mechanisms could influence efficiency as well. Hardwick, Adams and Zou (2011) tried to examine the impact of corporate governance mechanisms[1] on profit efficiency within UK life insurance companies but find little impact on efficiency with the board characteristics in the UK life insurance market from 1994 to 2004. Bahloul, Hachicha and Bouri (2013) introduce the score of CEO power into the cost efficiency analysis in order to test its impact on different European markets. As a result, the authors concluded that the optimal level of CEO power exerted a significant effect on both efficiency and productivity across European markets. However, they also suggested that higher CEO power is correlated with lower cost-efficiency score, as an increase of the CEO power score would imply that the firm would be operating towards CEO's interests, rather than those of firms, leading the insurance company to a suboptimal situation. To be specific, the Netherlands is the most efficient system over the 2002-2008 period - that is 0.7084 - when not taking into consideration the CEO power score. However, if the CEO power score had been considered, then the efficiency of the UK non-life sector would become the most efficient system (0.7318) in comparison with the others, and the UK insurance market would be ranked as having the best growth over this

[1] The tested mechanisms included the existence of an audit committee, the percentage of actuaries and non-executive directors on the board, and the separation between the board chairman and the CEO. But, a significant positive or negative effect on profit efficiency was observed only by the percentage of non-executive directors on the board.

period, as the average TFP is 7.84%. From the other perspective, Adams and Jiang (2016) find that both inside and outside board directors' expertise are the most significant contributors to a firm's financial performance for UK property-casualty insurers. However, their result is not consistent with those of Kumar and Sivaramakrishnan (2008) or Faleye, Hoitash and Hoitash (2011).

1.2.3 Literature Review on Productivity

Cummins and Weiss (2011) define productivity as changes in technology over time, such that technical progress refers to a firm that can produce more outputs at a given level of inputs; whereas technical regress refers to producing less outputs. However, one concern is raised about the fixed costs of adopting a new technology: the cost can be relatively high, thus affecting efficiency and productivity. Therefore, by examining changes in productivity over time and its decomposed components, the impact of both internal and external factors (such as management decisions to adopt a new methodology and competition due to deregulation) on performance can be found, and further actions can be taken to improve the firm's performance by managers. Moreover, from a regulatory perspective, understanding the nature of the driving factors behind productivity are critical for policymakers to avoid setting misleading rules. For example, deregulation may impose competitive pressure, which is supposed to boots M&As and further enhance a firm's productivity, or the adoption of a new regulation may be too costly for some particular firms.

Mahlberg and Url (2010) find that deregulation could lead to a decreasing tendency towards efficiency, but an opposite trend for productivity is observed in Germany from 1992 to 1996. They also identify the main contributors as technical progress and scale efficiency effects; two types of convergence were tested as well, but only σ-convergences is confirmed.[1] Controversially, according to (Boonyasai, Grace and Skipper's (2002) multinational study, under the impact of deregulation and liberalisation, improvements in productivity could be found in the Korean and Philippine life markets; however, no such impacts on productivity growth are observed in either the Thailand or Taiwan markets. A

[1] Based on Barro and Sala-i-Martin's (1995) definition, Mahlberg and Url (2010) hypothesis that external pressure (e.g., competition) would force insurance companies to improve their efficiency. Therefore, σ-convergence is defined as efficiency that should converge to the benchmark level. while the dispersion of efficiency should decline over time. And β-convergences hypothesise according to the notion that the lower or inefficient firms at the beginning of the period should have a higher rate of productivity growth afterwards. Convergence analysis is also considered in this chapter, and the results are shown in Appendix.

more competitive market with more new diversified products is the other potential result from deregulation. As expected, geographical diversification was positively related to the property/liability insurer's revenue efficiency and total factor productivity growth in the US from 1994 to 2003 (Cummins and Xie, 2008). At a later stage, by investigating 14 EU countries, Vencappa, Fenn and Diacon (2013) estimate and decompose both life and non-life insurers' productivity growth from 1995 to 2008. They reveal that changes in technical efficiency is the main factor that drives productivity changes, and that the trend of estimated productivity varies due to the choice of different output measurements.

In Spain, under the impact of consolidation, which could be attributed to deregulation as well, a growing trend in productivity and an increasing number of companies with decreasing return to scale are observed from 1989 to 1998, and the productivity gains are almost due to gains in efficiency (Cummins and Rubio-Misas, 2006).[1] Ownership is also found to explain the difference in productivity growth, *e.g.* Spanish stock companies face positive growth, but mutual companies experience negative growth. Eling and Schaper (2017) also state that efficiency increases are the main driver of growth in productivity and further emphasise that changes in the external business environment should be the main channel for productivity enhancements.

From Donni and Fecher's (1997) cross-country study, a growth in productivity could be observed among EU-15s, a trend attributable to technical progress improvements from 1983 to 1991. They also explain that U.K. insures are more dynamic in adopting new technology in comparison to the other 14 markets, and this helps the U.K. insurers to achieve higher productivity from 1983-1991. On the other hand, as Germany carries a greater power of technological improvements than in the U.K., this may explain why the UK is weaker in contrast to Germany (Hussels and Ward, 2007). Technical progress could be regarded as an effective factor, one which boosts both efficiency and productivity worldwide, as argued by Eling and Luhnen (2010b). From a slightly later study relevant to the impact of deregulation and liberalisation, Bertoni and Croce (2011) study five EU life markets and find significant productivity improvement over the 1997-2004 period. The U.K. market is one of the five markets and its annual total factor productivity growth

[1] There are 47% of insurers still operating with increasing return to scale at the end of 1998. However, the proportion of firms facing a decreasing return to scale had an upwards trend in the largest two size groups.

is about 9.62%, in which innovation in best-practice[1] (technology changes) contributes 76% of the productivity growth, and no significant correlation between TFP growth and a firm's financial stability is found.

From a study of the Swiss insurance industry in the 1997-2013 period, Biener, Eling and Wirfs (2016) find that total factor productivity decline in the life sector is mainly due to technical regress, which could be explained by the increasingly challenging business environmental factors, such as low interest rates and increased competition from banks. Although they do not find significant changes in general insurance and reinsurance sectors on average, annually improvements exist due to both positive technical changes and efficiency increases in these two sectors.

From another study on the Thai insurance market, Yaisawarng, Asavadachanukorn and Yaisawarng (2014) also find that both the technology effect and the scale effect negatively contribute to total factor productivity growth in non-life markets from 2000 to 2007, with positive growth in TFP occurring from 2005, but a decline beforehand.

Cummins and Xie (2013) adopted Data Envelopment Analysis to analyse efficiency, return to scale and used the Malmquist Index to represent productivity in the US property-liability insurance market from 1993 to 2009, their results confirm improvements in productivity. Based on this study, a similar study was done by Alhassan and Biekpe (2015), who focused on the non-life market in South Africa from 2007 to 2012. They observed that productivity growth attributable to technology change (*i.e.* innovation in production outputs) could be explained by the adoption of new technology through innovation. Technology change in sales, underwriting and other relevant services may force insurers to adopt the innovations.

Section 1.3 Research Methodology and Data

In this chapter, a comprehensive analysis of UK insurers' efficiencies and productivity is undertaken. Stochastic frontier analysis is used to estimate both efficiency and productivity. Meanwhile, comparisons among types of businesses, types of ownerships

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[1] Best practice innovation refers to improve current productivity through the introduction of new products and more efficient processes, which belong to technology progress; and best practice adoption means to simulate and adopt other insurers' best-practices processes, which is related to efficiency improvements (Bertoni and Croce, 2011).

are also illustrated. Then, Finally, changes in productivity over time and its decomposed components are examined.

1.3.1 Literature Review on Stochastic Frontier Analysis

Acknowledging existing studies, two main approaches that have been widely used to estimate the frontier: the non-parametric approach and the econometric approach. These methods all involve determining an efficient frontier in achieving either the observed minimum cost or observed maximum profit (or revenue).

The non-parametric approaches have the advantage that significantly less assumptions are required on the specification of function forms, while the disadvantage is that they do not decompose the error and the inefficiency terms (Eling and Luhnen, 2010b). A commonly applied method is data envelopment analysis (DEA), which was presented originally by Charnes, Cooper and Rhodes (1978). By using DEA, one limitation is the estimated result can only account for technical efficiency because this technique does not consider price vectors; another potential limitation is that the result is also sensitive to some constraints (Canton *et al.*, 2005).

In comparison to the non-parametric approaches, the econometric approaches focus on utilising production, cost, profit or revenue function, with specific assumptions on the shape of the distribution of error and inefficiency terms (Greene, 2008; Eling and Luhnen, 2010b; Cummins and Weiss, 2011). According to previous studies, three econometric approaches are popular to estimate efficiency: stochastic frontier analysis (SFA)[1], distribution-free approach (DFA) and thick frontier approach (TFA).

To be more specific, the composed error term (both error term and inefficiency term) in the production function is assumed to follow some kind of distributions within stochastic frontier approach (Aigner, Lovell and Schmidt, 1977; Meeusen and van Den Broeck, 1977; Stevenson, 1980). The distribution-free approach doesn't assume specific distribution assumptions on inefficiency term; therefore, it is assumed that the random noise averages out to zero and the efficiency of each firm is stable over time (Eling and Luhnen, 2010b). Thick frontier approach also does not make any distributional

[1] According to Eling and Luhnen's (2010b) survey, two configuration decisions - the choice functional forms and the distributional assumptions[1] - must be made when applying econometric approaches, especially in SFA. However, in Berger and Mester's (1997) study, the authors find that flexible form and translog form are equal to each other from the point of economic view, and their efficiency score are highly correlated. These assertions are also confirmed by Vennet (2002).

assumptions (Berger and Humphrey, 1991); yet, it could be built on the assumption that inefficiency appears difference between the lowest and highest quartile companies (Eling and Luhnen, 2010b).

Based on a sample set of 6,462 insurance companies from 36 countries, Eling and Luhnen (2010b) also state that cost and technical efficiencies calculated from DEA and SFA are in a similar extraordinary range. Therefore, similar scores could be presented within both approaches, if these methodologies were performing consistently and correctly. However, a slightly different statement is made by Cummins and Zi (1998), and they point out that there are differences in the estimated score when different distributional assumptions are imposed on the error term. Additionally, the average efficiencies are higher for econometric approaches than its counterpart, while the results from two methods are still significant correlated, i.e. the correlation is around 0.5 – 0.6.

As noted, there are advantages and disadvantages associated with both methods. And the SFA should provide the least biased result in principle because the constructive advantages of SFA allow the action of separating composited error into pure random error term and inefficiency term (Cummins and Weiss, 2011).[1] Then, the stochastic frontier analysis (SFA) is applied in this study, and the non-parametric approach would not be explained any further. The panel data analysis is adopted throughout the study, because the key advantage of this is to enable heterogeneity, whereas the cross-sectional approach may not be able to achieve it (Kumbhakar, Wang and Horncastle (2015), pp 241). Therefore, by utilizing panel data analysis via SFA, estimating efficiency can be achieved by introducing an individual unobservable effect variable, which is time-invariant and individual-specific, and does not interact with other variables.

Within developments of the frontier analysis, various advanced models are introduced from 1984 to 2014. However, those developments and assumptions are made regarding the generalised form, which can be written as:

$$\mathrm{y}_{\mathrm{it}} = \alpha_{\mathrm{i(t)}} + \mathrm{x}_{\mathrm{it}}\beta + \mathrm{v}_{\mathrm{it}}$$

where $\alpha_{\mathrm{i(t)}} = \beta_0 - \mathrm{u}_{\mathrm{i(t)}}$. the first assumption is regarding unobserved individual effects ($\alpha_{\mathrm{i(t)}}$): if this term is assumed of being a fixed-effect variable in different observations, the model is called *a fixed-effects model* (Schmidt and Sickles, 1984); otherwise, is

[1] The purely random departures from the frontier is not counted as inefficiency.

categorized as *a random-effects model* (Pitt and Lee, 1981; Kumbhakar, 1987). The second assumption is regarding the inefficiency term ($u_{i(t)}$): if the inefficiency term is assumed to be constant through the time, the model is called *a time-invariant model*[1]; otherwise, it is *a time-varying model* with $\alpha_{i(t)}$ and $u_{i(t)}$ in the above equation (Cornwell, Schmidt and Sickles, 1990; Lee and Schmidt, 1993). Further distributional assumptions on inefficiency term in time-varying model are also imposed into the above equation, as shown in studies from Kumbhakar (1990), Battese and Coelli (1992) and Kumbhakar and Wang (2005). Further, Greene (2005) introduced both the *true fixed-effects model* and *true random-effects model*, which aim at solving the heterogeneity drawback, and it introduces a time-varying inefficiency u_{it}:

$$y_{it} = \alpha_i + x_{it}\beta_i + v_{it} - u_{it}$$

However, as the number of observations (N) is getting larger, the incidental parameters problem exist in Greene's (2005) models. It means there would be an inconsistency in estimation, as the number of α_i increased with N. However, this problem can be solved by applying a first-difference transformation within u_{it}, *i.e.* to separate firm effects from persistent inefficiency (Wang and Ho, 2010; Chen, Schmidt and Wang, 2014; Kumbhakar, Wang and Horncastle, pp241, 2015).

In addition, Mundlak (1961) also suggests that it is important to identify persistent inefficiency, as it indicates the effects of management (or other unobserved inputs, which are vary across firms, but not over time). Kumbhakar and Heshmati (1995) develop a model that considers the separation between the persistent (time-invariant) inefficiency(τ_i), and the time-varying inefficiency(u_{it}) in their model. As this persistent inefficiency might produce a downwards bias in estimating of total inefficiency, the equation is now presented in form of:

$$y_{it} = \alpha_i + x_{it}\beta_i + v_{it} - (u_{it} + \tau_i)$$

[1] There are two main drawbacks of time-invariant model. First, if time is great, the inefficiency of a firm may not stay constant; otherwise, persisting an inefficient firm would not able to help the firm to survive in the market (Kumbhakar et al., pp 241, 2015). Second, the heterogeneity cannot be distinguished from inefficiency; therefore, the estimated inefficiency might be 'picking up heterogeneity' in addition to efficiency (Greene, 2005)

Up to the recent frontier studies, Kumbhakar, Lien and Hardaker (2014) develop a model based on the abovementioned models. Their model overcomes the shortages associated with the other models by splitting the inefficiency into four components: random shock effects(v_{it}), time-varying inefficiency(u_{it}), time-invariant (persistent) inefficiency(τ_i) and heterogeneity effects(μ_i), and the form of equation becomes:

$$\mathrm{y_{it}} = \alpha_\mathrm{i} + \mathrm{x_{it}}\beta_\mathrm{i} + \mathrm{v_{it}} - (\mathrm{u_{it}} + \tau_\mathrm{i} + \mu_\mathrm{i})$$

Throughout the study, some of the mentioned models will also be used to estimate efficiency for UK insurers, and mathematical details are presented Appendix 1.

1.3.2 Efficiency Functional Function

Although the following discussions and formulas focus on the estimating cost efficiency only, the estimation of profit efficiencies are also involved in this research and can be found by using the same logic. To be more specific, the following specification for the cost function (Battese and Coelli, 1995) can be used to find cost frontier:

$$\mathrm{TC_{it}} = \mathrm{f}(\mathbf{Y_{it}}, \mathbf{P_{it}}, \mathrm{T}) + \varepsilon_{\mathrm{it}}$$

Equation (1.1)

in which the TC_{it} stands for the total cost of insurer *i* in year *t*, the Y_{it} stands for a vector of outputs, P_{it} stands for vector of input price, and ε_{it} stands for the composited error term, which is specified as, $\varepsilon_{it} = \mathrm{v}_{it} + \mathrm{u}_{it}$. Apart from this, the inclusion of a time trend variable (T) ensures that changes over time in technology and underwriting cycle can be captured. The term v_{it} stands for the error term, u_{it} denotes insurer's inefficiency, and the inefficiency term u_{it} is usually assumed to follow a half normal or truncated normal distribution, and the truncated normal distribution is adopted in this paper, as half normal distribution is special case of truncated normal distribution.

The translog cost function, opted in here, takes the form of

$$\begin{aligned}\ln TC_{it} = \alpha_0 &+ \sum_{g}^{2}\alpha_g \ln Y_{igt} + \sum_{j}^{3}\beta_j \ln P_{ijt} \\ &+ \frac{1}{2}\left[\sum_{g}^{2}\sum_{k}^{2}\alpha_{gk}\ln Y_{igt}\ln Y_{ikt} + \sum_{j}^{3}\sum_{h}^{3}\beta_{jh}\ln P_{ijt}\ln P_{iht}\right] \\ &+ \sum_{g}^{2}\sum_{j}^{3}\delta_{gj}\ln Y_{igt}\ln P_{ijt} + \mu_1 T + \frac{1}{2}\mu_2 T^2 + \sum_{g}^{2}\rho_g T\ln Y_{igt} \\ &+ \sum_{j}^{3}\xi_j T\ln P_{ijt} + \varepsilon_{it}\end{aligned}$$

Equation (1.2)

where TC = Total Cost (or TP = Operating Profit)

Y_1 = Output 1: Incurred Losses

Y_2 = Output 2: Total Investment

P_1 = Input price 1: Price of Labor and Business

P_2 = Input price 2: Price of Financial Capital

P_3 = Input price 3: Price of Technical Reserves

T = Time Trend

and, the detail of these chosen variables is discussed later in the following section. The symmetry property requires that $\alpha_{ik} = \alpha_{ki}$, $\beta_{jh} = \beta_{hj}$ and $\delta_{ij} = \delta_{ji}$. The cost function is homogeneous of degree 1 in input price, and so the following restrictions apply: $\sum \beta_j = 1$, $\sum\sum \beta_{jh} = 0$, $\sum\sum \delta_{gj} = 0$, $\sum\sum \xi_j = 0$. These constraints can be substituted into the model; therefore, the homogeneity conditions are satisfied. This procedure amounts to using one of the input prices (e.g. P_1) to normalized total cost and another input price. Using P_1 as the normalizing price, the above equation can be simplified as follows:

$$\begin{aligned}\ln\left(\frac{TC}{P_1}\right) = {} & \alpha_0 + \alpha_1 \ln Y_1 + \alpha_2 \ln Y_2 + \beta_2 \ln\left(\frac{P_2}{P_1}\right) + \beta_3 \ln\left(\frac{P_3}{P_1}\right) \\ & + \frac{1}{2}\left[\alpha_{11}\ln Y_1 \ln Y_1 + \alpha_{22}\ln Y_2 \ln Y_2 + \beta_{22}\ln\left(\frac{P_2}{P_1}\right)^2 + \beta_{33}\ln\left(\frac{P_3}{P_1}\right)^2\right] + \alpha_{12}\ln Y_1 \ln Y_2 \\ & + \beta_{23}\ln\left(\frac{P_2}{P_1}\right)\ln\left(\frac{P_3}{P_1}\right) + \delta_{12}\ln Y_1 \ln\left(\frac{P_2}{P_1}\right) + \delta_{13}\ln Y_1 \ln\left(\frac{P_3}{P_1}\right) + \delta_{22}\ln Y_2 \ln\left(\frac{P_2}{P_1}\right) \\ & + \delta_{23}\ln Y_2 \ln\left(\frac{P_3}{P_1}\right) + \mu_1 T + \frac{1}{2}\mu_2 T^2 + \rho_1 T\ln Y_1 + \rho_2 T\ln Y_2 + \xi_2 T\ln\left(\frac{P_2}{P_1}\right) + \xi_3 T\ln\left(\frac{P_3}{P_1}\right) \\ & + \varepsilon_{it}\end{aligned}$$

Equation (1.3)

Maximum likelihood estimation techniques are used to estimate the parameters of the stochastic frontier models. The cost inefficiency scores can be estimated by using Jondrow *et al.'s* (1982) approach, while efficiency score can be obtained from (Battese and Coelli's (1988) approach.

Once the parameters are available for the cost frontier, it is possible to estimate cost-scale efficiency by using the formula for the elasticity of scale:

$$\text{Cost} - \text{Scale Efficiency} = \sum_i \frac{\partial \ln TC}{\partial \ln Y_i} = \sum_i \left[\alpha_i + \frac{1}{2}\sum_k \alpha_{ik}\ln Y_k + \sum_j \delta_{ij}\ln P_j\right]$$

Equation (1.4)

This formula represents the sum of the partial derivatives of the cost function, with respect to each of the output variables. If this value < 1, economies of scale (decreasing cost) exists; if the value > 1, it indicates diseconomies of scale (increasing costs).

Economies of scale are present if average costs per unit of output decline as the volume of output increases. The source of scale economies is the spreading of the insurer's fixed costs over a larger volume of output, for example, operating at larger scale may reduce the firm's cost of capital.

1.3.3 Estimating Productivity and its Decomposition

Broadly speaking, there are two main approaches have been widely applied to measure productivity growth in many studies on industrial productivity: the frontier approach and non-frontier approach. [1] The recent literature of financial industry has extensively followed the frontier approaches (parametric and non-parametric), which base on identifying the best-practice firms in the market, see, Esho and Sharpe (1994), Koop, Osiewalski and Steel (1999), Mahlberg and Url (2010), Cummins and Weiss (2011) and Eling and Schaper (2017). In line with efficiency estimation, the parametric SFA techniques has been used on panel data set throughout the study.[2] Within the SFA, by following both Karagiannis, Midmore and Tzouvelekas (2004) and Kumbhakar and Lozano-Vivas (2005), a Stochastic Distance Cost Frontier model with multi-output is used. They have pointed some advantages of using this model: (1) The distance cost function is able to accommodate multi-output, which is consistent with the setting of multi-outputs in efficiency estimation; (2) No restrictions on the implied return to scale; (3) Cost approach is more appropriate than production approach because insurers' outputs may be demand driven; and (4) Restrictions on market competition is not necessary in cost function approach.

According to Karagiannis, Midmore and Tzouvelekas (2004), Kumbhakar and Lozano-Vivas (2005) and Kumbhakar, Wang and Horncastle (2015), productivity changes, when there are multiple inputs (j inputs) and multiple outputs (m outputs), is measured by TFP growth, and can be defined as:

$$T\dot{F}P = \sum_m R_m \dot{y}_m - \sum_j S_j \dot{x}_j \ , \qquad \text{Equation (1.5)}$$

where $R_m = p_m y_m / R$ and $S_j = w_j x_j / C$, in which p is the output price, y is output vector and $R = \text{Total Revenue} = \sum_m p_m y_m$; and w is the input price, x is the input vector and

[1] Vencappa, Fenn and Diacon (2013) provide an introduction on the difference between these two approaches.

[2] The main advantage of choosing parametric approach is that both estimating and decomposing TFP growth is allowed, which cannot be achieved by non-parametric approach (Kumbhakar and Lozano-Vivas, 2005).

C = Total Cost $= \sum_j w_j x_j$. This measurement framework starts with a cost function if decomposition is also preferred; and the cost function can be identified as $C = C(y, w, t)$, where *t*, the time trend variable, is introduced to capture external technical changes. Thus, using the same method presented by Denny, Fuss and Waverman (1987), Kumbhakar and Lozano-Vivas (2005) and Kumbhakar, Wang and Horncastle (2015), the TFP growth and its components can now be defined as:

$$T\dot{F}P = TCC + TEC + [(1 - RTS^{-1})\dot{y}_c] + [\dot{y}_p - \dot{y}_c] \text{ ,} \qquad \text{Equation (1.6)}$$

where TCC is the technical change component;

TEC is the technical efficiency change component;

$(1 - RTS^{-1})\dot{y}_c$ is scale component, and $RTS^{-1} = \sum_m \partial \ln C / \partial \ln y_m$;

$\dot{y}_p - \dot{y}_c$ is the markup component, in which $\dot{y}_p = RTS\{\sum_m (\partial \ln C / \partial \ln y_m)\dot{y}_m\}$

and $\dot{y}_p = \sum_m R_m \dot{y}_m$; $\dot{y}_m = \partial \ln y_m / \partial t$ and $\dot{x}_m = \partial \ln x_j / \partial t$.

1.3.4 Data, Output and Input Factors Used in Efficiency Measurement

The database used in this chapter is built on information from financial statements of individual insurers, which included balance sheet and income statement, collected from Orbis, Fame and ISIS (or Insurance Focus) provided by Bureau van Dijk. The sample covers at least 90% of the market capacity from 1996 to 2017. In line with Eling and Luhnen (2008), Fenn *et al.* (2008), Kasman and Turgutlu (2011) and Yaisawarng, Asavadachanukorn and Yaisawarng (2014), companies were included in this analysis, if they have positive values for all outputs, inputs and input price variables, which are used to measure efficiency and productivity. This is because that the estimation of the efficiency function requires that the input prices are strictly positive. However, there is not required of data for all years; therefore, unbalanced panel data is accepted. To ensure all monetary values are directly comparable, we deflate each year's value by the consumer price index to the base year 2015.

Two types efficiencies, cost and profit efficiency, will be estimated. First, the insurer's operating expenses that associated with both underwriting and administrative costs is used to determined *total cost* (Berger *et al.*, 2000; Kasman and Turgutlu, 2011). Following Fenn *et al.* (2008), the claim paid is excluded in order to avoid confusion with the output factor. Additional, *total profit* is the simple operating profit, profit before tax, presented in financial statement. Then, in order to estimate efficiency scores, definition of outputs, inputs and their prices that shown in Equation (1.1) must also be specified.

Choice of output factors and output prices

There is a difficulty lies in previous efficiency studies of measuring insurance companies' outputs (Donni and Fecher, 1997; Diacon, Starkey and O'Brien, 2002; Eling and Luhnen, 2008; Cummins and Weiss, 2011). In addition to this difficulty, Cummins and Weiss (2011) further point out that the cause of this difficulty is attributed to the main feature around financial firms; in another words, the intangibility of outputs (consists primarily of services). Brockett *et al.* (2005) also have a similar statement, that the selection of variables to represent inputs and outputs is vital to the validity of the analysis, and it is difficult for financial services firms, as opposed to manufacturing firms of utilizing physical resources inputs to produce physical products as outputs. This stems from the statement of Hornstein and Prescott (1991), that a conceptual definition of output must be needed to measure its product; otherwise, it is not clear what data should be collected and how it should be used to compute output measures. In previous studies, there are many unresolved debates around the definition of outputs in the insurance industry, *e.g.* Berger *et al.* (2000), Eling and Luhnen (2010b), Cummins and Weiss (2011) and Yaisawarng, Asavadachanukorn and Yaisawarng (2014) also state that different measures of output lead to different conclusion on efficiency.

As summarised in the studies of Eling and Luhnen (2010b) and Cummins and Weiss (2011), three principal approaches used to measure outputs in financial services: the user-cost approach (Hancock, 1985), the intermediation approach (Brockett *et al.*, 1998), and the value-added approach (Berger and Humphrey, 1992). Appendix 1 provides a full review on these approaches. Since the value-added approach has been established as the best practice, and large numbers of authors choose it; then, it is adopted to measure outputs in this paper, and the following discussions are only based this chosen approach.

Cummins and Weiss (2011) explain that it is necessary to find suitable proxies for the volume of services provided by insurers, as these outputs from insurers are mostly intangible. (Zanghieri, 2009) mention that one of the most important challenges is how to proxy outputs for analysing efficiency in the financial services industry. According to Berger *et al.* (2000), Eling and Luhnen (2008), Zanghieri (2009) and Cummins and Weiss (2011), the output produced by the insurer is the provision of three principal services, and the pragmatic approach is therefore to identify these services, and to find measurable proxies that are highly correlated with these services (Diacon, Starkey and O'Brien, 2002). To be more specific, the three principal services are: the risk-pooling and risk-taking, the financial intermediation, and the 'real' financial services relating to insured losses. Details of these three services are summaries in Appendix 1.

Based on the defined services, Donni and Fecher (1997) suggest two alternatives can be chosen as output proxies: premiums or incurred losses (claims or benefits paid to policyholders), and the number of policies contracted.

Individuals tend to purchase insurance because they are risk averse. The price that individuals are willing to pay is an indicator of their degree of risk aversion and their willingness to transfer risk, as such net premiums are a reflection of the value-added for each individual policyholder of the insurance firm (Ward, 2002). This may be one of the reasons why premium could be included within the measure of output, particularly from a value-added perspective.

Prior to Yuengert (1993), most of studies measured risk bearing/pooling outputs as the value of premiums (Grace and Timme, 1992; Fecher *et al.*, 1993; Gardner and Grace, 1993). Hirshhorn and Geehan (1977) state that the premium could reflect the ability of an insurance company to select clients and to accept risks. It means that premiums collected directly concern the technical activities of insurers. By following this concept, the premium income may be the most acceptable indicator of an insurance company's services (Grace and Timme, 1992; Fecher *et al.*, 1993; Gardner and Grace, 1993; Rai, 1996; Hardwick, 1997; Boonyasai, Grace and Skipper, 2002; Diboky and Ubl, 2007; Hu *et al.*, 2009). Again, because all of the three services are related to premium income (Diboky and Ubl, 2007), risk-pooling and -bearing can be measured in terms of insurance coverage, and the intermediation services do depend on the level of funds collected from policyholders. Moreover, another issue concerning whether premiums should be net or gross, written or earned.[1]

[1] This issue needs to be concerned in long-term insurance policy, where there is a substantial delay between the collection of premiums and the payment of claims. Net written premiums or net earned premiums have been used as proxies for outputs in most early cost studies (e.g., Grace and Timme, 1992; Fecher *et al.*, 1993; Gardner and Grace, 1993; Rai, 1996; Donni and Fecher, 1997; Hardwick, 1997; Diacon, Starkey and O'Brien, 2002; Hao and Chou, 2005; Bikker and van Leuvensteijn, 2008).

However, Yuengert (1993) argues that premium should be a questionable measure of policies. It does not represent a count of output units (quantity), but a form of revenue (price times number of policies, price is included). Both Fenn *et al.* (2008) and Fiordelisi and Ricci (2010) state that the price of product provided by insurers could be viewed as the expected present value of future claims. However, premium paid normally exceeds this expected value, then the differences may result in misleading conclusions about insurers' operational efficiency. In addition to this, Doherty (1981) and Leverty, Lin and Zhou (2004) state that bias would be arsing by using premium, as it is not independent of the pricing policies (across the industry), which violates the assumption that independent variables should be exogenous. But, Allen (1974) and Blair, Jackson and Vogel (1975) suggest that a premium would be appropriate the proxy, if assuming the product is homogeneous and the market is competitive, and further compelling all insurers charge a similar price. In fact, this restriction of using premium as an output proxy is not be a serious problem in the UK insurance market. The liberalization and deregulation has resulted in enhancing the competition among EU insurers, further leading to a similar price competition potentially; and homogeneous product assumption is not very restrictive, as the UK insurers do offer fair homogeneous products. As these potential problems of using premium to proxy outputs, Yaisawarng, Asavadachanukorn and Yaisawarng (2014) mention that the number of policies issued would be an ideal measure of 'production' output because it represents the primary function of an insurance company; namely, to provide financial stability by selling 'protection' to policyholders in exchange for premiums. However, the number of policies written is unavailable or not published in most cases.

Alternatively, a large number of previous studies use the amount of losses incurred as a proxy (Cummins and Santomero, 1999; Cummins, Tennyson and Weiss, 1999; Cummins, Rubio-Misas and Zi, 2004; Cummins and Rubio-Misas, 2006). Berger *et al.* (2000) state that incurred losses is meaningful to represent both risk-pooling/bearing services and real financial services. It is attributed to the fact that incurred losses (claims or benefits) represents two ideas: the total amount redistributed by the pool and the legal protections amount offered by real financial services in unexpected events.

Based on this point, the present value of incurred losses is used as an output proxy (Berger, Cummins and Weiss, 1997; Berger *et al.*, 2000; Choi and Weiss, 2005; Weiss and Choi, 2008; Cummins *et al.*, 2009). Fiordelisi and Ricci (2010) and Kasman and Turgutlu (2011) use claims incurred net of reinsurance as a measure of insurance output[1]; Yuengert (1993) and Cummins and Rubio-Misas (2006) suggest that the value of real incurred losses (current losses paid plus additional to reserves) is a good indicator to proxy the amount of risk pooling/bearing and real financial services. Based on this suggestion, Cummins and Zi (1998), Carr, Cummins and Regan (1999), Boonyasai, Grace and Skipper (2002), Erhemjamts and Leverty (2010) and Huang and Paradi (2011) all use losses plus additional to reserve as an output proxy. Leverty and Grace (2010) use the expected losses, *i.e.* multiplying a firm's current year earned premiums by a three-year average of its loss rate.

However, one limitation of the suggestions from Yuengert (1993) and Cummins and Rubio-Misas (2006) is that reserves amount would change when new policies are sold or old policies are mature (Greene and Segal, 2004). Diacon, Starkey and O'Brien (2002) and Klumpes (2005) solved this issue by using premium paid, plus investment income, minus claims due to the accounting period, and minus changes in reserves. Again, the main drawback is not controlling the effect of the insurance price, as mentioned before.

Further to this point, it is difficult to understand why insurers would seek to maximize the value of claims, as it violates the insurers' characteristic identified by output, which should be preferred to less (if the output is claimed payments). Brockett *et al.* (2005) also disagree with using incurred losses as the proxy, and argue that if there was no change in inputs, a dramatically increase in losses can be expected (due to extreme events); and this would be a bad case as there would be a lack of efficient enhancement available for an insurer. Therefore, they use solvency scores, financial returns and claims-paying ability to replace losses as output; because owners, managers and regulators would be likely to take a response action in favour to improve these outputs. Yaisawarng, Asavadachanukorn and Yaisawarng (2014) further argue that losses incurred is not an appropriate output proxy, since it does not consider the quality of insurers' loss control and risk management; and insurers with excellent risk control skill should have a lower amount of losses incurred, therefore a producing lower output.

[1] Fiordelisi and Ricci (2010) used net incurred claim to approximate the output: it was defined as gross claims paid less claims received from reinsurers, plus increase in loss reserves (addition to reserve), and plus bonuses and rebates, but before the addition of claims management costs.

According to Eling and Luhnen (2008, 2010b), there are still many debates among those using the value-added approach, as to whether incurred losses (claims or benefits) or premiums (sum insured) are the most appropriate proxies for risk-pooling/-bearing outputs. They also recognise that there are more studies using incurred loses to proxy outputs than premiums (sum insured). However, no recognisable conclusion can be achieved.

As discussed, there is no simple 'right or wrong' solutions in directing the choice of the correct proxies. Taking into consideration of the risk-pooling/bearing activities, Cummins and Weiss (2000) state that no proxy was valid in principle. Thus, this study the choice of Berger *et al.* (2000), Fenn *et al.* (2008), Fiordelisi and Ricci (2010) and Kasman and Turgutlu (2011): using *net claims paid* (claims incurred net of reinsurance) to represent the risk pooling/bearing activity and the real financial services. Another reason is that the restricted homogeneous product assumption need to be made, if using premium as the proxy.

Moreover, Boonyasai, Grace and Skipper (2002) and Diacon, Starkey and O'Brien (2002) use investment income to represent output from the financial intermediation service. Alternatively, total investment amount is also chosen as one output by Grace and Timme (1992), Klumpes (2004), Hao and Chou (2005), Eling and Luhnen (2010b) and Yaisawarng, Asavadachanukorn and Yaisawarng (2014). The reason of imposing total investment is that insurers not only generate underwriting profit, but also make huge investments to meet future obligations for both policyholders and stakeholders (Yaisawarng, Asavadachanukorn and Yaisawarng, 2014). Therefore, the insurer's *total investment* is picked as the second output proxy to represent financial intermediation services.

To find out the TFP growth and its components, the prices of two outputs are required. Following Cummins and Xie's (2008) approach,[1],the price of output, which associated to risk pooling/bearing activity and real financial activities, can be defined as the insurer's

[1] Due to data availability, the exact measurements of output prices, from Cummins and Xie (2008), are not able to use in this study. However, the applied methods is selected based on the similar logic to Cummins and Xie's (2008) suggestion. For example, the underwriting income is a reasonable variable to proxy the difference between premium earned and losses incurred for reporting period; meanwhile, expected return on invested asset is defined as return on total investment because of the lack of information on individual asset data.

underwriting income divided by net claim amount. In addition, *the ratio of investment income to total investment* can represent the price of output from financial intermediation services.

Choice of input factors and input price

After considering the choice of outputs, the process of selecting appropriate input variables is much simpler and less controversial. According to Eling and Luhnen (2008) and Cummins and Weiss (2011), most of the studies used at least labour, financial capital, and add a third category as input vectors. There are two different methods to determine the price of these chosen inputs: (1) to assume that the price is invariable among firms when insurers purchase their production inputs in competitive markets, see, Hao and Chou (2005), Cummins and Rubio-Misas (2006), Fenn *et al.* (2008) and Kasman and Turgutlu (2011); and (2) to specify variable input prices for individual firms, *e.g.* Greene and Segal (2004), Barros, Barroso and Borges (2006) and Bikker and van Leuvensteijn (2008). The second method is adopted in this research, as the chosen input factors are firm-specific variables, which carry individual firm's characteristics.

By following the recent insurance efficiency studies, three input factors were selected: labour cost, business cost and financial capital. It is necessary to simplify this selection by combining labour cost and business cost as *administration expenses*. **S**implicity and data availability is the main reason behind using this simplification, and this practice has been used in many other studies, *e.g.* Diacon *et al.* (2002), Fenn *et al.* (2008) and Bahloul *et al.* (2013). This also helps to reduce the number of parameters (Ennsfellner, Lewis and Anderson, 2004)**.** By focusing on the studies of Hasan and Marton (2003), Kasman and Yildirim (2006) and Kasman and Turgutlu (2011), the proxy for the input price, which is related to the labour and business cost, is *the ratio of administration expenses to total assets*.

As discussed above, the risk pooling/bearing and the financial intermediation are two main functions of insurers. Financial capital can be regarded as the main input used to provide these services (Diboky and Ubl, 2007; Jeng, Lai and McNamara, 2007; Klumpes, 2007; Erhemjamts and Leverty, 2010). In fact, the inclusion of financial capital indicates that the contractual relationship (between capital supplier and the firms) is one major part of firm's operation. Therefore, two types of capital are considered: equity and debt capital. Equity serves as an important indicator of insurers' financial strength and reliability

(Hughes, 1999; Berger *et al.*, 2000; Eling and Luhnen, 2010b; Kasman and Turgutlu, 2011). Equity capital can be viewed as an input because it provides a source of funds that enable insurers to cover unexpected losses if the amount is larger than expected (Tone and Sahoo, 2005; Hardwick, Adams and Zou, 2011). However, equity is treated as the fixed input in studies of Berger, Cummins and Weiss (1997), Berger *et al.* (2000), Fenn *et al.* (2008), as they assume it has been built up over a long time and is difficult to adjust quickly. Zanghieri (2009) disagree with this point for two reasons: (1) insurers are able to raise equity capital quite rapidly in the EU capital market; and (2) the price of equity partially explain the level of risk implied in investing in the firm, and the insurer's risk level varies over time. Therefore, equity capital would be treated as a variable input in this research. Debt capital, in insurance companies, can be defined as the total borrowings from creditors (*e.g.* banks and policyholders), and it also represents the sources for the intermediation function of an insurance firm (Cummins and Weiss, 2011), which is a liability item. It can also be treated as a input variable.

Therefore, by adopting the method from the studies undertaken by Jeng and Lai (2005), Cummins and Weiss (2011), Yaisawarng, Asavadachanukorn and Yaisawarng (2014) and Alhassan and Biekpe (2016), the price of the equity capital is defined as the ratio of net income to equity capital. The price of debt capital is proxied as the ratio of investment income to total reserves. Due to data unavailability, it is hard to consider different proxies for capital prices separately. Therefore, the combination of two capital is preferred; thus the price of financial capital (the sum of equity and debt) is proxied *as the ordinary profits to the sum of equity capital and total reserve* (Jeng and Lai, 2005).[1] In line with Berger, Cummins and Weiss (1997), Berger *et al.* (2000) and Fenn *et al.* (2008), total net technical provisions (reserves)[2] is also included as the third inputs, and its price is the ratio of *total net technical provisions to total asset.*

Section 1.4 Results and Discussions

Table 1.1 shows the descriptive statistics of the discussed variables used to estimate the insurer's efficiency and productivity, and all variables are positive due to the modelling restrictions of translog form. As discussed, this study has applied different mathematical

[1] Ordinary profit is also called profit from operations, it could be calculated as the sum of underwriting profits, net investment income and other income minus other expenses related to investment; or the sum of total investment return (total investment * investment yield) and operating profit minus cost of investment.
[2] It includes unearned premium reserves, loss reserves, and mathematical reserves (Fenn et al. 2008).

approaches to estimate the insurer's efficiency; Appendix 1 presents the details of the estimated results from different models. Thus, the following discussions are based on the results estimated by using Kumbhakar, Lien and Hardaker (2014)'s model.

Table 1.1: Descriptive Statistics

Variable	*Obs.*	*Mean*	*Standard Deviation*	*Min*	*Max*
Total Cost	5716	10380.93	42863.84	0.07	979190.08
Total Profit	6252	969.42	4901.93	0.00	178617.88
Output 1	5794	4058.68	15927.84	0.00	431176.47
Output 2	6972	55529.61	444324.39	0.00	26883116.05
Input Price 1	5418	0.12	0.57	0.00	26.71
Input Price 2	5395	0.38	20.61	0.00	1509.00
Input Price 3	6412	0.54	0.35	0.00	5.27

Notes: *Total Cost* equals to Operating Expenses - Claim Paid. *Total Profit* is the profit before tax shown in the income statement. *Output 1* is Net Claims Paid, and *Output 2* is Total Investment. *Input Price 1* equals to the ratio of Administration Expenses to Total Asset. *Input Price 2* is the ratio of Ordinary Profits to the sum of Equity and Reserve. *Input Price 3* equals to Net Technical Provisions / Total Asset. The values of Total Cost, Total Cost, Output 1, Output 2 are in thousand pounds, while Input Price 1, Input Price 2, Input Price 3 are ratios. The detailed definition can be found in Section 1.3.4.

1.4.1 Efficiency Estimations

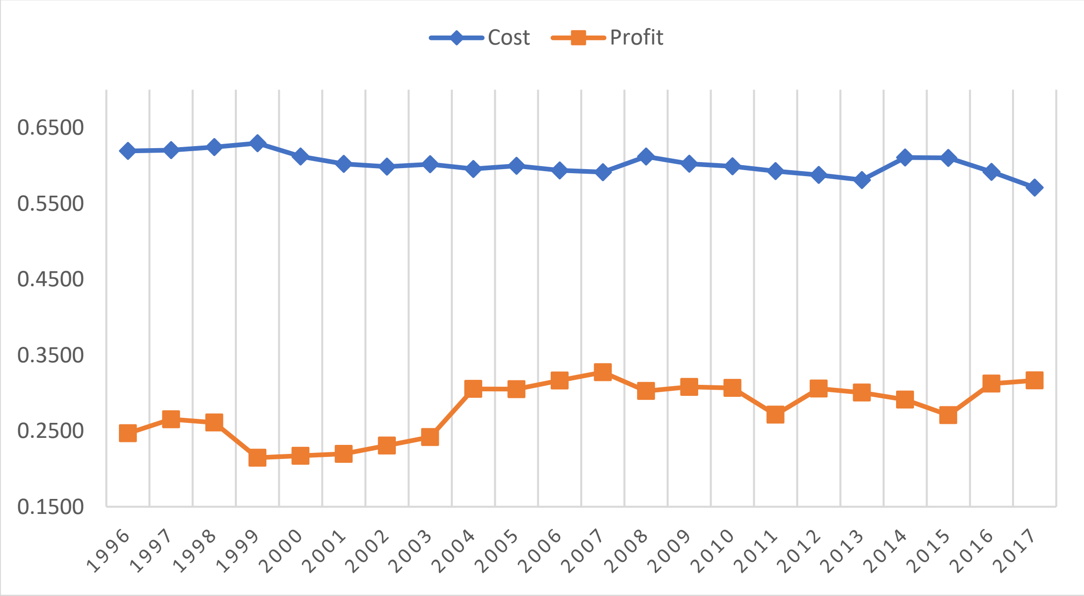
Table 1.2 presents the annual means of the predicted scores of cost and profit efficiencies. On one hand, the average cost efficiency score is around 0.6, in line with Eling and Luhnen's (2010) result of 0.615, but it is lower than the average score of 0.90 observed by Fenn *et al.* (2008). Then, from the spending (or cost) perspective, the average score of 0.6 suggests that most of the UK insurers spend 40% more on the cost compared to the best-practice player in the market. On the other hand, the average profit efficiency score is only about 0.30. Given the same level of input prices and outputs, most of the market players can only generate 30% of the profits attainable by the best-practice one. Moreover, this score is much less than Hardwick, Adams and Zou's (2011) finding, which is 0.69 on average. The differences between the estimated findings and the previous findings may be explained by the usage of different output and input vectors, estimation techniques and study periods. Despite the UK insurers' cost performance is always better than the profit performance, the 2008 financial crisis has had harmful influences on both cost and profit performance. Both have dropped from their peak values since 2008, the cost efficiency was dropped from 61.19% in 2008, and the profit efficiency was dropped from 30.81% in 2009. It is interesting to know that the profit performance was enhanced from 2012, while the cost performance was enhanced from 2014. Moreover, if looking backwards, the 2000 Dotcom Bubble crisis (or the internet crisis) may also affect the UK insurer's cost performance, as the cost efficiency score started to drop from 61.20% in 2000. No such pattern is found for profit performance.

Figure 1.1 clearly shows that the insurer's cost efficiency is higher than its profit efficiency, indicating that the UK insurers may tend to put more efforts on managing cost (*i.e.*, reducing its cost) than on generating profit. Gaganis, Hasan and Pasiouras (2013) and Alhassan and Biekpe (2016) also confirm the differences between cost efficiency and profit efficiency. Furthermore, the uncertainty of profit performance is higher because more significant fluctuations are associated with the movement of profit efficiency over the study period.

Table 1.2 Cost and Profit Efficiencies for All insurers

Year	Cost Efficiency	Profit Efficiency
1996	0.6193	0.2469
1997	0.6204	0.2654
1998	0.6243	0.2611
1999	0.6295	0.2147
2000	0.6120	0.2172
2001	0.6022	0.2198
2002	0.5986	0.2308
2003	0.6018	0.2419
2004	0.5955	0.3054
2005	0.5997	0.3051
2006	0.5937	0.3165
2007	0.5913	0.3274
2008	0.6119	0.3027
2009	0.6024	0.3081
2010	0.5990	0.3066
2011	0.5927	0.2715
2012	0.5876	0.3059
2013	0.5810	0.3006
2014	0.6107	0.2913
2015	0.6102	0.2708
2016	0.5917	0.3124
2017	0.5711	0.3166
Average	**0.6001**	**0.2908**

Figure 1.1 Cost and Profit Efficiencies for All Insurers



Tables 1.3 and 1.4 present the cost and profit efficiency scores over time, respectively, when the UK insurance market is decomposed into five sub-markets. Here, the types of businesses and organisational forms are the two main sub-groups of concern. The former involves non-life insurers, life insurers and Lloyds insurers, while stock and mutual insurers belong to the latter group. Apart from what has been discussed, Figures 1.2 and 1.3 show that the Lloyds insurers are in the leading position of reducing cost and generating profit. This finding should not be surprising because Lloyds comprises specialised insurers who have expertise in particular areas. In other words, they have better control of underwritings; meanwhile, it is difficult for the changes in external conditions to influence the special events that trigger the insurance claims in Lloyds firms.

In contrast, the life insurers resemble laggards because they always have the lowest scores in both cost and profit performance over the study period. Furthermore, in generating or maintaining a specified level of profit, life insurers face more uncertainties than non-life insurers. Between the two organisational forms, mutual insurers will more likely be the high-performing ones. Interestingly, the profit graph (Figure 1.3) clearly shows a concave curve from 2012 to 2017, while the cost graph (Figure 1.2) illustrates a convex shape from 2013 to 2017. These results suggest that the insurers might have needed to balance between generating profits and reducing costs from 2012 to 2017. Specifically, the UK insurers tended to pay more attention to cost management from 2012 to 2015; then, their strategies have focused on profit generation since 2015. Finally, there is a noteworthy absence of significant improvements in the UK market from both cost and profit perspectives over the study period.

Table 1.3: Cost Efficiency from Different Sub-groups

Year	All	Non-life	Life	Lloyds	Stock	Mutual
1996	0.6193	0.5985	0.5753		0.5753	0.6855
1997	0.6204	0.5942	0.5782		0.5748	0.6875
1998	0.6243	0.6011	0.5718		0.5807	0.6851
1999	0.6295	0.5867	0.5677		0.5771	0.6962
2000	0.6120	0.5706	0.5786		0.5630	0.6728
2001	0.6022	0.5744	0.5429		0.5408	0.6793
2002	0.5986	0.5720	0.5594		0.5438	0.6700
2003	0.6018	0.5755	0.5563		0.5578	0.6533
2004	0.5955	0.5742	0.5205	0.8446	0.5442	0.6583
2005	0.5997	0.5721	0.5316	0.8417	0.5517	0.6495
2006	0.5937	0.5614	0.5258	0.8529	0.5364	0.6493
2007	0.5913	0.5640	0.5178	0.8532	0.5395	0.6526
2008	0.6119	0.5981	0.5294	0.8663	0.5641	0.6725
2009	0.6024	0.5896	0.5356	0.8464	0.5576	0.6740
2010	0.5990	0.5851	0.5264	0.8473	0.5567	0.6489
2011	0.5927	0.5743	0.5284	0.8468	0.5481	0.6566
2012	0.5876	0.5740	0.5321	0.8361	0.5431	0.6532
2013	0.5810	0.5690	0.5339	0.8131	0.5413	0.6423
2014	0.6107	0.5980	0.5138	0.8857	0.5636	0.6598
2015	0.6102	0.5919	0.5305	0.8613	0.5678	0.6627
2016	0.5917	0.5865	0.4663	0.8519	0.5402	0.6723
2017	0.5711	0.5435	0.4960	0.8326	0.5188	0.6596
Average	**0.6001**	**0.5802**	**0.5356**	**0.8498**	**0.5526**	**0.6662**

This table presents the cost efficiency scores for the entire market and five sub-markets, which are non-life insurers, life insurers, Lloyds insurers, stock insurers and mutual insurers, from 1996 to 2017 (except for Lloyds insurers). The first three can be considered as different business types, and the latter two are different organisational forms. The cost efficiency is estimated by adopting Kumbhakar, Lien and Hardaker (2014)'s SFA model.

Table 1.4 Profit Efficiency from Different Sub-groups

Year	All	Non-life	Life	Lloyds	Stock	Mutual
1996	0.2469	0.4444	0.2135		0.2317	0.2829
1997	0.2654	0.4946	0.1813		0.2533	0.3026
1998	0.2611	0.5020	0.2056		0.2346	0.3171
1999	0.2147	0.4543	0.1653		0.1972	0.2722
2000	0.2172	0.4742	0.1604		0.2084	0.2378
2001	0.2198	0.4302	0.2350		0.2069	0.2746
2002	0.2308	0.4416	0.1724		0.2294	0.2249
2003	0.2419	0.4593	0.1757		0.2141	0.3062
2004	0.3054	0.4776	0.2233	0.5737	0.2671	0.3359
2005	0.3051	0.4981	0.2250	0.5747	0.2773	0.3367
2006	0.3165	0.4828	0.2690	0.5806	0.2775	0.3433
2007	0.3274	0.4985	0.2725	0.5993	0.2933	0.3372
2008	0.3027	0.4788	0.1776	0.5820	0.2892	0.2537
2009	0.3081	0.4798	0.2348	0.5905	0.2777	0.3274
2010	0.3066	0.4798	0.2207	0.5790	0.2771	0.3299
2011	0.2715	0.4473	0.2148	0.5414	0.2514	0.2887
2012	0.3059	0.4794	0.2268	0.6148	0.2710	0.3555
2013	0.3006	0.4609	0.2447	0.5833	0.2690	0.3297
2014	0.2913	0.4665	0.2083	0.5884	0.2641	0.2966
2015	0.2708	0.4281	0.2181	0.5425	0.2460	0.2460
2016	0.3124	0.4883	0.2262	0.6486	0.2830	0.3760
2017	0.3166	0.5363	0.2383	0.5683	0.2968	0.3444
Average	**0.2908**	**0.4747**	**0.2148**	**0.5848**	**0.2638**	**0.3074**

Notes: This table presents the profit efficiency scores for the entire market and five sub-markets, which are non-life insurers, life insurers, Lloyds insurers, stock insurers and mutual insurers, from 1996 to 2017(except for Lloyds insurers). The first three can be considered as different business types, and the latter two are different organisational forms. The profit efficiency is estimated by adopting Kumbhakar, Lien and Hardaker (2014)'s SFA model.

Figure 1.2 Cost Efficiencies for Different Sub-groups Over Time

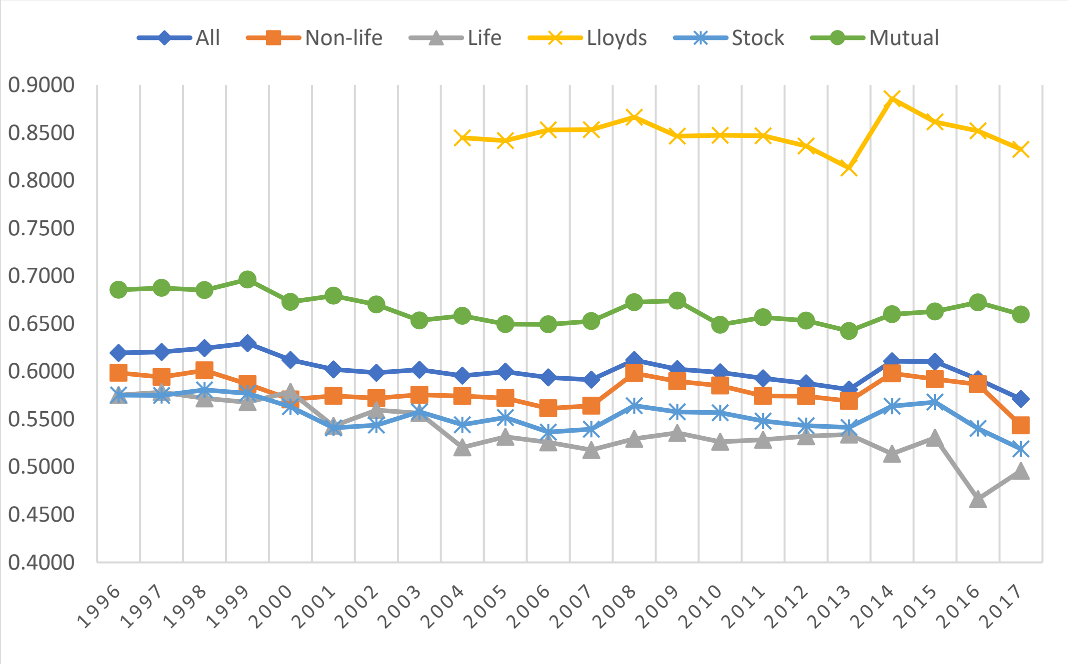


Figure 1.3 Profit Efficiencies for Different Sub-groups Over Time

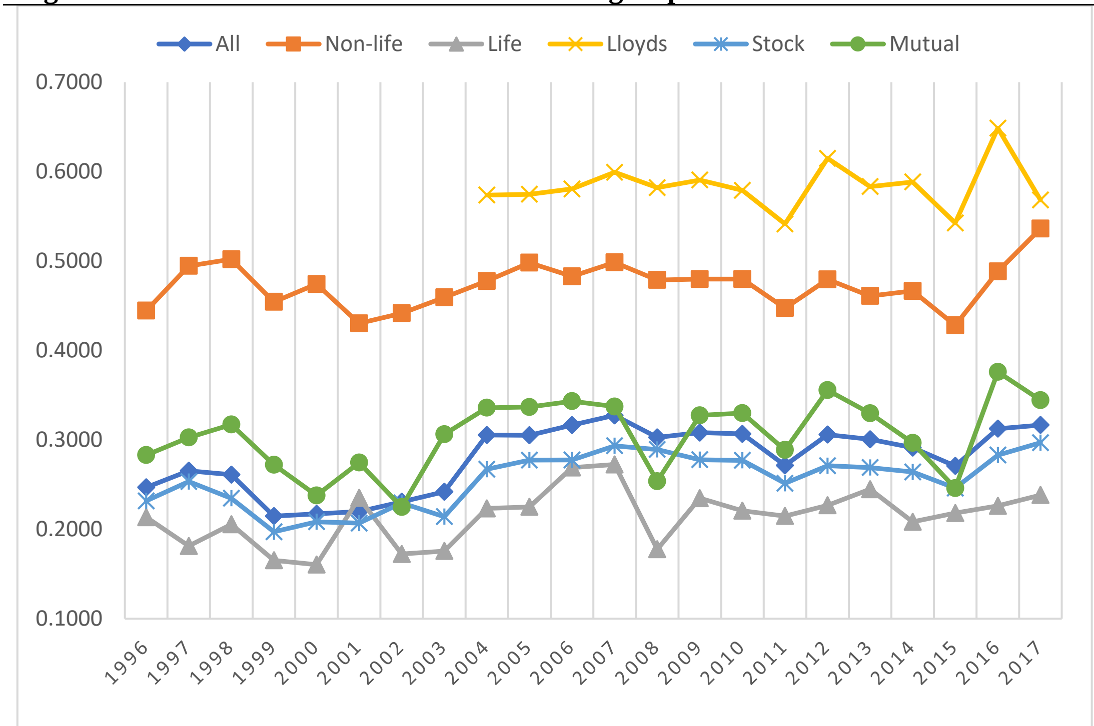
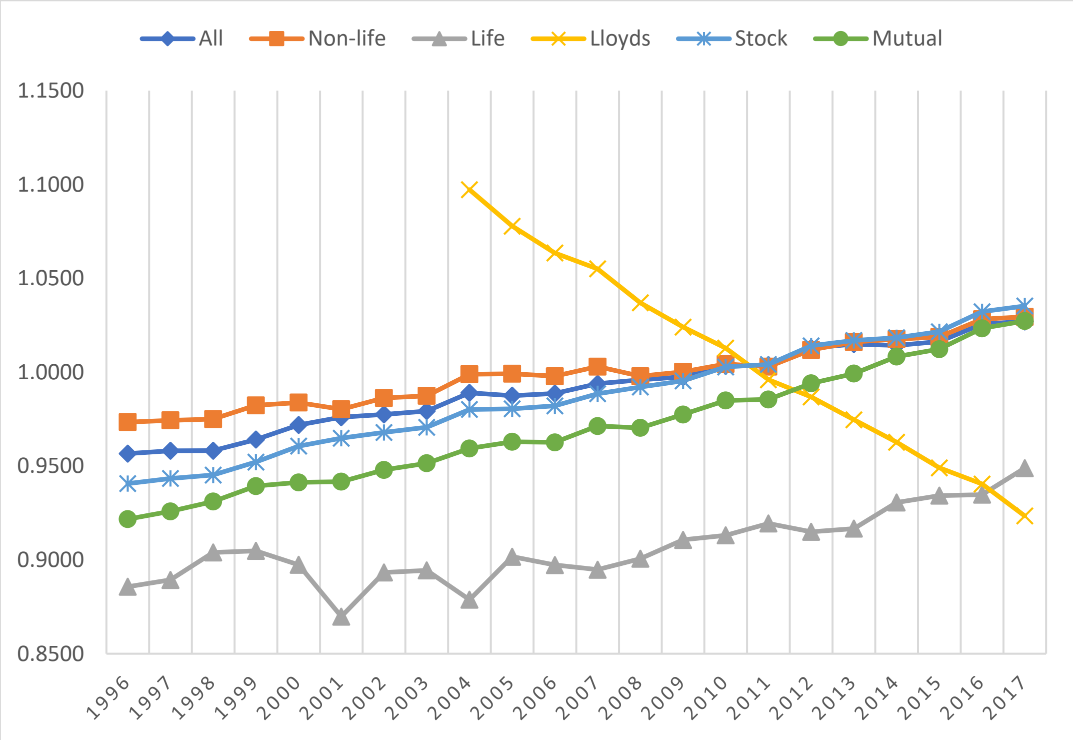


Table 1.5: Cost-Scale Efficiency for Different Sub-groups Over-Time

Year	(1) All	(2) Non-life	(3) Life	(4) Lloyds	(5) Stock	(6) Mutual
1996	0.9566	0.9734	0.8857		0.9406	0.9217
1997	0.9582	0.9744	0.8893		0.9434	0.9259
1998	0.9582	0.9750	0.9040		0.9452	0.9311
1999	0.9641	0.9823	0.9048		0.9521	0.9393
2000	0.9719	0.9838	0.8974		0.9606	0.9413
2001	0.9760	0.9802	0.8698		0.9648	0.9417
2002	0.9775	0.9863	0.8933		0.9679	0.9479
2003	0.9793	0.9874	0.8944		0.9707	0.9515
2004	0.9890	0.9989	0.8788	1.0972	0.9801	0.9594
2005	0.9875	0.9992	0.9017	1.0778	0.9805	0.9629
2006	0.9887	0.9979	0.8973	1.0635	0.9821	0.9626
2007	0.9938	1.0030	0.8948	1.0551	0.9885	0.9713
2008	0.9959	0.9978	0.9007	1.0370	0.9921	0.9703
2009	0.9975	1.0002	0.9107	1.0240	0.9954	0.9774
2010	1.0034	1.0044	0.9131	1.0128	1.0028	0.9849
2011	1.0037	1.0029	0.9194	0.9960	1.0041	0.9855
2012	1.0129	1.0118	0.9150	0.9868	1.0141	0.9940
2013	1.0150	1.0161	0.9167	0.9746	1.0169	0.9993
2014	1.0143	1.0176	0.9306	0.9627	1.0184	1.0083
2015	1.0163	1.0188	0.9343	0.9491	1.0216	1.0123
2016	1.0256	1.0282	0.9348	0.9404	1.0322	1.0234
2017	1.0270	1.0295	0.9489	0.9234	1.0353	1.0273
Average	**0.9905**	**0.9979**	**0.9055**	**1.0628**	**0.9854**	**0.9686**

Notes: This table presents the cost-scale efficiency for entire market and five sub-markets, which are non-life insurers, life insurers, Lloyds insurers, stock insurers and mutual insurers, for the period of 1996 to 2017(except for Lloyds insurers). The first three can be considered as different business types and the latter two are different organisational forms. The cost-scale efficiency can be estimated by using the elasticity of scale formula (see, section 1.3.2), once the parameters of the cost function are determined. If the cost-scale efficiency score < 1, economies of scale (decreasing cost) exists; if the cost-scale efficiency score > 1, it indicates diseconomies of scale (increasing costs).

Figure 1.4: Cost-Scale Efficiency for Different Sub-groups Over-Time



Based on the results of the cost analysis, the parameters of the cost function can be used to measure cost-scale efficiency, as shown in Equation (1.4). Table 1.5 and Figure 1.4 present the average of the insurers' scale efficiencies over time. It is measured for each insurer at its own output level. As mentioned, a value of less than one indicates economies of scale, which means that the unit average cost decreases as the output quality increases. Otherwise, if the unit cost increases as the output quality increases, decreasing returns to scale (*i.e.*, diseconomies of scale) exist. Column (1) in Table 1.5 shows that on average, the UK insurers may be scale efficient because they operate closely to constant returns to scale (scale = 0.99 ≈ 1). When considering different sub-markets, Columns (2) and (3) confirm that the non-life insurers are more closer to becoming scale efficient compared to the life insurers. In contrast, the Lloyds insurers operate at diseconomies of scale because their average score is more than one.

Figure 1.4 shows the movements of the scale efficiency over time. Except for the Lloyds sample, an upward trend in the cost scale-efficiency can be observed from all other sample groups. This finding potentially indicates that the insurers accept a higher unit cost as their output level increases. The 2009–2010 period is interesting because the changes occurred then. For example, when considering all insurers together, the insurers started to operate at diseconomies of scale in 2010. Similar findings are observed in the sub-markets of non-life (Column (2)) and stock (Column (5)). In contrast, Lloyds has operated at economies of scale since 2011 and has continued to operate at a lower degree of scale-efficiency (*i.e.*, a downward trend) since then. Furthermore, the life insurers comprise the only sub-group that always enjoys the benefit of economies of scale but with an upward trend towards scale efficient. Comparing stock and mutual firms, mutual insurers enter in the stage of diseconomies of scale four years later than stock firms, and on average, they have a slightly lower cost-scale efficiency than stock firms.

1.4.2 Productivity Estimations

Productivity represents the efficiency of converting inputs into outputs. This subsection focuses on two aims: 1) to examine changes in productivity and 2) to decompose it into different constituent parts. First, Table 1.6 and Figure 1.5 present the changes in productivity of the entire market and different sub-markets. Overall, except for the life insurers, others suffer productivity declines on average, that is, more and more inputs are used to produce outputs. Figure 1.5 shows more fluctuations in productivity since 2008, with the insurers entering a stage of decline; previously, the index was relatively stable over time. It is also noteworthy that the Lloyds insurers show a contradicting pattern compared with others. They have had a positive productivity index since 2014, while a negative index remains for the entire market group, the non-life group and the stock group; prior to that, the positions were reversed.

Table 1.7 summarises the insurers' productivity and its components. Studying various constituent parts helps in understanding how each component influences productivity. The results shown in Table 1.7 confirm that the life group (Panel C) is the only one that enjoys productivity growth and further reveal that the main driver is technical change/development. The results indicated in the other panels demonstrate that the negative productivity growth has mainly been driven by the decrease in the markup ability and the decline in technical efficiency, while some improvement has occurred in technical developments (except for Lloyds).

Table 1.6: Total Factor Productivity for Different Sub-groups

Year	(1) All	(2) Non-life	(3) Life	(4) Lloyds	(5) Stock	(6) Mutual
1996						
1997	0.1760	0.1378	0.3145		0.1637	0.1885
1998	0.0446	0.0400	0.0765		0.0652	-0.0012
1999	-0.0268	-0.0781	0.0837		-0.0539	0.0256
2000	-0.1383	-0.1682	-0.0537		-0.0979	-0.2123
2001	0.0858	0.0660	0.1489		0.1060	0.0503
2002	0.0471	0.0508	0.0749		0.0672	0.0138
2003	0.1091	0.0694	0.2546		0.1507	0.0316
2004	0.0424	0.0648	0.0393		0.0600	0.0324
2005	0.0885	0.0594	0.5317	-0.2694	0.1700	0.1227
2006	0.0996	0.0317	0.6036	-0.0721	0.1533	0.0276
2007	0.1001	0.0804	0.1248	0.0632	0.0795	0.1019
2008	0.0724	0.0915	0.0561	-0.0141	0.1204	-0.0753
2009	-1.1109	-1.6570	-0.0050	-0.0566	-1.7408	-0.0964
2010	1.0361	1.9299	0.0932	-1.0631	1.9151	0.2363
2011	-0.1533	-0.1943	0.0075	-0.1014	-0.1302	-0.3789
2012	-0.3405	-0.5145	0.1329	-0.0230	-0.5022	0.0801
2013	-0.5056	-0.6566	-0.5929	-0.0858	-0.0059	-4.6620
2014	-0.6439	-1.1392	0.0409	0.0376	-1.0042	0.2934
2015	-0.0249	-0.1003	0.1010	0.0575	-0.0633	0.0170
2016	-0.7279	-1.3337	0.0903	0.0562	-1.0537	-0.1283
2017	0.0061	0.0543	0.0363	-0.0078	0.0291	0.0818
Average	-0.1315	-0.2021	0.096	-0.1159	-0.1289	-0.1652

Notes: This table presents the total factor productivity score for the entire market and five sub-markets, which are non-life insurers, life insurers, Lloyds insurers, stock insurers and mutual insurers, from 1996 to 2017(except for Lloyds insurers). The first three can be considered as different business types, and the latter two are different organisational forms. The productivity score is estimated by using the Stochastic Distance Cost Frontier model with multi-output (see, section 1.3.3). If the productivity score < 0, productivity decline exists; if the cost-scale efficiency score > 0, it indicates productivity growth.

Figure 1.5: Total Factor Productivity for Different Sub-groups Over Time

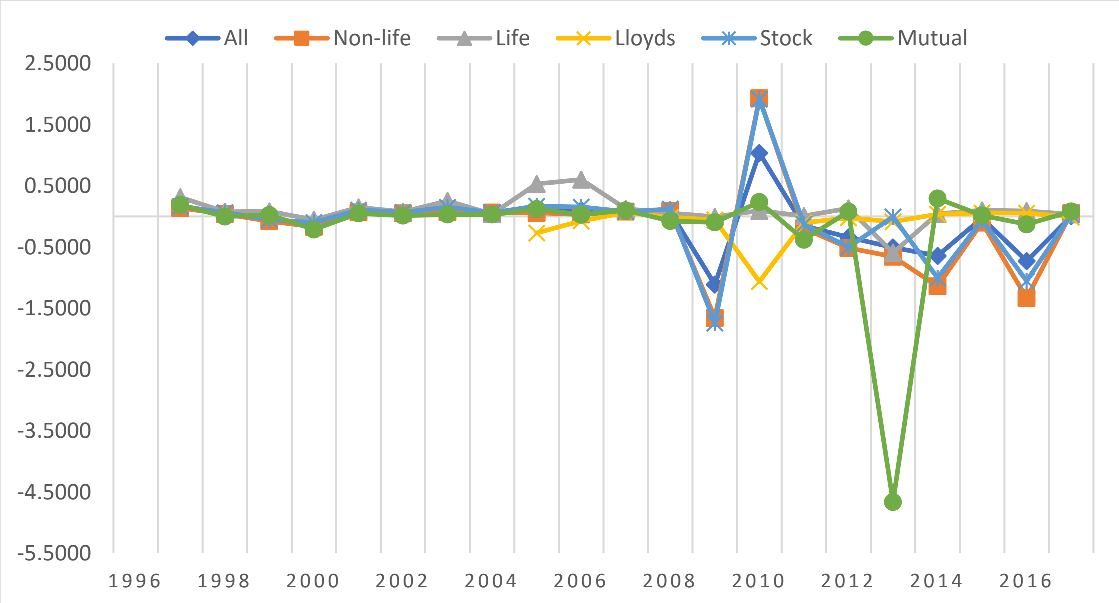


Table 1.7: Total Factor Productivity and its Components for Different Sub-groups

Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Panel A: All insurers				
Total Factor Productivity	-0.1315	8.1800	-281.2850	286.7017
Technical Change Component	0.0308	0.0161	-0.0170	0.0932
Scale Component	0.0034	0.1648	-7.4217	5.2056
Mark Up Component	-0.1833	8.1870	-283.3449	286.7073
Technical Efficiency Change	-0.0170	0.0030	-0.0224	-0.0127
Panel B: Non-life insurers				
Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Total Factor Productivity	-0.2021	10.1670	-273.7856	286.8146
Technical Change Component	0.0425	0.0192	-0.0131	0.1033
Scale Component	0.0024	0.4231	-23.3677	8.7202
Mark Up Component	-0.1801	8.0847	-281.8399	286.7179
Technical Efficiency Change	-0.0229	0.0049	-0.0311	-0.0151
Panel C: Life Insurers				
Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Total Factor Productivity	0.096	1.217	-23.923	12.636
Technical Change Component	0.049	0.041	-0.197	0.227
Scale Component	-0.005	0.689	-29.351	23.731
Mark Up Component	-0.191	9.072	-355.796	286.593
Technical Efficiency Change	-0.032	0.009	-0.046	-0.018
Panel D: Lloyds Insurers				
Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Total Factor Productivity	-0.1159	2.4346	-64.2118	8.2404
Technical Change Component	-0.0224	0.0646	-0.2481	0.3059
Scale Component	-0.0079	0.6216	-35.6765	7.3028
Mark Up Component	-0.1666	7.8275	-279.1986	286.0084
Technical Efficiency Change	0.0320	0.0149	0.0129	0.0620
Panel E: Stock Insurers				
Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Total Factor Productivity	-0.1289	9.6556	-277.2867	286.7546
Technical Change Component	0.0384	0.0204	-0.0214	0.1062
Scale Component	0.0043	0.1402	-4.3541	5.0541
Mark Up Component	-0.1835	8.1804	-280.8606	286.7478
Technical Efficiency Change	-0.0244	0.0054	-0.0333	-0.0160
Panel F: Mutual Insurers				
Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Total Factor Productivity	-0.1652	5.0751	-127.9028	9.1447
Technical Change Component	0.0436	0.0244	-0.0689	0.1391
Scale Component	0.0038	0.4101	-15.0216	19.4308
Mark Up Component	-0.1876	8.3103	-297.5512	286.7891
Technical Efficiency Change	-0.0209	0.0043	-0.0282	-0.0141

Notes: This table presents the total factor productivity and its components for the entire market and five sub-markets, which are non-life insurers, life insurers, Lloyds insurers, stock insurers and mutual insurers, from 1996 to 2017(except for Lloyds insurers). The first three can be considered as different business types, and the latter two are different organisational forms. The TFP components include technical change component, scale component, markup component and technical efficiency component. If the productivity score < 0, productivity decline exists; if the cost-scale efficiency score > 0, it indicates productivity growth.

Section 1.5 Conclusion

The purpose of this chapter is to provide a comprehensive analysis of the UK insurance market's performance. The first part of this chapter (Section 1.3) has presented a detailed literature review on two main performance measurements – efficiency and productivity. It has offered a basic understanding of the potential applications of using these indicators. Second, the methodology section has carefully discussed various mathematical approaches and the choices of model vectors. Finally, using a large unbalanced panel data from 1996 to 2017, cost and profit efficiencies, scale-efficiency scores and productivity are calculated by employing one of the latest developed stochastic frontier analysis (SFA) approaches, that is, Kumbhakar, Lien and Hardaker's (2014) model.

The results suggest that insurers have opportunities to improve their performance – approximately 40% for cost efficiency and 70% for profit efficiency. Nonetheless, the findings also indicate that both cost and profit efficiencies tend to remain within a relatively stable range over the study period (*i.e.*, no significant improvements in both cost and profit performance from the past 20 years). Besides, evidence shows that the UK insurers may tend to put more efforts on cost management since the insurers' cost efficiency is higher than their profit efficiency. After splitting the entire market into five sub-groups, the Lloyds insurers are in the leading position of reducing costs and generating profits, while the life insurers are in the lagging position.

Regarding the insurers' cost-scale efficiency, except for the life insurers, the year 2010 is vital because it acts as a break-even point. Specifically, on average, the entire market (except the Lloyds and the life insurers) started to operate at diseconomies of scale, while Lloyds started to operate at economies of scale in 2010. Moreover, the life insurers always enjoy the benefit of economies of scale. Except for the life insurers, other insurers suffer productivity declines on average (*i.e.*, more and more inputs are used to produce outputs). By decomposing productivity into various parts, the results show that the decrease in the markup ability has mainly driven the negative productivity growth. These findings can be used as the basis of further analysis.

CHAPTER 2: The Impact of Underwriting Risks, Investment Risks and Relevant Risk Management on Insurer's Performance: Evidence from the U.K. Market

Abstract

Insurers' risk-taking behaviour has stimulated researchers' attention because it concerns the financial interest of policyholders and insurers. This risk-taking is also a paramount concern of regulators because they must enhance insurers' performance and stabilise the financial system. Insurers face specific risks arising from their business and investment strategies. This chapter explores the relationship between risk-related activities (risk-taking and risk management) and firm performance in the UK market from 1996 to 2013. To examine the issues, both cost and profit efficiencies are used to present the firm's performance. The ordinary least squares (OLS) fixed effects model and the dynamic panel model are adopted to examine the impacts of two risk-taking strategies (*i.e.* underwriting and investment strategies) on insurers' performances. At the same time, the impacts of two risk management techniques—capital holding and using reinsurance—are further considered and embedded with the risk-taking strategies.

The overall findings confirm that underwriting and investment strategies are fundamental factors affecting insurers' performance from both cost and profit perspectives. Analysing the impacts of interaction between underwriting and investment strategies on the insurer performance reveals that short-term investment volatility takes the dominant role in lowering cost performance. However, the benefit of diversification can overcome short-term investment volatility and enhance insurers' abilities to generate profit. Thus, interactions between risk-taking and risk management significantly affect insurers' performance.

Section 2.1 Introduction

The primary task of running a business is carefully evaluating an insurer's performance and disclosing the driving forces behind changes in performance because insurers who perform well can easily fulfil stakeholder expectations and maintain firm solvency (Cummins, Rubio-Misas and Vencappa, 2017; Eling and Jia, 2018). Among all performance measurements, efficiency analysis can present a more accurate and unbiased indication of an insurer's ability and performance in a pool (Baluch, Mutenga and Parsons, 2011). Lin, Wen and Yang (2011) also state that cost-efficiency significantly reflects whether risk management could improve firm performance.

To effectively perform insurers' functions, enhance soundness and maintain a competitive position in the market, the firms' initial focus should be to identify and understand the risks they face**.** Risks to which insurers are exposed can be classified in many ways, and different international organisations have provided various guidelines to clarify risks across different business lines. For instance, the Casualty Actuarial Society (2000) categorised risks for property-casualty insurers, into four divisions: obligation risk, mismanagement risk, asset risk and interest rate risk. The Financial Services Authority (2001) also set six dimensions of risks across UK insurers: market risk, operational risk, group risk, credit risk, liquidity risk and insurance risk. It was only recently that the Solvency II (2009 Directive) unified these various guidelines and categorised risk factors into the 'life risk model' and the 'non-life risk model'. The five catalogues in the life risk model are persistency risk, mortality risk, longevity risk, expenses risk and morbidity risk; and the four catalogues in the non-life risk model are operating risk, market risk, underwriting risk and default risk. All factors in the non-life risk model also influence those in the life risk model.[1]

Traditionally, underwriting risk is a priority factor to consider in the spectrum of enterprise risks, as underwriting is the insurer's primary activity (Baranoff and Sager, 2011). Underwriting allows an insurer to remove risks from the policyholder in exchange for a premium. Stronger underwriting ability would potentially improve the insurer's performance (*i.e.* gaining underwriting profit) and maintain its competitiveness (*i.e.*

[1] More details about the Solvency II framework can be found from Directive 2009/138/EC on the European Insurance and Occupational Pensions Authority (EIOPA) website: https://eiopa.europa.eu/regulation-supervision/insurance/solvency-ii.

gaining market share). Unfavourable underwriting results may cause a high probability of financial distress (Browne and Hoyt, 1995). Underwriting risks arise when the sum of claims and expenses deviate from the received premium level due to accidents, errors and unexpected changes in circumstances, thus leading to uncertainty of underwriting profit or even underwriting losses. Thus, from the view of the technical process, Jakov and Žaja (2014) suggest that underwriting risks could be split into pricing risk, reserve risk, reinsurance risk and occurrence risk.

Product risks can also be treated as a branch of underwriting risks. For example, health insurance is riskier than the annuity contract in the life sector (Baranoff and Sager, 2002); homeowner and general liability insurance are more easily affected by external factors (*e.g.* underwriting cycle) than auto liability insurance in the non-life sector (Ren and Schmit, 2006); and insurers with diversified businesses can be more cost-effective than those with monoline businesses (Berger *et al.*, 2000). Sharpe and Stadnik (2007) demonstrate that the mix of an insurer's businesses influence the firm's financial soundness. Therefore, production plans or business strategies are essential in an insurer's underwriting and also play a vital role in a firm's operation (see Baranoff and Sager (2002); Hardwick and Adams (2002); Hu and Yu (2015)). For example, Berger and Humphrey (1997) state that a bank's profit inefficiency due to suboptimal production plans is much higher than its cost inefficiency; this is also true for insurance firms. A profit-inefficient insurer may write too many risky contracts or use inappropriate discount rates when pricing, thereby incurring excessive risk for both debtholders and shareholders in exchange for less effort needed to monitor policyholders' risk profiles (cost reduced). This leads the current research to focus on the insurer's performance from two different perspectives: cost and profit.

In addition to underwriting risks, according to Baranoff and Sager (2002), Lin, Wen and Yang (2011) and Zou *et al.* (2012), another type of risk that must be considered with underwriting risk is investment risk (asset risk). As there is a time gap between receiving premiums and paying off claims, apart from setting up regulatory reserves, insurers also invest most of the collected premiums into various assets to generate investment returns, which can fulfil stakeholders' expectations.[1] Hammond, Melander and Shilling (1976)

[1] For example, the investment return can be used to pay interests to debtholders and dividends to shareholders or can be treated as internal capital for future business expansions. There are even some

state that return on investments is important because insurer's underwriting results are often negative. Insurers not only generate excess returns through investment but also bear a higher level of risk from market volatility, resulting in more uncertain underwriting capacity and firm performance. Therefore, even if a firm has profited from its underwriting activities, it is still unable to meet all its obligations due to poor performance from investments, which results in higher insolvency risk. The insurer aims to manage and control its insolvency risk at the enterprise level, and, thus, it must make a trade-off among different risks. For example, under the asset-liability matching strategy, the insurer adjusts its investment strategy based on the nature of its underwriting strategy. Insurers with a highly volatile business may prefer investments with a high degree of liquidity and a low degree of volatility. Zou *et al.* (2012) demonstrate that it is difficult and costly to modify underwriting strategies, since such adjustment exerts an adverse effect on the long-term customer relationships.[1] From this perspective, investment strategies follow basic underwriting.

On the other hand, the insurer can also modify its underwriting strategy according to investment strategy, if the investment is costly and difficult to adjust at the time of market downturn. Thus, as stated by Hammond, Melander and Shilling (1976) nd Hammond and Shilling (1978), there should be interconnections between an insurer's underwriting risks and investment risks. Therefore, managing these two risks is the primary concern of the insurer's operations.

To improve customer protection, fulfil future liabilities and prevent unexpected losses, regulators and policymakers set up a series of appropriate policies or standards, which impose capital requirements based on insurers' risk appetites and disclosing firms' risk profile so that they may be assessed by the public. For an insurance company, the primary objective is to correctly specify types of risk taken from its operations and to use risk management techniques, such as reinsurance, to enhance performance and stability.

From regulatory perspectives, the primary objective of supervision is to strengthen the insurer's soundness and maintain adequate capital levels for the firm's number of

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products closely linked to investment activities, such as unit-link products, in which bonuses are paid to policyholders at maturity.

[1] Such as scaling down the liability amount by underwriting less business or changing underwriting criteria, which would reduce firm attractiveness.

obligations. Underwriting and investment activities automatically affect a firm's liability obligations and lead to a change in required capital. For example, Zanjani (2002) demonstrates that insurer's with more businesses exposed to natural disasters had more capital holding than others. Insurers hold financial capital to provide a future source of payments to policyholders when clients need to be paid if claims (benefits) are higher than expected and/or if investment returns are lower than predicted (Cummins and Nini, 2002). Brockett *et al.* (2004b, 2005) and Kasman and Turgutlu (2011) also mention that holding equity capital could be a buffer against unexpected future losses to fulfil insurance obligations. Thus, the higher an insurer's capital amount, the safer the policyholders' compensations (Brockett *et al.*, 2005). However, holding capital could be expensive because of the regulatory cost, agency cost and tax payments (Cummins and Grace, 1994). Still, insurers may face debt overhang problems if they hold too little equity capital because debtholders and policyholders are usually merged in the insurance industry, and this may further reduce a firm's ability to attract new customers; it may even start to lose current business as it faces more insolvency risk (Cheng and Weiss, 2012a). External factors can also influence the use of capital. For example, regulatory pressure plays a crucial role in determining whether equity capital should be held or should be used to make a different investment (Kasman and Turgutlu, 2011).

Apart from regulatory capital building, an efficient internal risk management system can also help insurers enhance safety for policyholders after quantitatively and qualitatively identifying the risks in its business activities—but also by allowing insurers to accept other (or more) risks to achieve higher profitability. Froot, Scharfstein and Stein (1993) also note that risk management techniques could enhance insurers' market values. Cummins *et al.* (2009) further point out that risk management decisions could be regarded as the consequences of external factors and that they provide insurers with an objective function to reduce their total costs. Smith and Stulz (1985) specify that risk management helps a company to reduce: 1) bankruptcy and distress costs, 2) financing costs, and 3) expected payments to stakeholders. They further suggest that using financial derivatives could manage investment risks to reduce costs, and this is confirmed by Clark and Siems (2002), Lieu, Yeh and Chiu (2005) and Rivas, Ozuna and Policastro (2006), who find that utilising derivatives can improve bank performance. Cummins, Phillips and Smith (2001) also suggest that insurers could use derivatives to hedge market risk. Lin, Wen and Yang

(2011) propose a study of using financial derivatives[1] and reinsurance to manage insurer's risk, as they believe that derivatives could be used to manage investment risk and that insurers use reinsurance to reduce underwriting risk. Froot and O'Connell (2008) further suggest that insurers are likely to use reinsurance when facing more non-standardised and difficult to assess risk exposures. Chen, Hamwi and Hudson (2001) argue that an insurer with solvency problems might like to use more reinsurance because raising financial capital would be too expensive. Thus, reinsurance not only mitigates policyholders' concerns about insurers' insolvency but also enables insurers to effectively manage cash flow volatility (e.g., pre-tax income volatility), maintain future underwriting capacity and enhance firms' ability to bear risk (Doherty and Tinic, 1981; Cole and McCullough, 2006; Shiu, 2011). Moreover, Liu, Shiu and Liu (2016) note that reinsurance could also reduce the liquidity problem arising from asset-liability mismatch due to the nature of general insurance.

This chapter mainly contributes to ongoing studies on revealing the determinants of insurer's efficiency (Lin, Wen and Yang, 2011; Biener, Eling and Wirfs, 2016; Bikker, 2016; Eling and Schaper, 2017). The purpose of this chapter is to exam the extent to which risk-taking behaviours (underwriting risk and investment risk) influence insurer performance, while simultaneously considering insurers' risk management activities, which are represented by usage capital and reinsurance. The expected results will be useful for policyholders, regulators and insurers to enhance understanding of the driving forces behind the insurers' performance in the UK market from the risk-related perspective.

Then, several contributions can be made to the literature. Firstly, this study investigates the impact of both risk-taking behaviours and risk management activities on the insurers' performance, but most of the extant studies only focus from one perspective (Lin, Wen and Yang, 2011; Biener, Eling and Wirfs, 2016). Secondly, it is the first study to consider the interaction effects between insurers' risk-taking behaviours and risk management activities. It is worth to determine such impacts, because of the fact that insurers' risk-taking behaviours and risk management activities are often jointly considered. Third, this chapter responds to measurement issues and employs product risk, diversification

[1] Due to lack of data, it is not possible to test derivatives-related activities in this study; therefore, it will focus only on using reinsurance as a strategy to mitigate underwriting risk.

strategy and pricing risk as underwriting risk measures. This provides more detailed information on insurers' underwriting strategies. Fourth, it is vital to consider the impact on both cost and profit efficiencies, as two efficiencies capture different information.

Moreover, the results confirm that both risk-taking and risk management strategies have significant impacts on insurer performance. Some impacts are consistent in both cost and profit models; others may have varied impacts across different models. In particular, by considering the interplay between risk-taking and risk-management (or between business strategies and financial decisions), the results confirm interacting effects that significantly contribute to insurer performance. This finding can help insurers devise appropriate strategies combining both business and operational activities at the aggregated level to improve performance. Regulators can also use the findings to establish regulations or standards related to insurers' business and operational activities.

The rest of this chapter is structured as follows. Section 2.2 develops this study's hypotheses based on the empirical literature, and Section 2.3 briefly discusses the methodology and interprets the data and variables used. Empirical results are presented in Section 2.4, and Section 2.5 concludes the chapter.

Section 2.2 Literature Review and Hypotheses Development

This section reviews relevant empirical literature linked to risk-taking, risk management and firm performance. The business-strategy hypothesis (Regan and Tzeng, 1999) notes that the choice of product or business strategy is the fundamental decision for a firm, and it might be seen as coming logically and operationally before other operating decisions, such as investment, capital raising and risk management.

Earlier studies (*e.g.* Barniv and Rave (1989); Barrese (1990); Brockett *et al.* (1994)) reveal the relationship between performance (efficiency) and firms' overall solvency, indicating a potential conflict in which solvency becomes the central concern of regulatory agencies and consumers while management professionals and investors focus on efficiency (especially in terms of profit). Later, Brockett *et al.*, (2004b) indicates that solvency exerts little or no influence on efficiency. This is not attributed to the lack of importance of solvency, but is based on the fact that all regulators, managers, investors and policyholders pay serious attention to their firms' solvency situations. Diacon, Starkey and O'Brien (2002) point out that solvency is positively associated with technical efficiency, where indicated customers seem willing to pay more premiums to high solvency ratio insurance companies. Shiu, (2004) also state that the solvency margin could be regarded as the driver of a firm's (revenue) efficiency, as it indicates an insurer's financial soundness. Insurers have a few options for managing solvency, such as through underwriting activities and business strategies, holding more capital and managing internal risk. In the following section, after splitting overall insolvency risk into risks related to underwriting and investment activities,[1] the hypothesis concerning the impact of each decision on insurer performance is developed; meanwhile, the hypothesis about interaction effects on performance will also be built.

Regarding performance indicators, potential relationships not only test on cost efficiency but also profit efficiency. Cost and profit efficiencies refer to a firm's cost minimisation and profit maximisation strategies, both of which are performance indicators. Compared to cost, Berger, Hancock and Humphrey (1993), Berger, Cummins and Weiss (1997) and Hardwick, Adams and Zou (2011) point out the advantages of considering profit as an indicator. Profit efficiency contains a much broader concept, which examines the firm's ability maximise profits given a set of inputs and outputs, while cost efficiency determines deviations from the best-practice firms in the market. Specifically, profit efficiency reflects differences due to unobserved product/service quality because customers are willing to accept a higher price for better quality products or services. Thus, considering both cost and profit efficiencies reveals a possible situation in which some insurers may provide superior products/services by imposing higher costs, which can then be offset by higher revenues. Profit efficiency can, therefore, be seen as an overall performance indicator, which jointly reflects the effects of minimising cost and maximising revenues (Hardwick, Adams and Zou, 2011). Finally, Berger, Hancock and Humphrey (1993) further suggest that the insurer's ability to control loss and manage risk can be reflected by profit efficiency because firms with better risk control techniques achieve higher risk-adjusted profit but not necessarily lower costs.

2.2.1 Business Strategy and Underwriting Risk

In previous banking literature, many studies use loan loss or reserve items to represent riskiness in the banking business (Kwan and Eisenbeis, 1997; Deelchand and Padgett, 2009). Kasman and Carvallo (2013) find a significant, positive impact of increased risk,

[1] Insurers faces both underwriting and investment risks, which simultaneously affect insolvency risk (Zou *et al.*, 2012).

also measured by loan loss reserve, on a firm's efficiency in Latin American banking. In a similar study in the European market, Altunbas *et al.* (2007) draw a consistent conclusion. However, these indicators do not adequately represent insurers' risk, as stated by Hu and Yu (2015). Baranoff and Sager (2002) treat an insurance policy as a contract to identify the embedded riskiness of different insurance products.

Every product sold by insurers is in the form of a contract; the more explicit the contract, the fewer the risks taken by both insurer and insured. In general, life insurers mainly offer various types of product—pension/annuity, life and health insurances, life reinsurance, etc. As described in the life studies of Baranoff and Sager (2002) and Baranoff, Papadopoulos and Sager (2007), transaction cost theory, introduced by Williamson (1985), can define the risk level embedded in each contract or product. Based on Williamson (1985), three contract types are identified regarding: classical (low-risk), neoclassical (medium-risk) and relational (high-risk). According to explanations from Baranoff and Sager (2002, 2011) and Baranoff, Papadopoulos and Sager (2007), a product that is non-specific and occasionally sold (does not need to be renewed), such as annuity/pension products, can be treated as a *classical contract*. Annuities/pensions are savings-type products, similar to bank deposits but maturing at the owner's death. Annuitants/pensioners do not need to meet specific underwriting criteria to obtain protection; the insurer's primary concern is longevity risk[1] (tied to age and sex). Life products can be seen as *neoclassical contracts* because they require underwriting criteria relating to individuals' lifestyles. In general, life products have a longer term than annuity/pension products, if the trigger event does not exist. Thus, they may pose a higher level of risk to the firm if the force of mortality changes dramatically. Most health products are sold recurrently, and coverages vary by different conditions. The actual payments to cover medical or treatment expenses are hard to define due to the dynamic changes in medical technology and the difficulty of illness/health predictions. So, Baranoff and Sager (2002, 2011) suggest that health products fit the features of *relational contracts*. Hu and Yu (2015) find that taking more product risks, defined as health writings plus accident writings, damage insurers' operating efficiency in the Taiwan insurance market due to extra cost or expenses for dealing with risky business, according to the transaction-cost hypothesis.

[1] Actuaries use a mortality table to predict the probability of death for different aged and gendered policyholders and to price products to reduce longevity risk.

Types of business in the non-life industry are much more complex than those in the life industry. Non-life insurers can have business in many segments—motor, property, catastrophe, liability, personal accident, miscellaneous and pecuniary loss insurance, etc. For example, Powell and Sommer (2007) and Mankaï and Belgacem (2016) use premiums raised in catastrophe business to represent product risk. Choi and Weiss (2005) state that profits are lower in insurance companies with more personal lines of business than in those with more commercial lines. Sharpe and Stadnik (2007) find that international business might cause a higher probability of financial distress in relation to fire insurance.

Moreover, Cheng and Weiss (2013) identify particularly risky lines as: commercial auto, allied, earthquake, surety, theft, inland marine, fire, international, boiler and machinery, reinsurance and medical malpractice lines. Concerning the complexity of non-life products, Sommer (1996), Pottier and Sommer (1999) and Zou *et al.* (2012) use the premiums of long-tail liability insurance to represent product risk in the non-life sector. Bikker and Popescu (2014) reveal that issuing fire and motor insurance positively impacts total cost in the Dutch non-life market. Froot (2001), Ibragimov, Jaffee and Walden (2009) and Upreti and Adams (2015) believe that motor insurance is less risky than legal liability and catastrophe insurance, which are more complex and less predictable. Most recently, Caporale, Cerrato and Zhang (2017) find financial loss insurance and marine, aviation and goods insurance to be the riskiest business groups with the highest default probability after the financial crisis, which began in 2007. They also stated that businesses exposed to catastrophes would be treated as risky products, such as accident, household and property, third-party liability, etc.

According to the expected bankruptcy costs argument,[1] it is reasonable to assume that insurers with more risky businesses are exposed to a higher likelihood of insolvency and, thus, face higher bankruptcy costs. To reduce insolvency risk and avoid bankruptcy costs, an insurer would choose to either monitor or rebalance its portfolio frequently or adopt risk management techniques (e.g., raising capital or purchasing reinsurance).

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[1] the expected bankruptcy costs argument is widely used to hypothesis the relationship between risk and capital (or reinsurance) building, for example, studies from (Baranoff and Sager, 2002; Baranoff, Papadopoulos and Sager, 2007; Shiu, 2011)

The fundamental concept of insurance business is risk mitigation technique, in which includes two components: risk identification and risk management. Product risk, which is one of the nature factors originated from the insurance business, need to be identified and cannot be avoided, as it is directly linked to day-to-day operations. Therefore, based on the nature of product risk and both transaction cost theory (Williamson, 1985) and the expected bankruptcy costs argument, this study's first hypothesis is developed as follows.

H1a: *Product risk negatively affects cost performance.*

H1b: *Product risk negatively affects profit performance.*

For a firm, underwriting risks not only arise from issuing risky products but also from the insurer's business strategies and technical processes (Bikker and Gorter, 2008; Jakov and Žaja, 2014; Mankaï and Belgacem, 2016). Business diversification (focus) is one of the key concepts relating to business strategies, and two types of diversification—product types and geographic area—are involved in underwriting activities. To be more specific, two hypotheses are used to explain the impact of business strategy on firm performance. Theconglomeration hypothesis predicts that diversification improves firm performance through economies of scope (Teece, 1980). In contrast, the strategic focus hypothesis predicts that insurers will be less likely to engage in unproductive business and only focus on one or a few profitable businesses (Berger *et al.*, 2000).

Product diversification refers to the degree of concentration on an insurer's core business, and, the lower the degree of concentration, the higher the product diversification. Adams (1996) mentions that product diversification can reduce an insurer's underwriting risk. For example, an increase in life expectancy can be seen as a systematic life risk, which can threaten life companies. However, the degree of damage depends on the insurers' business portfolio because the damage of annuity policy increases with longevity, while the risk of term insurance decreases with longevity. Thus, by producing economies of scale and scope, product diversification can also help the insurer realise efficiency benefits (Huberman, Mayers and Smith, 1983; Berger *et al.*, 2000; Meador, Ryan and Schellhorn, 2000; Hirao and Inoue, 2004; Alhassan and Biekpe, 2016). Hardwick and Adams (2002) also note that more diversified insurers enjoy greater growth rates because of the economies of scope. Upreti and Adams (2015) confirm that diversified insurers have higher growth in product-market shares as they have the advantage of accessing different distribution channels and reaching more potential customers.

Mayers and Smith (1990) point out that insurers might expose significant concentration risk (e.g., increasing cash flow volatility) if they focus on writing policies in a few lines of business, while higher concentration might also mean that insurers specialising in particular businesses should have better risk pricing and cost control techniques (Bikker and Gorter, 2008; Zhang and Nielson, 2015). In line with the focused strategy hypothesis, Bikker and Gorter (2008) find that monoline insurers (specialised insurers) have lower average costs than multiline insurers, but they pay out more substantial amounts in claims. This indicates that a diversification strategy would reduce firm value. Confirming this, Mankaï and Belgacem (2016) expect a positive link between business focus and overall risk-taking. Aligned with this result, Shim (2011) demonstrates that focused-firms might face more profit volatility but have higher returns on assets (ROAs) and returns on equity (ROEs). Cummins *et al.* (2010) also conclude that focus strategies are superior to the conglomeration hypothesis in non-life sectors, implying that diversification costs outweigh benefits (Shim, 2011). Findings from banking are inconsistent. Tan and Floros (2012) show that less diversified banks in China have higher profits, but this is contrary to the findings from Tan's (2017) Chinese banking analysis and Goddard, Molyneux and Wilson's (2004) UK banking study. Demirguc-Kunt and Huizinga (1999) explain that the negative relation is due to stronger competition in the banking sector.

Similar to the business mix, an insurer with more geographic expansion may reduce its overall risk because of the benefit of diversification (Wheelock and Wilson, 2000; Berger, DeYoung and Udell, 2001). Berger, DeYoung and Udell (2001) also suggest that increased geographic diversification can lead to an increase in both cost and revenue efficiencies. Leverty and Grace (2010) find that insurers with a specified line of business (or geographically focused insurers) operate better. Shim (2011) indicates that geographically focused insurers outperform geographically diversified insurers, but focused insurers have more volatile profits.

Diversification strategy is another nature factor originated from the insurance business, and is closely linked to insurers' operation. And it can also be treated as one of the risk management technique. Thus, as results from the prior studies are inconsistent, this study's second hypothesis is based on the conglomeration hypothesis.

H2a: *Diversification positively affects cost performance.*

H2b: *Diversification positively affects profit performance.*

From the perspective of the technical process, Jakov and Žaja (2014) suggest that underwriting risks could be split into pricing risk, reserve risk[1] and two other risks. For example, insurers writing larger growth premiums face large amounts of potential future claims, and the rapid growth of premiums may indicate there is a possible mispricing problem (Caporale, Cerrato and Zhang, 2017). Both under- and overvaluing will be a severe problem for insurers, as they may be unable to raise sufficient revenue to cover the promised claim payments if policies are undervalued, and they may become uncompetitive in the market due to charging excessive premiums (Jakov and Žaja, 2014). Aligned with Akotey *et al.* (2013), Alhassan, Addisson and Asamoah (2015) indicate that high probabilities of high-claim payments reduce both the firm's underwriting profit and overall return because of issuing high-risk business, and they find this damage is even more significant in the non-life sector than in the life sector. However, Alhassan and Biekpe (2016) confirm that the underwriting risk, measured by claim ratios, is positively related to both cost and profit efficiencies in South Africa's non-life market. Based on this discussion, hypothesis three is formulated as follows:

H3a: *Pricing risk negatively affects cost performance.*

H3b: *Pricing risk negatively affects profit performance.*

2.2.2 Investment Risk

Cummins *et al.* (2009) state that insurers may be regarded as financial intermediaries, who borrow premium payments from policyholders and invest the funds raised in financial assets—which is one of their most important activities for generating more returns. Insurers are highly involved with asset trading strategies; therefore, managing investment risk is at the core of insurers' operations and asset-liability management. Cummins *et al.* (2009) also explain that asset-liability management was first created to reduce the asset-liability mismatch, which was mainly due to investment return volatility. Because insurance companies also invest in various asset markets to generate a well-diversified investment portfolio, they also encounter other external risks related to their investments, such as inflation and interest rate risk, property risk, credit risk and equity risk. Therefore, the insurer's investment allocations can be adjusted based on changes in

[1] Reserve risk is defined as the amount of technical reserve is varied from insurers expectation. It can cause either insufficiency reserve holding or holding too much reserve, which leads to extra cost.

the external environment. For example, according to the Association of British Insurers (2014), from 2003 to 2007, 35% of total funds were allocated into the equity market, and about 40% were allocated into the bond market. However, the total investment in the equity market was cut to less than 30% after 2008. Compared to the continuing trend of decline in equity investment after 2008, the proportion of investment in the bond market remained at the same level, yet with a higher amount of investment into the private sector debt market. Moreover, there was a significant increase in unit trust investment, from 7% of the total fund in 2003 to 18% in 2013. Therefore, these movements indicate that the insurer will modify investment strategies and asset allocations to avoid losses or to generate profits due to market volatilities, most of which are unexpected and unpredictable. Therefore, insurers will take time when making investment modifications.

In banking studies, Berger and Humphrey's (1997) 'bad luck' hypothesis[1] assumes that nonperforming loans might arise because of adverse external factors beyond a bank's control, and they indicate that increased credit risk, which arises from those bad loans, will decrease firm efficiency because additional cost and more management efforts are required. This negative relation is confirmed by Berger and DeYoung (1997), but Fiordelisi, Marques-Ibanez and Molyneux (2011) do not find evidence to support this hypothesis. Still, instead of considering the firm's credit risk, Mamatzakis and Bermpei (2014) find evidence to support the bad luck hypothesis from perspectives on default risk and liquidity.

Breaking the firm's risks into internal and external components, Pastor (2002) also confirms that both could significantly affect a bank's estimated efficiency. Based on the results from Pastor (2002), Pastor and Serrano (2005) further find that the impact of credit risk, influenced by external factors, could become more important and meaningful for profit efficiency than for cost efficiency. In Chang and Chiu's (2006) study, value at risk (VaR) is used to measure investment risk, and they find that banks carrying a higher

[1] Originally, Berger and Humphrey (1997) proposed three hypotheses to reveal the relations between credit risk and performance in banking sectors. First, the bad luck hypothesis predicts the higher credit risk should lead to a drop in efficiency, and it assumes that bad loans are caused by external factors. Second, the bad management hypothesis assumes inefficient management causes bad loans; thus, it predicts that bad management of costs (low cost efficiency) will lead to greater credit risk. Finally, the skimping hypothesis predicts a positive relationship between cost efficiency and credit risk when banks do not allocate resources to monitor business application; thus, cost efficiency will lead to higher credit risk.

degree of VaR encounter decreasing efficiency. Sun and Chang (2011) investigate market risk and two other risk aspects, and they indicate that cost efficiency relates to these risks.

Because of the similarity between banks and insurers, the above findings may be reasonably used as references for the insurance industry and are also suitable for identifying the relationship between volatility of investment return and efficiency, in which most return volatilities are due to uncontrollable fluctuations in different asset markets or bad asset-liability management. Thus, if unexpected external events (e.g., external shocks) lead to capital market volatility, insurers may face higher risk in their investments, and they should spend more resources on managing this risk. Consequently, this can increase the insurer's cost and decrease its profit. For the insurance industry, Shiu (2004) demonstrates that stock insurers could invest in relatively risky assets, such as equities, and this could decrease performance. Similar to Pastor's (2002) findings, Huang and Paradi (2011) also find that both internal risk factors and external factors significantly impacted insurers' efficiency in the Chinese insurance market from 1999 to 2006. According to the profit-incentive hypothesis, which posits a positive relationship between efficiency and risk-taking, insurers may want to engage in risky financial investments to maximise profit because high risk, according to the investment principle, means high profitability. Both Liang, Lin and Huang (2011) and Hu and Yu (2015) prove this positive relationship. However, carefully monitoring and rebalancing investment portfolios is essential when insurers make risky investments; thus, the cost of monitoring and of modifying assets may weaken cost efficiency. Thus, the following hypotheses can be proposed.

H4a: *Investment risk negatively affects cost performance.*

H4b: *Investment risk positively affects profit performance.*

2.2.3 Capital

From early banking studies, not only portfolio risks, but also financial capital, were essential components of a firm's insolvency (Hughes and Mester, 1993; Berger and Mester, 1997). The use of capital is vital from the perspectives of investors and insurers. Investors are concerned about the security of their returns, while insurers are concerned about the tradeoff between the costs and benefits of raising capital (Kielholz, 2000). The primary benefit of holding capital is security. Under the assumption that holding more capital allows a firm to run better, well-capitalised firms should outperform those less-capitalised. Berger and DeYoung (1997), Kwan and Eisenbeis (1997) and Mongid, Tahir and Hsron (2012) prove this, finding that banks with more capital operate more efficiently than those with less capital. Hu and Yu (2015) also confirm this result in Taiwan's life insurance sector. However, by holding capital, insurers incur extra costs due to taxation and transaction costs. Thus, Kasman and Carvallo (2013) suggest that a decline in capital will lead to increased cost efficiency; this might indicate that the cost of capital is too high in Latin American banking, which was the subject of their study. A higher degree of equity capital may generate increased costs and prevent insurance companies from optimally using their resources. A mixed result was found in Altunbas *et al.* (2007). Most results were in line with Kasman and Carvallo's (2013) findings, but capital is also revealed to negatively impact efficiency for the most efficient banks and co-operative banks.[1] Therefore, the following hypotheses are developed:

H5a: *The capital level negatively affects cost performance.*

H5b: *The capital level affects profit performance.*

2.2.4 Reinsurance

Reinsurance contracts are based on the expected underwriting losses of a pool of policies. Thus, insurers could reduce these losses by using reinsurance (Niehaus and Mann, 1992). Insurers take out reinsurance to increase their ability to write new business, stabilise earnings/spending, reduce capital costs and lower the probability of ruin (Doherty and Tinic, 1981; Doherty, Lamm-Tennant and Starks, 2003; Shiu, 2004; Cummins *et al.*, 2008). Cummins *et al.* (2008) also states that reinsurance increases company value when the benefit of risk-shifting exceeds its cost. Reinsurance enables insurers to increase their market share (Upreti and Adams, 2015).

According to Donni and Fecher's (1997) national level study, countries with higher reinsurance rates are generally high in efficiency. Investigating the average shadow price of financial intermediation and risk management activities, Cummins *et al.* (2009) suggests that, in general, insurers could lower their costs by leveraging both. Rochet and Villeneuve (2011) also demonstrate that cash-rich firms are likely to use insurance to reduce risk and are more likely to outperform cash-poor firms.

Although Liu, Shiu and Liu (2016) reveal that reinsurance could help firms increase liquidity, they also find an inverted, U-shaped relationship between them. In the EU long-term (life) insurance market, a higher percentage of reinsurance is accompanied with

[1] Altunbas *et al.* (2007) split the sample into five types: all banks, commercial banks, savings banks, cooperative banks, most efficient banks and least efficient banks.

lower mix efficiency (Diacon, Starkey and O'Brien, 2002). Shiu (2004) also contends that the purchase of reinsurance could substitute for capital and allow insurance companies to hold less capital without increasing their probability of insolvency, but reinsurance decreases profitability over an extended period due to reinsurance premiums, which may be expensive. Similar to Shiu's (2004) result, Lin, Wen and Yang (2011) also find that using reinsurance is negatively linked to cost efficiency, indicating that reinsurance costs may be too high. Thus, the following may be postulated:

H6a: *Reinsurance negatively affects cost performance.*

H6b: *Reinsurance positively affects profit performance.*

2.2.5 Interactions

Interactions between underwriting and investment risks

Insurer's underwriting and investment risks are not independent, and insurers may control the overall insolvency risk by adjusting weight allocation between these risks (Hammond, Melander and Shilling, 1976; Hammond and Shilling, 1978). Therefore, the insurer would like to simultaneously adjust these two risks in order to achieve a target expected return.

Two hypotheses can explain the possible interplays between underwriting and investment risk—the trade-off hypothesis and the co-movement hypothesis (Zou *et al.*, 2012). The former posits a trade-off (negative relationship) between two risks when the insurer's total risk tolerance (overall insolvency risk) is limited. Hammond, Melander and Shilling (1976) support this hypothesis by studying property-liability insurers from 1952 to 1967. In contrast, the co-movement hypothesis predicts a positive relationship between the two risks.[1] Achleitner, Biebel and Wichels (2002) report that large insurers suffered a massive loss due to the events of September 11, 2001, mainly because of the high correlation between underwriting and investment risk. Baranoff and Sager (2002) test the relationship between the two risks and confirm a positive link. In the recent study, Zou *et al.* (2012) use simultaneous system equations to examine the relations, but they do not find any evidence to support either hypothesis. Based on the business strategy hypothesis, which assumes underwriting activity is the foundation of an insurer's business, the impact on performance of the interaction between these risks can be predicted as follows:

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[1] The co-movement hypothesis can be explained by two rationales: (1) two risks increase together if a firm's maximum risk tolerance level is not fully filled, and (2) investment return volatility leads to fluctuations in underwriting (Achleitner, Biebel and Wichels, 2002; Zou *et al.*, 2012).

H7a: *The interaction between underwriting risk and investment risk affects cost performance.*
H7b: *The interaction between underwriting risk and investment risk affects profit performance.*

Risks interacting with capital or reinsurance

Dhaene *et al.* (2017) state that insurers' underwriting activities are closely linked to their capital structures through creating additional obligations and future uncertainties. Capital structure is also connected to an insurers' investment activities; thus, insurers with more risky investments may be asked to hold adequate capital to offset the risk of investment losses. Under the transaction-cost hypothesis, according to Williamson (1988), insurers with risky policies or risky investments may try to hold more capital to respond to the higher level of risks and reduce insolvency risk. In turn, an insurer's financing decision is also affected by risk-taking. If an insurer is well-capitalised, this might mean the firm has greater ability to take more risks due to its higher power of protecting itself through financial capital or greater risk tolerance. These points indicate that the relation between risk-taking and capital is positive, and this is called the 'finite risk paradigm' or the 'capital buffer theory', in which the insurer seeks to limit overall risk.[1]

In sum, if a positive link between a firm's risk-taking and capital is assumed, then the insurer can adjust the firm's risk-taking (capital level) according to its capital level (risk-taking amount). For example, Zanjani (2002) proves that insurers with more business related to natural disasters would hold more capital.

According to Baranoff and Sager's (2002) study, it is also important to recognise the difference between asset risk (investment risk) and product risk (underwriting risk), because this difference may lead to varied conclusions on their relationships with a firm's capital. Separating the insurer's asset risk from product risk indicates a positive relationship between capital and asset risk but a negative relationship between capital and product risk. However, Hu and Yu (2014) find an opposite result in the Taiwanese market: a negative relationship between investment risk and capital and a positive relationship between underwriting risk and capital. Some negative relationships between capital and

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[1] Limiting overall risks implies that risk is increased in one area by reducing risk in another. Thus, a positive relationship between risks and capital is expected (Dhaene *et al.*, 2017).

risk-taking have also been found in banking studies[1] (Berger, 1995b; Jacques and Nigro, 1997; Mongid, Tahir and Hsron, 2012). The excessive risk paradigm can describe the negative relationship, in which no limits posited in overall risk, as a lower level of capital is associated with a higher level of risk-taking.[2] This can be explained by the fact that undercapitalised or low-franchise-value insurers like to engage in risk-seeking or risk-shifting activities to generate higher returns (Lee, Mayers and Smith, 1997; Dhaene *et al.*, 2017). In fact, most of the empirical literature believes that the insurance industry supports the finite risk paradigm or the capital buffer theory (e.g., Cummins and Sommer (1996); Baranoff and Sager (2003); Baranoff, Papadopoulos and Sager (2007); Shiu (2011); Cheng and Weiss (2013); Kasman and Carvallo (2013); Hu and Yu (2015); and Mankaï and Belgacem (2016)).

Simultaneously considering the impacts of risk and capital on firms' performance, Altunbas *et al.* (2007) tests relationships among risk, equity capital and cost inefficiency in European banking—showing that increasing risk and lowering capital can improve a bank's cost efficiency. Kasman and Carvallo (2013) confirm this result in Latin American banking. However, Hu and Yu (2015) note that less product risk and an increase in both asset risk and capital level enhances insurers' operating efficiency in Taiwan's life market. Tan (2016) studies the impacts of risk on Chinese banking and notes that well-capitalised commercial banks and more diversified business (reduced product risk) achieve better profit performance. However, these studies only consider the effects of risk and capital separately on performance and do not test the interaction effects. This interaction indicates the trade-off effect between the cost of protection and the benefit of taking more risks. Findings from previous studies are inconsistent and unclear, and the following hypotheses in this subsection are built from business-strategy theory and profit-incentive theory, which state that insurers make operational decisions based on underwriting/investment activities, and they seek a higher return from taking more risks.

There are many similarities between purchasing reinsurance and raising external capital. The aim of obtaining both is to enhance insurer stability and underwrite new business,

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[1] Jacques and Nigro (1997) use asset risk to investigate this relationship, and portfolio risk is adopted by Berger (1995b).

[2] The existence of external guaranteed funds (e.g., Financial Services Compensation Scheme (FSCS) in the UK), which provide external financial support to customers in case of insurer default, creates moral hazards, which can be seen as one of the reasons (Lee, Mayers and Smith, 1997). Dhaene *et al.* (2017) also notes that asset substitution could be another reason, due to the higher cost of raising external capital.

and both result in extra cost (reinsurance premiums and cost of capital). Indeed, according to the renting capital hypothesis, reinsurance can be used as an essential, off-balance-sheet financing source for primary insurers (Mayers and Smith, 1990; Adiel, 1996; Stulz, 1996; Dror and Armstrong, 2006). For example, as predicted by the risk-subsidy hypothesis, Lee, Mayers and Smith (1997) confirm that stock insurers tend to take more asset risks after the introduction of external guaranty funds. This supports the view that using (re)insurance extensively leads to higher risk-taking (Aunon-Nerin and Ehling, 2008; Shiu, 2011). Further, Mankaï and Belgacem (2016) study the interaction between using reinsurance and risk-taking, and they confirm the preceding results. They also find evidence that insurers tend to use more reinsurance when they have accepted more risks. Thus, the above discussions for capital can also be adopted to explain the impact of interactions between reinsurance and performance risks.

Due to the abovementioned interconnections between risk management, various risk factors (asset risk and product risk), performance and their complexities, it is worth to reveal the impact of the interactions on the insurer's performance.

H8a: *the interaction between risk management strategies (capital or reinsurance) and risk activities (underwriting risks or investment risk) affects cost performance.*

H8b: *the interaction between risk management strategies (capital or reinsurance) and risk activities (underwriting risks or investment risk) affects profit performance.*

Section 2.3 Data and Methodology

This section describes the empirical strategy employed to examine the impact of the insurer's risk-taking and risk management on the firm performance in the UK insurance market. The SFA technique that is employed to measure insurance efficiency is first described. The database used in this chapter is built on information from financial statements of individual insurers, which included balance sheet and income statement, collected from Orbis, Fame and ISIS (or Insurance Focus) provided by Bureau van Dijk. The World Bank database is the main source for those macro-economic data. The sample covers at least 90% of the market capacity from 1996 to 2013. There is no requirement of data for all the years; therefore, unbalanced panel data is accepted. To ensure all monetary values are directly comparable, we deflate each year's value by the consumer price index to the base year 2015.

2.3.1 Measuring cost and profit efficiency

In this study, insurance performance is measured by the Stochastic Frontier Analysis (SFA). More specifically, Kumbhakar, Lien and Hardaker's (2014) model is employed. The advantage of this model is that the composite error term is separated into four elements, namely firm effects, persistent inefficiency, time-varying inefficiency and random error, and time-varying inefficiency can be used to represented firm's performance. The model is specified in Equation 2.1 as:

$$\mathrm{y}_{it} = \mathrm{f}(\mathbf{Y_{it}}, \mathbf{P_{it}}, \mathrm{T}) + \mu_i + v_{it} - \mathrm{u}_{it} - \tau_i$$

Equation (2.1)

where y_{it} is the total cost or total profit for insurer *i* in year *t*. $\mathbf{Y}_{it}$ is the vector of outputs, $\mathbf{P_{it}}$ the vector of input price and T is the time trend. The term μ_i is the heterogeneity effect, which vary across firms only; v_{it} is the random shock (or statistical noise); u_{it} is time-varying inefficiency and τ_i represents the persistent inefficiency. The translog function is opted in here, and both Jondrow *et al.* (1982) and Battese and Coelli's (1988) methods can be used to find insurer's inefficiency and efficiency score, respectively[1].

In line with Fenn *et al.* (2008) and Yaisawarng, Asavadachanukorn and Yaisawarng (2014), companies are included in estimating efficiency, if they have positive values for all outputs and input price variables, since the estimation of the efficiency function requires that the input prices are strictly positive. As discussed, two types of efficiencies, namely, cost and profit efficiency, will be estimated. In order to estimate efficiency scores, the definition of outputs, inputs and their prices shown in Equation (2.1) must be specified. First, *total cost* (TC), excluding incurred claims in order to avoid confusion with the output measure (Fenn *et al.*, 2008), is defined as insurer operating expenses, including underwriting and administrative costs (Berger *et al.*, 2000). *Total profit* (TP) is the operating profit presented in a financial statement.

By following Berger and Humphrey (1992) and Cummins and Weiss (2011), the value-added approach is adopted to define output factors. *Net claims paid* and *total investment* are chosen as output vectors (see, Klumpes (2004), Eling and Luhnen (2010b), Fiordelisi and Ricci (2010), Kasman and Turgutlu (2011) and Yaisawarng, Asavadachanukorn and Yaisawarng (2014)). For the choice of inputs, according to Eling and Luhnen (2008) and Cummins and Weiss (2011), most of the studies use at least labour and financial capital

[1] More detail of Kumbhakar, Lien and Hardaker's (2014) model and efficiency functional function are provided on Section 1.3.2 and 1.3.3 from Chapter 1.

and add a third category as input vectors. In this study, by following Fenn *et al.* (2008), Kasman and Turgutlu (2011), and Yaisawarng, Asavadachanukorn and Yaisawarng (2014), labour and business, financial capital and technical reserves are selected to represent insurer's inputs. *The ratio of administrative expenses to the total asset* can be treated as *the proxy of* the input price of labour and business. Then, the price of capital is proxied by *the ratio of ordinary profits to the sum of equity capital and total reserve*.[1] Finally, the proxy of the price of the reserve is *the ratio of total technical provisions to the total asset.*

2.3.2 The Empirical Model

In order to estimate the effect of risk-taking and risk management (capital building or reinsurance purchased) on firm performance and to test the hypotheses described in section 2.2, a baseline model is formulated as below:

$$eff_{i,t} = \alpha + \beta_1 UWrisk_{i,t} + \beta_2 IVrisk_{i,t} + \beta_3 (UWrisk_{i,t} * IVrisk_{i,t}) + \varphi_i X_{i,t} + \varepsilon_{it}$$

Equation (2.2a)

$$eff_{i,t} = \alpha + \beta_1 UWrisk_{i,t} + \beta_2 IVrisk_{i,t} + \beta_3 Cap_{i,t} + \beta_5 (UWRisk_{i,t} * Cap_{i,t}) + \beta_6 (IVrisk_{i,t} * Cap_{i,t}) + \varphi_i X_{i,t} + \varepsilon_{it}$$

Equation (2.2b)

$$eff_{i,t} = \alpha + \beta_1 UWrisk_{i,t} + \beta_2 IVrisk_{i,t} + \beta_3 Rein_{i,t} + \beta_5 (UWRisk_{i,t} * Rein_{i,t}) + \beta_6 (UWrisk_{i,t} * Rein_{i,t}) + \varphi_i X_{i,t} + \varepsilon_{it}$$

Equation (2.2c)

where $eff_{i,t}$, which is estimated by using Equation (2.1), is the cost or profit efficiency score of insurer *i* at time *t*. $UWrisk_{i,t}$ is the underwrting risk measuments of insurer *i* at time *t*, and is used to test hypothesis 1 - 3. $IVrisk_{i,t}$ measures the investment risk of insurer *i* at time *t* and relates to hypothesis 4. $Cap_{i,t}$ represents the amount of capital holding and $Rein_{i.t}$ denoted the purchase of reinsurance of insurer *i* at time *t*, hypthesis 5 and 6 are tested by these two variables, respectively. $(UWrisk_{i,t} * IVrisk_{i,t})$ is the interaction term used to test hypothesis 7. Finanlly, hypothesis 8 can be tested by considered two interaction terms: $(UWrisk_{i,t} * Cap_{i,t})$ and $(UWrisk_{i,t} * Rein_{i,t})$. $X_{i,t}$

[1] Ordinary profit is calculated as the sum of underwriting profits, net investment income and other income minus other expenses related to investment.

is a set of control variables. α and ε_{it} are the constant term and error term, respectively. The detail of definition for each of the elements will be decribed in the following.

In the first step of this analysis, the fixed effect estimator[1] is used to wipe out the impact of time-invariant effect and to capture unobserved firm-specific characteristics (heterogeneity across firms).

2.3.3 Dynamic Panel Model

An important econometric consideration is the issue of endogeneity, which originated from: unobservable heterogeneity[2], simultaneity and dynamic nature of regressors (Wintoki, Linck and Netter, 2012). Although the issue arising from unobservable heterogeneity can be corrected by traditional fixed-effects estimation, the bias remains from the dynamic nature of the regressors (Nickell, 1981).

The dynamic panel Generalized Method of Moments (GMM) model[3], which was developed by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998), is used to control the bias raised from endogeneity. This model, first, allows firm-fixed effects to account for unobservable heterogeneity; second, allows the present value of variables to be influenced by their past performance; finally, introduces a set of instruments contained within the panel in order to allow the dynamic nature of the model (Wintoki, Linck and Netter, 2012). The last point indicates that some historical variables can be treated as valid instruments to account for simultaneity, and then it may eliminate the requirement of external instruments. Further, Roodman (2009) suggested the dynamic panel model was suitable to use when there were fewer periods relative to more

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[1] The null hypothesis of Hausman's (1978) test is rejected, suggesting that the fixed effect estimator is prefered.

[2] Unobservable heterogeneity represents the missing or non-constant firm/time conditions due to both internal and external changes (Arellano and Bover, 1995; Upreti and Adams, 2015).

[3] The Difference-GMM model, which is developed by Arellano and Bond (1991), uses the differencing in regressors. The DIF-GMM method specifies the model as a system of equations and it allows instruments (e.g., lags value of the endogenous variables) applicable to each equation to vary. However, the weakness of this method is that the lagged levels will be poor instruments if the first-differenced variables are close to a random walk. A System-GMM was modified by Arellano and Bover (1995) and Blundell and Bond (1998) based on Arellano and Bond's (1991) model. They assumed that the first differences of instrument variables are uncorrelated with the fixed effects, and both lagged levels as well as lagged value of the difference are included in SYS-GMM estimations. Thus, these allow more instruments to be introduced and improve efficiency of estimation. In this paper, the STATA command "xtabond2", written by Roodman (2009), is adopted. He summed up the above discussions and apply the "Windmeijer finite-sample correction" to the two-step standard errors that tend to be downward; this can make two-step estimations more efficient than one-step, especially for SYS-GMM. And the details of this correction could be found in Windmeijer's (2005) study.

individuals ("Small T, large N" panels) in the sample. Meanwhile, the relationships should assume to be linear, and the dependent variable should have a dynamic nature.

The two-step SYS-GMM is used to estimate the dynamic relations between the discussed variables and performance of the UK insurers. It has been indicated that the SYS-GMM is efficient to control unobserved heterogeneity and potential endogeneity in firm-level panel data (Upreti and Adams, 2015). To be specific, according to Roodman (2009) and Upreti and Adams (2015), orthogonal deviation is used as a transformation method of instruments in the SYS-GMM model to maximise the number of observations. In addition, in order to maintain the number of instruments used at a low level, thereby retain the power of Hansen test which examining the over-identifying restrictions, the maximum lag-depth of GMM-style instruments is limited with a ceiling up to the number of firms per model. Then, the collapsed form of the instrument matrix is used to minimise the number of GMM-style instruments (Roodman, 2009; Upreti and Adams, 2015).

2.3.4 Data: variables definitions

Based on the hypothesis developed in Section 2.2, four key variables are required to be defined: underwriting risk, investment (asset) risk, capital and reinsurance.

Underwriting risk variables (UWrisks)

As discussed in the hypothesis development section, three proxies are used to define underwriting risk in order to test Hypotheses 1-3. For Hypothesis 1, the logarithm of proportions of premium derived from the riskiest business lines (UWrisk1) is used to present product risk. By following Baranoff and Sager's (2002) study, the riskiest business in the life sector is health insurance. Thus the ratio of premium from health insurance to gross premium written (GPW) is used to proxy product risk for life business. For non-life insurance, due to the complexity of the product market, the sum of premium from 'property & liability' insurance, 'marine, aviation & transport' insurance and 'financial guarantee' insurance is used to represent the premium arose from the riskiest non-life business (Sommer, 1996; Froot, 2001; Caporale, Cerrato and Zhang, 2017).

Apart from product risk, the degree of diversification (UWrisk2) is the second proxy of underwriting risks; and two types of diversification, business diversification and geographic market diversification, are considered in this research. Herfindahl index[1] (HHI) is widely used to present the level of concentration from preceding literature, such as Powell and Sommer (2007), Shiu (2011) and Caporale, Cerrato and Zhang (2017). Although this method is popular to use, the number of observations will be dropped dramatically if HHI is applied due to data availability. Therefore, the number of business lines and the number of geographic business areas, which are more simple and direct indicators, are substitutes of the Herfindahl index. Consequently, a lower number indicates that the insurer is more specialized in writing a specific type of business or operating in a particular geographic location. Relatively, a higher number might mean that the firms prefer to build a well-diversified business portfolio.

The last underwriting risk proxy is defined as pricing risk (UWrisk3), which is arisen from the technical process. The expense ratio, loss ratio and combined ratio[2] are widely used to represent this risk (Sharpe and Stadnik, 2007; Zou *et al.*, 2012; Ng, Chong and Ismail, 2013). Here, similar to Lamm-Tennant and Starks (1993) and Eling and Marek's (2014) methods, the standard deviation of combined ratio with three-year rolling window is adopted to represent pricing risk[3], in which a higher standard deviation indicates a higher volatility of balancing between outflow and inflow in the firm's core business portfolio. Moreover, this measurement also corresponds to investment risk measurement in this analysis.

Investment (asset) risk variable (IVrisk)

In several prior studies, the amount of investment in different asset classes or the risk-adjusted items are used to measure investment risk, *e.g.* Pottier and Sommer (1999), Zou *et al.* (2012), and Hu and Yu (2015). However, due to data limitations, the detail of

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[1] *HHI* is defined as: $\text{HHI} = \sum_{i=1}^{N} S_i^2$, where S_i is the premium writtern for business line *i* (or geographic area *i*) as a presentage of the gross premium written (GPW), and *N* represents the number of different business lines (or geographic area). A higher the *HHI* indicates a lower level of diversification, the max value is 1. Then, *1- HHI* represents the degree of diversification (the higher the number means a higher degree the diversification).

[2] The expenses ratio is calculated as the ratio of aggregate expense from operating and underwriting to gross premiums written. The loss ratio is defined as the ratio of claim (or benefit) payments to gross premiums written. And the sum of expenses ratio and loss ratio is the combined ratio. A higher combined ratio implies a higher underwriting (pricing) risk (Zou *et al.*, 2012).

[3] Lamm-Tennant and Starks (1993) and Eling and Marek (2014) used standard deviation of loss ratio to represent the underwriting risk. However, when insurers price products in the technical process, they don't only make assumptions on future obligations but also costs (expenses) arised from various activities, such as underwritting and operating. Then, it is reasonable to combined ratio rather than only loss ratio to represent the risk from the point of pricing. Zou *et al.* (2012) also used the combined ratio as underwriting risk indicator, as the combined ratio is the sum of loss ratio and expenses ratio.

investment in different assets is unavailable. Thus, the standard deviation of the ratio of investment income to the total investment is used to represent investment (asset) risk,[1] and a higher standard deviation means the higher volatility of return from investments. The advantage of using this proxy is to consider the investment risk at the aggregate level, in which investment diversification/concentration effect is taken into account.

Capital ratio variable (Cap)

By following most of the previous studies, the ratio of surplus (equity) to total assets was widely adopted to represent the capital ratio of the insurer (Baranoff and Sager, 2002, 2003; Ng, Chong and Ismail, 2013; Hu and Yu, 2015), and this proxy is also used in this study.

Reinsurance variable (Rein)

The ratio of reinsurance premiums ceded to the net premium written is adopted by following Chen, Hamwi and Hudson (2001), Cole and McCullough (2006), and Sheikh, Syed and Ali Shah (2018).[2]

Control variables

Both firm characteristics and environmental factors that affect an insurer's performance are included as control variables and discussed.

Firm size is controlled and defined as the natural logarithm of total assets. On the one hand, large insurers are likely to gain benefits from economies of scale; on the other hand, large-scale operations can result in diseconomies of scale (Mahlberg and Url, 2003). Baranoff and Sager (2002) demonstrate that size plays a vital role in the insurer's risk-taking and capital holding. Also, by following Shim (2011) and Alhassan and Biekpe's (2015) studies, the square of size is also included to exam potential nonlinear relationship between firm size and performance. Worthington and Hurley (2002) and Eling and Luhnen (2010a) also confirm that a curve-linear relationship exists between size and efficiency.

[1] Standard deviation of return on equity, return on asset and its adjusted forms are often used as risk indicators, see Boyd and Runkle (1993), Baranoff and Sager (2011), and Cheng, Elyasiani and Jia (2011); however, due to data limitation, separated investment returns from different asset classes is not available, therefore, the investment return at firm level is used.

[2] The ratio of reinsurance premiums ceded to the gross premium written plus reinsurance assumed is a more robust measurement, as adopted by Liu, Shiu and Liu (2016) and Mankaï and Belgacem (2016). But, the amount of reinsurance assumed is not avaiable due to data availability.

In addition, *liquidity* is also one of the main concerns of insurers since the timing of future payments is uncertain in most cases, and it represents the insurer's ability to fulfil its short-term obligations (Mwangi and Murigu, 2015). Moreover, from banking study, liquidity is also treated as one of the vital driving force of the firm's performance (Mamatzakis and Bermpei, 2014). Thus, a firm's liquidity is closely associated with the firm's operation strategy, such as business writing, capital structure, reinsurance purchased and further affects the firm's stability and performance (see, Fresard (2010), Rochet and Villeneuve (2011), Liu, Shiu and Liu (2016), and Chiaramonte and Casu (2017). Chen and Wong (2004) also indicated that liquidity was one of the crucial factors in assessing insurer's solvency. Firms with a higher level of liquidity might face less risk in case of an unexpected extreme event than those with a lower level of liquidity. Thus it indicates a positive relationship between liquidity and performance (see banking examples, Athanasoglou, Brissimis and Delis (2008) and Mamatzakis and Bermpei (2014)). In contrast, Adams and Buckle (2003) support the notion that insurers with lower liquidity have better performance because high liquidity could increase agency cost by providing insurers opportunities to misuse excess liquid asset (*e.g.* cash). However, Diacon, Starkey and O'Brien (2002), Mwangi and Murigu (2015), and Cummins, Rubio-Misas and Vencappa (2017) find no relationships between firm performance and liquidity in various insurance markets. Here, the ratio of liquid assets to total assets represents an insurer's liquidity. Higher values of this ratio mean that insurers face less liquidity risk.

Aside from the firm-specific control variables, business environment factors are also included to control external influences. According to Eling and Schaper (2017), six factors are chosen to control environmental (uncontrollable) effects on firm performance: economic maturity, unemployment rate, inflation, interest rate, stock market performance and competition.[1] The *economic maturity* that is proxied by GDP per capita (or growth in GDP per capita) represents economic growth and national demand condition. The higher *unemployment rate* may also affect the insurer's surrender rate and the demand for insurance (Eling and Kochanski, 2013). *Inflation and interest rate* are the fundamental figures need to be considered and predicted when the insurer develops a product and price it, and the incorrect predictions on these may lead to unexpected payment raised in the

[1] From Eling and Schaper's (2017) study, the country average of equity capital to total assets is used to represent changes in regulation among countries as the authors treat regulation as the seventh uncontrollable factors. However, we do not consider this factor as external factors because capital adequacy is treated as firm specific variable in this research.

future (Huang and Eling, 2013). The *stock return* is one of the key components in the insurer's profit account, then the growth rate of annual average stock market return is a proxy of stock market performance. *Competition*, is used to control for the effect of market structure in the cost efficiency function, that is calculated as the cumulative market share held by the five largest insurers (five-firm concentration ratio) by following Pope and Ma (2008), Cummins, Rubio-Misas and Vencappa (2017), and Eling and Schaper (2017). In the profit function, the firm's market share is representing the degree of competition. Additional to the above variables, *underwriting income* is added as the control variable in profit function, it shows how well the insurer operates its core business. This variable is determined as the difference between total revenue and total underwriting expenses. In general, the higher the value indicates that that the insurer is in a sound condition to generate more profit.

Table 2.1 shows the descriptive statistics of the firm-specific and market-specific variables used to test hypotheses. Then, Table 2.2 further presents the correlation between the discussed variables. The highest correlation coefficient of 0.72 is observed between Firm Size and Underwriting Income, and the correlation coefficient between Stock Market Return and GDP per capital Growth is 0.69. It may lead to the potential issue of multicollinearity. Then, the variance inflation factor (VIF) analysis is computed for all independent variables. The highest individual score is 3.31, and the overall score is 1.69, these are well below the commonly accepted threshold value of 10, see, Kennedy (1998). Thus, multicollinearity is unlikely to be a serious issue in this study.

[Table 2.1: Descriptive Statistics insert here]

[Table 2.2 Correlation Coefficient Matrix insert here]

Table 2.1: Descriptive Statistics

Variables	Function	Observations	Mean	Median	Standard Deviation	Min	Max
Cost Efficiency	Dependent for Cost	5327	0.6173	0.6293	0.0908	0.0695	0.8572
Profit Efficiency	Dependent for Profit	4812	0.2908	0.3085	0.1315	0.0007	0.7971
Product Risk	Variable for H1	2698	48.6995	43.5000	31.7934	0.1000	100.0000
Business Diversification	Variable for H2	4991	3.1671	3.0000	2.1722	1.0000	14.0000
Geographic Market Diversification	Variable for H2	3548	2.4183	2.0000	1.8611	1.0000	17.0000
Pricing Risk	Variable for H3	8015	47.1398	0.2300	537.1321	0.0000	19006.3232
Investment Risk	Variable for H4	9207	0.3266	0.0052	4.7340	0.0000	218.4826
Capital	Variable for H5	9676	0.3164	0.2325	0.3322	-0.2118	0.9952
Reinsurance	Variable for H6	7796	0.7885	0.2198	1.9126	-1.4600	8.9709
Firm Size	Control Variable	10582	7.9375	7.9444	2.6649	-6.8330	17.4328
Liquidity	Control Variable	9804	-0.9286	-0.4577	1.3360	-12.9516	2.9571
Underwriting Income	Control Variable	4827	4.5387	4.5678	2.5269	-4.5890	13.2519
Competition Indicators: Market Share	Control Variable	8690	0.0025	0.0004	0.0091	-0.0268	0.1486
Competition Indicators: Concentration	Control Variable	27302	0.3379	0.3274	0.0383	0.2941	0.4667
Stock Market Return	Control Variable	26061	4.4597	4.6000	12.2281	-17.6000	20.9600
GDP per Capita	Control Variable	27302	24786.4277	25254.1595	1978.6242	20304.1784	27514.4982
GDP per Capita Growth	Control Variable	27302	1.5102	1.7447	1.7474	-4.9097	3.7706
Unemployment Rate	Control Variable	27302	6.0233	5.5900	1.2657	4.3220	8.1900
Inflation Rate	Control Variable	27302	1.9144	1.8891	0.8303	0.3680	3.8561

Note: Cost and Profit efficiencies are measured by Stochastic Frontier Analysis (SFA) with two outputs and three inputs; *Product Risk* defines as the ratio of premium from Health business (P&L, MAT and MR businesses) to Gross Premium Written for life (non-life) insurers; The number of business lines written by insurers is used to calculate the degree of Business Diversification; *Geographic Diversification* is calculated based on the number of geographic markets in which the insurer has business; *Pricing Risk* is calculated as the standard deviation of insurer's combined ratio with 3-year rolling window; *Investment Risk* is the standard deviation of insurer's investment return with 3-year rolling window; *Capital* is defined as the ratio of Surplus to Total asset; *Reinsurance* is the ratio of premium ceded to the net premium written; *Firm Size* is defined as the natural logarithm of total asset; *Liquidity* is the ratio of liquid asset to total asset; *Underwriting Income* is the natural logarithm of the Insurer's underwriting result; *Market Share* uses to represent market competition in cost function, it is defined as the ratio of individual premium to industry market premium; *Concentration* is the top 5 firms concentration ratio, that is the control variable for competition in profit function; other market specific control variables include Stock Market Return, Unemployment Rate, Inflation Rate, GDP per Capital (in cost function) and GDP per Capita Growth (in profit function). To mitigate the confounding effects of outliers, some firm-specific variables are winsorized at 3% level at each tail and further take natural logarithm to ensure the distribution is normally skewed.

Table 2.2 Correlation Coefficient Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Cost Efficiency	1																		
2. Profit Efficiency	-0.19*	1																	
3. Product Risk	-0.13*	-0.02	1																
4. Business Diversification	0.11*	0.14*	-0.16*	1															
5. Area Diversification	0.06	0.15*	-0.02	0.19*	1														
6. Pricing Risk	0.30*	0	-0.22*	0.09	-0.05	1													
7. Investment Risk	-0.03	-0.02	-0.13*	-0.06	-0.06	0.12*	1												
8. Capital	-0.05	-0.10*	0.15*	-0.49*	-0.05	-0.17*	0.16*	1											
9. Reinsurance	0.01	-0.03	0.04	0.01	0.08	-0.13*	-0.03	0.01	1										
10. Firm Size	-0.14*	0.16*	-0.11*	0.39*	0.18*	-0.29*	-0.08	-0.17*	0.04	1									
11. Liquidity	0.12*	-0.22*	0.04	-0.25*	0	-0.11*	0.04	0.24*	0.04	-0.18*	1								
12. Underwriting Income	-0.09*	0.37*	-0.11*	0.35*	0.16*	-0.09	-0.02	-0.17*	-0.03	0.72*	-0.24*	1							
13. Market Share	-0.19*	0.17*	0	0.21*	0.11*	-0.18*	-0.06	-0.07	0.08	0.55*	-0.04	0.43*	1						
14. Concentration	0.03	-0.09	0.01	-0.05	-0.03	-0.05	0.06	0.14*	0.07	-0.03	0.09	-0.11*	0.06	1					
15. Stock Market Return	-0.08	0.11*	0	-0.01	-0.04	-0.06	-0.05	-0.02	-0.01	0.02	-0.09	0.09	-0.01	-0.25*	1				
16. GDP per Capita	0.07	0.05	0	0.04	0.06	0.11*	0.01	-0.19*	-0.06	-0.05	-0.08	0.05	-0.16*	-0.42*	0.21*	1			
17. GDP per Capita Growth	-0.07	0	0.01	-0.05	-0.02	-0.06	-0.11*	0.01	0.01	0.02	-0.01	0.03	0.09	-0.06	0.69*	0.21*	1		
18. Unemployment Rate	-0.11*	-0.03	0.01	0.02	-0.08	-0.07	-0.03	0.02	-0.01	0.02	-0.15*	0.02	-0.06	0.17*	-0.03	-0.32*	-0.41*	1	
19. Inflation Rate	0.02	-0.10	-0.05	-0.02	-0.03	0.06*	0	-0.08	-0.07	-0.01	-0.08	-0.01	-0.15*	0.01	-0.10	0.41*	-0.07	0.29*	1

Notes: The correlation coefficient between Firm Size and Underwriting Income is 0.72, between Stock Market Return and GDP per capital Growth is 0.69, raising the potential issue of multicollinearity.
The variance inflation factor (VIF) analysis is computed for independent variables.
And the highest individual score is 3.31, and the overall score is 1.69, these are well below the commonly accepted threshold value of 10 (see, (Kennedy, 1998)).
Thus, multicollinearity is unlikely to be a serious issue in this study.
* represent statistical significance at p<0.001 levels.

Section 2.4 Results and Discussions

2.4.1 Efficiency Estimations

The annual means and standard deviations of the predicted score of cost and profit efficiencies are reported in Table 2.3. On average, the cost efficiency score of 0.619 suggests that most insurers in the UK market spend almost 40% more on cost compared to the best-practice insurers. This score is mainly in line with Eling and Luhnen's (2010a) result of 0.615, but it is lower than the average score of 0.90 observed by Fenn *et al.* (2008).[1] For profit efficiency, the overall average score is 0.279. This indicates that the UK insurers, on average, only generate 28% of the profits attainable by the best-practice firms, given the same level of input price and outputs. This profit score is much less than the 0.69 result determined by Hardwick, Adams and Zou (2011). This difference can be explained via the use of different output vectors and stochastic frontier analysis (SFA) models.[2]

In line with the insurance findings from Gaganis, Hasan and Pasiouras (2013) and Alhassan and Biekpe (2016), a higher level of cost efficiency compared with profit efficiency is confirmed here. Due to this difference between cost and profit efficiencies, an imperfect competitive market can be suggested (Bos and Kool, 2006; Alhassan and Biekpe, 2016). Over the investigation period, a higher level of uncertainties is associated with profit efficiency relative to cost efficiency from their standard deviations.

[1] Fenn *et al.* (2008) determined the cost efficiencies from 1995 to 2001 for life, non-life and composited markets separately, and the average scores were 0.78, 0.94 and 0.99, respectively. Thus, the overall average score for the UK insurance market is approximately 0.90. Eling and Luhnen (2010a) show that, from 2002 to 2006, the cost efficiencies for life insurers and non-life insurers were 0.64 and 0.59, respectively. So the overall avergae score is approximately 0.615. More detail regarding the predicted efficiency scores for different types of businesses can be found in Chapter 1.

[2] As discussed in Section 2.3, the efficiency scores are determined by Kumbhakar, Lien and Hardaker's (2014) model, which has four components in composite error terms. However, Hardwick, Adams and Zou (2011) only consider the random shock and inefficiency terms in the composite term.

Table 2.3: Summary of Average Efficiencies

	Cost Efficiency	Profit Efficiency
Year	Mean (s.d.)	Mean (s.d.)
1996	0.6345 (0.0767)	0.2469 (0.1264)
1997	0.6350 (0.0660)	0.2654 (0.1393)
1998	0.6356 (0.0677)	0.2611 (0.1418)
1999	0.6299 (0.0751)	0.2147 (0.1416)
2000	0.6243 (0.0793)	0.2172 (0.1449)
2001	0.6332 (0.0721)	0.2198 (0.1119)
2002	0.6313 (0.0650)	0.2308 (0.1427)
2003	0.6248 (0.0743)	0.2419 (0.1360)
2004	0.6116 (0.0667)	0.3054 (0.1165)
2005	0.6105 (0.0808)	0.3051 (0.1216)
2006	0.6033 (0.0823)	0.3165 (0.1156)
2007	0.6098 (0.0837)	0.3274 (0.1133)
2008	0.6286 (0.0934)	0.3027 (0.1409)
2009	0.6211 (0.0986)	0.3081 (0.1239)
2010	0.6216 (0.1032)	0.3066 (0.1169)
2011	0.6175 (0.0973)	0.2715 (0.1265)
2012	0.6158 (0.0971)	0.3059 (0.1264)
2013	0.6071 (0.0935)	0.3006 (0.1299)

2.4.2 Panel Estimations

By following Goddard, Molyneux and Wilson (2004) and Mamatzakis and Bermpei (2016), the main regression model is estimated using both OLS fixed effect estimation and the dynamic panel Generalized Method of Moment (GMM) model. The former not only eliminate the impact of time-invariant effect and to capture unobserved firm-specific characteristics (heterogeneity across firms), but also represents the long-run relationship. The GMM model is used to address the potential endogeneity issue that may arise in the OLS estimation; meanwhile, it can be used to further estimate the dynamic features of the model, which is the short-run relationship. Therefore, a comprehensive story, in which variabilities existed between the long-run relationship and the short-run relationship are considered, can be provided by comparing the results from these two models.

2.4.2.1 The impact of the underwriting risks, investment risk, capital and reinsurance

Cost Function

Tables 2.4 and 2.5 present the regression results for the ordinary least squares (OLS) fixed effects and dynamic panel regressions, in which cost efficiency is the performance indicator. Consistent with Hypothesis 1a, which is based on both transaction cost theory Williamson (1985) and the expected bankruptcy costs argument, the fixed effects model reveal a significant negative relationship between an insurer's product risk and cost efficiency (Model 1, 8-10 in Table 2.4). Dynamic panel models provide further evidence of this negative relationship (Models 1 and 8-10 in Table 2.5). These results indicate that insurers writing more risky business have lower cost efficiency because monitoring or rebalancing the business portfolios can be costly in both long-run and short-run. Thus, Hypothesis 1a is supported.

[Table 2.4: Individual Effect of Factors on Cost Efficiency – OLS insert here]

[Table 2.5: Individual Effect of Factors on Cost Efficiency – GMM insert here]

Table 2.4: Individual Effect of Factors on Cost Efficiency - OLS

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
VARIABLES	Cost Eff.	Cost Eff.	Cost Eff.	Cost Eff.	Cost Eff.	Cost Eff.	Cost Eff.	Cost Eff.	Cost Eff.	Cost Eff.
Product Risk	-0.0069**							-0.0099***	-0.0098***	-0.0104***
	(-2.332)							(-3.770)	(-3.357)	(-3.323)
Business Diversification		-0.0009						0.0024	0.0015	0.0031
		(-0.353)						(0.525)	(0.315)	(0.650)
Area Diversification			-0.0073***					-0.0054*	-0.0050*	-0.0056**
			(-2.882)					(-1.962)	(-1.827)	(-2.320)
Pricing Risk				0.0052***				0.0092***	0.0086***	0.0066**
				(5.026)				(3.942)	(3.489)	(2.389)
Investment Risk					-0.1464***			-0.2090	-0.2229	-0.3622
					(-6.419)			(-0.869)	(-0.937)	(-1.494)
Capital						0.0056**			0.0088**	
						(2.391)			(2.585)	
Reinsurance							0.0022**			0.0064***
							(2.030)			(3.030)
Firm Size	-0.0061	-0.0328*	-0.0533***	-0.0253*	-0.0356**	-0.0361**	-0.0295	-0.0368	-0.0245	-0.0186
	(-0.180)	(-1.705)	(-2.638)	(-1.648)	(-2.264)	(-2.277)	(-1.562)	(-0.943)	(-0.564)	(-0.444)
Square of Firm Size	-0.0002	0.0015	0.0025**	0.0010	0.0014*	0.0017*	0.0014	0.0019	0.0013	0.0010
	(-0.096)	(1.506)	(2.324)	(1.224)	(1.648)	(1.869)	(1.257)	(0.876)	(0.561)	(0.443)
Liquidity	0.0089**	0.0099***	0.0116***	0.0076***	0.0079***	0.0082***	0.0087***	0.0110***	0.0101***	0.0090***
	(2.576)	(3.950)	(4.006)	(3.928)	(4.028)	(4.058)	(4.610)	(3.306)	(3.123)	(2.643)
Market Share	-2.3021***	-0.5382***	-0.2177	-0.3317*	-0.4711**	-0.5274***	-0.4731**	-3.4221**	-3.5150**	-4.0007***
	(-3.328)	(-2.912)	(-1.296)	(-1.949)	(-2.426)	(-2.676)	(-2.248)	(-2.480)	(-2.487)	(-2.716)
Stock Market Return	-0.0467***	-0.0301***	-0.0309***	-0.0235***	-0.0306***	-0.0357***	-0.0345***	-0.0309**	-0.0314**	-0.0259**
	(-4.018)	(-4.097)	(-3.562)	(-3.785)	(-4.866)	(-5.450)	(-5.388)	(-2.346)	(-2.276)	(-2.224)
GDP per Capita	-0.0086**	-0.0076***	-0.0057**	-0.0053***	-0.0041***	-0.0040***	-0.0053***	-0.0082*	-0.0087**	-0.0088**
	(-2.175)	(-3.172)	(-2.200)	(-3.559)	(-2.976)	(-3.041)	(-3.803)	(-1.911)	(-2.015)	(-2.029)
Unemployment Rate	-0.0034**	-0.0025**	-0.0024*	-0.0015	-0.0001	-0.0006	-0.0011	-0.0043**	-0.0049***	-0.0031*
	(-1.972)	(-2.106)	(-1.829)	(-1.124)	(-0.079)	(-0.527)	(-0.960)	(-2.390)	(-2.717)	(-1.653)
Inflation Rate	-0.0001	0.0008	-0.0001	-0.0026**	-0.0038***	-0.0026**	-0.0037***	0.0001	0.0007	-0.0005
	(-0.051)	(0.564)	(-0.033)	(-2.212)	(-3.194)	(-2.283)	(-2.883)	(0.066)	(0.374)	(-0.225)
Constant	0.9604***	1.0061***	1.0563***	0.9355***	0.9500***	0.9415***	0.9391***	1.0882***	1.0567***	1.0190***
	(5.164)	(9.435)	(8.853)	(13.080)	(13.050)	(13.701)	(11.305)	(5.346)	(4.847)	(4.794)
Observations	1,067	1,966	1,389	3,022	3,029	3,295	2,801	822	784	723
Number of Firms	285	490	381	637	636	648	601	236	219	214
Adjusted R-squared	0.096	0.069	0.083	0.091	0.072	0.063	0.075	0.176	0.172	0.194
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	5.17***	6.56***	6.64***	11.32***	14.12***	10.11***	8.37***	5.69***	5.46***	5.81***

Robust t-statistics in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.5: Individual Effects on Cost Efficiency - GMM

VARIABLES	M1 Cost Eff.	M2 Cost Eff.	M3 Cost Eff.	M4 Cost Eff.	M5 Cost Eff.	M6 Cost Eff.	M7 Cost Eff.	M8 Cost Eff.	M9 Cost Eff.	M10 Cost Eff.
L. Cost Eff.	0.4585***	0.5106***	0.5234***	0.1872*	0.2821*	0.3056*	0.2827**	0.7119***	0.3992***	0.1497**
	(3.106)	(6.258)	(7.050)	(1.649)	(1.716)	(1.733)	(1.968)	(5.221)	(2.688)	(2.173)
Product Risk	-0.0209*							-0.0079	-0.0115*	-0.0198***
	(-1.692)							(-1.066)	(-1.868)	(-2.907)
Business Diversification		-0.0019						-0.0102*	0.0081	0.0318**
		(-0.449)						(-1.697)	(0.644)	(1.997)
Area Diversification			-0.0035**					0.0186***	0.0026	-0.0049
			(-1.988)					(3.270)	(0.520)	(-0.654)
Pricing Risk				0.0097***				0.0093***	0.0085**	0.0080*
				(3.343)				(3.799)	(2.600)	(1.872)
Investment Risk					-0.3081***			0.5116	0.1149	0.4447
					(-5.607)			(0.852)	(0.308)	(0.740)
Capital						0.0146**			0.0016	
						(2.277)			(0.206)	
Reinsurance							0.0121**			0.0172**
							(2.286)			(2.091)
Firm Size	-0.0216	-0.0363*	-0.0325	-0.0316	0.0226	0.0543*	0.0530**	-0.0132	0.0038	0.0697
	(-0.463)	(-1.735)	(-1.610)	(-1.016)	(0.631)	(1.846)	(2.157)	(-0.596)	(0.105)	(0.861)
Square of Firm Size	0.0013	0.0020*	0.0020*	0.0016	-0.0023	-0.0023	-0.0029**	0.0004	-0.0004	-0.0039
	(0.568)	(1.802)	(1.713)	(0.958)	(-1.180)	(-1.611)	(-2.547)	(0.314)	(-0.169)	(-0.757)
Liquidity	0.0076	0.0068	-0.0000	0.0099*	0.0148	-0.0086	0.0043	0.0117*	0.0062	0.0123
	(1.043)	(1.084)	(-0.001)	(1.721)	(1.533)	(-0.913)	(0.670)	(1.801)	(1.372)	(1.504)
Market Share	-0.4949	-0.8287*	-0.9640***	-0.8736	0.2100	-0.6178	0.5506*	2.0370	-5.4012**	-9.9536***
	(-0.959)	(-1.838)	(-2.662)	(-1.207)	(0.334)	(-1.238)	(1.750)	(0.878)	(-2.202)	(-2.648)
Stock Market Return	-0.0414***	-0.0181	-0.0114	-0.0293**	-0.0211	-0.0024	-0.0265**	0.0010	-0.0335	-0.0507**
	(-2.756)	(-1.589)	(-0.817)	(-2.574)	(-1.051)	(-0.115)	(-2.133)	(0.053)	(-1.371)	(-2.095)
GDP per Capita	0.0058*	-0.0046**	-0.0011	-0.0075***	-0.0014	-0.0018	-0.0021	-0.0041	-0.0076*	-0.0087
	(1.899)	(-2.506)	(-0.399)	(-4.263)	(-0.388)	(-0.646)	(-0.974)	(-1.311)	(-1.805)	(-1.360)
Unemployment Rate	-0.0029**	-0.0037***	-0.0044***	-0.0054***	-0.0062*	-0.0047*	-0.0014	-0.0061***	-0.0042**	-0.0030
	(-2.160)	(-3.473)	(-4.095)	(-2.850)	(-1.899)	(-1.737)	(-0.755)	(-3.332)	(-2.234)	(-1.380)
Inflation Rate	-0.0058	0.0012	-0.0006	0.0000	-0.0087**	0.0025	-0.0011	0.0082	0.0015	0.0014
	(-1.425)	(0.375)	(-0.203)	(0.006)	(-2.168)	(0.760)	(-0.660)	(1.608)	(0.448)	(0.311)
Constant	0.3849	0.6025***	0.4829***	0.9114***	0.5503*	0.2312	0.2998	0.4356***	0.6509***	0.5715
	(1.238)	(4.382)	(4.139)	(4.419)	(1.940)	(1.071)	(1.463)	(3.163)	(2.795)	(1.636)
Observations	822	1,523	1,079	1,278	575	369	1,345	683	426	389
Number of Firms	230	405	307	439	275	121	407	200	161	154
Number of Instruments	41	85	85	134	90	86	56	68	128	90
Robust	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	8.151***	17.77***	19.92***	9.952***	5.534***	3.967***	5.530***	11.28***	14.23***	5.194***
AR(1)	-1.815*	-2.939***	-2.520**	-2.636***	-2.115**	-2.275**	-2.852***	-1.701*	-1.669*	-2.626***
AR(2)	0.395	1.461	0.916	1.206	1.454	1.421	0.190	0.370	0.285	-1.694
Hansen Test (P-value)	30.39 (0.446)	78.98 (0.324)	79.70 (0.304)	127.1 (0.381)	87.28 (0.245)	88.11 (0.143)	55.60 (0.134)	63.41 (0.155)	109.2 (0.556)	83.34 (0.214)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Regarding Hypothesis 2a concerning cost efficiency, two types of diversification strategies—business diversification and geographic area diversification—are tested. Consistent with the results from Bikker and Gorter (2008) and Shiu (2011), and in line with the strategic focus hypothesis, a negative relationship between geographic area diversification and cost efficiency is found in both long-run and short-run model. Thus, it is reasonable to confirm that insurers with more businesses allocated in different geographic markets do not have any cost advantage, if only considering the impact of geographic area diversification. Thus, this result does not support Hypothesis 2a. Additionally, from the point of product mix, the results, from both tables, are inconsistent and significant. For example, a negative relationship is shown when only considering the impact of business diversification, while the relationship becomes positive when controlling for other key interest variables. Thus, to reveal a true impact of business diversification, joint effects with other vital variables must be considered. (More details will be provided in the interaction sections).

Surprisedly, Hypothesis 3a is significantly rejected. Strong positive evidence, from both Tables 2.4 and 2.5, is found on the relationship between pricing risk and cost efficiency. Specifically, more pricing risk may enhance the insurer's cost performance; this is also confirmed by Alhassan and Biekpe (2016). If this pricing risk comes in the wake of the insurer's business nature (i.e., business types, by definition, being accompanied by more pricing uncertainties, or pricing issues always being the primary concern.), then the insurers may have already paid serious attention to these risks.[1] In such a case, this underwriting uncertainty may benefit the cost structure through other monitoring activities, investment and risk management. This could explain the positive effect of pricing risk on cost efficiency.

As Hypothesis 4a expected, insurers with higher investment risk may face cost disadvantages due to the costs of asset monitoring and modification. It indicates that insurers who bear more investment risk may spend sources on asset monitoring or re-balancing. This result is significant when investment risk is solely considered in both long-run and short-run (Model 5 in Tables 2.4 and 2.5). The negative impact remains in the other models after controlling for key variables, but it is no longer significant.

[1] Brockett *et al.* (2004b) also suggests that the impact of overall solvency on efficiency is either little or invisible. They explain that the firm's solvency situation is given serious attention by all stakeholders.

Because there are costs associated with using both capital and reinsurance, Hypothesis 5a and 6a predicted that using them should negatively impact cost efficiency. However, the results of Models 6-10 in Tables 4 and 5 lead to rejecting both hypotheses. The positive impact from capital and reinsurance is confirmed, indicating that the benefits of risk-avoiding/shifting exceed the cost of using capital or reinsurance. It also indicates that cost of default is reduced by holding more capital or taking more reinsurance protections, then lead to enhance the cost performance. These results are in line with suggestions from Donni and Fecher (1997) and Hu and Yu (2015).

Profit Function

As discussed in Section 2.2, an alternative performance indicator (profit efficiency) is also considered. The individual impacts of critical variables (underwriting risks, investment risk, capital and reinsurance) on profit performance are shown in Tables 2.6 and 2.7—the fixed effects model (the long-run model) and the dynamic panel model (the short-run model), respectively.

[Table 2.6: Individual Effect of Factors on Profit Efficiency – OLS insert here]

[Table 2.7: Individual Effect of Factors on Profit Efficiency – GMM insert here]

Evidence to support Hypothesis 1b, which assumes a negative impact of product risk on insurers' profit performance, can be found from Model 1 in both Tables 2.6 and 2.7. However, this impact is not significant when controlling for the other key variables (except for dynamic Model 10 in Table 2.7). This further confirms both transaction cost theory and the expected bankruptcy costs argument, from the point of profit containing broader information than cost indicators. The result indicates that insurers who issue more risky business may not generate more profit and achieve better profit performance.

In contrast to the cost-regression, the impact of business diversification is more consistent and robust in the profit models. An insurer writing different types of products, tends to have a better ability to generate profit; significant evidence can be found in both long-run and short-run models (see, Models 8-9 in Table 2.6 and Model 2 in Table 2.7). Meanwhile, both models confirm a robust positive effect of geographic area diversification on profit efficiency, contradicting the negative impacts shown in the cost models. It also indicates that insurers with more businesses across different geographic area may have better ability to generate profit. Therefore, by comparing the different results between cost model and profit model, it is acceptable to suggest that the extra costs, arising from writing business in different geographic markets, can be overcome by geographic diversification. Thus, the results support Hypothesis 2b.

Table 2.6: Individual Effects on Profit Efficiency - OLS

VARIABLES	M1 Profit Eff.	M2 Profit Eff.	M3 Profit Eff.	M4 Profit Eff.	M5 Profit Eff.	M6 Profit Eff.	M7 Profit Eff.	M8 Profit Eff.	M9 Profit Eff.	M10 Profit Eff.
Product Risk	-0.0047*							-0.0021	-0.0032	-0.0017
	(-1.680)							(-0.804)	(-1.187)	(-0.613)
Business Diversification		-0.0020						0.0127**	0.0132**	0.0118**
		(-0.464)						(2.294)	(2.302)	(2.117)
Area Diversification			0.0074*					0.0017	0.0017	0.0014
			(1.802)					(0.337)	(0.298)	(0.289)
Pricing Risk				-0.0019				-0.0008	-0.0009	-0.0010
				(-1.547)				(-0.433)	(-0.438)	(-0.518)
Investment Risk					0.0706***			0.2056	0.0905	0.1468
					(3.763)			(0.675)	(0.288)	(0.447)
Capital						0.0139***			0.0062*	
						(5.441)			(1.923)	
Reinsurance							0.0007***			-0.0617**
							(5.148)			(-2.041)
Firm Size	0.0929**	0.0504**	0.0509*	0.0266	0.0248	0.0175	0.0370*	0.0872*	0.1015*	0.0907*
	(2.161)	(2.135)	(1.814)	(1.254)	(1.440)	(1.107)	(1.761)	(1.889)	(1.782)	(1.805)
Square of Firm Size	-0.0050*	-0.0024*	-0.0029*	-0.0016	-0.0015	-0.0008	-0.0023*	-0.0050*	-0.0060*	-0.0053*
	(-1.913)	(-1.766)	(-1.708)	(-1.292)	(-1.449)	(-0.864)	(-1.880)	(-1.771)	(-1.735)	(-1.712)
Liquidity	-0.0021	-0.0047	-0.0071**	-0.0105***	-0.0087***	-0.0105***	-0.0110***	-0.0028	-0.0020	-0.0023
	(-0.430)	(-1.323)	(-2.151)	(-3.755)	(-3.241)	(-4.040)	(-3.936)	(-0.607)	(-0.450)	(-0.492)
Underwriting Income level	0.0184***	0.0100***	0.0155***	0.0085***	0.0084***	0.0074***	0.0094***	0.0232***	0.0238***	0.0236***
	(6.496)	(4.461)	(6.303)	(5.162)	(5.137)	(4.874)	(5.881)	(8.229)	(7.223)	(8.243)
Stock Market Return	0.0906***	0.0664***	0.0788***	0.0824***	0.0868***	0.0773***	0.0768***	0.0811***	0.0859***	0.0821***
	(3.802)	(3.615)	(3.807)	(5.459)	(5.726)	(5.195)	(5.007)	(3.346)	(3.313)	(3.285)
GDP per Capita Growth	-0.0050***	-0.0041***	-0.0057***	-0.0044***	-0.0045***	-0.0039***	-0.0045***	-0.0050***	-0.0053***	-0.0052***
	(-3.609)	(-3.620)	(-4.552)	(-4.740)	(-4.835)	(-4.203)	(-4.718)	(-3.319)	(-3.287)	(-3.299)
Unemployment Rate	-0.0053***	-0.0062***	-0.0069***	-0.0041**	-0.0048***	-0.0050***	-0.0051***	-0.0058***	-0.0061***	-0.0062***
	(-2.665)	(-3.570)	(-3.675)	(-2.582)	(-3.010)	(-3.561)	(-3.600)	(-2.848)	(-2.618)	(-2.969)
Inflation Rate	-0.0078**	-0.0042	-0.0045	0.0014	0.0025	0.0028	0.0025	-0.0085**	-0.0087**	-0.0088**
	(-2.307)	(-1.576)	(-1.504)	(0.746)	(1.292)	(1.525)	(1.292)	(-2.246)	(-2.235)	(-2.258)
Concentration	0.1356	0.1557	0.2704*	0.0548	0.0485	0.0560	0.0842**	0.3892**	0.4096**	0.4549**
	(0.744)	(1.191)	(1.948)	(1.335)	(1.183)	(1.443)	(2.075)	(2.289)	(2.296)	(2.564)
Constant	-0.1429	0.0152	-0.0100	0.1491	0.1667**	0.2010***	0.1110	-0.2175	-0.2660	-0.2499
	(-0.746)	(0.135)	(-0.078)	(1.490)	(2.082)	(2.799)	(1.116)	(-1.087)	(-1.099)	(-1.140)
Observations	1,263	2,074	1,575	3,082	3,136	3,363	3,204	1,050	965	1,018
Number of Firms	346	550	440	674	683	708	675	294	280	286
Adjusted R-squared	0.159	0.072	0.126	0.054	0.056	0.058	0.060	0.218	0.217	0.225
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	10.85	10.85	10.85	10.85	10.85	10.85	10.85	10.85	10.85	10.85

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2.7: Individual Effects on Profit Efficiency - GMM

VARIABLES	M1 Profit Eff.	M2 Profit Eff.	M3 Profit Eff.	M4 Profit Eff.	M5 Profit Eff.	M6 Profit Eff.	M7 Profit Eff.	M8 Profit Eff.	M9 Profit Eff.	M10 Profit Eff.
L. Profit Eff.	0.0778*	0.1535**	0.0868*	0.0972*	0.0744*	0.0879*	0.1106**	0.0925*	0.1269*	0.1682***
	(1.654)	(2.017)	(1.859)	(1.942)	(1.651)	(1.908)	(2.378)	(1.684)	(1.937)	(2.747)
Product Risk	-0.0216*							0.0007	0.0009	-0.0169*
	(-1.679)							(0.084)	(0.135)	(-1.678)
Business Diversification		0.0426***						0.0023	0.0043	0.0067
		(2.729)						(0.204)	(0.440)	(0.463)
Area Diversification			0.0521***					0.0136*	0.0134*	0.0209**
			(4.901)					(1.688)	(1.715)	(2.140)
Pricing Risk				-0.0034*				-0.0014	0.0021	0.0013
				(-1.683)				(-0.284)	(0.583)	(0.375)
Investment Risk					0.1714***			0.1394	1.0090*	-0.0380
					(4.933)			(0.334)	(1.901)	(-0.051)
Capital						0.0267***			0.0168*	
						(3.068)			(1.760)	
Reinsurance							0.0004**			-0.0724*
							(2.105)			(-1.962)
Firm Size	0.0814	-0.0312	0.0402	0.1038***	0.1200***	0.1105***	0.1336***	0.0168	0.0301	-0.1232
	(0.796)	(-0.451)	(0.903)	(2.740)	(4.339)	(3.471)	(3.196)	(0.292)	(0.746)	(-1.560)
Square of Firm Size	-0.0052	0.0006	-0.0041*	-0.0072***	-0.0083***	-0.0068***	-0.0086***	-0.0010	-0.0019	0.0069
	(-0.802)	(0.161)	(-1.666)	(-3.430)	(-5.531)	(-3.932)	(-3.698)	(-0.287)	(-0.819)	(1.395)
Liquidity	-0.0188	-0.0040	-0.0158*	-0.0002	0.0026	0.0032	0.0015	-0.0314**	-0.0160**	-0.0192**
	(-1.460)	(-0.474)	(-1.848)	(-0.032)	(0.418)	(0.562)	(0.215)	(-2.027)	(-2.013)	(-2.053)
Underwriting Income level	0.0246**	0.0140***	0.0170***	0.0072**	0.0089***	0.0089***	0.0118***	0.0200***	0.0228***	0.0195**
	(2.466)	(3.211)	(4.480)	(2.386)	(3.088)	(3.251)	(3.449)	(3.285)	(4.542)	(2.427)
Stock Market Return	0.0711	0.1651***	0.1697***	0.1184***	0.0998***	0.1764***	0.1522***	0.1395***	0.1303***	0.1647***
	(1.586)	(3.751)	(3.752)	(3.739)	(3.124)	(5.681)	(4.528)	(3.801)	(3.405)	(2.918)
GDP per Capita Growth	-0.0067**	-0.0081***	-0.0118***	-0.0057**	-0.0075***	-0.0107***	-0.0057**	-0.0091***	-0.0064***	-0.0101***
	(-2.448)	(-2.946)	(-4.528)	(-2.502)	(-3.308)	(-4.515)	(-2.253)	(-3.960)	(-2.700)	(-2.744)
Unemployment Rate	-0.0108***	-0.0067**	-0.0108***	-0.0060**	-0.0113***	-0.0074**	-0.0048	-0.0141***	-0.0087**	-0.0122***
	(-3.133)	(-2.006)	(-2.734)	(-2.080)	(-3.041)	(-1.967)	(-1.298)	(-3.837)	(-2.353)	(-3.094)
Inflation Rate	-0.0092*	0.0041	0.0037	0.0089***	0.0106**	0.0094*	0.0128***	-0.0063	-0.0073	-0.0098
	(-1.653)	(0.789)	(0.592)	(2.647)	(2.260)	(1.841)	(2.796)	(-1.130)	(-1.496)	(-1.311)
Concentration All	0.8048**	0.2641	0.4335*	0.3366***	0.1155**	0.4045***	0.3145***	0.9614***	0.5584**	0.8805***
	(2.303)	(1.223)	(1.725)	(4.930)	(2.026)	(6.005)	(5.100)	(3.624)	(2.168)	(2.860)
Constant	-0.2196	0.3428	0.0653	-0.1974	-0.1448	-0.2469*	-0.3656**	-0.1076	-0.0401	0.5708*
	(-0.548)	(1.138)	(0.295)	(-1.154)	(-1.100)	(-1.650)	(-1.989)	(-0.449)	(-0.236)	(1.846)
Observations	919	1,535	1,190	2,473	2,505	2,454	2,302	827	794	799
Number of Firms	280	455	364	590	596	592	560	260	248	249
Number of Instruments	93	152	122	192	210	234	201	141	185	101
Robust	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	4.013***	6.540***	8.579***	8.922***	14.84***	13.98***	9.494***	6.345***	7.665***	6.072***
AR(1)	-4.826***	-4.753***	-4.681***	-5.784***	-6.157***	-5.868***	-5.919***	-4.608***	-4.213***	-4.346***
AR(2)	0.232	-0.817	-0.968	1.443	1.482	1.364	1.490	0.525	0.216	0.287
Hansen Test (p-value)	90.38 (0.223)	149.8 (0.270)	123.5 (0.179)	201 (0.136)	218.9 (0.147)	246 (0.129)	213 (0.111)	124.3 (0.500)	163.9 (0.575)	91.89 (0.261)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

As expected by Hypothesis 3b concerning the impact of pricing risk on profit efficiency, the negative effect can be found in most models in Tables 2.6 and 2.7. However, this effect is only significant in short-run model (see, Model 4 from Table 2.7), when pricing risk is solely included. It means that insurers who face more pricing issues may have weak ability to generate profit in short-run. And this weak evidence suggests that insurers always pay serious attention to pricing issue, as it leads to a harmful impact on profit performance.

From both fixed effects and dynamic panel models, there is evidence (see Model 5 in Tables 2.6 and 2.7) to support the profit-incentive hypothesis (Hypothesis 4b), which indicates that insurers are willing to use more aggressive investment strategies to achieve the goal of generating higher profits in both long-run and short-run. These results oppose those from the cost models. However, a positive impact is no longer significant after controlling for other key variables (except Model 9 in Table 2.7). Thus, Hypothesis 4b is supported, but the joint effects with other key factors must be considered. (More details will be provided in the interaction sections).

Models 6 and 9 in Tables 2.6 and 2.7 confirm that insurers with more capital are more profit efficient, and this is in line with the results of the cost model. The positive effect from the profit model further indicates that capital potentially helps insurers expand their underwriting abilities and receive higher levels of underwriting income. Regarding reinsurance, in both long-run and short-run models, there is a positive relationship between reinsurance and profit performance when the reinsurance variable is solely considered (Model 7). The positive result indicates that insurers can use reinsurance to mitigate exposures and to generate more profit. However, the conflicted result (a negative coefficient) is appeared after considering for other key variables (Model 10). That indicates the joint effects with other key factors must be considered.

The findings above show that underwriting risks, investment risks and risk management (capital and reinsurance) are significant determinants of UK insurers' cost and profit performance between 1996 and 2013. Insurers can make operational decisions on these factors to adjust their performance. Apart from these individual effects raised from the sole variables, further investigations on the impacts of interaction terms (underwriting risks interacting with investment risk, both interacting with capital, and risk factors interacting with reinsurance) are also shown in the following sections.

2.4.2.2 The impact of interaction with investment risk

<u>*Cost Function*</u>

Table 2.8 presents the OLS fixed effects model, and estimations from the dynamic panel model are shown in Table 2.9. Both tables disclose the potential impact of interactions between underwriting risk and investment risk on an insurer's cost efficiency. On average, the negative impact of investment risk can be confirmed by the results shown in both tables, and this is consistent with the findings in Tables 2.4 and 2.5. It confirms that insurers who have more risky asset may face cost disadvantages. Also, all the interaction impacts are significant in Table 2.9, which indicates that insurers do consider two types of risks together in the short-run mainly.

To be more specific, Model 1 in Tables 2.8 and 2.9 reveals the potential impacts related to the insurer's product risk. It confirms that the product risk negatively impacts insurers' cost efficiency. It further confirms that insurers issuing more risky businesses have lower cost efficiency. Surprisingly, the interaction term shows a significant positive impact, which may indicate that the insurer does consider investment decision based on pre-determined underwriting strategies in the short-run, but it is unclear why the interaction effect is positive for cost performance. However, a potential explanation can be made based on the trade-off hypothesis, which assumes that the insurer's overall risk is restricted. Then, by considering this together with transaction cost theory, the insurer may have more cost advantages when total risk tolerance is limited.

The negative interaction impacts are found in both diversification models (Models 2 and 3) at the 10% level in short-run (Table 2.9). These results reveal that interacted impacts are varied. To be more specific, insurers who have more diversified businesses and aggressive investment strategies would have lower cost efficiency becasue the cost of taking investment risk offsets the benefit of business diversification. On the other hand, the aggressive investment strategies would amplify the adverse effects of geographic diversification.

Inconsistent impacts of the interaction between pricing risk and investment risk on cost efficiency are found in the long-run model (Table 2.8) and the short-run model (Table 2.9). Model 4 in Table 2.8 shows a positive effect, which indicates that the insurer may take a reasonable level of investment risk, which can benefit its cost structure after its financial decisions are continuously adjusted in the long-run. On the other hand, the adverse impact of taking more investment risk may take the dominant role in the short-run.

[Table 2.8: Interaction Effects with Investment risk on Cost Efficiency – OLS insert here]

[Table 2.9: Interaction Effects with Investment risk on Cost Efficiency – GMM insert here]

Table 2.8: Interaction Effects with Investment Risk on Cost Efficiency - OLS

VARIABLES	M1 Cost Eff.	M2 Cost Eff.	M3 Cost Eff.	M4 Cost Eff.
Investment Risk	-0.3608	-0.0229	-0.0245	-0.1218***
	(-1.442)	(-0.194)	(-0.126)	(-6.206)
Product Risk	-0.0075**			
	(-2.239)			
Product Risk * Investment Risk	0.0633			
	(0.623)			
Business Diversification		-0.0004		
		(-0.135)		
Diversified Business * Investment Risk		-0.1558		
		(-1.361)		
Area Diversification			-0.0069**	
			(-2.368)	
Diversified Area * Investment Risk			-0.1154	
			(-0.707)	
Pricing Risk				0.0049***
				(4.885)
Pricing Risk * Investment Risk				0.0344***
				(2.674)
Firm Size	-0.0051	-0.0340*	-0.0551***	-0.0277*
	(-0.132)	(-1.660)	(-2.753)	(-1.831)
Square of Firm Size	-0.0001	0.0016	0.0025**	0.0010
	(-0.057)	(1.498)	(2.429)	(1.308)
Liquidity	0.0087**	0.0099***	0.0114***	0.0075***
	(2.440)	(3.864)	(3.839)	(3.874)
Market Share	-2.5070***	-0.6399**	-0.2112	-0.3457**
	(-3.026)	(-2.582)	(-0.746)	(-2.056)
Stock Market Return	-0.0471***	-0.0294***	-0.0307***	-0.0251***
	(-3.830)	(-3.838)	(-3.356)	(-4.110)
GDP per Capita	-0.0090**	-0.0078***	-0.0055*	-0.0052***
	(-2.187)	(-3.114)	(-1.930)	(-3.697)
Unemployment Rate	-0.0038**	-0.0027**	-0.0026*	-0.0014
	(-2.079)	(-2.160)	(-1.784)	(-1.082)
Inflation Rate	-0.0001	0.0005	-0.0002	-0.0026**
	(-0.058)	(0.342)	(-0.098)	(-2.250)
Constant	0.9622***	1.0182***	1.0620***	0.9501***
	(4.644)	(8.944)	(8.801)	(13.426)
Observations	1,009	1,858	1,334	3,009
Number of Firms	279	477	371	632
Adjusted R-squared	0.092	0.070	0.083	0.103
Fixed effects	Yes	Yes	Yes	Yes
F-test	4.25***	4.95***	5.39***	17.83***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2.9: Interaction Effects with Investment Risk on Cost Efficiency - GMM

VARIABLES	M1 Cost Eff.	M2 Cost Eff.	M3 Cost Eff.	M4 Cost Eff.
L. Cost Eff.	0.6880***	0.7653***	0.5923***	0.4420**
	(4.954)	(3.319)	(7.796)	(2.524)
Investment Risk	-3.4788**	-0.4765	0.8973*	-0.1782***
	(-2.090)	(-1.002)	(1.955)	(-2.825)
Product Risk	-0.0076			
	(-1.399)			
Product Risk * Investment Risk	1.0875**			
	(2.553)			
Business Diversification		0.0198*		
		(1.689)		
Diversified Business * Investment Risk		-0.9531*		
		(-1.659)		
Area Diversification			-0.0045	
			(-0.840)	
Diversified Area * Investment Risk			-0.6556*	
			(-1.695)	
Pricing Risk				0.0103***
				(2.906)
Pricing Risk * Investment Risk				-0.2675*
				(-1.812)
Firm Size	-0.0005	-0.0451	0.0044	0.0186
	(-0.036)	(-1.045)	(0.158)	(0.518)
Square of Firm Size	0.0002	0.0025	-0.0001	-0.0010
	(0.295)	(1.029)	(-0.043)	(-0.504)
Liquidity	0.0097*	0.0124	0.0075	0.0052
	(1.653)	(1.114)	(1.298)	(0.600)
Market Share	-0.8160	-1.4985*	0.6743	1.3158
	(-1.422)	(-1.736)	(0.513)	(1.440)
Stock Market Return	-0.0441**	-0.0495**	-0.0143	-0.0236*
	(-2.095)	(-2.573)	(-0.947)	(-1.794)
GDP per Capita	-0.0009	-0.0027	-0.0073*	-0.0014
	(-0.287)	(-0.508)	(-1.695)	(-0.622)
Unemployment Rate	-0.0060***	-0.0034	-0.0044***	0.0007
	(-4.055)	(-1.587)	(-2.764)	(0.406)
Inflation Rate	0.0009	-0.0025	0.0055*	-0.0046**
	(0.317)	(-0.788)	(1.743)	(-2.185)
Constant	0.2765	0.4589	0.4224***	0.3312
	(1.616)	(1.120)	(2.608)	(1.146)
Observations	834	333	1,101	1,274
Number of Firms	236	178	315	436
Number of Instruments	143	90	109	78
Robust	Yes	Yes	Yes	Yes
F-test	15.60***	8.672***	10.86***	8.234***
AR(1)	-1.965**	-2.532**	-2.433**	-2.795***
AR(2)	0.603	1.311	0.803	1.554
Hansen Test (P-value)	134.1 (0.385)	85.61 (0.235)	99.75 (0.376)	57 (0.750)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Profit Function

The results of the interaction impacts on profit performance are shown in Tables 2.10 and 2.11—the fixed effects (long-run) and dynamic panel (short-run) models, respectively. The significant impacts of all interaction terms found in the dynamic models further confirm that insurers do consider both underwriting strategies and financial decisions in the short-run. Further, by imposing financial decisions together with underwriting strategies, the amplified effect of investment risk is confirmed.

To be more specific, the interaction between product risk and investment risk hurts the insurer's profit performance (Model 1 in Table 2.11). This result is logical and reasonable. Based on the profit incentive hypothesis, the insurer's overall risk level increases when seeking more returns. As a result, it imposes further uncertainties for generating short-term profit as the risk level increased. This logic is also true for the insurer bearing pricing risk, and the negative interaction effect found in Model 4 in Table 2.11 further proves the above explanation from profit viewpoint.

Regarding two diversification strategies, individual impacts align with the previous findings in Tables 2.6 and 2.7. The positive interaction effects suggest that an insurer, who is more diversified and willing to take more investment risk, will have better profit performance in short-run only (see, Table 2.11). It indicates that the benefit of diversification is offset the harmful effect raised from holding risky asset. Moreover, there is an amplified effect of taking more investment risk, as the magnitude of interaction effects is more extensive than individual effects (Models 2 and 3 in Table 2.11).

[Table 2.10: Interaction Effects with Investment risk on Profit Efficiency – OLS insert here]

[Table 2.11:Interaction Effects with Investment risk on Profit Efficiency – GMM insert here]

Table 2.10: Interaction Effects with Investment Risk on Profit Efficiency - OLS

VARIABLES	M1 Profit Eff.	M2 Profit Eff.	M3 Profit Eff.	M4 Profit Eff.
Investment Risk	2.2371*	-0.0903	0.0327	0.0404
	(1.692)	(-0.540)	(0.107)	(0.578)
Product Risk	0.0017			
	(0.470)			
Product Risk * Investment Risk	-0.5683			
	(-1.527)			
Business Diversification		-0.0015		
		(-0.348)		
Diversified Business * Investment Risk		0.0401		
		(0.257)		
Area Diversification			0.0076*	
			(1.663)	
Diversified Area * Investment Risk			-0.0776	
			(-0.444)	
Pricing Risk				-0.0015
				(-1.239)
Pricing Risk * Investment Risk				-0.0113
				(-0.426)
Firm Size	0.1037**	0.0514**	0.0430	0.0250
	(2.355)	(2.083)	(1.464)	(1.176)
Square of Firm Size	-0.0056**	-0.0025*	-0.0024	-0.0015
	(-2.061)	(-1.753)	(-1.362)	(-1.208)
Liquidity	-0.0016	-0.0059*	-0.0066*	-0.0099***
	(-0.323)	(-1.668)	(-1.920)	(-3.549)
Underwriting Income	0.0193***	0.0103***	0.0158***	0.0085***
	(6.415)	(4.427)	(6.269)	(5.159)
Stock Market Return	0.0922***	0.0761***	0.0794***	0.0833***
	(3.723)	(4.105)	(3.813)	(5.528)
GDP per Capita Growth	-0.0049***	-0.0044***	-0.0055***	-0.0043***
	(-3.399)	(-3.841)	(-4.429)	(-4.643)
Unemployment Rate	-0.0053**	-0.0069***	-0.0073***	-0.0040**
	(-2.522)	(-3.835)	(-3.688)	(-2.519)
Inflation Rate	-0.0081**	-0.0047*	-0.0056*	0.0013
	(-2.304)	(-1.704)	(-1.844)	(0.667)
Concentration	0.1777	0.2049	0.3312**	0.0437
	(0.966)	(1.469)	(2.178)	(1.055)
Constant	-0.2354	-0.0004	0.0022	0.1577
	(-1.177)	(-0.004)	(0.016)	(1.553)
Observations	1,193	1,953	1,508	3,060
Number of Firms	330	531	427	669
Adjusted R-squared	0.171	0.078	0.129	0.056
Fixed effects	Yes	Yes	Yes	Yes
F-test	9.034	9.034	9.034	9.034

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2.11: Interaction Effects with Investment Risk on Profit Efficiency - GMM

VARIABLES	M1 Profit Eff.	M2 Profit Eff.	M3 Profit Eff.	M4 Profit Eff.
L. Profit Eff.	0.2489**	0.4583***	0.2895***	0.1221**
	(2.144)	(5.055)	(4.048)	(2.249)
Investment Risk	7.5375**	-0.5031*	-0.6420*	-0.6447*
	(2.147)	(-1.804)	(-1.711)	(-1.839)
Product Risk	0.0450*			
	(1.806)			
Product Risk * Investment Risk	-2.4069**			
	(-2.034)			
Business Diversification		0.0185*		
		(1.894)		
Diversified Business * Investment Risk		0.3365*		
		(1.655)		
Area Diversification			0.0149*	
			(1.711)	
Diversified Area * Investment Risk			0.5956*	
			(1.706)	
Pricing Risk				0.0064
				(1.424)
Pricing Risk * Investment Risk				-0.2871**
				(-2.064)
Firm Size	0.0597	0.0537	0.0449	0.1214*
	(0.776)	(1.568)	(1.402)	(1.854)
Square of Firm Size	-0.0046	-0.0038*	-0.0035*	-0.0080**
	(-0.913)	(-1.803)	(-1.861)	(-2.173)
Liquidity	0.0365*	-0.0099	-0.0149*	-0.0017
	(1.733)	(-1.089)	(-1.851)	(-0.259)
Underwriting Income level	0.0456***	0.0063*	0.0069	0.0091***
	(4.504)	(1.761)	(1.105)	(2.592)
Stock Market Return	0.0541	0.1462***	0.1447***	0.0403
	(0.895)	(3.881)	(4.568)	(1.216)
GDP per Capita Growth	-0.0037	-0.0094***	-0.0089***	0.0001
	(-0.923)	(-3.464)	(-4.358)	(0.019)
Unemployment Rate	-0.0029	-0.0064*	-0.0071**	0.0068*
	(-0.503)	(-1.783)	(-2.391)	(1.732)
Inflation Rate	-0.0066	-0.0030	-0.0042	0.0008
	(-0.823)	(-0.634)	(-0.898)	(0.236)
Concentration	1.1730***	0.2971	0.3306*	0.2793***
	(2.747)	(1.183)	(1.746)	(4.090)
Constant	-0.6060	-0.0931	0.0014	-0.3376
	(-1.548)	(-0.627)	(0.009)	(-1.198)
Observations	232	1,535	1,176	2,404
Number of Firms	137	455	356	568
Number of Instruments	106	244	242	173
Robust	Yes	Yes	Yes	Yes
F-test	5.819***	15.46***	9.073***	5.789***
AR(1)	-4.811***	-5.052***	-4.471***	-5.583***
AR(2)	-0.726	0.316	-0.345	1.069
Hansen Test	93.49 (0.437)	243 (0.266)	215.2 (0.719)	176 (0.168)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

2.4.2.3 The impact of interaction with capital

<u>Cost Function</u>

From Tables 2.12 and 2.13, the positive impact of capital, the negative impact of product risk and the positive impact of pricing risk on cost performance remain consistent with the previous findings from the individual analyses shown in Tables 2.4 and 2.5. Concerning the interaction effects with capital, all interactions are significant in dynamic panel models, as shown in Table 2.13.

To be more specific, the interaction term between product risk and capital is negative from both fixed effects and dynamic panel models, and it is only significant at the 10% level in the short-run model. This indicates that insurers, who issue more risky products and are willing to hold more capital to reduce insolvency risk, may face cost disadvantages in short-run only. This can be explained by the dominant effect of product risk. However, holding capital does help insurers mitigate the negative impact arising from issuing more risky products. The evidence is that the coefficient of the term of Product Risk * Capital is smaller than the coefficient of Product Risk (Model 1 in Table 2.13).

As discussed in Section 2.4.2.1, the individual effect of business diversification on cost efficiency is inconclusive (Models 8 and 10 in Table 2.5). Here, a significant positive impact of business diversification on cost efficiency has been confirmed when this variable is considered together with capital in short-run (Model 2 in Table 2.13). Further, their interaction term is also positive; this implies that multiline insurers enjoy the benefit of diversification on cost structure if they have strong capital supports. It is also worth noting that the benefit of diversification may be reduced by imposing more capital, because the coefficient of the Business Diversification * Capital term is less than the coefficient of Business Diversification (Model 2 in Table 2.13).

Regarding geographic area diversification (Model 3 in Tables 2.12 and 2.13), a significant positive impact of its interaction term on cost performance is indicated by both fixed effects and dynamic panel analyses. This means that the insurers operate their cost structures more efficiently when geographic diversification is backed up by sufficient capital holding in both long-run and short-run. Compared to the negative effect observed from individual analyses, it is particularly noteworthy that the benefit of geographic diversification is significant only when both capital and geographic diversification are jointly considered. This indicates that insurers with a geographic diversification plan will have better cost performance, when the capital level is increased.

Model 4 in Tables 2.12 and 2.13 reveal the relationship related to pricing risk. Aligning with the results from Section 2.4.2.1, the individual impact of pricing risk remains positive, and the significant positive interaction effect is also confirmed at the 1% level from in both long-run and short-run. This highly significant result further confirms that the previous suggestion (in Section 2.4.2.1), which assumes that insurers always consider pricing risk as their primary concern and make their best efforts to mitigate further uncertainties via different risk management activities, such as holding more capital. The magnitude of the interaction effect is less than the individual effects for both capital and pricing risk, even though the interaction is positive. This may indicate that there might be cost disadvantages by imposing extra capital after pricing risk is well-controlled. Therefore, insurers need to consider to build up an appropriate level of capital when considering pricing risk, if it is well-controlled.

Apart from underwriting risks, capital can also be used to amplify or mitigate the impacts of investment activities. Model 5 in Tables 2.12 and 2.13 shows the impact of this relationship on cost efficiency. Model 5 in Table 2.12 confirms that adverse impact arises from taking more investment risk, while the interaction between two variables is not significant. However, in short-run (Table 2.13), Model 5 shows that the interaction impact is positive and significant, and the individual effect of investment risk is converted to positive in short-run. This result is in line with Hypothesis 8a (the finite-risk paradigm), which states that using capital is intended to limit the insurer's overall risk level, and the interaction effect should be positive, when considered with the expected bankruptcy costs argument. It implies that insurers would hold more capital to mitigate investment risk and to improve its cost structure. In addition, the amplified effect associated with imposing extra capital is also found, as the magnitude of the interacting impact is higher than the individual impact arising from investment risk.

[Table 2.12: Interaction Effects with Capital on Cost Efficiency – OLS insert here]

[Table 2.13:Interaction Effects with Capital on Cost Efficiency – GMM insert here]

Table 2.12: Interaction Effects with Capital on Cost Efficiency - OLS

VARIABLES	M1 Cost Eff.	M2 Cost Eff.	M3 Cost Eff.	M4 Cost Eff.	M5 Cost Eff.
Capital	0.0275**	0.0072**	0.0064**	0.0075***	0.0046*
	(2.548)	(2.179)	(2.246)	(2.600)	(1.685)
Product Risk	-0.0110*				
	(-1.947)				
Product Risk * Capital	-0.0042				
	(-1.280)				
Business Diversification		0.0012			
		(0.248)			
Diversified Business * Capital		0.0009			
		(0.537)			
Area Diversification			0.0026		
			(0.688)		
Diversified Area * Capital			0.0066***		
			(3.118)		
Pricing Risk				0.0075***	
				(4.357)	
Pricing Risk * Capital				0.0015**	
				(2.310)	
Investment Risk					-0.0862**
					(-2.579)
Investment Risk * Capital					0.0846
					(1.611)
Firm Size	0.0040	-0.0196	-0.0353*	-0.0221	-0.0337**
	(0.107)	(-1.027)	(-1.729)	(-1.399)	(-2.073)
Square of Firm Size	-0.0005	0.0009	0.0015	0.0010	0.0014
	(-0.263)	(0.970)	(1.397)	(1.171)	(1.614)
Liquidity	0.0078**	0.0096***	0.0104***	0.0077***	0.0080***
	(2.316)	(3.910)	(3.672)	(3.816)	(3.920)
Market Share	-2.2351***	-0.5372***	-0.2192	-0.4786***	-0.5618***
	(-3.328)	(-2.917)	(-1.068)	(-2.739)	(-2.972)
Stock Market Return	-0.0448***	-0.0272***	-0.0278***	-0.0234***	-0.0305***
	(-3.915)	(-3.754)	(-3.250)	(-3.778)	(-4.863)
GDP per Capita	-0.0095**	-0.0083***	-0.0059**	-0.0055***	-0.0043***
	(-2.415)	(-3.456)	(-2.307)	(-3.658)	(-3.098)
Unemployment Rate	-0.0044**	-0.0033***	-0.0033**	-0.0021	-0.0007
	(-2.561)	(-2.798)	(-2.515)	(-1.539)	(-0.513)
Inflation Rate	0.0010	0.0016	0.0004	-0.0024**	-0.0036***
	(0.591)	(1.085)	(0.224)	(-2.071)	(-2.953)
Constant	0.9618***	0.9710***	0.9999***	0.9344***	0.9506***
	(4.785)	(9.373)	(8.383)	(13.023)	(12.965)
Observations	1,024	1,915	1,345	2,931	2,938
Number of Firms	268	472	363	612	610
Adjusted R-squared	0.114	0.071	0.087	0.095	0.073
Fixed effects	Yes	Yes	Yes	Yes	Yes
F-test	5.60***	5.54***	5.94***	9.36***	13.16***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2.13: Interaction Effects with Capital on Cost Efficiency - GMM

VARIABLES	M1 Cost Eff.	M2 Cost Eff.	M3 Cost Eff.	M4 Cost Eff.	M5 Cost Eff.
L. Cost Eff.	0.4931***	0.5033***	0.3049*	0.4133***	0.2495**
	(2.872)	(5.554)	(1.774)	(3.677)	(2.455)
Capital	0.0569*	-0.0046	0.0210	0.0194***	-0.0023
	(1.960)	(-0.714)	(1.082)	(2.957)	(-0.329)
Product Risk	-0.0225*				
	(-1.733)				
Product Risk * Capital	-0.0156*				
	(-1.773)				
Business Diversification		0.0223**			
		(1.994)			
Diversified Business * Capital		0.0083*			
		(1.915)			
Area Diversification			0.0647**		
			(2.182)		
Diversified Area * Capital			0.0415***		
			(2.629)		
Pricing Risk				0.0238***	
				(4.531)	
Pricing Risk * Capital				0.0066***	
				(3.413)	
Investment Risk					0.4842*
					(1.673)
Investment Risk * Capital					0.8118**
					(2.072)
Firm Size	-0.0044	-0.0178	-0.1964**	0.0296*	-0.0164
	(-0.112)	(-1.134)	(-2.569)	(1.765)	(-0.507)
Square of Firm Size	0.0005	0.0008	0.0107**	-0.0014*	0.0008
	(0.208)	(1.026)	(2.588)	(-1.684)	(0.454)
Liquidity	-0.0089	0.0181***	-0.0068	-0.0071	0.0108*
	(-0.811)	(3.089)	(-0.576)	(-1.355)	(1.765)
Market Share	-2.4413	-0.5165*	-3.6740*	-0.1540	-0.6769**
	(-1.324)	(-1.915)	(-1.720)	(-0.321)	(-2.104)
Stock Market Return	-0.0629**	-0.0575***	-0.0264	-0.0081	-0.0483***
	(-2.091)	(-3.732)	(-1.607)	(-0.541)	(-4.026)
GDP per Capita	0.0044	-0.0061**	-0.0079*	-0.0018	-0.0046***
	(0.692)	(-2.092)	(-1.821)	(-0.996)	(-3.088)
Unemployment Rate	-0.0042**	-0.0052***	-0.0083***	-0.0040**	-0.0034**
	(-2.546)	(-4.435)	(-2.793)	(-2.081)	(-2.043)
Inflation Rate	-0.0066	0.0004	0.0036	0.0041*	-0.0038*
	(-1.510)	(0.120)	(0.823)	(1.895)	(-1.715)
Constant	0.3369	0.5986***	1.5681***	0.3380**	0.7148***
	(1.302)	(4.309)	(3.977)	(2.456)	(3.471)
Observations	491	1,480	1,079	759	1,249
Number of Firms	185	386	307	206	425
Number of Instruments	93	168	69	146	170
Robust	Yes	Yes	Yes	Yes	Yes
F-test	6.259***	25.11***	3.918***	8.595***	7.277***
AR(1)	-1.770*	-3.044***	-1.850**	-3.620***	-3.035***
AR(2)	0.234	0.928	0.144	1.631	0.960
Hansen Test (P-value)	82.86 (0.391)	159.6 (0.383)	53.29 (0.578)	150.3 (0.145)	168.1 (0.259)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Profit Function

The results of the different interaction impacts on profit performance are shown in Tables 2.14 and 2.15—the fixed effects model and the dynamic panel model, respectively. Both models strongly confirm that holding more capital can help insurers become more profit efficient, as capital can use to expand the insurers' businesses

Similar to the finding from cost analysis, Model 1 in Tables 2.14 and 2.15 indicates that there is a negative relationship between the Product Risk * Capital term and profit performance, and this relationship is significant at the 5% level in short-run only. Thus, insurers, who have more risky products and hold more capital may become profit inefficient. One possible reason is that insurers may use capital to write more risky businesses. Although the impact is negative, holding capital does reduce exposure arising from writing risky business, as the coefficient of the interaction term is smaller than the coefficient of the individual variable; it is the same as the finding from cost regression. It indicates that insurers do not only use capital to expand the business, but also use capital as risk buffer when the cost of capital is lower than the cost of default.

Regarding business diversification and geographic area diversification, the individual impacts of both on profit efficiency are significant and positive. These findings are confirmed by the results of Models 2 and 3 in both long-run and short-run. Similar to the results of the cost function, a significant, positive impact of business diversification and capital on profit efficiency is found in short-run. This implies that multiline insurers can enjoy profit advantages when they hold more capital. Meanwhile, the benefit of diversification is also weakened by imposing more capital, as the magnitude of interaction is smaller than the magnitude of individuals. On the other hand, operating in many different geographic markets may damage insurers' abilities to generate profits, as the interaction effect of business diversification and capital is negative. This can be explained by the cost of capital overcoming the benefit of geographic area diversification, when extra capital is imposed to cover the costs of operating in different markets. It is also true that the extra cost needed to manage different product types is much less than the cost required to operate in different markets.

No indication is made regarding the impact of the interaction between pricing risk and capital on profit performance, as the impacts are varied between the long-run and short-run models. A negative effect is found in the fixed effects model, as shown by Model 4 in Table 2.14. This may indicate that the negative effect of pricing risk (further leading to claim uncertainties) may take the dominant role, if this risk further leads to operating losses in long-run. On the other hand, the positive impact revealed in the dynamic panel model (Model 4 in Table 2.15) indicates that the positive effect of imposing capital to cover unexpected losses may dominate in the short-run. This implies that the harmful effect of pricing risk is offset by the benefit of holding more capital.

Although, solely, the effects of capital and investment risk are both positive and significant in the dynamic panel model (Model 5 in Table 2.15), their interaction effect on profit efficiency is negative. This result aligns with the profit incentive hypothesis and the excessive risk paradigm (Hypothesis 8b), and it indicates that the insurer is willing to take additional investment risks when extra capital is imposed. This increased risk leads to more uncertainties in profit earning (i.e., profit inefficiency).

[Table 2.14: Interaction Effects with Capital on Profit Efficiency – OLS insert here]

[Table 2.15:Interaction Effects with Capital on Profit Efficiency – GMM insert here]

Table 2.14: Interaction Effects with Capital on Profit Efficiency - OLS

VARIABLES	M1 Profit Eff.	M2 Profit Eff.	M3 Profit Eff.	M4 Profit Eff.	M5 Profit Eff.
Capital	0.0168**	0.0115***	0.0089***	0.0141***	0.0159***
	(2.053)	(2.827)	(2.801)	(4.423)	(5.615)
Product Risk	-0.0087**				
	(-2.060)				
Product Risk * Capital	-0.0022				
	(-0.875)				
Business Diversification		-0.0041			
		(-0.585)			
Diversified Business * Capital		-0.0010			
		(-0.358)			
Area Diversification			0.0150*		
			(1.722)		
Diversified Area * Capital			0.0046		
			(1.221)		
Pricing Risk				-0.0043**	
				(-2.260)	
Pricing Risk * Capital				-0.0013*	
				(-1.811)	
Investment Risk					0.0423
					(0.960)
Investment Risk * Capital					-0.0212
					(-1.223)
Firm Size	0.0965**	0.0355	0.0342	0.0176	0.0194
	(1.969)	(1.275)	(0.943)	(0.813)	(1.149)
Square of Firm Size	-0.0052*	-0.0014	-0.0019	-0.0009	-0.0010
	(-1.771)	(-0.914)	(-0.918)	(-0.756)	(-1.046)
Liquidity	-0.0007	-0.0044	-0.0074**	-0.0109***	-0.0085***
	(-0.139)	(-1.172)	(-2.182)	(-3.849)	(-3.174)
Underwriting Income	0.0185***	0.0090***	0.0146***	0.0074***	0.0073***
	(5.747)	(3.722)	(5.242)	(4.555)	(4.476)
Stock Market Return	0.0947***	0.0658***	0.0811***	0.0782***	0.0842***
	(3.625)	(3.379)	(3.655)	(5.051)	(5.412)
GDP per Capita Growth	-0.0050***	-0.0037***	-0.0054***	-0.0038***	-0.0040***
	(-3.213)	(-3.069)	(-4.047)	(-4.022)	(-4.197)
Unemployment Rate	-0.0056**	-0.0062***	-0.0070***	-0.0041**	-0.0048***
	(-2.433)	(-3.286)	(-3.352)	(-2.454)	(-2.884)
Inflation Rate	-0.0078**	-0.0040	-0.0043	0.0011	0.0023
	(-2.243)	(-1.458)	(-1.390)	(0.568)	(1.204)
Concentration	0.1480	0.1459	0.2762*	0.0470	0.0395
	(0.775)	(1.075)	(1.906)	(1.129)	(0.954)
Constant	-0.1353	0.0906	0.0725	0.2029*	0.2102**
	(-0.619)	(0.683)	(0.436)	(1.934)	(2.565)
Observations	1,170	1,958	1,470	2,934	2,991
Number of Firms	331	533	424	657	665
Adjusted R-squared	0.161	0.067	0.116	0.061	0.062
Fixed effects	Yes	Yes	Yes	Yes	Yes
F-test	20.21	20.21	20.21	20.21	20.21

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2.15: Interaction Effects with Capital on Profit Efficiency - GMM

VARIABLES	(1) Profit Eff.	(2) Profit Eff.	(3) Profit Eff.	(4) Profit Eff.	(5) Profit Eff.
L. Profit Eff.	0.2471**	0.5658***	0.1633**	0.1148**	0.0700*
	(2.450)	(6.880)	(2.373)	(2.444)	(1.758)
Capital	0.0889***	0.0439***	0.0290***	0.0396***	0.0256***
	(2.823)	(4.384)	(3.037)	(4.030)	(2.623)
Product Risk	-0.0295*				
	(-1.713)				
Product Risk * Capital	-0.0205**				
	(-2.567)				
Business Diversification		0.0644***			
		(2.791)			
Diversified Business * Capital		0.0216**			
		(2.021)			
Area Diversification			0.0057		
			(0.270)		
Diversified Area * Capital			-0.0179*		
			(-1.759)		
Pricing Risk				0.0014	
				(0.387)	
Pricing Risk * Capital				0.0040*	
				(1.957)	
Investment Risk					0.0907***
					(2.972)
Investment Risk * Capital					-0.0466***
					(-2.804)
Firm Size	0.0447	0.0761**	0.0787	0.1399**	0.1041*
	(0.836)	(1.995)	(1.568)	(2.434)	(1.812)
Square of Firm Size	-0.0035	-0.0038*	-0.0048*	-0.0083**	-0.0068**
	(-1.111)	(-1.858)	(-1.758)	(-2.502)	(-2.014)
Liquidity	-0.0166	-0.0084	-0.0076	0.0005	0.0046
	(-1.221)	(-0.814)	(-0.886)	(0.080)	(0.814)
Underwriting Income	0.0344***	-0.0048	0.0083**	0.0076**	0.0089***
	(4.146)	(-0.888)	(2.018)	(2.351)	(2.786)
Stock Market Return	0.0715	0.0956**	0.1375***	0.1295***	0.1054***
	(1.345)	(2.004)	(3.914)	(3.910)	(2.885)
GDP per Capita Growth	-0.0071**	-0.0051*	-0.0079***	-0.0092***	-0.0086***
	(-2.232)	(-1.797)	(-3.438)	(-3.738)	(-3.626)
Unemployment Rate	-0.0084*	-0.0023	-0.0054*	-0.0052	-0.0101**
	(-1.831)	(-0.656)	(-1.672)	(-1.470)	(-2.581)
Inflation Rate	-0.0166**	-0.0070	0.0066	0.0008	0.0076
	(-2.415)	(-1.020)	(1.422)	(0.178)	(1.642)
Concentration	0.7868***	0.1873	0.4150*	0.1624***	0.0914
	(2.906)	(1.006)	(1.722)	(2.692)	(1.609)
Constant	-0.0815	-0.1549	-0.1586	-0.2823	-0.0646
	(-0.367)	(-0.882)	(-0.659)	(-1.204)	(-0.283)
Observations	908	1,492	1,149	2,409	2,443
Number of Firms	282	444	353	580	586
Number of Instruments	143	175	202	239	230
Robust	Yes	Yes	Yes	Yes	Yes
F-test	8.362***	24.02***	11.52***	13.42***	38.31***
AR(1)	-4.406***	-5.286***	-4.361***	-5.570***	-5.932***
AR(2)	0.162	-0.0179	-1.034	1.380	1.255
Hansen Test (p-value)	135.1 (0.338)	179.2 (0.155)	200.1 (0.260)	247.2 (0.148)	238.7 (0.138)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

2.4.2.4 The impact of interaction with reinsurance

Cost Function

Tables 2.16 and 2.17 show the impact of interaction with reinsurance on cost efficiency; the former presents OLS fixed effects models, and the latter presents dynamic panel models. The individual impact of reinsurance on cost performance is found to be positive and consistent in two models—in line with previous findings. This further proves that using reinsurance can enhance insurers' cost efficiency, as it can mitigate the risk of default.

As expected, from Model 1, the impact of product risk remains negative and significant in both tables. However, the impact of the interaction between product risk and reinsurance on cost efficiency is not found. It is reasonable to assume that, if an insurer's business nature involves writing risky products, then that firm is unlikely to use reinsurance to avoid inherent uncertainties, as reinsurance is costly.

Model 2 in Tables 2.16 and 2.17 further confirms that business diversification positively impacts cost efficiency, and this is only significant in dynamic panel model (Table 2.17). This implies that insurers with more diversified businesses would have better cost performance in short-run. A positive and significant interaction impact is observed in the dynamic model, which is consistent with the findings when considering the interaction with capital. This result should not be surprising because reinsurance does share some of capital's functions. Another similar point is that the benefit of diversification may be weakened by purchasing more reinsurance, due to the cost of reinsurance. this indicates that insurers with multiline businesses can be cost effieint if they are supported by reinsurance contracts in short-run.

In addition to the first diversification strategy, the impact of the interaction between geographic diversification and reinsurance is negative and significant concerning cost efficiency (Model 3 in Table 2.17). This implies that insurers with more geographic area diversified business would have a lower cost efficiency if they use reinsurance to mitigate exposures in short-run. This negative effect contrasts with the positive effect observed in capital regression (Model 3 in Table 2.13). As mentioned, the cost/risk of operating in various geographic markets is much higher than the cost/risk associated with writing multiple businesses. Thus, using reinsurance to reduce the uncertainties arising from operating in various geographic markets would incur much higher premiums. However, it is also worth noting that using reinsurance could reduce the adverse effects stemming from geographic diversification, as the negative magnitude of the interaction term is much smaller than the negative magnitude of geographic diversification.

The individual pricing effect on cost efficiency remains positive and significant for Model 4 in Tables 2.16 and 2.17, and it is consistent with previous findings. Also, the coefficient of the Pricing Risk * Reinsurance term is positive in both tables, but only significant in the dynamic model. Therefore, these positive signs further confirm that insurers always consider pricing risk as their primary concern. Again, due to the cost of reinsurance, purchasing additional reinsurance may reduce cost efficiency when pricing risk has been well-adjusted.

Model 5 in Tables 2.16 and 2.17 reveals the impact of investment risk and its interaction on cost efficiency. As expected, the individual effect of investment risk remains significantly negative, as in the preceding models. Then, the impact of the interaction between reinsurance and investment risk is also negative and significant concerning the insurer's cost efficiency in both long-run and short-run. This negative interaction impact is mainly created by the dominant-negative effect arising from investment risk. It indicates that insurer with more investment risk may have a lower cost performance, even they use reinsurance to mitigate the exposure. This can be explained by the relationship between reinsurance and difference risk sources. There is a direct relationship between underwriting risk and reinsurance, while the relationship between reinsurance and investment risk is indirect. The aim of purchasing reinsurance is that the primary insurer is willing to transfer part of its underwriting risk directly to reinsurers. However, it is unlikely to shift investment risk in this way unless the promised claim payment is closely related to investment return (for example, the promised benefit with unit-linked products). Thus, investment risk potentially takes the dominant role.

[Table 2.16: Interaction Effects with Reinsurance on Cost Efficiency – OLS insert here]

[Table 2.17:Interaction Effects with Reinsurance on Cost Efficiency – GMM insert here]

Table 2.16: Interaction Effects with Reinsurance on Cost Efficiency - OLS

VARIABLES	M1 Cost Eff.	M2 Cost Eff.	M3 Cost Eff.	M4 Cost Eff.	M5 Cost Eff.
Reinsurance	0.0058**	0.0049***	0.0047***	0.0024**	0.0025**
	(2.209)	(3.521)	(3.019)	(2.092)	(2.235)
Product Risk	-0.0087**				
	(-2.209)				
Product Risk * Reinsurance	0.0000				
	(0.020)				
Business Diversification		0.0022			
		(0.610)			
Diversified Business * Reinsurance		0.0033**			
		(2.311)			
Area Diversification			-0.0050*		
			(-1.896)		
Diversified Area * Reinsurance			0.0009		
			(0.808)		
Pricing Risk				0.0048***	
				(3.687)	
Pricing Risk * Reinsurance				0.0005	
				(1.251)	
Investment Risk					-0.2778***
					(-4.762)
Investment Risk * Reinsurance					-0.0513**
					(-2.366)
Firm Size	-0.0090	-0.0297	-0.0408	-0.0113	-0.0269
	(-0.218)	(-1.242)	(-1.443)	(-0.576)	(-1.479)
Square of Firm Size	0.0004	0.0014	0.0018	0.0003	0.0010
	(0.179)	(1.114)	(1.211)	(0.307)	(1.046)
Liquidity	0.0084**	0.0100***	0.0108***	0.0082***	0.0082***
	(2.270)	(3.693)	(3.585)	(4.365)	(4.371)
Market Share	-2.3093***	-0.4628***	-0.1736	-0.3569*	-0.4534**
	(-3.361)	(-2.679)	(-1.133)	(-1.830)	(-2.146)
Stock Market Return	-0.0333***	-0.0243***	-0.0276***	-0.0241***	-0.0298***
	(-3.401)	(-3.458)	(-3.354)	(-3.913)	(-4.859)
GDP per Capita	-0.0128***	-0.0092***	-0.0045	-0.0061***	-0.0055***
	(-3.115)	(-3.527)	(-1.471)	(-4.101)	(-3.918)
Unemployment Rate	-0.0039**	-0.0031**	-0.0015	-0.0023*	-0.0012
	(-2.126)	(-2.365)	(-0.942)	(-1.879)	(-1.009)
Inflation Rate	0.0010	0.0015	-0.0014	-0.0037***	-0.0048***
	(0.526)	(0.923)	(-0.759)	(-2.728)	(-3.546)
Constant	1.0657***	1.0368***	0.9769***	0.9009***	0.9519***
	(5.142)	(8.536)	(6.861)	(9.789)	(11.058)
Observations	933	1,673	1,193	2,489	2,491
Number of Firms	260	436	341	564	562
Adjusted R-squared	0.142	0.099	0.094	0.101	0.100
Fixed effects	Yes	Yes	Yes	Yes	Yes
F-test	5.34***	5.98***	6.01***	7.68***	23.98***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2.17: Interaction Effects with Reinsurance on Cost Efficiency - GMM

VARIABLES	M1 Cost Eff.	M2 Cost Eff.	M3 Cost Eff.	M4 Cost Eff.	M5 Cost Eff.
L. Cost Eff.	0.5411***	0.6495***	0.5309***	0.5406***	0.5229***
	(4.815)	(6.801)	(6.239)	(8.913)	(3.174)
Reinsurance	0.0034	0.0059*	0.0084***	0.0057**	0.0154*
	(0.295)	(1.710)	(2.663)	(2.583)	(1.749)
Product Risk	-0.0151*				
	(-1.740)				
Product Risk * Reinsurance	-0.0012				
	(-0.342)				
Business Diversification		0.0147*			
		(1.804)			
Diversified Business * Reinsurance		0.0065**			
		(2.086)			
Area Diversification			-0.0137***		
			(-2.909)		
Diversified Area * Reinsurance			-0.0043*		
			(-1.916)		
Pricing Risk				0.0069***	
				(4.344)	
Pricing Risk * Reinsurance				0.0013**	
				(2.147)	
Investment Risk					-3.0552*
					(-1.966)
Investment Risk * Reinsurance					-1.1064*
					(-1.737)
Firm Size	-0.0729**	-0.0265	0.0471**	0.0216*	-0.0883
	(-2.213)	(-1.477)	(2.069)	(1.755)	(-1.066)
Square of Firm Size	0.0040**	0.0014	-0.0023*	-0.0013*	0.0045
	(2.286)	(1.508)	(-1.875)	(-1.957)	(1.138)
Liquidity	0.0030	0.0052	0.0056	0.0027	-0.0139
	(0.539)	(0.897)	(1.215)	(0.867)	(-1.327)
Market Share	-1.1761**	-0.4549	0.0271	-0.2685	-0.5059
	(-2.131)	(-0.595)	(0.057)	(-1.010)	(-1.045)
Stock Market Return	-0.0196	0.0031	-0.0370***	-0.0080	0.0035
	(-1.184)	(0.265)	(-2.779)	(-1.054)	(0.112)
GDP per Capita	-0.0034	-0.0078**	-0.0028	-0.0040***	-0.0028
	(-0.612)	(-2.201)	(-0.901)	(-3.159)	(-1.101)
Unemployment Rate	-0.0043**	-0.0059***	-0.0041***	-0.0032***	-0.0075***
	(-2.461)	(-4.003)	(-2.946)	(-2.930)	(-3.356)
Inflation Rate	0.0051	0.0073*	-0.0029	-0.0005	0.0024
	(0.951)	(1.890)	(-0.932)	(-0.380)	(0.475)
Constant	0.7627***	0.5649***	0.1873	0.3452***	0.8485*
	(3.495)	(3.348)	(1.232)	(3.799)	(1.963)
Observations	440	1,311	914	1,463	1,138
Number of Firms	173	362	268	416	421
Number of Instruments	82	112	111	206	64
Robust	Yes	Yes	Yes	Yes	Yes
F-test	8.685***	16.55***	18.12***	17.52***	4.115***
AR(1)	-3.088***	-3.930***	-3.374***	-5.302***	-3.143***
AR(2)	-1.051	0.745	0.0197	1.418	-0.0297
Hansen Test (P-value)	78.09 (0.212)	116.8 (0.107)	101.3 (0.390)	214 (0.143)	53.52 (0.378)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Profit Function

Tables 2.18 and 2.19 (the fixed effects model and the dynamic panel model, respectively) show the impact of interaction with reinsurance on profit efficiency. First, Model 1 considers the impact of the interaction between product risk and reinsurance. The individual effects of reinsurance and product risk are negative and significant—consistent with findings from the previous sections. However, their interaction effect is significantly positive for the insurer's profit efficiency in both fixed effects and dynamic models. This indicates that insurers, who issue more risky products, would like to use reinsurance to reduce potential uncertainties and expand their underwriting abilities. The combination can further improve insurers' profit efficiency. It is, however, worthwhile to remember the question asked of the cost model, in which no significant impact was observed from the interaction term on cost efficiency. By considering both the cost and profit models, it is reasonable to conclude that an insurer, who prefers to issue more risky products, would like to use reinsurance to make its operations efficient from the profit side.

Models 2 and 3 disclose the impact of the combination of diversification and reinsurance—the former revealing business diversification and the latter focusing on geographic diversification. Generally speaking, the individual effects from two diversification variables and reinsurance are in line with previous findings. The interaction between business diversification and reinsurance has a negative impact, while the coefficient of the Diversified Area * Reinsurance term is positive. The insurer with various types of businesses indicates that it has a complex business portfolio, and the cost of reinsurance tends to be high due to this complexity. Thus, the cost of reinsurance may dominate the benefit of business diversification, and further lead to lower insurer's profit.

Regarding geographic diversification, as previously mentioned, writing business in different geographic markets is more costly and associated with more unexpected, uncontrollable risks than issuing various types of business. Thus, it is more effective and efficient to use reinsurance to mitigate the uncertainties arising from operating in different geographic markets because reinsurers provide not only risk-shifting services but also offer extra information about the primary insurer's portfolio. In other words, insurers would use capital to manage diversified businesses, but use reinsurance to manage geographically diversified businesses which may require more information and harder to mitigate the risk exposures. Moreover, these discussions can be further proved by comparing them with the capital-profit table (Table 2.15), in which Model 2 reveals a positive impact and Model 3 a negative impact.

Model 4 shows a straightforward relationship. The primary purpose of using reinsurance is to reduce the risks from the mismatch (or the gap) between premiums collected and promised claim/benefit payments. This is the pricing risk. Therefore, it is not surprising that the interaction effect between pricing risk and reinsurance positively impacts profit efficiency in both long-run and short-run. The cost model (Model 4 in Table 2.17) also confirms this point.

As discussed above, there is an indirect link between reinsurance and investment risk. This link would be more stable if insurance products were unit-linked types, in which an investment return is promised. Similar to the cost models (Model 5 in Tables 2.16 and 2.17), investment risk potentially takes the dominant role. It indicates that insurers may accept to take more risky investment to achieve a higher return, when they have reinsurance contract to mitigate the harmful effects from risky investment. Thus, the impact of the interaction between reinsurance and investment risk on profit efficiency is positive, based on the profit incentive hypothesis.

[Table 2.18: Interaction Effects with Reinsurance on Profit Efficiency – OLS insert here]

[Table 2.19:Interaction Effects with Reinsurance on Profit Efficiency – GMM insert here]

Table 2.18: Interaction Effects with Reinsurance on Profit Efficiency - OLS

VARIABLES	M1 Profit Eff.	M2 Profit Eff.	M3 Profit Eff.	M4 Profit Eff.	M5 Profit Eff.
Reinsurance	-0.3279**	0.0289	-0.0301***	0.0005***	0.0004***
	(-2.309)	(1.086)	(-5.222)	(12.167)	(9.428)
Product Risk	-0.0056*				
	(-1.878)				
Product Risk * Reinsurance	0.0726**				
	(2.180)				
Business Diversification		-0.0021			
		(-0.494)			
Diversified Business * Reinsurance		0.0254			
		(0.996)			
Area Diversification			0.0066*		
			(1.651)		
Diversified Area * Reinsurance			0.0303***		
			(5.657)		
Pricing Risk				-0.0017	
				(-1.289)	
Pricing Risk * Reinsurance				0.0001***	
				(7.403)	
Investment Risk					0.0739***
					(4.372)
Investment Risk * Reinsurance					0.0524***
					(6.492)
Firm Size	0.1094**	0.0558**	0.0724***	0.0380*	0.0360
	(2.399)	(2.250)	(2.765)	(1.662)	(1.586)
Square of Firm Size	-0.0060**	-0.0028*	-0.0042**	-0.0024*	-0.0023*
	(-2.143)	(-1.947)	(-2.537)	(-1.812)	(-1.787)
Liquidity	-0.0015	-0.0040	-0.0052*	-0.0108***	-0.0093***
	(-0.311)	(-1.072)	(-1.692)	(-3.704)	(-3.204)
Underwriting Income	0.0185***	0.0110***	0.0173***	0.0095***	0.0095***
	(6.476)	(4.788)	(7.020)	(5.433)	(5.472)
Stock Market Return	0.0922***	0.0678***	0.0726***	0.0817***	0.0813***
	(3.757)	(3.532)	(3.520)	(5.053)	(5.038)
GDP per Capita Growth	-0.0050***	-0.0040***	-0.0050***	-0.0045***	-0.0043***
	(-3.522)	(-3.374)	(-4.084)	(-4.507)	(-4.390)
Unemployment Rate	-0.0052***	-0.0061***	-0.0071***	-0.0042**	-0.0048***
	(-2.603)	(-3.416)	(-3.769)	(-2.577)	(-2.844)
Inflation Rate	-0.0083**	-0.0051*	-0.0067**	0.0013	0.0022
	(-2.428)	(-1.828)	(-2.274)	(0.651)	(1.078)
Concentration	0.1750	0.2079	0.3779***	0.0755*	0.0640
	(0.913)	(1.506)	(2.627)	(1.775)	(1.477)
Constant	-0.2204	-0.0166	-0.1293	0.1090	0.1258
	(-1.071)	(-0.142)	(-1.129)	(1.008)	(1.138)
Observations	1,222	1,969	1,503	2,848	2,850
Number of Firms	339	526	423	633	632
Adjusted R-squared	0.165	0.079	0.157	0.060	0.061
Fixed effects	Yes	Yes	Yes	Yes	Yes
F-test	174.9	174.9	174.9	174.9	174.9

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2.19: Interaction Effects with Reinsurance on Profit Efficiency - GMM					
	M1	M2	M3	M4	M5
VARIABLES	Profit Eff.	Profit Eff.	Profit Eff.	Profit Eff.	Profit Eff.
L. Profit Eff.	0.2170**	0.3415***	0.1733**	0.1022**	0.0780*
	(2.061)	(5.422)	(2.488)	(2.305)	(1.751)
Reinsurance	-1.5012*	-0.0820***	-0.1854*	0.0007***	-0.0002
	(-1.948)	(-2.684)	(-1.725)	(5.828)	(-1.451)
Product Risk	-0.0046				
	(-0.348)				
Product Risk * Reinsurance	0.3721*				
	(1.748)				
Business Diversification		0.0430***			
		(2.723)			
Diversified Business * Reinsurance		-0.0746**			
		(-2.461)			
Area Diversification			0.0142		
			(1.223)		
Diversified Area * Reinsurance			0.1814*		
			(1.668)		
Pricing Risk				-0.0036**	
				(-2.138)	
Pricing Risk * Reinsurance				0.0001**	
				(2.118)	
Investment Risk					0.1801***
					(4.778)
Investment Risk * Reinsurance					0.0748**
					(2.392)
Firm Size	-0.0352	-0.0913	-0.0684	0.0883**	0.1268***
	(-0.507)	(-1.353)	(-0.813)	(2.151)	(3.409)
Square of Firm Size	0.0013	0.0044	0.0025	-0.0063***	-0.0086***
	(0.313)	(1.288)	(0.509)	(-2.744)	(-4.384)
Liquidity	0.0124	-0.0009	-0.0083	-0.0034	0.0009
	(1.126)	(-0.085)	(-0.509)	(-0.544)	(0.166)
Underwriting Income	0.0249**	-0.0042	0.0199***	0.0104***	0.0116***
	(2.254)	(-0.602)	(4.454)	(3.628)	(3.641)
Stock Market Return	0.0603	0.1825***	0.1445***	0.0863***	0.0769**
	(1.067)	(3.629)	(3.465)	(2.651)	(2.332)
GDP per Capita Growth	-0.0030	-0.0112***	-0.0090***	-0.0062**	-0.0050**
	(-0.935)	(-2.939)	(-3.595)	(-2.505)	(-2.100)
Unemployment Rate	-0.0010	-0.0113***	-0.0114***	-0.0060	-0.0067*
	(-0.241)	(-3.176)	(-3.498)	(-1.599)	(-1.776)
Inflation Rate	-0.0086	-0.0033	-0.0134***	0.0050	0.0068
	(-1.095)	(-0.471)	(-2.741)	(1.290)	(1.620)
Concentration	0.5329	0.4176	0.7242***	0.2230***	0.1174**
	(1.525)	(1.359)	(2.718)	(3.664)	(1.975)
Constant	0.2215	0.6109**	0.4192	-0.1055	-0.2073
	(0.653)	(2.072)	(1.267)	(-0.584)	(-1.161)
Observations	279	1,467	1,138	2,296	2,291
Number of Firm	146	434	349	558	554
Number of Instruments	100	183	120	209	209
Robust	Yes	Yes	Yes	Yes	Yes
F-test	6.065***	10.28***	6.467***	12.08***	11.94***
AR(1)	-4.103***	-5.580***	-3.796***	-5.867***	-5.917***
AR(2)	0.319	0.186	-1.087	1.549	1.329
Hansen Test	78.31 (0.710)	185.1 (0.188)	116.3 (0.233)	210 (0.219)	205 (0.297)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

2.4.2.5 The impact of control variables

Regarding control variables, the impacts of economic maturity (gross domestic product (GDP) per Capita in the cost model and GDP per Capita Growth in the profit model), unemployment and inflation are negative in most of the cost and profit models. The result observed from economic maturity variables is inconsistent with results from Eling and Schaper (2017), who expected and found a positive relationship between GDP per Capita and cost efficiency. However, Huang and Eling (2013) confirmed a negative impact and explained that efficiency was not the primary consideration of insurers when the market demand was expanding. The negative results from both unemployment and inflation are straightforward. Unemployment increases the surrendered/lapse rate, and inflation changes directly influence product pricing and asset-liability management; thus, these two would hurt firm performance.

The relationships between stock market return and performance are inconsistent in cost and profit models. Stock market return enhances profit efficiency but weakens cost efficiency. The latter point does not align with Eling and Schaper's (2017) finding. This indicates that insurers tend to operate more efficiently when generating profit rather than optimising cost structure if the stock market is performin well. Similar inconsistent results are also found in both cost and profit models when the competition variable is considered. Specifically, this is likely to suggest that insurers would have better profit performance in a more concentrated market.

Considering other firm-specified variables, results from Profit Tables 2.10, 2.11, 2.14, 2.15, 2.18 and 2.19 suggest a significant, non-linear relationship, the inverted U-shape, between firm size and profit performance. On the other hand, a weak U-shape relationship between size and cost efficiency is only found in Tables 2.8, 2.10, 2.13 and 2.17. The impact of liquidity contributes differently to cost and profit performance, as well. Holding more liquid assets increases the insurer's cost efficiency but decreases its profit efficiency. As expected, the coefficient of underwriting income is positive in the profit model, and it indicates that better underwriting ability enhances insurers' profit efficiency.

2.4.2.6 The model's validity

The F-test and the value of adjusted R-squared are reported to show the validity of all OLS fixed effects models. The F-test confirms the validity of the model, and the value of adjusted R-squared across all the models is in a reasonable range, consistent with Shim's (2011)'s results.

To check the validity of all models' specifications and the instrument variables used in the GMM-SYS model, the F-test, AR(1), AR(2) and the Hansen test of overidentification restriction are reported in each of the tables. First, the significance of the F-test confirms the validity of the model. Then, the Arellano-Bond test confirms the significant AR(1) serial correlation and the lack of AR(2) serial correlation across all models. Further, the results of the Hansen test indicate that none of the GMM-SYS models are overidentified.

2.4.3 Robustness checks and Sensitivity

2.4.3.1 Aggregated Model for Interactions

There are significant differences between life and non-life business regarding operations, investments and duration of liabilities (Hoyt and Trieschmann, 1991; Brockett *et al.*, 1994; Pottier and Sommer, 1997; Kasman and Turgutlu, 2009). For life insurers, Boose (1993) found that only one-third of the profits were generated from investment activities. The level of capitalisation is also different between the two sectors (Cummins and Sommer, 1996). Zou *et al.* (2012) also states that life insurers' future obligations/claims should be more predictable than those of non-life insurers due to the use of mortality tables in the life sector. These differences make it safe to assume that potential impacts on performance will vary between the life and non-life sectors. Thus, a dummy variable *Life*, which indicates life type business by assigning a value of 1, is included for this study's sensitivity and robustness check.

Managerial control mechanisms also differ between stock insurers and mutual insurers, such as the managerial discretion hypothesis and the expense preference hypothesis (Mayers and Smith, 1988, 1994). Thus, difference in ownership is likely to significantly affect firm performance. Stock insurers separate the functions of managers, owners and policyholders and face more conflict of interest issues on operating strategies. In contrast, mutual insurers are better able to control conflicts between owners and policyholders because they are merged into mutual firms, but their control over owner-manager conflicts is much weaker. This may indicate that mutual insurers (managers) have less incentives to improve their performance due to limited managerial discretion (Fama and Jensen, 1983). Thus, *Stock* is also included and measured through a dummy variable, which assigns a value of 1 for stock insurers and 0 otherwise.

Apart from controlling for the type of business and organisational forms, all individual risk factors are also included in the robustness models to check the sensitivity of the interactions' impacts on insurers' cost and profit efficiencies at an aggregated risk level. Tables 2.20, 2.21 and 2.22 show the results from dynamic panel models for the mentioned purposes, and the lowercase letters *a* and *b* in the headings of the tables represent the cost model and profit model, respectively.

As shown in Tables 2.20 through 2.22, most findings concerning the interaction terms are significant and remain constant with the previous results and discussions from section 2.4.2. However, the exemptions (in bold font) are found in Models 4 and 6 in Table 2.21a and Model 2 in Table 2.22b. When all risk factors are considered together, the coefficient of Pricing Risk * Capital becomes negative in the cost model (Models 4 and 6 in Table 2.21a). This contradicts the results from Model 4 in Table 2.15. In turn, the coefficient of the interaction between business diversification and reinsurance is insignificant and negative in Model 2, Table 2.22b.

Furthermore, it is worth remembering that Section 2.4.2.4 poses a question when considering the impact of Product Risk * Reinsurance on cost efficiency (Tables 2.16 and 2.17), as no clear indications were confirmed from either the fixed effects or the dynamic models. However, this question can now be answered by Table 2.22a, in which Model 1 confirms that insurers, who are willing to offer more risky products, also tend to use reinsurance to optimise their cost structures in the short-run. Neither dummy variable—business type or organisational form—significantly impacts cost performance. On the other hand, they have significant adverse effects on profit function.

Table 2.20a: Aggregated Interaction Effects with Investment Risk on Cost Efficiency - GMM

VARIABLES	(1) Cost	(2) Cost	(3) Cost	(4) Cost	(5) Cost
L. Cost Eff.	0.5019***	0.4773***	0.5003***	0.5874***	0.6153***
	(3.390)	(2.872)	(5.110)	(5.147)	(5.671)
Product Risk * Investment Risk	0.7995**				-0.8641
	(2.050)				(-1.597)
Diversified Business * Investment Risk		-0.6420***			-0.8763*
		(-2.767)			(-1.830)
Diversified Area * Investment Risk			-0.5193*		-0.3326
			(-1.716)		(-1.069)
Pricing Risk * Investment Risk				-0.4149*	0.1989
				(-1.855)	(0.714)
Product Risk	-0.0199**	-0.0067	-0.0061	-0.0048	0.0105
	(-2.279)	(-0.778)	(-0.678)	(-0.577)	(1.554)
Business Diversification	0.0091	0.0209**	0.0195*	0.0009	0.0161
	(0.853)	(2.252)	(1.796)	(0.135)	(1.653)
Area Diversification	-0.0067	0.0031	-0.0002	0.0094**	0.0117*
	(-1.336)	(0.366)	(-0.020)	(2.008)	(1.753)
Pricing Risk	0.0099***	0.0116***	0.0069**	0.0137***	0.0106**
	(3.195)	(3.301)	(2.115)	(3.782)	(2.590)
Investment Risk	-2.8702**	0.7459**	0.2586	-0.7346	4.4901**
	(-2.080)	(2.381)	(0.771)	(-1.345)	(2.059)
Firm Size	-0.0333	-0.0290	-0.0104	-0.0208	-0.0019
	(-0.731)	(-0.708)	(-0.219)	(-1.116)	(-0.076)
Square of Firm Size	0.0022	0.0020	0.0005	0.0010	0.0003
	(0.811)	(0.850)	(0.181)	(0.939)	(0.185)
Liquidity	-0.0033	0.0109	0.0079	0.0083	0.0118
	(-0.387)	(1.110)	(1.108)	(1.318)	(1.519)
Market Share	-7.0811**	-7.5595**	-4.1174	-0.6795	-1.2401
	(-2.338)	(-2.178)	(-1.545)	(-0.433)	(-0.611)
Stock Market Return	-0.0360	-0.0330	-0.0359*	-0.0248	-0.0198
	(-1.346)	(-1.259)	(-1.873)	(-1.560)	(-1.131)
GDP per Capita	-0.0097**	-0.0121**	-0.0045	-0.0049	-0.0090**
	(-1.990)	(-2.117)	(-1.041)	(-0.994)	(-2.161)
Unemployment Rate	-0.0062***	-0.0066***	-0.0036**	-0.0061***	-0.0041**
	(-3.235)	(-3.271)	(-2.256)	(-3.545)	(-2.018)
Inflation Rate	0.0050	0.0079*	0.0024	0.0025	0.0053
	(1.291)	(1.827)	(0.706)	(0.721)	(1.246)
Life	-0.0252	-0.0016	0.0464	0.0015	-0.0047
	(-0.567)	(-0.030)	(0.315)	(0.077)	(-0.262)
Stock	0.0164	0.0090	0.0023	0.0109	-0.0186
	(1.363)	(0.730)	(0.065)	(1.482)	(-1.029)
Constant	0.7808***	0.7980***	0.5200**	0.5594***	0.4739***
	(3.231)	(2.761)	(2.193)	(3.669)	(2.720)
Observations	438	438	678	683	438
Number of Firms	170	170	198	200	170
Number of Instruments	111	95	103	140	134
F-test	10.48***	7.319***	11.60***	18.91***	12.75***
AR(1)	-1.757*	-1.807*	-1.905*	-1.741*	-1.698*
AR(2)	0.416	0.271	0.419	0.428	0.295
Hansen Test	100.1 (0.289)	84.97 (0.250)	84.63 (0.491)	118.6 (0.570)	106.3 (0.659)

Table 2.20b: Aggregated Interaction Effects with Investment Risk on Profit Efficiency - GMM

VARIABLES	(1) Profit	(2) Profit	(3) Profit	(4) Profit	(5) Profit
L. Profit Eff.	0.1140*	0.0945*	0.2311*	0.1263*	0.2605*
	(1.748)	(1.659)	(1.862)	(1.824)	(1.839)
Product Risk * Investment Risk	-0.6661**				-1.6947**
	(-2.169)				(-1.995)
Diversified Business * Investment Risk		1.0694**			0.8236
		(2.118)			(0.737)
Diversified Area * Investment Risk			0.6779**		-2.2160
			(2.008)		(-1.111)
Pricing Risk * Investment Risk				-0.3339*	-0.9323*
				(-1.819)	(-1.721)
Product Risk	0.0108	-0.0113	-0.0211	-0.0204*	0.0122
	(1.195)	(-1.265)	(-1.504)	(-1.947)	(0.816)
Business Diversification	0.0250	-0.0087	0.0125	0.0029	-0.0198
	(1.247)	(-0.529)	(0.841)	(0.313)	(-0.672)
Area Diversification	0.0213**	0.0220*	0.0059	0.0024	0.0238
	(1.998)	(1.917)	(0.681)	(0.219)	(0.744)
Pricing Risk	-0.0061	0.0006	-0.0033	0.0012	0.0095
	(-1.532)	(0.106)	(-0.608)	(0.233)	(1.293)
Investment Risk	2.6738***	-0.6556	-0.4893	-0.9916*	3.8612*
	(2.749)	(-1.074)	(-0.662)	(-1.946)	(1.829)
Firm Size	0.1447	0.0184	0.0044	-0.0205	0.0339
	(1.197)	(0.368)	(0.052)	(-0.297)	(0.337)
Square of Firm Size	-0.0102	-0.0009	-0.0017	0.0013	-0.0027
	(-1.364)	(-0.307)	(-0.332)	(0.319)	(-0.466)
Liquidity	0.0070	-0.0046	-0.0249	-0.0081	0.0018
	(0.492)	(-0.568)	(-1.221)	(-0.758)	(0.125)
Underwriting Income level	0.0261***	0.0175***	0.0313**	0.0206***	0.0429***
	(4.836)	(2.752)	(2.203)	(2.771)	(3.983)
Stock Market Return	0.0434	0.1222***	0.0509	0.1058***	-0.0553
	(0.924)	(3.049)	(0.867)	(2.642)	(-0.802)
GDP per Capita Growth	-0.0061**	-0.0071***	-0.0068*	-0.0054**	-0.0032
	(-2.096)	(-3.093)	(-1.673)	(-1.974)	(-0.885)
Unemployment Rate	-0.0042	-0.0075**	-0.0121**	-0.0104**	-0.0013
	(-0.892)	(-2.185)	(-2.316)	(-2.385)	(-0.199)
Inflation Rate	-0.0147**	-0.0092	-0.0128*	-0.0116**	-0.0236***
	(-2.215)	(-1.487)	(-1.909)	(-2.117)	(-3.231)
Concentration	0.6224**	0.7042***	0.6014*	0.8024***	0.6218
	(2.491)	(2.741)	(1.831)	(2.728)	(1.591)
Life	-0.0684	-0.1683	-0.1678***	-0.3017***	-0.3646**
	(-0.228)	(-0.898)	(-3.215)	(-3.786)	(-2.226)
Stock	-0.0295	-0.0578*	0.0081	-0.0060	-0.0210
	(-0.522)	(-1.695)	(0.370)	(-0.219)	(-1.030)
Constant	-0.4953	0.0429	0.1440	0.1820	-0.1768
	(-1.027)	(0.194)	(0.432)	(0.557)	(-0.449)
Observations	830	830	827	822	822
Number of Firms	261	261	260	257	257
Number of Instruments	117	144	82	166	65
F-test	5.173***	4.928***	12.41***	11.94***	11.68***
AR(1)	-4.112***	-4.245***	-3.898***	-3.993***	-3.290***
AR(2)	-0.158	0.103	0.351	0.0338	-0.0670
Hansen Test	98.76 (0.460)	130.3 (0.354)	73.55 (0.171)	142.2 (0.596)	38.77 (0.655)

Table 2.21a: Aggregated Interaction Effects with Capital on Cost Efficiency - GMM

VARIABLES	(1) Cost	(2) Cost	(3) Cost	(4) Cost	(5) Cost	(6) Cost
L. Cost Eff.	0.4897***	0.4186***	0.3646***	0.4841***	0.3419***	0.3737***
	(3.593)	(3.276)	(3.207)	(2.836)	(3.142)	(3.080)
Product Risk * Capital	-0.0137**					-0.0017
	(-2.013)					(-0.176)
Diversified Buss * Capital		0.0093*				0.0019
		(1.868)				(0.200)
Diversified Area * Capital			0.0214**			0.0169*
			(2.199)			(1.667)
Pricing Risk * Capital				**-0.0171*** **		**-0.0079*** *
				(-3.211)		**(-2.224)**
Investment Risk * Capital					1.3030*	0.8288
					(1.857)	(1.236)
Product Risk	-0.0218**	-0.0031	-0.0091	-0.0012	0.0028	-0.0058
	(-2.231)	(-0.650)	(-1.039)	(-0.128)	(0.361)	(-0.468)
Buss Diversification	0.0102	0.0226*	-0.0022	0.0098*	0.0074	0.0090
	(1.093)	(1.710)	(-0.205)	(1.870)	(0.845)	(0.475)
Area Diversification	-0.0014	-0.0000	0.0356***	0.0018	-0.0102	0.0304*
	(-0.195)	(-0.007)	(2.698)	(0.208)	(-1.459)	(1.768)
Pricing Risk	0.0074***	0.0101***	0.0090***	-0.0161**	0.0100**	-0.0026
	(2.673)	(3.511)	(2.843)	(-2.087)	(2.565)	(-0.435)
Investment Risk	-0.0534	0.2397	0.3341	0.7922*	1.2359*	0.1021
	(-0.126)	(0.624)	(0.695)	(1.802)	(1.884)	(0.164)
Capital	0.0455	-0.0114*	-0.0096	-0.0141	-0.0119	-0.0270
	(1.478)	(-1.788)	(-0.930)	(-1.255)	(-1.060)	(-0.751)
Firm Size	-0.0152	-0.0334	-0.0456	0.0318	-0.1236**	-0.0389
	(-0.503)	(-0.969)	(-1.561)	(0.615)	(-2.394)	(-0.772)
Square of Firm Size	0.0007	0.0018	0.0023	-0.0017	0.0071**	0.0023
	(0.424)	(0.896)	(1.350)	(-0.668)	(2.456)	(0.752)
Liquidity	0.0201***	0.0020	0.0139**	-0.0011	0.0096	0.0088*
	(2.955)	(0.339)	(2.033)	(-0.162)	(1.556)	(1.745)
Market Share	-2.4141	-4.9524	-2.5819	-3.0904**	-3.5101	-4.9485*
	(-1.506)	(-1.415)	(-1.259)	(-2.150)	(-1.545)	(-1.700)
Stock Market Return	-0.0284	-0.0654**	-0.0017	-0.0184	-0.0150	-0.0240
	(-1.207)	(-2.426)	(-0.108)	(-1.464)	(-0.877)	(-1.198)
GDP per Capita	-0.0091**	0.0009	-0.0133***	-0.0014	-0.0145***	-0.0082*
	(-2.256)	(0.187)	(-3.857)	(-0.259)	(-2.683)	(-1.797)
Unemployment Rate	-0.0056***	-0.0044**	-0.0062***	-0.0024	-0.0066**	-0.0053**
	(-2.845)	(-2.409)	(-3.748)	(-1.113)	(-2.599)	(-2.459)
Inflation Rate	0.0090**	-0.0020	0.0033	0.0002	0.0078*	0.0019
	(2.075)	(-0.491)	(1.104)	(0.068)	(1.795)	(0.413)
Life	0.0603	-0.0186	-0.0534	0.0340	-0.0571*	-0.0375
	(0.970)	(-0.797)	(-1.281)	(0.640)	(-1.964)	(-0.992)
Stock	-0.0404	0.0185	0.0167	-0.0231	0.0245*	0.0085
	(-1.465)	(0.619)	(1.535)	(-0.403)	(1.885)	(0.734)
Constant	0.7654***	0.5250**	1.0161***	0.2334	1.3037***	0.7874***
	(3.944)	(2.316)	(5.782)	(0.648)	(4.990)	(2.674)
Observations	665	426	660	665	660	660
Number of Firms	192	161	190	192	190	190
Number of Instruments	119	132	118	75	138	119
F-test	8.136***	15.78***	8.125***	11.88***	5.471***	11.15***
AR(1)	-1.745*	-1.654*	-1.666*	-1.746*	-1.681*	-1.651*
AR(2)	0.201	0.149	0.0570	0.550	0.356	0.149
Hansen Test	104.7 (0.353)	115.1 (0.427)	105.6 (0.307)	51.14 (0.659)	112.3 (0.654)	101.8 (0.323)

Table 2.21b: Aggregated Interaction Effects with Capital on Profit Efficiency - GMM

VARIABLES	(1) Profit	(2) Profit	(3) Profit	(4) Profit	(5) Profit	(6) Profit
L. Profit Eff.	0.2247*	0.1481*	0.0894*	0.0947*	0.0979*	0.1407*
	(1.770)	(1.748)	(1.666)	(1.668)	(1.659)	(1.842)
Product Risk * Capital	-0.0142*					-0.0078
	(-1.711)					(-1.417)
Diversified Buss * Capital		0.0185**				0.0154*
		(2.088)				(1.690)
Diversified Area * Capital			-0.0155*			-0.0079
			(-1.713)			(-0.805)
Pricing Risk * Capital				0.0073*		-0.0013
				(1.702)		(-0.279)
Investment Risk * Capital					-2.1046**	-1.5288**
					(-2.034)	(-2.158)
Product Risk	-0.0778**	-0.0017	0.0040	-0.0055	0.0088	-0.0114
	(-2.202)	(-0.162)	(0.262)	(-0.585)	(0.964)	(-1.032)
Buss Diversification	-0.0326	0.0313*	0.0068	-0.0007	-0.0044	0.0365**
	(-1.068)	(1.707)	(0.515)	(-0.061)	(-0.465)	(1.992)
Area Diversification	0.0176	0.0108	-0.0237	0.0049	0.0019	-0.0160
	(0.575)	(1.484)	(-1.188)	(0.510)	(0.164)	(-0.735)
Pricing Risk	0.0036	0.0000	-0.0014	0.0118	0.0014	-0.0008
	(0.619)	(0.011)	(-0.248)	(1.328)	(0.352)	(-0.110)
Investment Risk	-0.7448	-0.0179	0.0525	-0.3284	-1.8200*	-1.8293**
	(-0.580)	(-0.044)	(0.072)	(-0.539)	(-1.667)	(-2.287)
Capital	0.0609**	0.0113	0.0160*	0.0335***	0.0260*	0.0590**
	(2.094)	(0.802)	(1.662)	(2.854)	(1.867)	(2.252)
Firm Size	-0.0496	0.1213	0.0760	0.0980	0.0629	0.0778
	(-0.341)	(1.407)	(0.890)	(1.334)	(1.132)	(0.828)
Square of Firm Size	0.0046	-0.0075	-0.0053	-0.0055	-0.0034	-0.0053
	(0.509)	(-1.491)	(-1.027)	(-1.226)	(-0.983)	(-0.931)
Liquidity	0.0313	-0.0094	-0.0122	-0.0088	-0.0032	-0.0357*
	(1.073)	(-1.363)	(-1.476)	(-1.051)	(-0.293)	(-1.969)
Underwriting Income level	0.0303**	0.0261***	0.0192***	0.0177***	0.0234***	0.0254***
	(2.268)	(3.006)	(2.743)	(3.247)	(4.040)	(4.080)
Stock Market Return	-0.0247	0.0677	0.1074***	0.1121**	0.0812**	0.0853*
	(-0.350)	(1.491)	(2.750)	(2.404)	(2.179)	(1.780)
GDP per Capita Growth	0.0002	-0.0046*	-0.0063**	-0.0059**	-0.0032	-0.0057*
	(0.051)	(-1.675)	(-2.457)	(-2.156)	(-1.316)	(-1.955)
Unemployment Rate	-0.0022	-0.0080**	-0.0108***	-0.0082**	-0.0059	-0.0104**
	(-0.348)	(-2.202)	(-2.703)	(-2.321)	(-1.561)	(-2.585)
Inflation Rate	-0.0173*	-0.0183***	-0.0079	-0.0100*	-0.0089*	-0.0099*
	(-1.905)	(-3.551)	(-1.364)	(-1.756)	(-1.692)	(-1.842)
Concentration	0.9418**	0.7036**	0.6326**	0.8663***	0.4758*	0.6817**
	(2.181)	(2.208)	(2.485)	(3.081)	(1.899)	(2.458)
Life	-0.6130	-0.2380**	-0.1548***	-0.2154***	-0.2408***	-0.1526***
	(-1.379)	(-2.246)	(-2.740)	(-4.980)	(-5.867)	(-2.715)
Stock	-0.1305*	-0.0336**	-0.0250*	-0.0312**	-0.0327**	-0.0084
	(-1.662)	(-2.278)	(-1.676)	(-1.984)	(-2.497)	(-0.408)
Constant	0.3780	-0.4032	-0.1524	-0.3191	-0.1645	-0.1686
	(0.627)	(-1.277)	(-0.410)	(-1.016)	(-0.737)	(-0.483)
Observations	206	802	794	802	802	799
Number of Firms	119	252	248	252	252	251
Number of Instruments	84	132	143	161	144	148
F-test	3.874***	11.13***	11.48***	12.48***	17.67***	9.693***
AR(1)	-3.283***	-4.034***	-4.305***	-4.118***	-4.160***	-4.487***
AR(2)	-0.539	-0.0879	0.172	0.0215	0.304	0.278
Hansen Test	57.69 (0.698)	104.8 (0.673)	119.1 (0.582)	133.3 (0.664)	119.6 (0.595)	139.5 (0.161)

Table 2.22a : Aggregated Interaction Effects with Reinsurance on Cost Efficiency - GMM

VARIABLES	(1) Cost	(2) Cost	(3) Cost	(4) Cost	(5) Cost	(6) Cost
L. Cost Eff.	0.6037***	0.3945***	0.5161***	0.5840***	0.3923***	0.6563***
	(5.242)	(3.399)	(4.682)	(6.585)	(4.117)	(5.264)
Product Risk * Reinsurance	**0.0060****					0.0025
	(2.253)					(0.983)
Diversified Buss * Reinsurance		0.0101*				0.0028
		(1.665)				(0.739)
Diversified Area * Reinsurance			-0.0059**			-0.0041**
			(-1.984)			(-2.077)
Pricing Risk * Reinsurance				0.0047**		-0.0004
				(2.028)		(-0.258)
Investment Risk * Reinsurance					-0.6093**	0.0060
					(-1.979)	(0.013)
Product Risk	0.0075	-0.0085	-0.0043	-0.0045	-0.0007	0.0066
	(0.903)	(-1.151)	(-0.578)	(-0.575)	(-0.089)	(1.181)
Buss Diversification	-0.0121	0.0101	0.0100	-0.0085	-0.0071	0.0014
	(-1.438)	(0.791)	(1.209)	(-0.941)	(-0.810)	(0.138)
Area Diversification	-0.0024	-0.0010	-0.0042	0.0131*	0.0039	-0.0071***
	(-0.466)	(-0.111)	(-0.591)	(1.728)	(0.631)	(-2.620)
Pricing Risk	0.0039	0.0074*	0.0151***	0.0103***	0.0080**	0.0092**
	(1.257)	(1.658)	(3.252)	(3.318)	(2.455)	(2.289)
Investment Risk	-0.1474	0.1944	0.3257	0.2013	-0.0203	-0.0234
	(-0.312)	(0.384)	(0.551)	(0.405)	(-0.021)	(-0.034)
Reinsurance	-0.0161	0.0140***	0.0107**	0.0124**	0.0120***	-0.0017
	(-1.442)	(2.625)	(2.099)	(2.538)	(2.891)	(-0.180)
Firm Size	0.0189	-0.0346	-0.0168	0.0529	-0.0183	0.0076
	(0.331)	(-0.592)	(-0.383)	(1.481)	(-0.390)	(0.203)
Square of Firm Size	-0.0009	0.0018	0.0010	-0.0028	0.0004	-0.0000
	(-0.275)	(0.512)	(0.394)	(-1.370)	(0.140)	(-0.018)
Liquidity	0.0053	0.0098	0.0038	0.0061	0.0039	0.0056
	(0.782)	(1.649)	(0.577)	(0.867)	(0.546)	(0.771)
Market Share	0.1675	-3.8656	-4.6409*	-2.6257	-0.7153	-1.5511
	(0.076)	(-1.183)	(-1.788)	(-1.647)	(-0.509)	(-0.566)
Stock Market Return	-0.0380**	-0.0127	-0.0010	-0.0315***	-0.0009	-0.0057
	(-2.409)	(-0.803)	(-0.057)	(-2.641)	(-0.054)	(-0.419)
GDP per Capita	-0.0069	-0.0090**	-0.0068	-0.0017	-0.0082**	-0.0090**
	(-1.224)	(-2.223)	(-1.210)	(-0.439)	(-2.481)	(-2.192)
Unemployment Rate	-0.0042**	-0.0046**	-0.0041*	-0.0036*	-0.0019	-0.0049***
	(-2.204)	(-2.518)	(-1.831)	(-1.828)	(-1.127)	(-2.621)
Inflation Rate	-0.0016	0.0057	0.0020	-0.0044	0.0033	0.0043
	(-0.370)	(1.391)	(0.414)	(-1.568)	(0.813)	(1.524)
Life	-0.0595	0.0083	-0.0026	0.0471	0.0306	-0.0258
	(-0.934)	(0.206)	(-0.085)	(0.844)	(1.109)	(-0.636)
Stock	-0.0283	0.0419	0.0068	-0.0032	0.0087	-0.0369*
	(-0.815)	(1.072)	(0.561)	(-0.322)	(0.901)	(-1.734)
Constant	0.3880	0.8213***	0.6182***	0.1468	0.7427***	0.4431**
	(1.394)	(2.797)	(2.664)	(0.671)	(2.967)	(2.195)
Observations	600	600	250	596	600	389
Number of Firms	182	182	122	180	182	154
Number of Instruments	101	101	87	100	101	135
F-test	7.798***	12.05***	16.64***	12.68***	6.704***	13.96***
AR(1)	-2.929***	-2.663***	-2.884***	-3.117***	-2.701***	-2.935***
AR(2)	-1.167	-1.126	-0.771	-0.964	-0.770	-0.795
Hansen Test	87.14 (0.328)	80.51 (0.526)	67.95 (0.479)	76.58 (0.618)	80.10 (0.539)	106.5 (0.628)

Table 2.22b: Aggregated Interaction Effects with Reinsurance on Profit Efficiency - GMM

VARIABLES	(1) Profit	(2) Profit	(3) Profit	(4) Profit	(5) Profit	(6) Profit
L. Profit Eff.	0.0956*	0.2149**	0.1442*	0.1404*	0.2035*	0.1305**
	(1.967)	(2.127)	(1.967)	(1.788)	(1.819)	(1.998)
Product Risk * Reinsurance	0.4691*					0.5890*
	(1.897)					(1.960)
Diversified Buss * Reinsurance		**-0.3683**				-0.0992
		(-1.562)				(-0.355)
Diversified Area * Reinsurance			0.2169*			0.1507*
			(1.838)			(1.957)
Pricing Risk * Reinsurance				0.1308*		-0.0514
				(1.744)		(-0.759)
Investment Risk * Reinsurance					12.1673*	31.7499
					(1.800)	(1.580)
Product Risk	-0.0133	-0.0341**	-0.0055	-0.0062	-0.0222**	-0.0042
	(-1.262)	(-2.038)	(-0.704)	(-0.715)	(-2.007)	(-0.321)
Buss Diversification	-0.0015	0.0070	-0.0076	-0.0109	-0.0108	-0.0001
	(-0.087)	(0.435)	(-0.577)	(-0.933)	(-1.044)	(-0.009)
Area Diversification	0.0168	-0.0038	0.0084	0.0124	0.0159	0.0169*
	(1.491)	(-0.284)	(0.653)	(1.389)	(1.634)	(1.821)
Pricing Risk	0.0012	-0.0094	-0.0031	0.0006	-0.0055	0.0007
	(0.304)	(-1.316)	(-0.719)	(0.159)	(-1.450)	(0.158)
Investment Risk	0.3361	-0.3898	0.1008	-0.1277	0.1060	0.0788
	(0.515)	(-0.396)	(0.294)	(-0.336)	(0.286)	(0.125)
Reinsurance	-1.7709**	0.2537	-0.0649***	0.3274	-0.1234***	-2.4613**
	(-1.997)	(1.303)	(-2.666)	(1.275)	(-2.665)	(-1.981)
Firm Size	-0.0607	-0.0337	-0.0099	-0.0789	0.0546	0.0440
	(-0.951)	(-0.250)	(-0.215)	(-1.332)	(1.307)	(0.564)
Square of Firm Size	0.0036	0.0016	0.0002	0.0042	-0.0048*	-0.0023
	(0.835)	(0.202)	(0.075)	(1.189)	(-1.752)	(-0.436)
Liquidity	-0.0072	0.0039	-0.0013	-0.0066	0.0012	-0.0028
	(-0.845)	(0.265)	(-0.091)	(-0.755)	(0.134)	(-0.332)
Underwriting Income level	0.0244***	0.0286***	0.0241***	0.0274***	0.0260***	0.0154**
	(4.351)	(3.571)	(3.261)	(3.832)	(3.777)	(2.122)
Stock Market Return	0.1143***	-0.0854	0.0662	0.0885*	0.0526	0.0923**
	(2.598)	(-1.335)	(1.407)	(1.843)	(1.310)	(2.151)
GDP per Capita Growth	-0.0062**	0.0007	-0.0029	-0.0039	-0.0024	-0.0032
	(-2.308)	(0.177)	(-1.024)	(-1.618)	(-0.980)	(-1.263)
Unemployment Rate	-0.0102***	0.0004	-0.0081**	-0.0073**	-0.0049	-0.0067**
	(-2.857)	(0.079)	(-2.374)	(-2.273)	(-1.307)	(-2.027)
Inflation Rate	-0.0082	-0.0244***	-0.0171***	-0.0180***	-0.0177***	-0.0127**
	(-1.232)	(-2.689)	(-3.113)	(-3.022)	(-3.174)	(-2.156)
Concentration	0.9209***	0.7197*	0.8957***	1.0775***	0.5246**	0.7991***
	(3.277)	(1.763)	(3.616)	(4.050)	(2.105)	(2.836)
Life	-0.2930***	-0.2557	-0.2773**	-0.3038***	-0.2553***	-0.2430***
	(-4.593)	(-0.959)	(-2.471)	(-5.488)	(-4.678)	(-2.649)
Stock	-0.0209	-0.0189	-0.0261	-0.0121	-0.0371	-0.0287*
	(-1.255)	(-0.364)	(-0.666)	(-0.323)	(-1.099)	(-1.901)
Constant	0.2696	0.2397	0.0766	0.2839	0.0334	-0.1453
	(1.149)	(0.406)	(0.410)	(1.230)	(0.180)	(-0.511)
Observations	801	373	799	799	795	799
Number of Firms	250	169	249	249	247	249
Number of Instruments	116	99	111	124	116	121
F-test	13.61***	3.401***	11.46***	20.39***	9.920***	22.92***
AR(1)	-4.421***	-3.308***	-4.040***	-3.933***	-3.382***	-4.171***
AR(2)	0.289	-0.263	0.142	0.181	0.0534	0.321
Hansen Test	106.6 (0.216)	87.72 (0.235)	107.5 (0.114)	101.6 (0.550)	103.8 (0.275)	104.7 (0.278)

Section 2.5 Conclusion

As mentioned by Kielholz (2000), underwriting and investment strategies are fundamental factors affecting insurer performance. Starting from this view, the present research discusses how these two strategies influence UK insurers' performance from the risk perspective. Four indicators are used to represent underwriting strategies (risks), and the uncertainty of investment return indicates the level of investment risk. The summarised results from Panel A in Table 2.23 confirm that both underwriting and investment strategies are crucial determinants of insurer performance from both cost and profit perspectives. Specifically, issuing more risky business will damage both cost and profit efficiencies, while the positive impact is observed from business diversification. The impacts from geographic diversification and investment risk are mixed for both the cost and profit performance.

The impacts of interaction between underwriting and investment strategies are also determined in this research, and the results reveal that short-term investment volatility takes the dominant role in cost function. On the other hand, from the profit point of view, the benefit of diversification can overcome short-term investment volatility. Further, the effect of accepting investment risk is positive for the insurer's profit efficiency, and this beneficial impact is amplified by taking additional investment risk.

To manage the individual impacts (risks/benefits) arising from underwriting and investment activities, building adequate capital and purchasing reinsurance are likely to be the primary choices for insurers. The beneficial effects of holding capital and using reinsurance on cost performance are determined here, as shown in Table 2.30. However, these two risk-management tools have contradictory impacts on profit performance. Meanwhile, the significant effects arising from the interplay between risk-taking activities (underwriting and investment) and risk management (using capital and reinsurance) on the insurer's performance are also proved, as presented in Panels C and D. These findings further indicate that using capital would be more helpful for improving the insurer's cost performance, and the usage of reinsurance may be more beneficial for enhancing profit efficiency. Apart from the above results, further cautions must be made: there is a difference between long-term and short-term behaviours associated with some of the factors, as revealed by the results of the OLS fixed effects and dynamic models.

Table 2.23: Summary of Hypotheses and Results

Hypotheses	Expected Sign on Cost	Result	Expected Sign on Profit	Results
Panel A: Hypotheses 1-6				
Product Risk	-	-	+	-
Diversified Business	+	+	+	+
Diversified Area	+	-	+	+
Pricing Risk	-	+	-	-
Investment Risk	-	-	+	+
Capital	-	+	N/A	+
Reinsurance	-	+	+	-
Panel B: Hypothesis 7 – Interactions with Investment Risk				
Product Risk * Investment Risk	N/A	+	N/A	-
Diversified Business * Investment Risk	N/A	-	N/A	+
Diversified Area * Investment Risk	N/A	-	N/A	+
Pricing Risk * Investment Risk	N/A	-	N/A	-
Panel C: Hypothesis 8 – Interactions with Capital				
Product Risk * Capital	N/A	-	N/A	-
Diversified Business * Capital	N/A	+	N/A	+
Diversified Area * Capital	N/A	+	N/A	-
Pricing Risk * Capital	N/A	+	N/A	+
Investment Risk * Capital	N/A	+	N/A	-
Panel D: Hypothesis 8 - Interactions with Reinsurance				
Product Risk * Reinsurance	N/A	+	N/A	+
Diversified Business * Reinsurance	N/A	+	N/A	-
Diversified Area * Reinsurance	N/A	-	N/A	+
Pricing Risk * Reinsurance	N/A	+	N/A	+
Investment Risk * Reinsurance	N/A	-	N/A	+

Thus, this study can provide insights for managers and regulators on the driving forces of performance in the UK insurance market. In particular, managers can set up appropriate operational strategies to achieve better developments. It is also suggested that the links between strategies play a vital role, and this should be considered by the regulators when they set up relevant requirements, such as capital requirements.

CHAPTER 3: What Drives the U.K. Insurers' Capital Structure? The Role of Internal Behaviours and the External Pressures from Market Structure

Abstract

This chapter determines the factors affecting on the insurers' capital structure in the UK market, concerning both internal and external factors. To be more specific, the insurers' behaviours – i.e. the past level of leverage, retained earnings, operating volatilities and the usage of reinsurance – are considered as internal factors, while different concepts of market structure are the external factors. Three measurements, the Boone indicator, the Lerner index and the Herfindahl-Hirschman index (HHI), represent the features of market structure from different perspectives, i.e. the market competition, the pricing power (or the market power) and the market concentration. First, the result of these measurements reveal that the UK insurance market is competitive; and further suggest that either the strength of pricing power or the intensity of market concentration might be originated from the intensity of competition.

By focusing on the UK insurance market from 1998 to 2017, the OLS fixed-effect and two-step system GMM dynamic panel estimators have applied to exam the impacts of both internal and external factors on the insurer's capital structure. The results from estimations not only confirm the significant influences from the targeted factors, but also reveal that different market structure indicators represent various concepts of the market, and they are not mutually exclusive. Unlike previous studies, the interaction terms between the internal factors and three market structure indicators (separately) are included in the regressions to confirm that the impacts of internal behaviours on capital structure vary according to the changes in market structure. In order words, the market structure has different impacts on the insurers' capital structure via different channels (insurers' behaviour). In addition, there are evidences to support that a non-linear relationship exists between the individual concept of market structure and the insurers' capital choice; and the impact of internal factors changes with respect to this non-linear relationship.

Section 3.1 Introduction

Since the early 1990s, the European insurance market has adopted a series of financial reforms, such as the 1994 Deregulation, the 2002 Solvency I, the 2004 Financial Conglomerates Directive, the 2007 Reinsurance Directive and the 2016 Solvency II.[1] The primary goal is to stimulate economic growth and improve individual welfare. One consequence of these European Union (EU)-wide regulatory changes, is a wave of mergers and acquisitions (M&As) in the European insurance industry since deregulation (Fenn *et al.*, 2008), indicating a change in market structure. From another perspective, a dramatic environmental change resulting from these regulatory developments is that competition is higher in systems with more freedom (Schaeck and Cihák, 2014).

Liberalisation—which is generally associated with increasing foreign rivals, the new presence of large firms and improved diversification ability—also results in an increasingly competitive market (e.g., Turk Ariss (2008); Delis (2012); Alhassan and Biekpe (2017). Thus, it has a further, positive effect on customers by offering various choices for insurance products (Cummins and Rubio-Misas, 2006). Eventually, insurers must improve their business/management practices and become more prudent due to these external pressures and further provide momentum to the economic system.[2] From the supervision perspective, the issues of market structure (e.g., the degree of competition or concertation) have attracted significant attention in the financial sectors, not only because of the recent financial crisis but because they are a useful regulatory tool influencing individual players and the financial system.

Extensive literature investigates the importance of market structure in the financial industry from different perspectives.[3] For example, the relationship between market competition and firm performance (profitability), a well known structure-performance hypothesis, is much discussed in both banking and the insurance industry (Joskow, 1973;

[1] A brief introduction of some of these reforms is presented in Appendix 3.

[2] By studying the relationship between the growth in insurance and the economic system, Hou, Cheng and Yu (2012) use fixed effects to argue that both life business and banking activity can predict economic growth in the Euro zone. Lee, Lee and Chiu (2013) and Chang, Lee and Chang (2014) also confirm that there iinsurance activities enhance economic growth, which is in line with Ward and Zurbruegg’s (2000) major findings.

[3] Claessens (2009) provides a detailed review of competition in financial sectors. He discusses the nature of competition in the financial market, the importance of competition and its relativity with other factors (e.g., firm specific or policy-related), etc.

Lloyd-Williams, Molyneux and Thornton, 1994; Choi and Weiss, 2005; De Jonghe and Vennet, 2008; Pope and Ma, 2008; Njegomir and Stojić, 2011; Bikker, 2016).

Another actively debated topic is the impact of market structure on individual stability,[1] which can be described by the competition-fragility hypothesis and the competition-stability hypothesis. The former indicates that higher competition damages a firm's stability, while the latter expresses the opposite. Schaeck, Cihák and Wolfe (2009) and Liu, Mirzaei and Vandoros (2014) study the impact of banking competition on the aggregated market level and indicate that competition boosts systemic stability (e.g., in banking) and economic growth, respectively.

Apart from the competitive effects arising from deregulations, Solvency II, which was launched in 2016 across the EU and is an international type of regulatory regime, also aims at creating a uniform playing field by establishing identical rules for all joining members—enabling a fair, cross-board competitive environment. Indeed, the primary goal of Solvency II is to strengthen the insurers' soundness via maintaining capital adequacy matched to insurers' risk levels, thereby fulfilling future obligations conducted at the enterprise level. Staking and Babbel (1995) share a similar view, arguing that increasing the level of capitalisation should be one of the important signals of having abilities to meet long-term commitments. Cummins and Nini (2002) state that insurers hold equity capital because they face uncertainties from future cash flows—either inflows or outflows from written business and investment. A similar view is expressed by Brockett *et al.* (2004b, 2005) and Kasman and Turgutlu (2011), who mention that equity capital serve as a cushion against unexpected losses that might exceed collected premiums. Then, policyholders may face a lower default rate when they purchase policies from insurers with more capital (Brockett *et al.*, 2005).

Academic researchers have also long paid much attention to various topics related to financial firms' capital from different perspectives—revealing the importance of the capital structure.[2] As suggested by Jensen (1986), financing debt capital might allow managers to manage a firm's future free cash flows effectively and reduce agency cost

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[1] Studies investigating the impact of competition on financial firms' stability include Berger, Klapper and Turk-Ariss (2009); Ye *et al.* (2009); Hakenes and Schnabel (2011); Fu, Lin and Molyneux (2014); Kasman and Kasman (2015); Fernández, González and Suárez (2016); and Cummins, Rubio-Misas and Vencappa (2017).

[2] Kielholz (2000) and Dhaene *et al.* (2017) provide detailed reviews of insurers' capital structure.

by setting restrictions on the manager's ability to spend free cash flows. Adams and Buckle (2003) and Luhnen (2009) confirm this free-cash-flow hypothesis in insurance markets, whilst Alhassan and Biekpe (2015) and Biener, Eling and Wirfs (2016) find evidence to support Jensen and Meckling's (1976) conflicts of interest hypothesis,[1] which indicates a negative relationship between debt capital and insurer performance. The adverse impact of capital (leverage) on firms' franchise (market) value has also determined by Staking and Babbel (1995) in the property-liability (PL) insurance industry, and they explain that this effect depends on the trade-off between tax advantage and the cost of default associated with increased leverage. From another perspective, Cummins and Lamm-Tennant (1994) suggest that insurers' leverage should be considered when using the cost of equity to determine premium levels, as the cost of equity is sensitive to leverage.

It is also true that insurers may face debt overhang[2] and asset substitution[3] issues if they hold too much debt (too little equity) because of the merger of debtholders and policyholders in the insurance industry (Dhaene *et al.*, 2017). Cheng and Weiss (2012) also point out that overhang issues (or conflicts between shareholders and policyholders) are detrimental for insurance business strategies, such attracting new business. In fact, Cummins and Nini (2002) find that most insurers overutilise equity capital in the US market. However, the cost of taxation is incurred by holding equity (Cummins and Grace, 1994; Cheng and Weiss, 2012a). Kielholz (2000) also notes that holding too much equity could be expensive due to transaction costs (e.g., commission fees for issuing equity), agency costs and taxation. Therefore, one of the major concerns of insurers is determining the optimal capital structure and discovering the factors affecting it.

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[1] Jensen and Meckling (1976) suggest that the optimal capital structure is determined by a trade-off between owner-manager conflict and owner-policyholder conflict. They indicate a negative relationship between leverage and performance relationship due to disputes between debtholders (policyholders) and shareholders (owners). This implies that higher leverage leads to lower performance.

[2] Due to conflict between debtholders and shareholders, in which debtholders' claims to assets have priority over shareholders' claims, two problems may arise. The manager is unable to make new investments, or the shareholders are unlikely to add extra capital because of the leverage position and the increased amounts paid to debtholders. This is the debt overhang issue (or underinvestment problem) (Myers, 1977).

[3] Asset substitution, or the problem of risk shifting, is the second agency issue arising from increasing the leverage level (Jensen and Meckling, 1976). It indicates that both managers and shareholders have incentives to take more risky investments associated with a high rate of return but a low rate of success. Thus, in the case of investment fails, debtholders bear most of the losses—e.g., loss of interest and principle—whereas shareholders reap most of the returns if investments succeed.

Regarding an insurer's optimal capital structure and the factors affecting its capital structure, two popular theories, trade-off theory and pecking order theory,[1] can be used to explain the choice of the insurer's capital structure. Testing the existence of trade-off theory can indicate whether the insurer is seeking to build up an optimal capital structure. On the other hand, the pecking order theory assumes no optimal capital structure and further indicates that the external financing is more costly than internal financing sources due to information asymmetries. Cheng and Weiss (2012) are the first to directly test both trade-off and pecking order theories in the PL insurance market. Then, Dhaene *et al.* (2017) provide a detailed discussion and review on the applicability of these theories to the insurance industry.

Apart from the above theory, Cummins and Doherty (2002) also provide evidence that both firm-specific factors and regulatory factors are essential to determining capitalisation. Cummins and Lamm-Tennant (1994) and Zanjani (2002) denote that insurers' business natures impact the cost of equity and amount of capital holding, respectively. Cummins and Sommer (1996), Baranoff and Sager (2002, 2003) and Baranoff, Papadopoulos and Sager (2007) study the relationship between capital holding and different risk factors. Hu and Yu (2015) investigate the significant interplay among capital, risk and firm efficiency in Taiwan's life market, and a similar study is developed by Mankaï and Belgacem (2016), who establish the triangular relationship between risk, capital and reinsurance level in the US PL insurance market. The reason for including reinsurance purchased is that it can be treated as a substitute for insurer capital (Berger, Cummins and Tennyson, 1992; Plantin, 2006; Shiu, 2011).

Note that the definition of capital is ambiguous or unclear in the insurance market. One source of capital can be called the traditional type, such as funds raised from both shareholders and debtholders; on the other hand, based on the way insurers' operatins run,

[1] Based on Modigliani and Miller's (1958) irrelevance proposition, the trade-off theory predicts that a firm can achieve optimal capital structure by considering the trade-off between the benefit and cost associated with holding capital. In contrast, Myers (1984) develops the pecking order theory based on Donaldson's (1961) work, discovering that the preference of financing sources was raised because of informational asymmetries between firms' managers and external investors. Although there are other theories for explaining a firm's capital structure, such as market timing theory (Baker and Wurgler, 2002) or stock return theory (Welch, 2004), these are not applicable in the UK insurance industry because the market value associated with firms' elements are not available as most insurers are not publicly traded.

policyholders are also dominant suppliers of capital,[1] providing insurance leverage (Cummins and Lamm-Tennant, 1994; Pope and Ma, 2008). Therefore, it is reasonable to assume that there is a connection between market structure and an insurer's capital structure. To be more specific, the insurer's underwriting ability (or performance) will be affected by the level of competition,[2] which further affects a firm's capital structure.

Brander and Lewis (1986), Maksimovic (1988) and Showalter (1999) provide a theoretical framework connecting a firm's capital structure and market behaviour. The impact of market structure on a firm's capital structure (leverage, in most of the studies) has been found in product market studies, including Chevalier (1995); Phillips (1995); Rathinasamy, Krishnaswamy and Mantripragada (2000); Pandey (2004); Guney, Li and Fairchild (2011); and Sarkar (2014), among others.

Claessens (2009) suggests that competition could be facilitated, not only by liberalisation, but also by removing barriers, such as lowering costs for consumers and small- and medium-sized enterprises (SMEs). One of the significant costs insurers consider originates from the capital structure; the cost of capital is essential for both investors and insurance managers. Kielholz (2000) also recognises that deregulation should have a substantial effect on capital cost, and Fenn *et al.* (2008) share a similar presumption, which assumes that a competitive market, resulting from deregulation, drives down costs via increasing insurers' efficiency.

However, this specific relationship shared by the market structure and the firm's capital structure has received far less attention in the financial market, and the banking industry has typically been the major investigated target (Berger, Klapper and Turk-Ariss, 2009; Allen, Carletti and Marquez, 2011; Soedarmono, Machrouh and Tarazi, 2011; Schaeck and Cihák, 2012; Beck, De Jonghe and Schepens, 2013a; Schaeck and Cihák, 2014; Akins

[1] The premiums paid by policyholders are pooled together to pay future qualified claims or benefits. Therefore, within the context of policyholder roles, he/she is not only a product buyer but also a supplier of capital to be used to pay claims or write more businesses.

[2] The relationship between market structure and firm performance can be tested by the concentration-profit hypothess developed by Bain (1951), the collusion theory formalised by Stigler (1964) or the most commonly known framework, the structure-conduct-performance hypothesis. See studies from Joskow (1973); Chidambaran, Pugel and Saunders (1997); Bajtelsmit and Bouzouita (1998); Choi and Weiss (2005); Hussels, Ward and Zurbruegg (2005); Pope and Ma (2008); and Alhassan, Addisson and Asamoah (2015), among others.

et al., 2016).[1] Only Cummins, Rubio-Misas and Vencappa (2017), when studying insurers' stability, indirectly focus on exploring this relationship in the European life insurance industry.

This chapter mainly contributes to ongoing discussions on insurers' capital structure (Campello, 2003; Shiu, 2011; Cheng and Weiss, 2012a; Altuntas, Berry-Stölzle and Wende, 2015; Dhaene *et al.*, 2017). The main aim of this chapter is to reveal the impacts of potential factors on insurers' capital structure. To be more specific, Internal factors include insurer's past leverage level, retained earnings, volatilities and the use of reinsurance, while external factor is the market structure. Moreover, both internal factors and external factor will be simultaneously considered to test the interaction effects. The expected results will help the regulator and insurers to consider their behaviours when the market structure is changed. Cummins, Rubio-Misas and Vencappa (2017)use the Boone indicator to measure the degree of competition from 1999 to 2011, and they find that the competition level actually deteriorated in the EU life market. Nearly two decades after the adoption of the Third Insurance Directive, it is important to reconsider the market structure status in the UK insurance market due to both its global significance and the most recent political change.

Then, several contributions can be made to the literature. Firstly, in contrast to the financial studies on capital structure, such as those focusing on the banking industry, there is relatively little investigation on determinants of insurers' capital structure. Secondly, the impact of market structure (e.g., competition) on an insurer's capital structure is ambiguous. It is important to fill the gap. Therefore, the main contribution of this study is to determine how market structure affects UK insurers' capital structure directly and indirectly—for example, considering the individual effect of market structure and its interactions with firm-specific characteristics on the UK insurance market's capital structure. Third, this chapter responds to measurement issues and employs Boone indicator, Lerner Index and HHI as market structure measures. By implying three different indicators, it provides a comprehensive picture of market structure in the UK insurance industry. Fourth, in comparison to other capital studies related to the UK market,

[1] Among these studies, only Schaeck and Cihák (2012) and Allen, Carletti and Marquez (2011) provide detailed discussions and tests directly concerning the impact of competition on banks' capital ratios.

the sample used in this chapter can be considered the largest, and its acquired data are also the most recent and the widest in coverage regarding time (from 1998 to 2017).

The results confirm the significant influences from the targeted factors, and further suggest that different market structure indicators represent various concepts of the market. Moreover, it is worth to note that the impact of internal behaviours on capital structure varies according to the changes in market structure. Thus, these findings will have meaningful significance for both individual participants and national policymakers. For example, policymakers can use these results to develop effective regulations, which consider various concepts of market structure and its potencial influences on insurers' behaviours. Insurers can develop more effective strategies by considering the aggregated effects arising from external pressures and capital requirements, especially when making plans related to firms' cost structures and stability. As a result, the insurance industry can be expected to be more beneficial to both customers and the economic system.

The rest of this chapter is organized as follows. Section 3.2 outlines the literature on relevant topics and develops the key hypotheses. Section 3.3 presents data and methodology and specifically discuss how to measure market competition. The UK's degree of insurance competition will be reported in the first part of Section 3.4, and the second part will illustrate the empirical results. Section 3.5 will conclude the chapter.

Section 3.2 Literature Review and Hypotheses Development

3.2.1 Capital Structure: Trade-Off and Pecking Order Theories

First, to better understand the choice of capital structure in the UK insurance market, two prevailing theories, the trade-off and the pecking order theories, are tested (see surveys on both theories from Harris and Raviv (1991), Frank and Goyal (2008) and Dhaene *et al.* (2017).

The trade-off theory has been developed based on Modigliani and Miller's (1958) logic, which argues that a firm's value (i.e., the total value of equity and debt) and its capital structure are irrelevant to each other under friction-free assumptions.[1] It assumes that the firm's capital structure is defined by predetermined investment decisions. Thus, the available free cashflow to be paid to the financial provider is fixed, after considering all

[1] For example, the market is perfect and efficient, with no tax costs or transaction costs involved.

other stakeholders. Therefore, a firm's value is irrelevant to its capital structure. However, these friction-free assumptions are not realistic, and capital structure affects the available amount of free cashflow, which can be distributed to different capital suppliers.

Considering the above logic together with Modigliani and Miller's (1963) tax shield effect and Jensen and Meckling's (1976) agency cost theory,[1] the trade-off theory posits that a firm seeks to balance the benefits against the cost of holding leverage to achieve maximised value, and the firm takes actions to return to this optimum balanced level when it deviates from it. Thus, a firm should have an optimal capital structure (Cagle and Harrington, 1995; Cummins and Danzon, 1997).

On the other hand, Myers's (1984) pecking order theory presumes no optimal capital structure and is developed based on Donaldson's (1961) results. According to this theory, the firm prefers internal financing sources over external sources for two reasons. First, the cost of external financing is greater than the cost of internal financing, due to information asymmetries that arise from differences in understanding the true value of assets between the managers (the firm) and external investors. Secondly, managers must act in the interests of current shareholders, and annoucning new issuing is harmful to current shareholders. Under the pecking order theory, firms would first like to use up retained earnings, followed by debts, and use equity as a last resort (Dhaene *et al.*, 2017).

In the extant empirical literature, Pandey (2004) indicates that both behaviours exist in his study. Jacques and Nigro (1997) find a very slow adjustment for capital ratios to a bank's desired level, with an adjusting speed of approximately 0.035. Flannery and Rangan (2006) find the existence of trade-off behaviour, as they present evidence that nonfinancial firms identify and pursue the target capital structure. Although Huang and Ritter (2009) find support for firms adjusting their leverage levels to the target, they have stronger evidence to support the market timing hypothesis. Chang *et al.* (2015) also state that firms operated in a competitive industry quickly adjust their leverage towards targeted levels.

In contrast, Fama and French (2002) find evidence to support the pecking order theory. By comparing the UK and Italian markets, Panno (2003) also confirms the existence of

[1] The former indicates that there is a beneficial tax treatment, and the latter complements the viewpoint concerning the tax-bankruptcy balance.

the pecking order theory and further reveals that firms might have a long-term leverage ratio in the UK market. Later, by testing French manufacturing firms, Margaritis and Psillaki (2010) also reveal signs of the pecking order theory. Lemmon and Zender (2010) prove this behaviour as well. as well, and they also argue that undercapitalised firms must raise equity because they are unable to borrow further from the market. Mitani, (2014) analyses the relationship between profitability and leverage, and supports the pecking order hypothesis.

From studies related to the insurance market, Shiu (2011) confirms the trade-off hypothesis from a growth opportunity point of view. Cheng and Weiss (2012) test both the trade-off and pecking order theories in the US PL insurance market and indicate that the former dominates the latter when both behaviours exist. Studying the cyclical behaviour in French PL insurance, Bruneau and Sghaier, (2015) also present evidence that the trade-off theory is prioritised over the pecking order theory. Further, by reviewing other studies on the relationship between price and insolvency risk, Sommer (1996), Phillips, Cummins and Allen (1998) and Cummins and Weiss (2016) conclude that most of the insurance evidence supports the trade-off hypothesis. Thus, the following hypotheses can be developed:[1]

H1a*: The trade-off behaviour exists in the UK insurance market.*
H1b*: The pecking order behaviour exists in the UK insurance market.*

3.2.2 Market Structure on Capital Structure

Regarding studies on the product market (or industrial companies), conclusions about the relationship between the effect of market structure and firms' capital structure are not unanimous. The hypotheses associated with this relationship can be considered or developed from two perspectives: the output maximisation object and the expectation of bankruptcy costs.

[1] Shiu (2011) uses a positive tax convexity-leverage relation, a positive firm size-leverage relation and a negative growth opportunities-leverage relation to define the trade-off hypothesis, while using a negative profitability-leverage relation and a negative firm size-leverage relation to define pecking order theory. Mitani (2014) assumes that the pecking order hypothesis will be supported when a negative relationship is found between profitability and leverage; otherwise, the trade-off theory will be supported, and profitability will be expressed as EBITDA/Total Asset. Titman and Wessels (1988) and Frank and Goyal (2009) also find profit to be negatively related to debt.. Therefore, it is reasonable to use profitability or profit performance to test the pecking order hypothesis, and profit performance should be negatively related to leverage, while positively related to equity capital as retained earning. However, it is questionable to use firm size or growth opportunities to identify trade-off theory because neither would be able to explain the existence of a targeted capital lever.

On the one hand, there is a postive relationship between firms' market power and debt levels. The firm's objective is to maximise shareholder wealth by increasing the firm's output level. Based on Jensen and Meckling's (1976) agency cost theory, managers (on behalf of shareholders) are willing to take more borrowings[1] (i.e., leverage) because the risks shift from shareholders to debtholders. In other words, the poorer outcomes (e.g., decline in profitability in unfavourable conditions) will be ignored by shareholders and passed to creditors (Pandey, 2004).[2] The shareholders will receive the rewards when the outcome is beneficial. Further, Brander and Lewis (1986) suggest that the oligopoly firm (i.e., those with more market power) should have advantages for enhancing profitability by maximising output level. Also, according to Modigliani and Miller's (1963) tax shield effect, firms with higher profit like to borrow bacause of tax deductible interest. After all these comprehensive considerations, it can be assumed that firms operating in a less competitive market or having higher market power would like to maximise output levels by holding more debts.

On the other hand, as described by Pandey (2004), Guney, Li and Fairchild (2011) and Fosu (2013), the predatory strategy[3] explains the negative relationship between firms' market power and capital structure (using leverage). According to the expected bankruptcy costs argument, a firm with a higher leverage ratio faces a greater likelihood of being financially distressed (Shiu, 2011; Saona, 2016). Then, it is reasonable to predict that a low-leveraged firm with high profitability will easily eliminate its rivals by adopting the predatory strategy of maximising its production or cutting prices in a concentrated market. To be more specific, a firm with more market power should reduce its leverage ratio to maintain its current competitive advantage[4] or to drive its competitors out of the market.[5] Moreover, according to pecking order theory (Myers, 1984), internal financing is preferred to external debt due to asymmetric information, if the greater market power potentially leads a greater profitability. Thus, a negative relationship between a firm's market power and its leverage level can be expected.

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[1] More risky businesses/investments/projects can be taken by using borrowing to maximize output level.

[2] Pandey, (2004) uses the term 'shareholders' limited liability status' to explain the siuation.

[3] The predatory strategy assumes that a low-leveraged firm is likely to plunder benefits from a high-leveraged firm.

[4] Competitive advantage will be waived when the agency costs outweigh the benfits associated with holding more leverage.

[5] Fosu (2013) suggests that the incumbent firm with greater market power should set the market price below the monopoly price to keep new entrants (i.e., those with less market power or more vulnerable financial structures) out of the market.

Based on the above discussion of industrial capital structure, Pandey (2004) not only provides evidence that market power positively affects debt ratio but also supports a prediction that there is a cubic relationship in the Malaysia market. Moreover, this cubic relation indicates that firms with either higher or lower market power enjoy holding more debt, while firms in the intermediate range try to reduce leverage. Later, Guney, Li and Fairchild (2011) confirm that companies with more market power would like to have more leverage in China. They also point out that the approved relationship changes when they adopt different analytical approaches to example it. For example, they only find a non-linear relationship in some industries when using OLS regression.

Among others, Istaitieh and Rodríguez (2003), MacKay and Phillips (2005), Smith, Chen and Anderson (2010) and Sarkar (2014) provide evidence for the positive relationship between firms' market power and capital structure. In contrast, Mitani (2014) suggests that firms with high market shares hold a lower level of debt. Rathinasamy, Krishnaswamy and Mantripragada (2000) find supports for both relationships in different industries.

Due to the difference in nature between general product markets and financial industries, both banks and insurance companies, for example, are highly leveraged firms. Researchers are, therefore, more likely to use equity to identify a firm's capital structure and adopt approaches such as the Herfindahl-Hirschman Index (HHI), the Lerner index and the Boone indicator to directly measure the degree of competition. As noted, only a few studies make a direct investigation of the relationship between market structure and individual capital decisions in financial sectors.

From banking studies, Allen, Carletti and Marquez's (2011) framework predicts that competition incentivises banks to have more equity. Consistent with this prediction, Schaeck and Cihák (2012) confirm that market competition, measured by *H-Statistic*, enhances banks' capital holding. For example, a bank's capital level would be increased by 3.7% (3.9%) for commercial banks (all banks in the sample) when market competition increased by 1%.

From other relevant literature, the market structure-capital relationship is observed indirectly when the authors consider the impact of competition on individual stability.[1] For example, by using HHI to measure the degree of market power in both deposit and loan markets, Berger, Klapper and Turk-Ariss (2009) indicate that banks enjoy high equity levels when they have more market power. Further, a non-linear relationship, an inverted-U shape, is found between market power for loans and equity. Consistent with this positive market power-equity relation, Akins *et al.* (2016) explain that banks in a more concentrated market build up equity because the profitability is greater. In contrast, Schaeck, Cihák and Wolfe (2009) reveal that banks holding more capital are less likely to suffer from systemic crises in a competitive market.

Soedarmono, Machrouh and Tarazi (2011) and Beck, De Jonghe and Schepens (2013a) use the Lerner index to represent banks' market power, and the latter authors believe that market power contributes to bank stability through holding more capital. On the other hand, the former authors suggest that, although firms with more market power would like to have more equity capital, these amounts are still not sufficient to cover the uncertainties arising from bank risk-taking.

Schaeck and Cihák (2014) also present evidence to support the idea that competition could enhance European bank stability by encouraging banks to build up capital. Similar investigations appear in the insurance market. Using HHI to represent the market structure in Cananda, Guidara and Lai (2015) state that the insurers' capital level increases in a concentrated market. Cummins, Rubio-Misas and Vencappa (2017) study the impact of market competition, measured by the Boone indicator, on insurer stability in the European life market. At the same time, they test the effect of competition on three components of Z-score, and their results suggest that competition encourages insurers to hold less capital, while boosting the reallocation effect of profits from inefficient to efficient insurers to enhance soundness.

[1] Berger, Klapper and Turk-Ariss (2009), Soedarmono, Machrouh and Tarazi (2011), Schaeck and Cihák (2012, 2014) and Beck, De Jonghe and Schepens (2013a) use Z-score as the proxy of bank stability. As expected, a higher Z-score indicates lower probability of insolvency and a more stable firm. In most cases, the researchers test, not only the impact of market structure on Z-score, but also on its components—profitability (return on assets), equity (equity/total asset) and return volatility (s.d. of ROA).

As discussed, the impact of different concpets of market structure on insurers' capital structure is inconclusive from previous studies. Thus, the following hypothesis is developed.

***H2**: Market Structure affects the insurer's capital structure*

3.2.3 Volatility on Capital Structure

According to Williamson's (1988) transaction-cost economics theory, firms that face greater risk (higher volatility) are expected to carry more (equity) capital because it is harder to raise debt capital due to greater uncertainty of meeting further obligations. By estimating the simultaneous equations, Shrieves and Dahl (1992) find a positive impact of changes in asset risk on adjustment in the capital-to-asset ratio in banking. They further attribute this positive relationship to regulatory and bankruptcy costs. A similar conclusion was reached by Jacques and Nigro (1997), after considering the Tier 1 capital requirement in banking.

However, evidence of the impact of a firm's volatility on capital structure is inconsistent in the financial industry. Kwan and Eisenbeis (1997) reveal that there is a negative relationship between banks' credit risk and capital amounts, in line with the moral hazard hypothesis (Cummins, 1988). For example, the existence of deposit insurance in banking or guaranty funds for insurers encourages firms to take more risks (Lee, Mayers and Smith, 1997).[1]

From insurance literature, studying the US PL market from 1797 to 1990, Cummins and Sommer (1996) also apply simultaneous equation methodology and indicate that insurers with higher portfolio risk hold more equity capital. Meanwhile, their results also support early findings from Hammond, Melander and Shilling (1976) and Harrington and Nelson (1986), who hypothesise a negative relationship between insurers' portfolio risk and leverage ratio (i.e., the ratio of premium to equity). Zanjani (2002) proves that insurers with more risky business, such as policies to cover natural disasters, tend to build more capital. In line with capital buffer theory,[2] Mankaï and Belgacem (2016) also

[1] The explanation for the moral hazard hypothesis is that external guaranty funds can encourage firms to engage in more risky behaviours because the shortfall between capital and liabilities can be covered (Downs and Sommer, 1999). Lee, Mayers and Smith (1997) also express the idea of moral hazard as a risk-subsidy hypothesis applicable to stock insurers.

[2] Insurers tend to hold excess capital beyond regulatory requirements against unexpected losses and to avoid regulatory cost.

support the positive relationship. In comparison to monitoring hypotheses,[1] Downs and Sommer (1999) find evidence to support the moral hazard hypothesis, which assumes that insurers facing higher volatility would tend to have less capital, for listed insurers with insider ownership.[2] Furthermore, by dividing insurers' volatilities into asset risk and product risk, Baranoff and Sager (2002) note that the asset risk-capital relation is positive and confirm a negative product risk-capital connection. Cheng and Weiss (2013) present evidence showing that the relationship between capital and two volatility components (underwriting and investment risk) were both positive in the PL insurance market from 1993 to 2007. Hu and Yu (2014, 2015) provide similar research in the Taiwanese life market, but opposing results are found, indicating that (undercapitalised) insurers tend to reduce capital level as investment risks increase, whereas medium- and well-capitalised insurers increase their capital holding when underwriting risks are raised.

In sum, there are two conflicting pieces of logic regarding the relationship between an insurer's volatility and its capital position. The first, supported by the bankruptcy-cost-avoidance hypothesis (Orgler and Taggart, 1983), the transaction-cost economics theory (Williamson, 1988) and the capital buffer theory (see, Shim (2010)), indicates that insurers with a higher level of volatility should hold more (equity) capital. In contrast, the second piece of logic posits a negative relationship, assuming that the presence of external guaranty funds encourages insurers to take more risks when capital is reduced, as demonstrated by Cummins (1988) and Lee, Mayers and Smith (1997). Moreover, as argued by Cheng and Weiss (2013), it is theoretically possible that this negative relationship may be due to the 'mispricing' of certain types of risks in the risked based capital (RBC) formula, which may further encourage insurers to increase the aggregated risk while decreasing capital. Thus, the hypothesis for insurers' business volatility can be stated as follows.

***H3**: Insurers' volatility affects the insurer's capital structures.*

3.2.4 Reinsurance usage on Capital Structure

Staking and Babbel (1995) state that firms use hedging strategies to increase their value when the cost of hedging is lower than the cost of bankruptcy. They further mention that

[1] The monitoring hypothesis asserts that insurers would like to reduce their risk to avoid increased guarantee fund assessments because market players would like to monitor and follow their competitors' actions, leading to an act of unity (Lee, Mayers and Smith, 1997). In sum, the aggregated risk level may remain the same or even lower, because the cost of the guaranty funds might offset their risk-taking incentives.

[2] Lee, Mayers and Smith's (1997) ownership hypothesis states that managers with stock ownership, in stock insurance companies, have incentives to take more risks.

firms will still choose hedging strategies, even when they are costly, because the insurer's franchise value[1] would be lost in the event of insolvency. Graham and Rogers (2002) suggest that there might be two-way causality between hedging strategies and leverage. Using reinsurance and using derivatives[2] can both be categorised as hedging strategies in the insurance market. Specifically, regarding reinsurance, their role in defining and determining capital requirements has been well recognized (Hoerger, Sloan and Hassan, 1990; Garven and Lamm-Tennant, 2003; Eling and Holzmüller, 2008; Scordis and Steinorth, 2012).

The primary functions associated with using (re)insurance are to mitigate a firm's insolvency risks (Berger, Cummins and Tennyson, 1992) and to enhance its underwriting (debt) capacities (Chen, Hamwi and Hudson, 2001; Cole and McCullough, 2006; Cummins *et al.*, 2008; Zou and Adams, 2008). Due to the difficulty of adjusting capital structure in the short-run, as well as the cost of raising capital, the advantage of using reinsurance should be greater to insurers with solvency problems; less solvent insurers may take more reinsurance (Chen, Hamwi and Hudson, 2001). The other benefits of reinsurance, summarised by Liu, Shiu and Liu (2016), are reducing expected tax payments[3] and obtaining real services[4] from reinsurers.

By considering the risk-capital relationship (see previous section) alongside Lee, Mayers and Smith's (1997) risk-subsidy hypothesis, it is reasonable to presume that using reinsurance may impact the insurer's capital structure. Specifically, according to the expected bankruptcy cost theory, highly leveraged insurers have a greater likelihood of becoming insolvent, and, thus, they bear massive bankruptcy costs. However, reinsurance can prevent insurers from suffering huge losses and further reduce the chance of insolvency. Plantin (2006) suggests that capital structure should be determined with reinsurance usage.

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[1] Franchise value includes intangible assets, such as reputation, agency force and various types of licensing. This concept has been widely studied in the banking industry, but only marginally researched in the insurance industry. Ren and Schmit (2009) investigate the interplay among insurers' franchise values, risk taking and competition.

[2] The main difference between the two is that derivatives can be used for speculation (Adams, Hardwick and Zou, 2008). Due to data availability, only the reinsurance use from primary insurers is considered in this study.

[3] The reinsurance-tax relation is studied by Adams, Hardwick and Zou (2008).

[4] According to Liu, Shiu and Liu (2016), real services include underwriting advice and claims handling.

Although investigations considering the impact of reinsurance on insurers' capital structures are finitely demonstrated, the results are relatively consistent. Cummins and Nini (2002) state that the degree of diversification in an insurer's portfolio could be increased via reinsurance because of a better spread of risks; then, less equity capital is needed. Consistent with the renting capital hypothesis, reinsurance can function as an essential, off-balance-sheet financing source for primary insurers (Mayers and Smith, 1990; Adiel, 1996; Stulz, 1996; Dror and Armstrong, 2006). Thus, the substitutive effect (or the renting capital hypothesis)—a negative (positive) relationship between equity (leverage) and reinsurance—can be expected (Cummins *et al.*, 2008; Shiu, 2011; Mankaï and Belgacem, 2016). However, Mankaï and Belgacem (2016) further split the sample into affiliated and non-affiliated insurers and find that the substitutive effect only appeared in the former group. The exception is presented by Cheng and Weiss (2012), whose results indicate that the leverage is actually reduced by increased reinsurance use. This unexpected result could be due to the increase in insurers' risk levels because of their high dependence on reinsurer financial health. That is, higher reinsurance levels lead to higher risk (see Kim *et al.* (1995) and Pottier and Sommer (1999)). Then, the above discussion leads to the following hypothesis:

H4: *Reinsurance ceded affects the insurer's capital structure.*

3.2.5 Market Structure and its interactions

In addition to the hypotheses mentioned above, those associated with each firm-specific factor, and the interplay between competition and those factors, are briefly reviewed here. The aim of including these interactions is to test whether there is an impact of interference and amplification resulting from the competition in the above hypotheses (Tabak, Fazio and Cajueiro, 2012; Fosu, 2013).

The structure-conduct-performance (SCP) hypothesis and the efficiency-structure (ES) hypothesis are widely used to reveal the interplay between market structure and individual performance (see Fenn *et al.* (2008); Pope and Ma (2008); Tabak, Fazio and Cajueiro (2012); and Alhassan, Addisson and Asamoah (2015)). The former assumes that insurers' behaviours are affected by market structure, such as collusive behaviour leading to higher market profit (or more market share) in less competitive conditions. Studying the US life insurance market, Cummins, Denenberg and Scheel (1972) not only find a negative relationship between market concentration and competition, but also confirm that market concentration boosts firm performance. The ES hypothesis expects that more efficient insurers, who have lower marginal costs, should perform better than their counterparts in a competitive market.

Apart impacting individual performance, market structure also influences individual stability or risk-taking behaviours. As previously noted, two famous hypotheses explain the impact of competition on a firm's stability in the financial sector.[1] The first is the competition-fragility hypothesis, which proposes that competition promotes a firm's risk-taking behaviours (such as writing risky business or making risk investments) and erodes its stability (Leroy and Lucotte, 2017). The second is the competition-stability view, which argues that intense competition may enhance a firm's soundness because of the effect of profit reallocation (Cummins, Rubio-Misas and Vencappa, 2017). Schaeck and Cihák (2014) suggest and confirm that competition enhances a bank's stability via improved efficiency. Cummins, Rubio-Misas and Vencappa (2017) find a similar transmission mechanism in the EU life market. Investigating the connection between competition and a bank's credit risk, Soedarmono and Tarazi (2016) determine that banks operating in a market with weaker competition immediately accept more credit risks. However, these firms tend to reduce their levels of risk-taking after a one-year time lag.

If the competitive environment encourages insurers to accept more risks, then two types of strategies can be used to manage these excessive amounts of risk in the insurance industry. One is the external scheme, which can be provided or encouraged by the government or other regulatory bodies.[2] Another way to achieve the goal is via internal management—for example, management decisions about using reinsurance. Claessens (2009) suggests that the interaction between competition and consumer protection schemes is an essential consideration in the financial sector because too little or too much competition may damage customer benefits.

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[1] The 'competition-fragility/stability' nexus is not well debated in insurance sectors but is widely discussed and applied in the banking sector—e.g., Berger, Klapper and Turk-Ariss (2009); Hong Liu *et al.*, (2010); Jiménez, Lopez and Saurina (2013); Kasman and Kasman (2015); Kabir and Worthington (2017); Leroy and Lucotte (2017), among others. Due to the similarty between banking and the insurance industry, it is reasonable to use the same logic for both. However, the traditional 'competition-stability' view, from banking, argues that the market power of banks (concentrated market) leads to charging higher interest ratees and further increases in loan default rates, subsequently resulting in a less stable position (Boyd and Nicoló, 2005). Obviously, this explanation is inappropriate for application in the insurance industry. This is why the profit-reallocation effect is used to explain the competition-stability hypothesis (see Cummins, Rubio-Misas and Vencappa (2017)).

[2] For example, guaranty funds protect policyholders in the US. In the UK, a similar protection, the Financial Services Compensation Scheme (FSCS), prevents both customers and SMEs from suffering unexpected financial losses.

Due to the abovementioned interconnections between market structure and various firm-specific factors (performance, an insurer's stability and internal risk management) and their complexities, it is worth to reveal the impact of the interactions on the insurer's capital structure. Thus, the hypothesis can be developed as followed:

***H5**: The interaction between market structure and firm-specific factors affects the insurer's capital structure.*

Section 3.3 Data and Methodology

This section describes the empirical approach employed to examine the discussed hypotheses. The partial adjustment model that is employed to test the impact on capital structure is first described. Then, three key competition indicators are discussed, and the definitions of both explanatory and control variables follow. The database used in this chapter is built on information from financial statements of individual insurers, which included balance sheet and income statement, collected from Orbis, Fame and ISIS (or Insurance Focus), and provided by Bureau van Dijk. The World Bank database is the main source for those macro-economic data. The sample covers at least 90% of the market capacity in the UK market from 1998 to 2017. There is no required data for all years; therefore, unbalanced panel data is accepted. To ensure all monetary values are directly comparable, we deflate each year's value by the consumer price index to the base year 2015.

3.3.1 Data: Capital structure variable and Competition indicators

One of the critical contributions of this chapter is to test the impact of competition on the insurer's capital structure, and it is represented by Hypotheses 2 and 5. The choices/definitions of these two key measurements, capital structure and competition degree, are discussed here.

Capital structure variable

Two popular proxies are widely used to represent the insurer's capital structure. One is measured by the ratio of premium written to surplus, indicating insurer's leverage (*e.g.* Cummins and Lamm-Tennant, 1994; Shiu, 2011; Cheng and Mary A Weiss, 2012; Liu, Shiu and Liu, 2016). Another represents insurer's equity; it is measured by the ratio of surplus to the total asset (*e.g.* Cummins and Sommer, 1996; Baranoff, Papadopoulos and Sager, 2007; Mankaï and Belgacem, 2016). Because most of the U.K. insurers are not publicly traded, it is not available to use market value to define these measurements. Dhaene et al. (2017) pointed out that studies, which tested the logic of the trade-off and pecking order theories, are most likely to use leverage ratio to represent the insurer's capital structure. Following Dhaene et al. (2017) and Shiu (2011), the leverage ratio is adopted to test the discussed hypotheses. In line with Cheng and Mary A Weiss (2012) and Mankaï and Belgacem (2016), the traditional leverage ratio is calculated as the ratio of Net Premium to Surplus.

Market Structure indicators

Market structure (competition) can be measured by two approaches, named as a structural and non-structural approach.[1] By investigating the connection between structural method (HHI) and the non-structural one (Boone indicator) in container liner shipping industry, Sys (2000) find a conflicting result on the direction of change in competition between two methods. Creusen, Minne and Wiel (2006) achieve a similar conclusion by using four indicators from these two approaches to measure competition in the Netherlands. Among different non-structural models, on the one hand, Doan and Stevens (2012) and Clerides, Delis and Kokas (2015) show that a consistent result could be achieved from different non-structural indexes on measuring the degree of competition. On the other hand, Degryse, Kim and Ongena (2009) suggest that different models would carry different information on competition in the banking industry from various aspects. By comparing P-R *H* statistic and Boone indicator, Schaeck and Cihák (2014) also find that two measures are far from perfect negative correlation,[2] it may indicates different methods measure the competition concept in various ways.

As discussed in Appendix 3, all approaches have their own feaures, and face pros and cons. Similar to many previous studies (*e.g.* Mrabti, 2010; Delis, 2012; Kasman and Kasman, 2015; Leon, 2015; Tan, 2016), three different indicators, which are HHI, Lerner index and Boone indicator, are adopted to measure competition/concertation in the present study. By using multiple methods allows us to capture different concepts of market structure and to achieve a more robust result.

[1] Appendix 3 presents a discussion on various approaches to measure market structure.
[2] If two measures represent the same thing, it can be assumed that the correlation between them should be perfectly negative (at least, nearly). Because, the higher *H* statistic values in the range between negative infinity and one indicates that the more intense competition in the market, while, a more negative value signals more competition if the Boone indicators located between negative infinity and zero.

First, the Herfindahl-Hirschman Index (HHI) is used to proxy the structure of the U.K. insurance market. This HHI calculates as the sum of squares of the individual insurer's market share in the industry, thus

$$HHI_t = \sum_{i=1}^{n} ms_{it}^2 \times 10000$$

where ms_{it} is the market share of an insurer at time t, it is proxied as the ratio of an insurer's gross premium written to gross market premium. The index tells us that the higher the index, the more concentrated the market is. As a benchmark, an index that overs 1800 represents a highly concentrated market.

Secondly, the Lerner index is determined by adopting Kumbhakar, Baardsen and Lien's (2012) approach, which is based on stochastic frontier analysis, so-called "Stochastic" Lerner index. Coccorese (2014) also summaries some advantages concerning the usage of this approach, two of them are vital in this study. First, it provides a simple estimation, which originates from efficiency theory, avoids outside manipulation arose from the conventional two-step procedure[1]; second, non-negative Lerner index can be achieved. To be more specific, the SFA-Lerner index is defined as

$$SFA - Lerner_{it} = \frac{\theta_{it}}{1 + \theta_{it}}$$

Equation (3.1)

where θ_{it} is another definition of mark-up that can be expressed as

$$\theta_{it} = \frac{P_{it} - MC_{it}}{MC_{it}}$$

Equation (3.2)

in the fraction, the denominator is equal to $\frac{\partial TC_{it}}{\partial Q_{it}}$; and the numerator decribes the degree of mark-up, which can be estimated as the inefficiency term (u_{it} in "composed error term") by the stochastic frontier approach, as discussed below.

[1] In the conventional Lerner index approach, it contains two componets, which are prices and marginal cost. The first step is estimating the price and marginal costs separately. Then, to find the Lerner index calculated as the ratio of the mark-up (the difference between price and marginal cost) to price. By using the stochastic frontier approach to estimate Lerner index, the information on output prices is not required as the mark-ups is gathered from the stochastic frontier analysis.

According to Kumbhakar, Baardsen and Lien (2012) and Coccorese (2014), the strategy starts from the interpretation of the insurer's revenue-cost relationship[1] by using a stochastic cost frontier model, thus writing

$$\frac{TR_{it}}{TC_{it}} = RC_{it} = \sum_{g}^{2} \frac{\partial \ln TC_{it}}{\partial \ln Q_{igt}} + \nu_{it} + u_{it}$$

Equation (3.3)

Here, RC_{it} is the observed revenue-cost ratio. And $\sum_{g}^{2} \frac{\partial \ln TC_{it}}{\partial \ln Q_{igt}} + \nu_{it}$ is the minimum level RC_{it} can achieve, it is the frontier. Of which, ν_{it} represents a noise term that catches unobserved factors (e.g., optimization error) and $\sum_{g}^{2} \frac{\partial \ln TC_{it}}{\partial \ln Q_{igt}}$is referred as cost elasticity ($E_{TC,Q}$) with respect to output, and it can be computued from an estimated translog cost function[2] as

$$\frac{\partial \ln TC_{it}}{\partial \ln Q_{it}} = E_{TC,Q} = \alpha_q + \alpha_{qq} \ln Q_{it} + \sum_{j}^{2} \beta_{jh} \ln \frac{P_{jit}}{P_{3it}} + \alpha_{qt} T$$

Equation (3.4)

Therefore, substituting Equation 3.7 in Equation 3.3, the revenue-cost equation becomes:

$$RC_{it} = \frac{TR_{it}}{TC_{it}} = \alpha_q + \alpha_{qq} \sum_{i}^{2} \ln Q_{it} + \sum_{j}^{2} \alpha_{jq} \ln \frac{P_{ijt}}{P_{i3t}} + \mu_{tq} T + \nu_{it} + u_{it}$$

Equation (3.5)

Equation 3.5 now looks like the stochastic frontier model, then maximum likelihood estimation techniques and related distributional assumption of both ν_{it} and u_{it}

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[1] Coccorese (2014) exhibited a transformation from the mark-up relationship (i.e., $P_{it} \geq MC_{it}$) to revenue-cost relationship (i.e.,$TR_{it}/TC_{it} \geq \partial \ln TC_{it}/\partial \ln Q_{it}$), and explained why the mark-up can be derived from revenune-cost relationship by using stochastic frontier approach.

[2] The cost function with three input prices and two outputs takes the following the translog form:

$$\ln TC_{it} = \alpha_0 + \sum_{g}^{2} \alpha_g \ln Q_{igt} + \sum_{j}^{3} \beta_j \ln P_{ijt}$$
$$+ \frac{1}{2}\left[\sum_{g}^{2}\sum_{k}^{2} \alpha_{gk} \ln Q_{igt} \ln Q_{ikt} + \sum_{j}^{3}\sum_{h}^{3} \beta_{jh} \ln P_{ijt} \ln P_{iht}\right]$$
$$+ \sum_{g}^{2}\sum_{j}^{3} \delta_{gj} \ln Q_{igt} \ln P_{ijt} + \mu_1 T + \frac{1}{2}\mu_2 T^2 + \sum_{g}^{2} \rho_g T \ln Q_{igt} + \sum_{j}^{3} \xi_j T \ln P_{ijt}$$

where, TC_{it} represents insurer's total cost at time t. Consistence with value-added approach and insurance litertures (*e.g.* Cummins, Rubio-Misas and Zi, 2004; Hao and Chou, 2005; Cummins and Rubio-Misas, 2006; Yaisawarng, Asavadachanukorn and Yaisawarng, 2014), the outputs, Q_{igt}, is defined as net claims paid (claims incurred net of reinsurance) and total investment; and P_{ijt} measures the three input prices, i.e. labor, capital and technical reserves. The time trend variable (T) captures the changes over time in technology and underwriting cycle. In the function, the symmetry property requires that $\alpha_{gk} = \alpha_{kg}$, $\beta_{jh} = \beta_{hj}$ and $\delta_{gj} = \delta_{jg}$. Also, the linear homogeneity conditions are satisfied by imposing the restrictions as:$\sum \beta_j = 1, \sum\sum \beta_{jh} = 0, \sum\sum \delta_{gj} = 0, \sum\sum \xi_j = 0$. The procedure amounts to using one of the input prices (e.g., P_{3it}) to normalized total cost and other input price.

(i.e.,$u_{it} \sim N^{+}(0, \sigma_u^2), v_{it} \sim N^{+}(0, \sigma_v^2),$) are used to estimate the equation. u_{it} is estimated by using Jondrow *et al.*'s (1982) approach and it is able to capute the mark-up (and market power) of insurer i at time t, rather than cost inefficiency. A smaller estimated value of u_{it} indicates a lower amount of mark-up. Next, the resulting parameters from Equation 3.5 are substituted back to Equation 3.4 to generate $\widehat{E_{TC,Q}}$. Then both $\widehat{E_{TC,Q}}$ and u_{it} are used to calculate $\widehat{\theta_{it}}$ that can be used to find the SFA-Lerner index shown in Equation 3.1.

The last, in line with the theoretical work developed by (Boone, 2008) and the other empirical studies from Schaeck and Cihák (2010), (2014), Bikker and Popescu (2014), Liu, Mirzaei and Vandoros (2014) and Cummins, Rubio-Misas and Vencappa (2017), the indicator is constructed from the following basic form as:

$$\ln \pi_{it} \;\; or \;\; \ln MS_{it} = \alpha + \beta \ln MC_{it} + \varepsilon_{it}$$

Equation (3.6)

where MC_{it} is the mariginal cost of an insurer *i* at time *t*. The coefficienct of MC_{it}, which is expected to be negative[1], that is β, so-called Boone indicator; it indicates a relationship that an insurer with higher marginal cost will have less potentical ability to gain benefit relative to its counterparties, in a compeititve envirment. A larger β in absolute terms indicates a stronger competitive effect. The paramenter β, which is estimated by using a dynamic GMM panel model, is then used as one of the key regressors in the empirical investigation. The adoption of the GMM-style estimator is due to the fact that insurer's performance and cost are jointly determined; and one-year lags of explanatory variables and the GDP per capital are selected as instruments, see a similar adoption from Schaeck and Cihák (2014) and Cummins, Rubio-Misas and Vencapp (2017). As suggested by Kasman and Kasman (2015), the log-log function is used to deal with the issue of heteroscedasticity.

As shown in Equation 3.6, the dependent variable can be selected as either the insurer's profit π_{it} or its market share MS_{it} at time *t*. Canton *et al.* (2005) argue that any one of these is reasonable to choose because both would react stronger on marginal cost as the competition strengthened. Although the relative profit is originally used to develop the theory by Boone, observations with negative profit need to be dropped due to the

[1] According to van Leuvensteijn *et al.* (2011) and Tabak, Fazio and Cajueiro (2012), there is a possibility that the β can be positive, which means increasing firm's marginal cost will earn more market share. van Leuvensteijn *et al.* (2011) offered two reasons, (1) the level of collusion is exceptionally high in the market; (2) preventing new entrants by increasing the marginal cost in the market as a whole.

logarithms function form of the model. However, working with market share provides two advantages as mentioned by van Leuvensteijn *et al.* (2011); first, there is a clear visible relation between an individual's efficiency and market share. Secondly, market share only provides positive value. And another difference between these is that the profit represents the profitability of past businesses while the latter reflects the current business (Canton *et al.*, 2005).

Therefore, by following Bikker and Popescu (2014) and Bikker (2016), and the discussed advantages with using market share, the Equation 3.6 is modified as:

$$\ln MS_{it} = \alpha + \sum\nolimits_{t=1}^{T} \beta_t D_t \ln MC_{it} + \sum\nolimits_{t=1}^{T-1} \gamma_t D_t + \varepsilon_{it}$$

Equation (3.7)

where MS_{it}, which is the market share of insurer *i* at at time *t*, equals the ratio of an individual's premium written to the market premium at a time point. By involving both time dummy variables (D_t, for year 1 to T) and their interactions in the Equation 3.7, it is able to capture the time effect. And, ε_{it} is the error term.

The primary challenge of adopting Boone's (2008)'s approach is that the marginal cost needs to be constructed as it is not directly gatherable. The conventional method adopts to obtain marginal cost[1], which is derived from the translog cost function as showed on Page 150 and estimated it by using stochastic frontier analysis (Koetter, Kolari and Spierdijk, 2012). Then, the marginal cost can be expressed as the following form:

$$\begin{aligned} MC_{it} &= \sum\nolimits_{g}^{2} MC_{igt} = \sum\nolimits_{g}^{2} \frac{\partial TC_{it}}{\partial Q_{igt}} = \sum\nolimits_{g}^{2} \left(\frac{\partial \ln TC_{it}}{\partial \ln Q_{igt}}\right)\left(\frac{TC_{it}}{Q_{igt}}\right) \\ &= \sum\nolimits_{g}^{2} \frac{TC_{it}}{Q_{igt}} \left(\alpha_g + \alpha_{qg} \ln Q_{igt} + \frac{1}{2}\alpha_{qg} \ln Q_{ig't} + \sum\nolimits_{j}^{2} \beta_{jgh} \ln \frac{P_{jit}}{P_{3it}} + \alpha_{qgt} T\right) \end{aligned}$$

Equation (3.8)

<u>3.3.3 Data: Independent variables and other control variables</u>

Independent variables

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[1] Two methods are widely used to determine marginal cost in financial studies. First, an average cost, defines as the ratio of total cost (or management cost) to total premium (income), that is an easy calculated proxy of marginal cost (e.g., Schaeck and Cihák, 2010, 2014; Mirza, Bergland and Khatoon, 2016; Cummins, Rubio-Misas and Vencappa, 2017). Second, a marginal cost can be derived from a translog cost function, while it is a complex process (e.g., van Leuvensteijn *et al.*, 2011; Tabak, Fazio and Cajueiro, 2012; Kasman and Kasman, 2016). By using both methods, Bikker and van Leuvensteijn (2008) point out that outcomes from both a similar. However, average cost is less accurate due to the fact that no distinguish between variable and fixed costs (Canton *et al.*, 2005).

Following Pandey (2004), Guney, Li and Fairchild (2011) and Soedarmono, Machrouh and Tarazi (2013), the square term of competition is included to capture the non-linearity effect of competition on the insurer's capital structure. In addition, to test the other hypotheses on pecking order theory (H1b), firm's volatility (H3), the usage of reinsurance (H4) and their interactions with competition (H5), the key variables are defined below.

According to the pecking order theory, firms prefer to use internal sources to raise capital rather than external sources. Park and Pincus (2001) explain that using internal funding should be more efficient, and the cost of it should be lower than external sources. Therefore, the *Retained Earnings*, the primary source of internal funding, is collected from insurers' financial statements to verify Hypothesis 1b [1]. A negative relationship between Retained Earning is expected if the pecking order hypothesis is satisfied.

Firms with a higher level of volatility (lower stability) generally lower the leverage ratio to maintain financial soundness. According to Cummins, Rubio-Misas and Zi (2004) and Eling and Jia (2018), business volatility is one of the fundamental indicators to determine an insurer's failure, as a higher the business volatility would lead to a higher likelihood of insolvency. Therefore, it can be expected that there is a negative relationship between the insurer's volatility and its leverage level. Following both Eling and Marek (2014) and Eling and Jia (2018), *Income Volatility* is measured by the standard deviation of return on shareholder's fund (ROSF) with a three year rolling window. This indicator measures an insurer's return volatility at the firm's aggregated risk level. A higher figure represents that the insurer has less certainty of its future returns, and it may face a higher likelihood of failure. Thus, the insurer may need to pay more attention to monitor its risk-tolerance and capital position.

Eling and Marek (2014) also suggest that an insurer's volatilities come from various sources, not only its asset holdings but also its issued products, *etc*. Then, from this perspective, the insurer's volatility may also be raised from claim uncertainty associated with business written. To be more specific, the insurer has more uncertainties about the future value of losses (from claim/benefit payments), and thus contributes to the insurer's

[1] Alternatively, it is also reasonable to assume that the insurers with better abilities to generate profits should have sufficient internal funds that can be converted into capital as in the form of retained earnings. Thus, the insurer's profit efficiency, which is found by Stochastic Frontier Analysis, that is also adopted to make the robustness check.

aggregate level of risks, damaging its stability, when the loss ratio is highly volatile. Both Hoerger, Sloan and Hassan (1990) and Mankaï and Belgacem (2016) support that the increased loss (claim) volatility of claims would have an impact on the insurer's aggregated risk-level. Therefore, *Bussiness Volatility* is also involved to represent the insurer's volatility from another prespective, and it is approximated by the standard deviation of the loss ratio[1] with a three-year rolling window. So the expected impact of claim volatility is negative on the leverage ratio.

Regarding Hypothesis 4 - the impact of reinsurance uasge on the insurer's capital structure - the traditional ratio of Reinsurance Ceded to Gross Premium Written is used to denote *the usage of Reinsurance*. This measurement is widely used by Fecher *et al.* (1993), Lin, Lai and Powers (2014), Alhassan and Biekpe (2015), Liu, Shiu and Liu (2016), Cummins, Rubio-Misas and Vencappa (2017) and Sheikh, Syed and Ali Shah (2018), and among others. Then, Hypothesis 4 can be verified by concerning the coefficient of this variable, and a positive sign would be expected.

Control Variables

The cost of either raising or holding capital is a vital factor of the capital level (Modigliani and Miller, 1958; Kielholz, 2000). It is difficult to measure the cost of capital directly in practice. For example, Cummins and Lamm-Tennant (1994) suggested that the cost of equity capital should be estimated by using the CAPM. However, due to the lack of market data, the CAPM is not suitable to use. Following Mankaï and Belgacem (2016), the *cost of equity capital* is approximated by the most recent three-year average of positive return on shareholder's fund (ROSF).

Following both Shiu (2011) and Mankaï and Belgacem (2016), the insurer's *size* is included as one of the control variables. For instance, Shiu (2011) assumed a positive relationship between the firm size and leverage under trade-off theory, while a negative one appeared under the pecking order theory. The rationale for this relationship is that larger firms have easier access to capital markets and is easier to borrow at a favourable intereste rate (Ferri and Jones, 1979). The natural logarithm of total assets is used to measure the insurer's size.

[1] The loss ratio measures the total incurred losses in relation to the total gross premium written.

The insurer's *liquidity* is a widely used indicator to represent the ability to fulfill its the short-term obligations. Panno (2003) suggest two possible effects on capital structure. First, the postive relationship existes when the liquid assets are used to support a relative higher debt ratio. Second, if the liquid assets are used to finance finance the firm's investment,then a negative relationship can be expected. Current ratio, defined as the ratio of liquid asset to total liability, is used to represent the insurer's liquidity level.

In line with preceding literture from Pandey (2004), Chen *et al.* (2009), Najjar and Petrov (2011), Fier, McCullough and Carson (2013) and Chang *et al.* (2015), profitability is also chosen as a control variable. In this study, *Investment Return*, is measured as return on investment assets, denotes the insurer's profitability. In addition, according to Modigliani and Miller's (1963) tax shield effect, the insurer would like to use more debt when the tax rate is higher. Thus, the amount of *tax* payment is used and a positive relationship should be expected.

Following Sheikh, Syed and Ali Shah (2018), the *interest* rate and *inflation* are closely related to the insurer's capital structure. For example, an increase in the interest rate would result in bond price falling, and insurers then face questions of whether to issue new equity capital. However, issuing equity is costly due to various costs.[1] And inflation also has direct impact on premium pricing and bond pricing. For instance, higher inflation rates reduce the insurer's profit margins. Therefore, these two variables are included to control the cost of borrowing at the market level. Finally, *growth in GDP* is also included to control the overall economic condition.

3.3.4 Empirical Models and Estimation Techniques

Following Shrieves and Dahl (1992), Cummins and Sommer (1996), Baranoff and Sager (2002), Flannery and Rangan (2006), Cheng and Weiss (2012a), Lin, Lai and Powers (2014) and Mankaï and Belgacem (2016), a partial adjustment model is used to determine whether insurers have a target capital structure and the speed of adjustments, and then to test the discussed hypotheses related to different explanatory factors. In a frictionless world, the insurers would always maintain their target capital structure. However, the optimal capital structure is unobservable in the real world, and it is easy to

[1] For example, the transaction costs arising from underwriting and the adverse selection costs due to information asymmetry

vary across individual insurers and over time. The general target capital structure equation is estimated:

$$Capital\ ratio^{*}_{i,t} = \alpha X_{i,t}$$

Equation (3.9)

where $Capital\ ratio^{*}_{i,t}$ represents the measure of target capital structure, the leverage ratio is adopted in this study, for insurer *i* at time *t*. $X_{i,t}$ is a vector of the insurer's specific factors that influence the insurer's capital structure. α is the coefficients corresponding to the vactor of insurer's specific factors, and indicates a long-run impact of firm-specific factors on capital strcuture. And Equation (3.9) is an unbiased relationship (an equilibrium relation) in which the error term is not required. Then, the standard partical adjustment model is expressed as:

$$Capital\ ratio_{i,t} - Capital\ ratio_{i,t-1} = \delta\left[Capital\ ratio^{*}_{i,t} - Capital\ ratio_{i,t-1}\right] + \varepsilon_{i,t}$$

Equation (3.10)

in Equation (3.10), the difference in the capital ratio on the left-hand side indicates the actual change in capital from time *t-1* to *t*, that can be expressed as a fraction δ of the desired change for the same period, as shown on the right-hand side. According to Cheng and Weiss (2012a), δ is the short-run adjustment speed; if $\delta = 1$, it indicates that there are effective and instantaneous adjustments on capital towards the desired capital ratio in the same period. On the other hand, if $\delta = 0$, it means that there is no observable changed in capital from the previous time period *t-1*. And δ has the range between these two extreme values.

Then, substituting Equation (3.9) into Equation (3.10), the standard model becomes:

$$Capital\ ratio_{i,t} = (1-\delta)\left[Capital\ ratio_{i,t-1}\right] + (\delta\alpha)X_{i,t} + \varepsilon_{i,t}$$

Equation (3.11)

Equation (3.11) implies that insurers take steps to reduce the gap between the actual capital level and the desired level at each stage. As noticed, the short-run adjustment speed δ is caculated as 1 minus the coefficient of $Capital\ ratio_{i,t-1}$; and the long-run impacts from firm-specific factors on capital structure are given by the coefficient of X_{it} divided by δ. And Hypothesis 1a will be supported if $(1-\delta)$ is siginificant and less than 1.

By considering the above discussions on both the theoretical model and data definition, Equation 3.11 can be re-written as:

$$Leverage_{i,t} = (1-\delta)\left[Leverage_{i,t-1}\right] + (\delta\alpha_1)Market\ Structure_{i,t} + (\delta\alpha_2)Retained\ Earnings_{i,t} + (\delta\alpha_3)Volatilities_{i,t} + (\delta\alpha_4)Reinsurance_{i,t} + (\delta\lambda_n)Interactions_{i,t,n} + (\delta\phi_m)Controls_{i,t,m} + \varepsilon_{i,t}$$

Equation (3.12)

where $Leverage_i = NPW_i/Surplus_i$. Three different proxies of market stucture (*ie.* concentration, pricing power and competition), which are HHI, SFA-Lerner index and Boone indicator, are run separately. The $Interactions_{i,t,n}$ show the interacted terms between the proxies of market structure and the *nth* regressor[1]. The purpose of including the interaction terms is to exam the combined effect on the insurer's capital structure. To be more specific, the interaction term is of key interest as the siginifcant coefficient ($\delta\lambda_n$) should be indicative of either the potential effect of the market structure on the relationships between capital structure and four regressors, or the joint effect of market structure and four regressors on the insurer's capital structure. Similar approaches, in which a interaction term between the proxy of market structure and another regressor is involved to determine the joint impact, can be found from Schaeck and Cihák (2012), Tabak, Fazio and Cajueiro (2012), Soedarmono, Machrouh and Tarazi (2013), Ryan, O'Toole and McCann (2014) and Saadaoui (2014).

Nevertheless, apart from determining the driving force on the insurer's capital structure, testing the dominance between trade-off theory and pecking order theoty is essential. As indicated by Cheng and Weiss (2012a), it is useful to test the impacts on change in capital structure (i.e., change in leverage) because it is not only providing further evidence on pecking order theory but also testing the relative importance of two theories. Thus, based on this purpose, Equation 3.12 will re-run with the dependent variable of $\Delta Leverage_{i,t}$.[2] Under the pecking order theory, the coefficient of Retained Earnings is expected to be negative and siginificant.[3] The relative importance of two theories can be tested by comparing the economic impact of a one-standard-deviation change in the leverage and

[1] Regressors includes the variables of the leverage ratio, retained earnings, volatilities and reinsurance.
[2] Then, the change in capital structure equation can be expressed as:

$$\Delta Leverage_{i,t} = (\delta)\left[Leverage_{i,t-1}\right] + (\delta\alpha_1)Market\ Structure_{i,t} + (\delta\alpha_2)Retained\ Earnings_{i,t} + (\delta\alpha_3)Volatility_{i,t} + (\delta\alpha_4)Reinsurance_{i,t} + (\delta\phi_m)Controls_{i,t,m} + \varepsilon_{i,t}$$

where $\Delta Leverage_{i,t} = Leverage_{i,t} - Leverage_{i,t-1}$, and the other variables are defined as before.
[3] Cheng and Weiss (2012a) used the variable of financial deficit to test pecking order theory and expected a siginificant positive sign. However, a more direct indicator – retained profit – is used in this study. Then, the coefficient $\delta\alpha_2$ is expected to be negative under pecking order theory.

retained earnings variables.[1] According to Cheng and Weiss (2012a), the trade-off theory is more important than pecking order theory if the economic impact of leverage is larger than the economic impact of retained earning; otherwise, the pecking order theory dominants the trade-off theory. The results from Cheng and Weiss's (2012a) insurance study indicates the trade-off is more important.

Then, in the first step, the main regression model (*i.e.* Equation 3.12) are estimated using the OLS fixed effect estimator.[2] Because of the inclusion of a lagged dependent variable, the problem of endogeneity could be another important econometric issue need to be considered. Then, the dynamic panel Generalized Method of Moments (GMM) model[3], which was developed by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998), is used to control the bias raised from endogeneity. The one-year lags of the explanatory variables are chosen as instrument variables; this approach is in line with the literature on dynamic panel models, such as Koetter, Kolari and Spierdijk (2012), Schaeck and Cihák (2014) and Liu and Zhang (2016).

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[1] Following Flannery and Rangan (2006) and Cheng and Weiss's (2012a) approaches, the the economic impact (E.I.) of a one-standard-deviation change in the Leverage is computed as:

$$\text{E. I. of Leverage} = \frac{\text{coefficient for } lagged\ Leverage \times \text{s. d. of } target\ Leverage}{\text{standard deviation of the } predicted\ value \text{ for } \Delta Leverage}$$

where the coefficient for *lagged Leverage* (i.e., δ) and the *predicted value for* $\Delta Leverage$ can be caputed from Eqaution 3.12 and Equation shown in Footnote 1 by using OLS regressions, respectively; and the *target Leverage* can be found using Equation 3.1. In order to test the relative importance of two theories, the regression is run without interaction terms. Similarly, the economic impact of Retained Earning (E.I. of RE) variableis found by caculating :

$$\text{E. I. of RE} = \frac{\text{coefficient for Retained Earning} \times \text{s. d. of Retained Earning}}{\text{standard deviation of the } predicted\ value \text{ for } \Delta Leverage}$$

[2] The null hypothesis of Hausman's (1978) test is rejected, suggesting that the fixed effect estimator is prefered.

[3] The Difference-GMM model, which is developed by Arellano and Bond's (1991), uses the differencing in regressors. The DIF-GMM method specifies the model as a system of equations and it allows instruments (e.g., lags value of the endogenous variables) applicable to each equation to vary. However, the weakness of this method is that the lagged levels will be poor instruments if the first-differenced variables are close to a random walk. A System-GMM was modified by Arellano and Bover (1995) and Blundell and Bond (1998) based on Arellano and Bond's (1991) model. They assumed that the first differences of instrument variables are uncorrelated with the fixed effects, and both lagged levels as well as lagged value of the difference are included in SYS-GMM estimations. Thus, these allow more instruments to be introduced and improve efficiency of estimation. In this paper, the STATA command “xtabond2”, written by Roodman (2009), is adopted. He summed up the above discussions and apply the “Windmeijer finite-sample correction” to the two-step standard errors that tend to be downward; this can make two-step estimations more efficient than one-step, especially for SYS-GMM. And the details of this correction could be found in (Windmeijer, 2005)’s study. Then, the two-step SYS-GMM is adopted in this chapter.

Section 3.4 Results and Discussions

Table 3.1 shows the descriptive statistics of the firm-specific and market-specific variables used to test hypotheses 1-5. Table 3.2 presents the correlation between the discussed variables. The highest correlation coefficient of 0.50 is observed between Retained Earnings and Firm Size. It may lead to the potential issue of multicollinearity. Then, the variance inflation factor (VIF) analysis is computed for all independent variables. The highest individual score is 1.79 from Inflation Rate, and the overall score is 1.32; these are well below the commonly accepted threshold value of 10 (see, Kennedy (1998)). Thus, multicollinearity is unlikely to be a serious issue in this study.

[Table 3.1: Descriptive Statistics insert here]

[Table 3.2 Correlation Coefficient Matrix insert here]

Table 3.1: Descriptive Statistics

Variables	Function	Observations	Mean	Median	Standard Deviation	Min	Max
Leverage	Dependent Variable	7193	2.6406	0.8576	5.2286	0.0000	25.2320
Retain Earning	Hypothesized Variable	9555	232.5543	13.7694	884.6509	-1395.3488	3804.9587
Boone Indicator	Hypothesized Variable	24820	0.6939	0.7359	0.3039	-0.1214	1.1439
Lerner Index	Hypothesized Variable	4501	0.1142	0.0823	0.0897	0.0052	0.8536
HHI	Hypothesized Variable	24820	0.0347	0.0327	0.0062	0.0283	0.0508
Income Volatility	Hypothesized Variable	8942	2.1957	2.2800	1.4377	-6.7639	5.0513
Business Volatility	Hypothesized Variable	7942	1.6966	0.0867	5.6678	0.0000	38.8700
Reinsurance	Hypothesized Variable	7569	0.3540	0.2272	0.3614	0.0000	1.5158
Cost of Equity	Control Variable - Firm	10889	19.0959	9.7950	36.0308	-77.3371	143.5897
Firm Size	Control Variable - Firm	10625	7.9381	7.9312	2.4717	2.9716	12.9566
Liquidity	Control Variable - Firm	9923	0.5761	0.6259	0.3170	0.0000	19.2411
Investment Return	Control Variable - Firm	9398	0.3430	0.0310	9.5262	-34.9300	784.0000
Tax Payment	Control Variable - Firm	7535	142.1947	6.4440	1256.0476	-36015.5039	44446.2810
Interest rate	Control Variable - Market	27302	3.1222	3.8750	2.4203	0.2500	7.2500
Inflation Rate	Control Variable - Market	27302	1.9144	1.8891	0.8303	0.3680	3.8561
GDP Growth	Control Variable - Market	27302	2.1064	2.4102	1.6518	-4.1878	4.0382

Notes: *Leverage* is the ratio of Net Premium Written to Surplus. *Retain Earnings* is the retained profit shown on the income statement. *Boone Indicator* is calculated by using firm's market share and marginal cost, and the negative coefficient β denotes the Boone indicator; hence, a larger negative value of β is indicating a more competitive market. In this study, a positive Boone Indicator is adopted by timing the negative β with -1. Thus, the larger the value of the Boone indicator denotes that a more competitive market. *Lerner Index* is calculated by using Stochastic Frontier Analysis (SFA) involved with two outputs and three inputs. The larger the Lerner index indicates that the firm has more mark-up power, then the market is more (less) concentrated (competitive). *HHI* is the Herfindahl-Hirschman Index is based on market share. A higher index (beyond 1800) means the market is concentrated. *Income Volatility* is the the standard deviation of return on shareholder's fund (ROSF) with a three year rolling window. *Bussiness Volatility* is the standard deviation of the loss ratio with a three-year rolling window. *Reinsurance* is the ratio of reinsurance ceded to gross premium written. *Cost of Equity* is measured as the most recent three-year average of return on shareholder's fund. *Firm Size* is the natural logarithm of the insurer's total assets. *Liquidty* is the ratio of liquid asset to total liability. *Investment Return* is the return on investment assets. *Tax Payment* is the amount of tax payment shown on financial statement. Market variables - *Interest Rate, Inflation Rate and GDP Growth* - are collected from World-Bank database. To mitigate the confounding effects of outliers, some firm-specific variables are winsorized at 3% level at each tail and further take natural logarithm to ensure the distribution is normally skewed.

Table 3.2: Correlation Coefficient Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Leverage	1.00															
2. Retained Earning	-0.07*	1.00														
3. Boone Indicator	-0.05*	0.09*	1.00													
4. Lerner Index	-0.19*	0.04*	**0.05***	1.00												
5. HHI	-0.05*	0.03	**0.32***	**0.01**	1.00											
6. Income Volatility	0.23*	-0.00	-0.04*	-0.00	-0.06*	1.00										
7. Business Volatility	-0.06*	-0.01	0.04	0.15*	0.00	-0.02	1.00									
8. Reinsurance	-0.13*	-0.10*	0.03	0.17*	0.02	0.05*	0.01	1.00								
9. Cost of Equity	0.35*	0.04	0.02	0.06*	-0.08*	0.24*	-0.04	-0.03	1.00							
10. Firm Size	0.12*	0.50*	0.08*	-0.25*	0.05*	0.07*	0.00	-0.11*	0.05*	1.00						
11. Liquidity	0.06*	-0.11*	-0.01	-0.14*	0.02	0.06*	-0.07*	-0.07*	0.02	-0.06*	1.00					
12. Investment Return	0.06*	0.05*	-0.08*	0.06*	-0.07*	0.04*	-0.02	-0.06*	0.03	0.01	-0.02	1.00				
13. Tax Payment	-0.02	0.38*	0.05*	-0.04	0.01	-0.02	-0.02	-0.08*	0.05*	0.31*	-0.05*	0.02	1.00			
14. Interest rate	0.05*	-0.01	-0.27*	-0.01	-0.29*	0.01	-0.07*	-0.02	0.07*	-0.00	0.13*	0.17*	0.04	1.00		
15. Inflation Rate	0.04	0.06*	-0.38*	-0.03	-0.44*	0.08*	0.00	-0.01	0.10*	-0.02	-0.09*	0.02	0.00	-0.17*	1.00	
16. GDP Growth	-0.02	-0.04	-0.09*	-0.02	0.03	-0.11*	-0.04	-0.02	-0.04*	0.02	0.04*	0.06*	0.02	0.44*	-0.30*	1.00

Notes: The highest correlation coefficient is 0.50, observed between Retain Earnings and Firm Size, raising the potential issue of multicollinearity.
The variance inflation factor (VIF) analysis is computed for all the independent variables.
The highest individual score is 1.79 from Inflation Rate, and the overall score is 1.32.
These are well below the commonly accepted threshold value of 10 (see, (Kennedy, 1998)). Thus, multicollinearity is unlikely to be a serious issue in this study.
A positive Boone Indicator is adopted by timing the negative β with -1. Thus, the larger the value of this positive Boone indicator denotes that the market is more competitive.
* represent statistical significance at 5% level at least.

3.4.1 Market Structure Estimations

Table 3.3 presents, by year, the results of three proxies for market structure over the study period, from three different perspectives—the Boone indicator, the Lerner index and the HHI. The Boone indicator is estimated by regressing the marginal cost on the insurer's market share, as discussed in Section 3.3. The negative coefficient of the marginal cost is the Boone indicator, as shown in Table 3.3; increasingly negative figures indicate that the insurance market is more competitive. The second proxy of market structure is the non-negative Lerner index, which is estimated by SFA; the higher the index, the more pricing power (or market power) the individual insurer has. This also indirectly denotes that the level of competition (concentration) is low (high) in the market. The HHI is a direct measurement of market concentration; the higher the value, the more concentrated the market. Figures 3.1 and 3.2 are the graphic representations of the values presented in Table 3.3; with the former indicating the trends of market structure from 1998 to 2017 and the latter representing annual fluctuations.

Figure 3.1 suggests that there is a trend of growth from all three market structure measurements over the studied period. Specifically, this trend in the (positive) Boone indicator represents competition become more intense in the UK insurance market. However, the increasing trend in both the Lerner Index and the HHI suggests that the market is becoming less competitive (or more concentrated) over time. These contradictory results further confirm Claessens and Laeven's (2004) and Sekkat's (2009) suggestions, which reveal highly competitive behaviour in a concentrated market. This finding is also confirmed by the significant and positive correlation between the Boone indicator and the Lerner index (or the HHI), as shown in Table 3.2.

Apart from the smoothed trend shown in Figure 3.1, Figure 3.2 represents how the market structure changes from different perspectives by year, without the smoothing effect. From both Table 3.3 and Figure 3.2, the Boone indicator and the Lerner index begin to increase around 2000 to 2001; then, the increasing trend stops around 2008 and begins to decrease significantly. The movement suggests that the intensities of market competition and concentration (or mark-up power) were reduced during the most recent financial crisis and reached the least intensity around 2011. Although the direct measurement of market concentration—HHI—does not have a similar movement pattern, it still shows that the degree of concentration is being affected by the financial crisis, and there are frequent fluctuations during a similar period. Furthermore, the intensity of all three measurements begins to raise with small fluctuations around 2012 and achieves the most intensive level in 2016. From Table 3.3, it is also worth mentioning that the HHI value across the study period is far below the threshold value of 1,800, which is used to identify whether the market is concentrated. This suggests that the degree of market concentration is low.

Table 3.3: Market Structure Indicators

Year	Boone Indicator	Lerner Index	HHI
1998	-0.44491	0.11646	0.02888
1999	-0.53710	0.10019	0.02906
2000	-0.27441	0.08909	0.03028
2001	-0.40755	0.08563	0.03932
2002	-0.50831	0.08961	0.03920
2003	-0.51145	0.09969	0.04123
2004	-0.62805	0.09875	0.02987
2005	-0.73718	0.10958	0.02961
2006	-0.94905	0.10142	0.03213
2007	-0.76229	0.11128	0.03328
2008	-0.73455	0.12995	0.03136
2009	-0.83528	0.12853	0.03355
2010	-0.84924	0.12785	0.03215
2011	0.12143	0.10986	0.03330
2012	-0.81878	0.11667	0.02831
2013	-0.64621	0.11565	0.03018
2014	-1.14392	0.11974	0.03398
2015	-1.07683	0.11000	0.04199
2016	-1.10279	0.12948	0.05085
2017	-1.03182	0.12675	0.04633
Average	-0.69391	0.11360	0.03507

Notes: Boone Indicator is calculated by using firm's market share and marginal cost, and the negative coefficient β of marginal cost denotes the (negative) Boone indicator as shown in this table; hence, a larger negative value of β is indicating a more competitive market. In the following, a positive Boone Indicator is adopted by timing the negative β with -1, as shown in Figure 3.1 and 3.2. Thus, the larger the value of the positive Boone indicator denotes that the market is more competitive. *Lerner Index* is calculated by using Stochastic Frontier Analysis (SFA) involved with two outputs and three inputs. The larger the Lerner index indicates that the firm has more mark-up power; it further presumes the market is more (less) concentrated (competitive). *HHI* is the Herfindahl-Hirschman Index is a traditional measurement of market concentration. A higher index (beyond 1800) means the market is more concentrated.

Figure 3.1: Changing of Market Structure in the UK insurance Market with Smoothing Effect

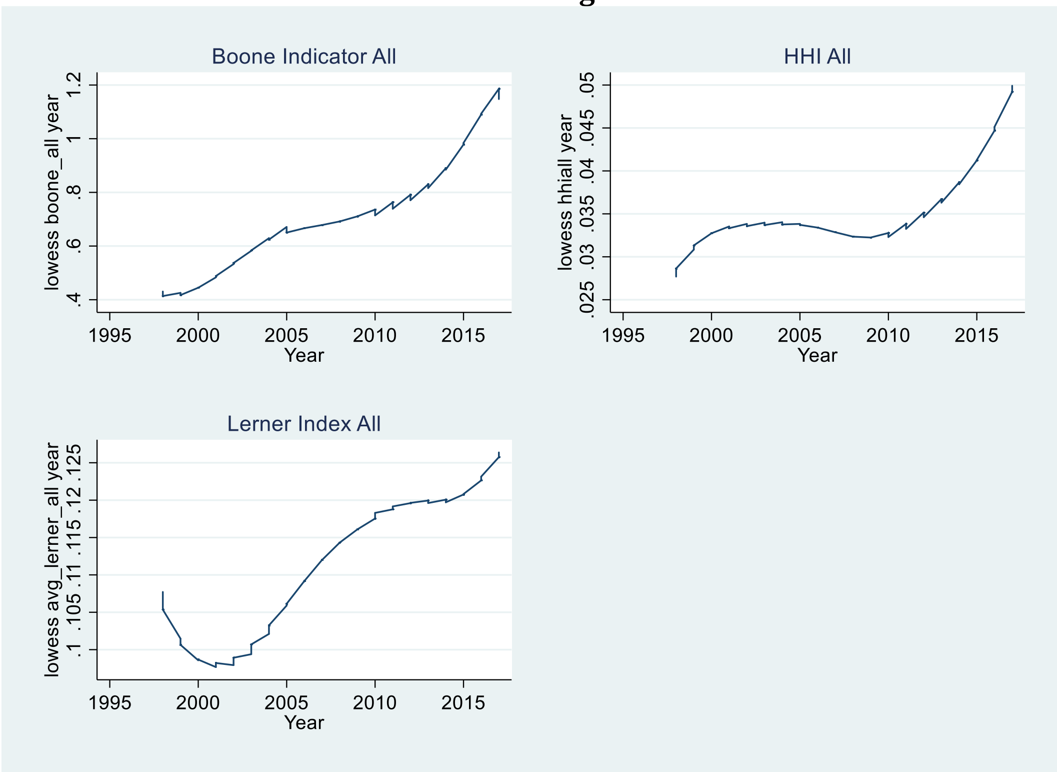
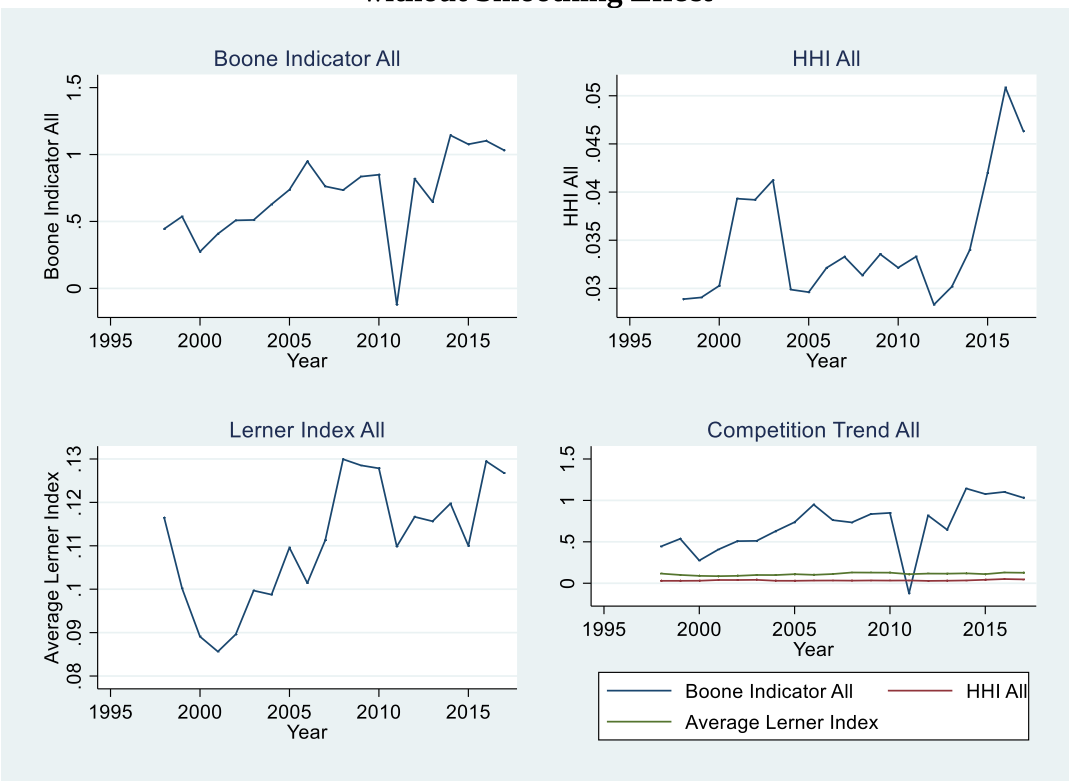


Figure 3.2: Changing of Market Structure in the UK insurance Market without Smoothing Effect



Clearly, the indications raised from these three different proxies of market structure contradict each other in some respects. The possible explanation for this might be found in the fact that these measurements enclose different information, as discussed in Section 3.3.1. To be more specific, the Boone indicator presents the degree of competition directly after considering the reallocation effect; the Lerner index denotes an individual's pricing power as suggested by Beck, De Jonghe and Schepens (2013a); and the traditional HHI is a direct proxy of market concentration. More carefully, the Boone indicator takes a leading role, with one to two years' lead-time, in terms of evolution, compared to the Lerner index and the HHI. This may indicate that competition leads to an increase in insurers' market power and market concentration. Therefore, it is inappropriate to explain these three measurements with only one unique definition, such degree of competition. In the rest of this study, market structure will be represented by three different concepts—competition, pricing power and concentration—as these are not mutually exclusive. Moreover, the impact of market structure on individuals' capital structure is also revealed from these three perspectives.

3.4.2 Panel Estimations

By following Goddard, Molyneux and Wilson (2004) and Mamatzakis and Bermpei (2016), the main regression model is estimated using both OLS fixed effect estimation and the dynamic panel Generalized Method of Moment (GMM) model. The former not only eliminate the impact of time-invariant effect and to capture unobserved firm-specific characteristics (heterogeneity across firms), but also represents the long-run relationship. The GMM model is used to address the potential endogeneity issue that may arise in the OLS estimation; meanwhile, it can be used to further estimate the dynamic features of the model, which is the short-run relationship. Therefore, a comprehensive story, in which variabilities existed between the long-run relationship and the short-run relationship are considered, can be provided by comparing the results from these two models.

This section presents the results of the main model—Equation (3.12). To be more specific, Tables 3.4 and 3.5 illustrate the estimations of Equation (3.12), which reveals the impact of individual factors on an insurer's leverage ratio. Hypothesis 1 to Hypothesis 4 can be verified by the results in these two tables. Regarding Hypothesis 5, the results from Tables 3.6 to 3.11 disclose the impacts of the interactions between individual factors and market structure on insurers' capital structures.

3.4.2.1 Trade-off Theory, Pecking order Theory, Market Structure, Volatilities and Reinsurance

Tables 3.4 and 3.5 present the results of the OLS fixed effects and the GMM dynamic panel regressions, respectively. Models 1 and 9-11 show that the coefficient of the lagged leverage is significantly positive and less than one. Thus, Hypothesis 1a is supported. It indicates that insurers should have a target capital structure and continuously adjust it toward its optimal level. Then the trade-off theory is supported, it indicates that the UK insurers seek to balance the benefit against the cost of holding leverage to achieve maximized value and the firm takes actions to try to return to the optimum balanced level.

Hypothesis 1b is also valid because the coefficient of retained earnings is negative and significant, as shown in Models 2 and 9-11. The validity of Hypothesis 1b indicates that insurers may prefer internal financing over external financing. As discussed in the introduction, it is reasonable for two reasons: 1. Cost of external financing is higher than cost of internal financing; 2. Issuing new shares harm the value of current shareholders. These results are valid in both OLS fixed effects and GMM models and are consistent with findings from Cheng and Weiss (2012), who also reveal the existence of both trade-off and pecking-order behaviour in the US insurance market.

Overall, the results suggest that insurers prefer internal financing to achieve an optimal capital structure. Apart from testing the appearance of these two theories, the regression models, with the dependent variable of changing the leverage ratio, are estimated to test the relative importance between two fundamental theories.[1] The result indicates that the pecking-order theory dominates the trade-off theory in the UK insurance market.

To verify Hypothesis 2, in which the impact of market structure on insurers' capital structure is discussed, three proxies are used to represent market structure from different concepts. Although these proxies explain the concept of market structure from different perspectives, their impacts on insurers' capital structures are consistent and negative.

[1] Adopting the methodology described by Cheng and Weiss (2012) alongside the regression results from Models 9-11 in Table 3.4, the economic impact of change in leverage and retained earnings is found. (Table A3.1 in Appendix 3 shows the results of OLS regression on change in leverage, and the summaries of the economic impacts are shown in Table A3.2). Across all models, the economic impacts of retained earnings are larger than the economic impacts of leverage. Thus, it is reasonable to suggest that the pecking-order theory dominates the trade-off theory in the UK insurance market. This result further confirms that insurers would like to use internal sources to achieve target capital structures.

Evidence can be found from Models 4-5 and 9-10 in Tables 3.4 and 3.5. The negative coefficients mean that the corresponding market structure variables are inversely related to the insurers' leverage ratios. Specifically, insurers may reduce the use of leverage when it has greater -pricing power, as indicated by the negative coefficient of Lerner index. On the other hand, the negative coefficient of Boone indicator suggests that the insurers' leverage ratio can be reduced when the market is competitive. It is also worth to know that these two results do not conflict with each other, because the increased pricing power can be a result of intensive competition. The coefficient of market concentration—HHI—is negative, but it is not strongly significant. That is, weak significance can be found only in Model 11 in Table 3.5. The observed negative relationship is consistent with findings from Soedarmono, Machrouh and Tarazi (2011); Beck, De Jonghe and Schepens (2013b); Schaeck and Cihák (2014); and Guidara and Lai (2015). These authors used different proxies to represent various concepts of market structure. However, Cummins, Rubio-Misas and Vencappa (2017) suggest that insurers hold less equity capital (more leverage) when competition becomes intensive.

Table 3.4: Individual Effect of Factors on Capital Structure – OLS

VARIABLES	(1) H1a Leverage	(2) H1b Leverage	(3) H2a Leverage	(4) H2b Leverage	(5) H2c Leverage	(6) H3a Leverage	(7) H3b Leverage	(8) H4 Leverage	(9) Boone Leverage	(10) Lerner Leverage	(11) HHI Leverage
Lagged Leverage	0.2799***								0.1939***	0.2401***	0.1961***
	(3.724)								(3.066)	(3.765)	(3.080)
Retained Earnings		-0.2002***							-0.1221***	-0.1269**	-0.1336***
		(-3.916)							(-2.587)	(-2.572)	(-2.704)
Boone Indicator			-0.4959***						-0.3856**		
			(-2.613)						(-2.131)		
Lerner Index				-2.5377***						-1.8258***	
				(-3.530)						(-2.702)	
HHI					-0.0097						0.0068
					(-1.012)						(1.039)
Income Volatility						0.1827***			0.1604**	0.0940**	0.1674***
						(3.609)			(2.491)	(2.020)	(2.599)
Business Volatility							-0.0548***		-0.0369**	-0.0182	-0.0409**
							(-3.488)		(-2.015)	(-1.005)	(-2.195)
Reinsurance								-0.4280***	-0.2796***	-0.1487**	-0.2826***
								(-4.824)	(-4.015)	(-2.427)	(-4.023)
Cost of Equity	-0.0084*	0.0011	-0.0017	0.0192**	-0.0022	-0.0036	-0.0040	-0.0009	-0.0042	0.0128*	-0.0046
	(-1.649)	(0.208)	(-0.321)	(2.578)	(-0.421)	(-0.581)	(-0.675)	(-0.157)	(-0.648)	(1.944)	(-0.712)
Firm Size	-0.2455*	-0.1382	-0.1695	-0.0740	-0.1805	-0.1996	-0.3235**	-0.2499	-0.4203**	-0.0247	-0.4508**
	(-1.762)	(-1.098)	(-1.235)	(-0.548)	(-1.329)	(-1.393)	(-2.322)	(-1.635)	(-2.232)	(-0.253)	(-2.420)
Liquidity	0.0546	0.0814	0.0878	-0.0054	0.0889	0.0888	0.0444	-0.0031	0.0034	-0.0314	-0.0025
	(0.940)	(1.406)	(1.463)	(-0.107)	(1.456)	(1.443)	(0.668)	(-0.044)	(0.057)	(-0.567)	(-0.040)
Investment Return	0.1151***	0.1128***	0.1130***	2.8898***	0.1132***	0.1137***	0.1073***	0.2562***	0.2378***	7.8786***	0.2331***
	(2.789)	(2.838)	(2.768)	(3.217)	(2.815)	(2.855)	(2.725)	(6.675)	(6.318)	(2.693)	(6.167)
Tax Payment	-0.0154	0.0014	-0.0201	-0.0433	-0.0223	-0.0250	-0.0215	-0.0198	-0.0031	-0.0359	-0.0017
	(-0.945)	(0.108)	(-1.266)	(-0.865)	(-1.368)	(-1.353)	(-1.254)	(-1.532)	(-0.319)	(-0.866)	(-0.170)
Interest rate	0.1206***	0.1631***	0.1455***	0.0815***	0.1510***	0.1550***	0.1444***	0.1015***	0.0543*	0.0110	0.0724**
	(5.154)	(5.915)	(5.574)	(2.891)	(5.604)	(5.220)	(4.343)	(3.332)	(1.900)	(0.421)	(2.452)
Inflation Rate	-0.0213	-0.0115	-0.1062	-0.0054	-0.0431	-0.0263	-0.0378	-0.0477	-0.1405**	-0.0261	-0.0460
	(-0.395)	(-0.211)	(-1.415)	(-0.122)	(-0.839)	(-0.439)	(-0.677)	(-0.947)	(-2.263)	(-0.732)	(-0.936)
GDP Growth	-0.0133	-0.0394**	-0.0472***	-0.0132	-0.0368**	-0.0267	-0.0426**	-0.0237	0.0009	0.0091	0.0063
	(-0.836)	(-2.321)	(-2.818)	(-0.682)	(-2.187)	(-1.431)	(-2.330)	(-1.128)	(0.044)	(0.466)	(0.318)
Constant	3.4079***	2.9585***	3.8647***	2.3248**	3.7866***	3.0811**	4.9365***	3.3744**	4.9605***	0.7681	4.4707***
	(2.763)	(2.735)	(3.593)	(2.099)	(3.008)	(2.484)	(3.949)	(2.458)	(3.052)	(0.847)	(2.839)
Observations	4,677	5,398	5,120	3,082	5,120	4,860	4,485	4,452	3,511	2,281	3,511
Number of Firms	630	664	642	540	642	638	608	594	533	447	533
Adjusted R-squared	0.153	0.073	0.074	0.055	0.071	0.083	0.087	0.120	0.210	0.189	0.208
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	8.47***	7.1***	5.95***	10.82***	5.88***	8.34***	6.83***	13.61***	14.71***	5.84***	14.73***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.5: Individual Effect of Factors on Capital Structure - GMM

VARIABLES	(1) H1a Leverage	(2) H1b Leverage	(3) H2a Leverage	(4) H2b Leverage	(5) H2c Leverage	(6) H3a Leverage	(7) H3b Leverage	(8) H4 Leverage	(9) Boone Leverage	(10) Lerner Leverage	(11) HHI Leverage
Lagged Leverage	0.3976***	0.4381***	0.5144***	0.3860***	0.3807***	0.4505***	0.2982***	0.2081***	0.2784***	0.3344***	0.2750***
	(4.616)	(4.436)	(4.003)	(4.896)	(4.453)	(3.814)	(3.008)	(2.698)	(3.735)	(3.831)	(3.471)
Retained Earnings		-0.7552***							-0.0889*	-0.2761**	-0.2694*
		(-3.461)							(-1.711)	(-2.001)	(-1.679)
Boone Indicator			-0.3971***						-0.5454***		
			(-3.077)						(-2.750)		
Lerner Index				-1.5088**						-2.6762*	
				(-1.999)						(-1.898)	
HHI					-0.0019						-0.0120*
					(-0.363)						(-1.695)
Income Volatility						0.2169**			0.2961***	0.2860*	0.3914***
						(2.262)			(3.322)	(1.881)	(3.282)
Business Volatility							-0.0314*		-0.0325	-0.0736*	-0.1958*
							(-1.884)		(-0.916)	(-1.732)	(-1.893)
Reinsurance								-0.3659**	-0.3173**	-0.4241***	-0.3114***
								(-2.373)	(-2.559)	(-3.404)	(-2.796)
Cost of Equity	0.0031	0.0038	-0.0041	0.0023	0.0061	0.0058	-0.0020	-0.0004	0.0015	0.0138*	0.0055
	(0.483)	(0.609)	(-0.379)	(0.311)	(0.667)	(0.778)	(-0.204)	(-0.048)	(0.125)	(1.691)	(0.796)
Firm Size	0.2669**	0.3190**	0.3001**	0.3010	0.3904**	0.2577*	0.3259**	-0.2275	0.0409	0.1924	0.0260
	(1.993)	(2.065)	(2.322)	(1.519)	(2.339)	(1.688)	(2.026)	(-0.994)	(0.191)	(0.912)	(0.136)
Liquidity	0.2308*	0.0111	0.1156	0.1639*	0.1051	0.0636	0.0988	0.0978	0.2807	0.0619	-0.0242
	(1.901)	(0.045)	(0.386)	(1.758)	(0.882)	(0.603)	(0.158)	(0.769)	(1.147)	(0.500)	(-0.154)
Investment Return	0.1917**	0.2624**	0.1292**	2.2950*	0.1485*	0.1099*	0.2826*	0.3005***	0.3360***	-3.2517	0.2607**
	(2.105)	(2.272)	(2.010)	(1.929)	(1.916)	(1.656)	(1.908)	(7.094)	(3.435)	(-1.201)	(2.370)
Tax Payment	-0.2891*	0.0811**	-0.0093	0.0066	-0.0159	0.0029	-0.5443	-0.0346	-0.0115	0.1317	0.0126
	(-1.724)	(2.226)	(-0.764)	(0.073)	(-0.666)	(0.089)	(-0.997)	(-1.514)	(-1.034)	(0.966)	(0.181)
Interest rate	0.0460*	0.0286	0.0072	0.0198	0.0243	0.0330	0.0506	0.0735*	-0.0259	0.0066	-0.0174
	(1.840)	(0.803)	(0.225)	(0.629)	(0.733)	(1.000)	(1.603)	(1.807)	(-0.637)	(0.154)	(-0.521)
Inflation Rate	-0.0279	0.0013	-0.0977*	0.0320	-0.0070	-0.1260*	-0.0354	-0.1109	-0.1245*	-0.0234	-0.0881**
	(-1.376)	(0.031)	(-1.956)	(0.468)	(-0.097)	(-1.790)	(-0.620)	(-1.177)	(-1.920)	(-0.326)	(-2.208)
GDP Growth	-0.0036	-0.0068	-0.0143	-0.0235	0.0095	-0.0025	-0.0004	-0.0770**	0.0361*	0.0152	0.0223
	(-0.335)	(-0.308)	(-0.991)	(-0.847)	(0.874)	(-0.075)	(-0.031)	(-2.265)	(1.846)	(0.384)	(1.286)
Constant	-1.2497	-1.7838	-1.1957	-1.6012	-2.3816*	-1.5652	-1.5654	2.9051	0.4766	-1.7214	0.2180
	(-1.148)	(-1.402)	(-1.088)	(-0.986)	(-1.857)	(-1.237)	(-1.177)	(1.536)	(0.283)	(-0.869)	(0.119)
Observations	4,677	4,624	4,519	2,749	4,519	4,651	4,308	3,813	3,354	1,748	3,215
Number of Firms	630	628	616	511	616	629	601	562	503	385	479
Number of Instruments	108	95	106	157	148	147	116	160	166	176	182
Robust	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	7.825***	7.583***	11.90***	9.749***	7.790***	12.68***	5.015***	13.34***	6.139***	10.54***	5.228***
AR(1)	-3.5***	-3.595***	-3.249***	-2.701***	-3.360***	-3.251***	-3.090***	-3.108***	-2.993***	-2.240**	-2.998***
AR(2)	1.038	0.500	1.203	0.655	1.110	1.175	0.388	1.209	0.658	-0.214	0.569
Hansen Test (P-value)	110.8 (0.177)	95.62 (0.182)	110.8 (0.128)	165.8 (0.0.125)	145.9 (0.286))	157 (0.106)	114.7 (0.244)	156.5 (0.320))	169 (0.150)	167.9 (0.338))	183.2 (0.185)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Concerning the hypothesis on the relationship between an insurer's volatilities and capital structure, both income volatility and business volatility are tested. Income volatility has a positive relationship with leverage usage, while business volatility is negatively related to leverage ratio. The positive effect of income volatility supports the suggestions from Lee, Mayers and Smith (1997) and Cheng and Weiss (2013), while the negative impact associated with business volatility is consistent with the bankruptcy-cost-avoidance hypothesis (Orgler and Taggart, 1983), the transaction-cost economics theory (Williamson, 1988) and the capital buffer theory (Shim, 2010). In other words, insurers who face more income volatilities are likely to take more leverage due to using external guaranty funds (Lee, Mayers and Smith, 1997) or the existence of mispricing (Cheng and Weiss, 2013). Another explanation for the positive relationship is that insurers may potentially write more business when they face more income uncertainties, which increases the business leverage as the written net premium increases.

On the other hand, the coefficient of business volatility is negative in both long-run and short-run. It indicates that insurers are willing to reduce leverage use or raise equity capital (i.e. to avoid imposing extra bankruptcy cost) when they issue more risky products. Therefore, the results also suggest that different types of volatility may have various impacts on insurers' capital structures. It is not surprising to have such contradictory results because both Baranoff and Sager (2002) and Hu and Yu (2014) confirm that uncertainties from different sources have varied impacts on insurers' capital structures.

Inconsistent with most of the previous findings (e.g., Shiu, 2011; Liu, Shiu and Liu, 2016; Mankaï and Belgacem, 2016), the impact of reinsurance on leverage ratio is found to be significantly negative, as presented by Models 8-11 in both the long-run (OLS fixed effects) and the short-run (dynamic GMM) tables. The negative coefficient indicates that insurers who accept more reinsurance protections should have a lower leverage ratio, and it is different from what expected. Although Cheng and Weiss (2012) are the only authors also confirming a negative relationship between reinsurance and leverage ratio, they do not provide further explanations. On one hand, reinsurance that provides extra protection can act as a substitute of capital (renting capital), then taking more reinsurance may indicate two things: 1) the primary insurer's original risk level is very high; or 2) the primary insurer may highly rely on reinsurers' health status, then face more credit risks.

Thus, the behaviour of taking more reinsurance may potentially meant that the primary insurer is high risk. It is reasonable, therefore, to reduce the likelihood of insolvency at the enterprise level via lowering the leverage.

3.4.2.2 Interaction with Market Structure: Boone Indicator

The Boone indicator presents the degree of competition in the UK insurance market. A higher (positive) Boone indicator means the degree of market competition is high. This section seeks to determine how internal factors influence capital structure due to the impact of the competition. Table 3.6 presents the OLS fixed effects model, and estimations from the dynamic panel model are shown in Table 3.7. Both tables disclose the potential impacts of the interactions between the Boone indicator and internal factors in the insurer's capital structure. From both the long-run and the short-run tables, the negative impact of competition on leverage ratio can be confirmed across most of the models; the expected individual effects of all key variables also remain significant. Regarding the interaction terms, most effects are significant, except for those of the Retained Earnings * Boone term in the long-run table (Table 3.6) and the Reinsurance * Boone term in both tables. The other significant results imply that the degree of competition influences insurers' behaviours, which are relevant to their capital structures.

To be more specific, the negative coefficients for the Lagged Leverage * Boone term (Model 1) suggest that insurers, who have a higher leverage ratio from the past, are willing to reduce the use of leverage when the market is competitive. Based on the 'competition-stability' theory, insurers would like to maintain their stability in a competitive market. Therefore, they should lower their leverage ratios when the inherent risks are high. Then, a similar interpretation can be used to explain the negative of the coefficient for the Income Volatility * Boone term (Model 3). In a competitive market, insurers who face more income volatility should choose to lower the use of leverage to maintain at a relatively stable position.

On the other hand, the positive effects raised from the other interaction terms indicate that insurers may increase the level of leverage in a competitive market when they have more retained earnings (Model 2) or issue more risky policies (Model 4). Based on the competition-fragility theory, intensive competition increases insurers' risk-taking incentives, such as issuing riskier policies to attract more customers, which further increases the amount of business leverage. Under competition, insurers not only maintain their soundness but also try to attract more customers and issue more policies continuously. Retained earnings contribute to insurers' equity and provide them with the opportunity to expand their business, which further increases the leverage ratio (if the increase in business leverage is more significant than the contribution from retained earnings).

Furthermore, it's interesting to know that tha impacts of two interaction terms related to different volatilities (Model 3 and 4) on capital structure are contradicted. The possible explanation is that insurers try to seek limit the overall risk level, adjusted their capital structures by balancing risk portfolios from different perspectives, in line with the 'finite risk paradigm' or the 'capital buffer theory'.

Regarding the interaction between competition and reinsurance usage (Model 5), the impact is positive, but insignificant in both long-run and short-run. Although the positive coefficient indicates the renting capital hypothesis and denotes that primary insurers, who take more reinsurance protections, should require less equity capital and have a higher leverage ratio in a competitive market, the result is not significant.

Table 3.6: Interacted Effects with Market Structure (Boone) on Capital Structure - OLS

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.4670***	0.2961***	0.2840***	0.1808***	0.1874***	0.2437**
	(4.520)	(3.524)	(3.630)	(2.618)	(3.152)	(2.274)
Boone Indicator	-0.0879	-0.5320***	0.3518	-0.4712**	-0.4469*	0.7976
	(-0.601)	(-2.828)	(1.260)	(-2.428)	(-1.963)	(1.515)
Lagged Leverage * Boone	-0.2508***					-0.0672
	(-3.510)					(-0.603)
Retained Earnings		-0.2629***				-0.1543*
		(-2.864)				(-1.752)
Retained Earnings * Boone		0.1246				0.0536
		(1.179)				(0.594)
Income Volatility			0.4487***			0.4984**
			(3.388)			(2.516)
Income Volatility * Boone			-0.4039***			-0.4860**
			(-2.629)			(-2.084)
Business Volatility				-0.0800***		-0.0704
				(-2.831)		(-1.431)
Business Volatility * Boone				0.0376*		0.0376
				(1.706)		(0.769)
Reinsurance					-0.3335***	-0.3073***
					(-3.159)	(-2.993)
Reinsurance * Boone					0.0104	0.0445
					(0.141)	(0.576)
Cost of Equity	-0.0085*	-0.0067	-0.0076	-0.0071	-0.0054	-0.0036
	(-1.659)	(-1.222)	(-1.385)	(-1.352)	(-0.848)	(-0.554)
Firm Size	-0.2599*	-0.2356	-0.2744*	-0.3843**	-0.3676**	-0.4252**
	(-1.817)	(-1.589)	(-1.852)	(-2.382)	(-2.027)	(-2.299)
Liquidity	0.0608	0.0533	0.0722	0.0385	-0.0242	0.0083
	(1.095)	(0.903)	(1.324)	(0.587)	(-0.340)	(0.138)
Investment Return	0.1140***	0.1131***	0.1156***	0.1072***	0.2408***	0.2381***
	(2.737)	(2.708)	(2.745)	(2.628)	(6.126)	(6.495)
Tax Payment	-0.0130	0.0038	-0.0143	-0.0140	-0.0160	-0.0032
	(-0.819)	(0.263)	(-0.977)	(-0.920)	(-1.356)	(-0.343)
Interest rate	0.1066***	0.1133***	0.1024***	0.1007***	0.0506*	0.0593**
	(4.210)	(4.405)	(3.934)	(3.794)	(1.879)	(2.113)
Inflation Rate	-0.0889	-0.1183	-0.1106	-0.1344*	-0.1518**	-0.1213**
	(-1.307)	(-1.530)	(-1.456)	(-1.886)	(-2.335)	(-1.996)
GDP Growth	-0.0231	-0.0208	-0.0191	-0.0268*	-0.0029	-0.0080
	(-1.503)	(-1.345)	(-1.122)	(-1.662)	(-0.160)	(-0.396)
Constant	3.7546***	3.9044***	3.2508***	5.6611***	4.8021***	4.1212***
	(3.134)	(3.239)	(2.642)	(4.045)	(3.111)	(2.605)
Observations	4,519	4,471	4,495	4,151	3,665	3,511
Number of Firms	616	613	615	587	548	533
Adjusted R-squared	0.175	0.172	0.172	0.138	0.190	0.216
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	12.15***	7.39***	9.23***	6.39***	13.39***	12.03***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.7: Interacted Effects with Market Structure (Boone) on Capital Structure - GMM

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	1.0680***	0.4737***	0.4529***	0.2861***	0.2641***	0.4425**
	(5.398)	(4.308)	(3.960)	(3.115)	(3.625)	(2.134)
Boone Indicator	0.6702*	-1.1000***	1.5555*	-0.9698***	-0.5419**	-0.1791
	(1.814)	(-3.484)	(1.737)	(-4.076)	(-2.044)	(-0.159)
Lagged Leverage * Boone	-0.9836***					-0.4295*
	(-5.581)					(-1.859)
Retained Earnings		-0.4982*				-0.5248**
		(-1.918)				(-2.493)
Retained Earnings * Boone		0.3128*				0.2959**
		(1.860)				(2.170)
Income Volatility			0.9899***			0.1465
			(3.059)			(0.270)
Income Volatility * Boone			-1.1295**			0.1512
			(-2.446)			(0.265)
Business Volatility				-0.0605**		0.0016
				(-1.976)		(0.034)
Business Volatility * Boone				0.0685*		-0.0334
				(1.694)		(-0.716)
Reinsurance					-0.2640*	-0.1370
					(-1.763)	(-0.628)
Reinsurance * Boone					0.0458	0.1922
					(0.398)	(0.917)
Cost of Equity	0.0245	0.0420**	0.0057	0.0008	-0.0038	0.0157*
	(1.281)	(2.348)	(0.823)	(0.111)	(-0.445)	(1.767)
Firm Size	0.4434***	0.3747**	0.3276**	0.3914**	0.3734	0.5173*
	(2.994)	(2.070)	(2.144)	(2.457)	(1.305)	(1.962)
Liquidity	0.4439	0.1366	0.0201	0.0378	1.0598**	0.2907*
	(1.132)	(0.498)	(0.187)	(0.307)	(2.284)	(1.764)
Investment Return	0.2214*	0.3167***	0.1417**	0.0692	0.3349***	0.2828***
	(1.867)	(3.283)	(2.036)	(0.843)	(6.723)	(4.733)
Tax Payment	0.0197	0.0039	0.0169	-0.2861	-0.0164	0.0022
	(0.605)	(0.149)	(0.470)	(-0.854)	(-0.726)	(0.049)
Interest rate	-0.0419	-0.0941*	0.0210	0.0084	0.0201	-0.0263
	(-0.632)	(-1.816)	(0.666)	(0.165)	(0.577)	(-0.624)
Inflation Rate	-0.1015	-0.3773**	-0.1709**	-0.2150***	-0.1497***	-0.2368**
	(-0.772)	(-2.500)	(-2.053)	(-3.123)	(-2.658)	(-2.062)
GDP Growth	-0.0530*	-0.0923**	-0.0571**	-0.0711***	0.0073	0.0084
	(-1.806)	(-2.260)	(-2.033)	(-2.612)	(0.411)	(0.209)
Constant	-2.9554**	-0.8918	-3.1089*	-0.7931	-1.1357	-2.9468
	(-2.343)	(-0.588)	(-1.945)	(-0.621)	(-0.539)	(-1.102)
Observations	4,519	4,471	4,495	4,151	3,499	3,511
Number of Firms	616	613	615	587	517	533
Number of Instruments	88	71	147	112	164	194
Robust	Yes	Yes	Yes	Yes	Yes	Yes
F-test	12.67***	5.862***	10.32***	9.520***	10.94***	8.315***
AR(1)	-3.331***	-3.431***	-3.244***	-3.339***	-3.291***	-2.370***
AR(2)	1.562	0.687	0.993	0.771	1.334	0.205
Hansen Test (P-value)	81.39 (0.32)	65.70 (0.23)	140.2 (0.34)	112.5 (0.17)	172.4 (0.11)	194.1 (0.14)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.4.2.3 Interaction with Market Structure: Lerner Index

Tables 3.8 and 3.9 (the fixed effects model and the dynamic panel model) reveal the impacts of interactions via the Lerner index on insurers' capital structures. As discussed, the Lerner index directly represents insurers' pricing power (or market power) and indirectly shows the degree of market concentration. The coefficient on the Lerner index itself is consistently significant and negative in most of the models, implying that more pricing power enables insurers to reduce their leverage ratios. Most of the interactions via the Lerner index are significant in both tables, indicating that pricing power influences insurers' capital structures through different behaviours and channels in both long-run and short-run.

Although the Lerner index and the Boone indicator represent different concepts of the market structure, it is surprising to realise that the interactions via the Lerner index have the same influences as the interactions via the Boone indicator on insurers' capital structures, except for the interaction term regarding reinsurance. From Models 1 and 3, the negative coefficients indicate that insurers, whose existing leverage ratio is high or who face more return uncertainties, tend to reduce leverage use when they have more pricing power.

A negative coefficient for the Reinsurance * Lerner term in short-run model (Table 3.9) denotes that insurers adopting more reinsurance may lessen their leverage ratios if their pricing power is enhanced in the short-run. A plausible reason is that firms with more pricing power can adopt more substantial proportions of reinsurance protection when their risk tolerance is beyond the limit in the short-run, to reduce bankruptcy cost.

On the other hand, the impacts of interactions in cases of retained earnings (Model 2) and business volatility (Model 4) on insurers' capital structures are positive, similar to the results observed from the case of competition (the Boone indicator). The results suggest that insurers, who have more retained earnings or issue more risky businesses, may increase leverage when they have significant pricing power. As previously discussed, increased retained earnings may encourage insurers to write more businesses and, hence increase the leverage ratio. Insurers who have greater pricing power are willing to adjust the product price, corresponding to the riskiness of the product—affecting the amount of business leverage.

Similar to section 3.4.2.2, the contradicted results from two interaction terms related to volatilities (Model 3 and 4) also confirm that the insurers seek to limit the overall risk, as described by the 'finite risk paradigm' or 'capital buffer theory'.

Table 3.8: Interacted Effects with Market Structure (Lerner) on Capital Structure - OLS

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Leverage	Leverage	Leverage	Leverage	Leverage	Leverage
Lagged Leverage	0.5287***	0.3085***	0.2762***	0.2749***	0.2053***	0.4510***
	(3.792)	(3.918)	(4.334)	(4.430)	(3.479)	(4.162)
Lerner Index	0.2853	-1.4508**	-0.3610	-1.6848**	-1.6211**	0.8173
	(0.426)	(-2.514)	(-0.517)	(-2.020)	(-2.151)	(0.829)
Lagged Leverage * Lerner	-3.4639*					-2.7230
	(-1.901)					(-1.500)
Retained Earnings		-0.2539***				-0.1473**
		(-2.682)				(-1.974)
Retained Earnings * Lerner		1.0574*				0.2840
		(1.806)				(0.682)
Income Volatility			0.1576*			0.1861**
			(1.878)			(2.425)
Income Volatility * Lerner			-0.4931			-0.7520
			(-0.805)			(-1.237)
Business Volatility				-0.1121*		-0.0520
				(-1.754)		(-1.588)
Business Volatility * Lerner				0.2592*		0.2075*
				(1.838)		(1.922)
Reinsurance					-0.2098***	-0.1294
					(-2.885)	(-1.513)
Reinsurance * Lerner					0.2675	-0.1878
					(0.776)	(-0.464)
Cost of Equity	0.0129**	0.0110**	0.0118**	0.0116**	0.0131*	0.0141**
	(2.441)	(2.298)	(2.312)	(2.261)	(1.865)	(2.161)
Firm Size	-0.0924	-0.0784	-0.0857	-0.0997	-0.0422	-0.0306
	(-0.671)	(-0.575)	(-0.641)	(-0.695)	(-0.435)	(-0.318)
Liquidity	0.0124	-0.0024	0.0031	-0.0066	-0.0255	-0.0225
	(0.294)	(-0.053)	(0.072)	(-0.134)	(-0.463)	(-0.454)
Investment Return	2.6845**	2.8110***	2.7423***	3.1463***	7.9329***	8.2437***
	(2.510)	(2.801)	(2.745)	(2.637)	(2.671)	(2.797)
Tax Payment	-0.0100	-0.0259	-0.0422	-0.0522	-0.0453	-0.0227
	(-0.162)	(-0.430)	(-0.669)	(-0.800)	(-1.063)	(-0.544)
Interest rate	0.0269	0.0374*	0.0226	0.0242	0.0025	0.0051
	(1.293)	(1.743)	(1.117)	(1.132)	(0.098)	(0.199)
Inflation Rate	-0.0273	-0.0124	-0.0295	-0.0223	-0.0355	-0.0285
	(-0.835)	(-0.359)	(-0.867)	(-0.633)	(-0.994)	(-0.838)
GDP Growth	0.0009	0.0023	0.0086	-0.0016	0.0071	0.0121
	(0.053)	(0.135)	(0.516)	(-0.094)	(0.365)	(0.627)
Constant	1.7627	1.7735	1.5597	2.1089*	1.0847	0.4996
	(1.575)	(1.620)	(1.339)	(1.769)	(1.157)	(0.551)
Observations	2,749	2,715	2,743	2,667	2,330	2,281
Number of Firms	511	508	510	499	452	447
Adjusted R-squared	0.201	0.206	0.178	0.190	0.163	0.207
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	9.34***	7.66***	7.59***	5.35***	7.23***	6.622***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.9: Interacted Effects with Market Structure (Lerner) on Capital Structure - GMM

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.9758***	0.4562***	0.3544***	0.2840***	0.2803***	0.6637***
	(3.311)	(5.541)	(2.750)	(3.283)	(3.156)	(3.921)
Lerner Index	2.0740	-2.3426**	2.8860	-2.9450***	-3.9887**	4.2478**
	(0.713)	(-2.356)	(0.544)	(-3.087)	(-2.143)	(2.010)
Lagged Leverage * Lerner	-5.8890*					-4.0728*
	(-1.922)					(-1.795)
Retained Earnings		-0.3188***				-0.2226**
		(-2.892)				(-2.035)
Retained Earnings * Lerner		1.0982**				-0.1101
		(2.059)				(-0.181)
Income Volatility			0.8528***			0.3816**
			(3.135)			(2.461)
Income Volatility * Lerner			-3.4912**			-2.2284**
			(-2.373)			(-2.519)
Business Volatility				-0.0693*		-0.0345
				(-1.905)		(-0.904)
Business Volatility * Lerner				0.1726*		-0.1320
				(1.696)		(-0.944)
Reinsurance					0.0549	0.0956
					(0.267)	(0.520)
Reinsurance * Lerner					-2.5775**	-1.6889*
					(-2.027)	(-1.827)
Cost of Equity	0.0066	0.0079	0.0126*	-0.0196*	-0.0037	0.0002
	(0.795)	(1.151)	(1.768)	(-1.728)	(-0.399)	(0.015)
Firm Size	0.0769	0.2107	0.0333	-0.1982	0.5998**	0.3325**
	(0.522)	(1.526)	(0.126)	(-0.672)	(2.357)	(2.279)
Liquidity	0.0668	0.1714**	0.0120	0.1138	-0.0065	0.2580
	(0.633)	(2.036)	(0.101)	(0.431)	(-0.017)	(1.446)
Investment Return	2.6752*	2.2903**	0.9128*	4.5823**	7.8568***	8.7963***
	(1.664)	(2.011)	(1.675)	(2.133)	(3.022)	(2.965)
Tax Payment	0.3505	-0.0137	-0.1263	0.0327	-0.0655	0.0172
	(0.476)	(-0.295)	(-0.162)	(0.551)	(-0.495)	(0.269)
Interest rate	-0.0157	0.0019	0.0062	0.0913	0.0352	-0.0456
	(-0.612)	(0.057)	(0.169)	(1.545)	(0.724)	(-1.160)
Inflation Rate	-0.0984*	-0.0360	-0.0834	0.0765	0.0354	0.1448*
	(-1.784)	(-0.466)	(-1.216)	(0.852)	(0.545)	(1.713)
GDP Growth	0.0133	-0.0214	0.0164	-0.0576	-0.0926**	-0.0211
	(0.498)	(-0.748)	(0.536)	(-1.487)	(-2.242)	(-0.854)
Constant	-0.2351	-0.6626	-0.6349	3.2001	-4.3597*	-2.9275**
	(-0.172)	(-0.638)	(-0.216)	(1.156)	(-1.837)	(-2.111)
Observations	2,749	2,715	2,743	2,667	2,330	2,281
Number of Firms	511	508	510	499	452	447
Number of Instruments	133	199	147	128	157	302
Robust	Yes	Yes	Yes	Yes	Yes	Yes
F-test	18.44***	10.21***	13.55***	4.434***	5.018***	6.452***
AR(1)	-2.596***	-2.844***	-2.409**	-2.291**	-2.310**	-2.638***
AR(2)	0.998	-0.106	0.408	0.588	1.038	0.604
Hansen Test	124.9 (0.39)	196.3 (0.29)	143.1 (0.28)	118 (0.4)	145.9 (0.44)	267.7 (0.72)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.4.2.4 Interaction with Market Structure: HHI

The effects of interactions via the HHI on insurers' capital structures are presented in Tables 3.10 and 3.11, the OLS fixed effects regression and the GMM dynamic panel regression, respectively. The HHI is a direct proxy of market concentration; the higher the index, the greater the market concentration. However, the HHI is relatively low in the UK market. It indicates that the UK market is competitive. The HHI coefficient is significant and positive from the GMM regressions (Table 3.11), indicating that an increase in market concentration enables insurers to enlarge their leverage ratio in the short-run. From the traditional point of view, if both the Lerner index and the HHI represent the same concepts of market structure (i.e.m the degree of concentration), the impact raised from these two measurements and their interaction terms should be consistent. However, positive coefficient is found with the HHI, but the coefficient of the Lerner index is negative. Regarding the interaction terms, the significant interaction effects are only found in the dynamic regressions (Table 3.11), implying that the effects are only significant in the short-run. Comparing the results from Tables 3.10 and 3.11 with the findings in the previous section (Lerner index), contradictory results also exist in the interaction terms for business volatility and reinsurance.

To be more specific, insurers, who have a higher past leverage ratio (Model 1) or face significant income volatility (Model 3), tend to reduce their leverage ratio when the degree of market concentration is intensified, while insurers with a higher level of retained earnings (Model 2) may accept more leverage. These results are consistent with the findings from Models 1, 2 and 3 in Tables 3.8 and 3.9, where the interactions via the Lerner index are considered. Nevertheless, the results from Models 4 and 5 are inconsistent with the findings observed in the Lerner index section. Model 4 shows that the coefficient of the Business Volatility * HHI term is significantly negative, implying that insurers with more risky policies try to reduce the leverage ratio if concentration is enhanced. At the same time, adopting more reinsurance protections enables insurers to accept more leverage, as shown in Model 5.

Further, considering Models 3 and 4 together, the signs for the two interaction terms in the case of volatilities are both negative, which differs from the contradictory results observed with the Boone indicator and the Lerner index. However, the negative coefficients can still confirm the appearance of the 'finite risk paradigm' or the 'capital buffer theory.' The negative coefficient indicates that insurers limit overall risk levels by imposing more equity capital (i.e., lowering the leverage) when volatilities associated with insurers' operations are high.

Table 3.10: Interacted Effects with Market Structure (HHI) on Capital Structure - OLS

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.4286*	0.2970***	0.2855***	0.1822***	0.1905***	0.0208
	(1.658)	(3.520)	(3.607)	(2.616)	(3.178)	(0.123)
HHI	0.0011	-0.0089	-0.0118	0.0035	0.0126	0.0056
	(0.123)	(-0.999)	(-0.938)	(0.514)	(1.192)	(0.318)
Lagged Leverage * HHI	-0.0043					0.0053
	(-0.594)					(0.910)
Retained Earnings		-0.4697*				-0.1555
		(-1.800)				(-1.115)
Retained Earnings * HHI		0.0083				0.0006
		(1.107)				(0.176)
Income Volatility			0.0458			0.0685
			(0.175)			(0.243)
Income Volatility * HHI			0.0035			0.0029
			(0.445)			(0.379)
Business Volatility				-0.0533		-0.0399
				(-0.942)		(-0.565)
Business Volatility * HHI				0.0001		-0.0000
				(0.043)		(-0.027)
Reinsurance					-0.4518**	-0.5211***
					(-2.463)	(-2.868)
Reinsurance * HHI					0.0035	0.0071
					(0.695)	(1.498)
Cost of Equity	-0.0092*	-0.0074	-0.0085	-0.0077	-0.0060	-0.0043
	(-1.675)	(-1.361)	(-1.580)	(-1.454)	(-0.957)	(-0.671)
Firm Size	-0.2671*	-0.2473*	-0.2876*	-0.4018**	-0.4050**	-0.4548**
	(-1.833)	(-1.683)	(-1.957)	(-2.526)	(-2.248)	(-2.439)
Liquidity	0.0625	0.0528	0.0774	0.0351	-0.0282	-0.0048
	(1.052)	(0.880)	(1.385)	(0.522)	(-0.392)	(-0.079)
Investment Return	0.1145***	0.1135***	0.1153***	0.1068***	0.2352***	0.2319***
	(2.780)	(2.765)	(2.775)	(2.667)	(5.956)	(6.116)
Tax Payment	-0.0160	0.0081	-0.0181	-0.0150	-0.0166	-0.0025
	(-0.980)	(0.514)	(-1.176)	(-0.977)	(-1.378)	(-0.242)
Interest rate	0.1175***	0.1257***	0.1070***	0.1190***	0.0714**	0.0705**
	(4.897)	(5.202)	(4.380)	(4.356)	(2.574)	(2.394)
Inflation Rate	-0.0329	-0.0365	-0.0486	-0.0383	-0.0443	-0.0499
	(-0.640)	(-0.719)	(-0.965)	(-0.732)	(-0.883)	(-0.988)
GDP Growth	-0.0125	-0.0123	-0.0035	-0.0199	0.0034	0.0068
	(-0.796)	(-0.776)	(-0.205)	(-1.259)	(0.189)	(0.338)
Constant	3.5938***	3.7354***	3.8815***	5.1181***	4.1057***	4.5558***
	(2.872)	(2.670)	(2.826)	(3.509)	(2.676)	(2.690)
Observations	4,519	4,471	4,495	4,151	3,665	3,511
Number of Firms	616	613	615	587	548	533
Adjusted R-squared	0.160	0.169	0.166	0.135	0.187	0.209
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	7.58***	8.05***	9.37***	6.74***	11.49***	11.58***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.11: Interacted Effects with Market Structure (HHI) on Capital Structure - GMM

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	1.2243***	0.3568***	0.4225***	0.1816*	0.2287***	0.7041*
	(3.459)	(3.419)	(3.666)	(1.879)	(2.819)	(1.787)
HHI	0.0257**	-0.0137	0.0669*	0.0065	0.0555*	0.0309
	(2.053)	(-1.615)	(1.670)	(0.393)	(1.673)	(1.049)
Lagged Leverage * HHI	-0.0240**					-0.0151
	(-2.395)					(-1.201)
Retained Earnings		-0.5922***				-0.4700**
		(-2.848)				(-2.021)
Retained Earnings * HHI		0.0124**				0.0113*
		(2.558)				(1.704)
Income Volatility			1.3736*			0.1307
			(1.964)			(0.298)
Income Volatility * HHI			-0.0346*			0.0057
			(-1.654)			(0.434)
Business Volatility				0.2028*		0.1874*
				(1.821)		(1.665)
Business Volatility* HHI				-0.0058**		-0.0057**
				(-2.023)		(-2.041)
Reinsurance					-1.3722***	-1.0208***
					(-2.700)	(-2.869)
Reinsurance * HHI					0.0315**	0.0200**
					(2.070)	(1.992)
Cost of Equity	-0.0135*	0.0130	-0.0087	-0.0095	0.0228	0.0028
	(-1.877)	(1.123)	(-1.269)	(-0.989)	(1.159)	(0.333)
Firm Size	-0.1583	0.5184***	0.3955***	-0.3041	-0.3488	-0.2810
	(-1.176)	(2.634)	(2.819)	(-1.470)	(-1.247)	(-1.201)
Liquidity	0.1694**	0.1416	0.1472	0.1838*	0.0826	0.1113
	(1.994)	(1.427)	(1.568)	(1.665)	(0.677)	(0.774)
Investment Return	0.1351***	0.1193**	0.1255*	0.1192**	0.2849***	0.2950***
	(2.765)	(2.085)	(1.760)	(2.447)	(4.634)	(6.653)
Tax Payment	-0.0239	0.0006	-0.0011	-0.0356	-0.0166	-0.0172
	(-0.895)	(0.043)	(-0.070)	(-1.106)	(-0.208)	(-0.745)
Interest rate	0.1093***	0.0839*	0.0513*	0.1999***	0.0536	0.0210
	(3.168)	(1.715)	(1.701)	(2.952)	(1.159)	(0.372)
Inflation Rate	0.0821	-0.2176**	0.0220	-0.0499	-0.0936	-0.0456
	(1.492)	(-2.131)	(0.389)	(-0.392)	(-0.990)	(-0.799)
GDP Growth	-0.0215	-0.0880**	0.0431*	-0.0841**	-0.0645**	0.0090
	(-1.448)	(-2.480)	(1.703)	(-2.291)	(-2.062)	(0.313)
Constant	1.1461	-2.4778	-5.1921**	3.8849**	1.8948	1.6224
	(1.084)	(-1.483)	(-2.541)	(2.098)	(0.912)	(0.735)
Observations	4,519	4,471	4,495	3,975	3,499	3,354
Number of Firms	616	613	615	560	517	503
Number of Instruments	155	110	168	180	113	292
Robust	Yes	Yes	Yes	Yes	Yes	Yes
F-test	7.556***	3.884***	8.508***	6.974***	8.094***	10.71***
AR(1)	-3.223***	-3.390***	-3.213***	-2.911***	-2.971***	-2.994***
AR(2)	1.422	0.470	1.062	0.649	1.237	0.617
Hansen Test	161.4 (0.14)	104 (0.30)	158 (0.42)	188.6 (0.12)	112.4 (0.19)	299.3 (0.12)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.4.2.5 The impact of control variables

Regarding control variables, the impacts of investment return are positive in most of the models, indicating that firms with higher investment returns tend to increase their leverage ratios. The impact of firm size varies between the long-run and the short-run. In general, the negative impact appears in the long-run, while there is a positive impact in the short-run. These results suggest that larger firms can accept more leverage in the short-term and adjust their leverage ratios back to an acceptable level in the long-run. Concerning macro-economic factors, the coefficients of the inflation rate and GDP growth are positive in most cases, and the opposite impact arises from increased interest rates.

3.4.2.6 The model's validity

The validity of all OLS-fixed effect models is verified by the result of the F-test and the value of adjusted R-squared. To check the validity of all models' specification and the instrument variables used in GMM-SYS model, the F-test, AR(1), AR(2) and the Hansen test of overidentification restriction are reported in each of the tables. The results from all these tests indicate that all dynamic panel models are valid.

3.4.3 Sensitivity and Robustness Checks

As discussed in Section 3.4.1, market structure can be explained via different concepts, such as the degree of competition, the individual's pricing power and the level of concentration in the market. As further noted, the results from Section 3.4.2 verify the differences among these measurements. The effects on capital structure observed from the interactions via the Lerner index (Tables 3.8 and 3.9) and the Boone indicator (Tables 3.6 and 3.7) are similar from the perspectives of individuals' pricing power and market competition. On the other hand, there are contradictory results between pricing power (i.e.m the Lerner index) and market concentration (i.e. HHI), as shown in Tables 3.10 and 3.11). These results suggest that it is inappropriate to use different measurements to define the unique concepts of market structure, such as competition. In other words, three measurements—the Boone indicator, the Lerner index and the HHI—carry different information about market structure. Then, following Claessens and Laeven's (2004) suggestion, it is reasonable to assume that these concepts are not mutually exclusive, and the following scenarios may exist: (1) insurers with more pricing power survive in a competitive market; (2) insurers compete when the degree of market concentration is intensified; and (3) insurers should have more pricing power in a concentrated market.

In this section, the existence of the above scenarios and their impacts on insurers' capital structure are estimated by adding various interactions between different concepts of market structure, such as the Boone * Lerner term (Scenario 1), the Boone * HHI term (Scenario 2) and the Lerner * HHI term (Scenario 3). The relevant results in Tables 3.12 to 3.14 illustrate whether there is a difference between the impacts of a single concept of market structure and the impacts of the abovementioned scenarios on insurers' capital structures.

*3.4.2.4 Interactions with Market Structure: Boone*HHI, Boone*Lerner and Lerner*HHI*

Tables 3.12-3.14 report the results of two-step GMM dynamic panel models, in which the interaction terms of Boone * Lerner, Boone * HHI, and Lerner * HHI are respectively utilised. Overall, the results from Model 1 (in all three tables) verify the existence of the abovementioned scenarios and further suggest that their impacts are significant and positive. To be more specific, the positive coefficient for the Boone * Lerner term (Table 3.12) implies that insurers with more pricing power (or market power) tend to accept more leverage in a competitive market. The positive impact arising from Boone * HHI (Table 3.13) indicates that insurers have a higher leverage ratio when the degree of concentration is increased due to market competitiveness. Finally, the results from Model 1 (*i.e.* Lerner * HHI) in Table 3.14 suggest that insurers with more pricing power (or market power) tend to accept more leverage when the level of concentration is intensified.

There are two possible explanations for the consistency of these positive results. First, the UK insurance market is competitive, and either the strength of pricing power or the intensity of market concentration might originate from increased competition. This assumption can be verified by considering the smaller value of HHI with the significant, positive correlations found between the Boone indicator and the Lerner index or the HHI. Another common trend is shown in Table 3.3 and Figures 3.1 and 3.2; the Boone indicator takes a leading role with one to two years lead-time, in terms of evolution, compared to the Lerner index and the HHI. Mirzaei and Moore (2014) also find a similar pattern in their banking study. Under this assumption, intensive competition may encourage insurers to take more business leverage (i.e. issuing more policies), to maximise output level and fulfil shareholders' expectation (i.e. maximising shareholders' wealth), as discussed in Section 3.2.2. Second, as previously noted, these three measurements individually represent part of the information on market structure. Thus, combining two of the three measurements might present the full picture of the market structure, which consistently impacts the insurers; capital structures. In fact, the second explanation is developed through the first assumption; otherwise, the three measurements might be considered mutually exclusive.

To test whether the postulated scenarios can affect insurers' capital structures differently via various channels, the interaction terms of two proxies for market structure further interact with the variables of interest. The results of estimations are presented in Models 2 through 6 in Tables 3.12 to 3.14.

Considering the three-variable interaction terms via lagged leverage, retained earnings and income volatility, the significant results from Models 2 to 4 not only support the existence of impacts on insurers' capital structures but also confirm that impacts are coincident under different scenarios (see Tables 3.12 to 3.14). Further, as evidenced in Tables 3.7, 3.9 and 3.11, the coefficients of the interactions for these three variables do not vary under different concepts of market structure, and they are consistent with the results in this section.

To be more specific, coefficients of the interaction terms in cases of lagged leverage and income volatility are significant and negative. The results imply that insurers, who have a higher past leverage ratio or face more income uncertainties, may reduce the leverage ratio when there are remarkable external pressures or when they want to maintain their competitive advantage. The positive coefficient associated with the interaction in cases of retained earnings means that insurers tend to accept more leverage if there are higher levels of internal funds contributing to equity capital. It is, therefore, worthwhile to ask why consistent impacts are raised from these interaction terms, even though different proxies are used to represent varied features of market structure. One reasonable explanation is that there must be 'something in common' among the three measurements, and that this common factor, which represents the prevailing nature of the market, might further significantly impact insurers' capital structures. This explanation is also based on the suggested assumption, which states that changes in pricing power and market concentration might be due to increased competition.

Nevertheless, two coefficients associated with the interaction terms in cases of business volatility (Model 5) and reinsurance (Model 6) vary differently under each scenario. The results from Table 3.12 indicate that insurers with higher levels of business volatility tend to increase their leverage ratios when they have more pricing power in a competitive market, while their leverage ratios will be reduced by adopting more reinsurance. The negative coefficients of the interactions (Table 3.13) suggest that insurers, who operate in the market where levels of concentration are increased due to competition, may reduce their leverage via purchasing more reinsurance to maintain competitive advantage. At the same time, insurers facing more business volatilities would also reduce their leverage ratios.

In contrast, the behaviours of insurers change if they have more pricing power (or market power), in which the level of concentration is increased. For example, insurers would tend to increase leverage ratios to maximise shareholders' wealth, if they want to adopt more reinsurance or issue more risky businesses. Consequently, these results indicate that the impact on the insurers' leverage ratios can change via different channels (i.e., the variables of interest) under varied market scenarios.

It is worth recalling that the impacts of market structure on insurers' capital structure via different channels (i.e., the variables of interest) can be classified as invariant (Models 2 to 4) and variant effects (Models 5 and 6), implying that market structure is a combination of various concepts. In order words, the impacts arising from some concepts of market structure might be consistent, while other natures of the market structure might affect insurers' capital structure differently. The variations further suggest that market structure must be considered along with insurers' behaviours—for example, the upper limits of taking risky businesses and reinsurance.

Table 3.12: Interacted Effects with Boone * Lerner on Capital Structure - GMM

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.4612***	0.9157***	0.4307***	0.3506***	0.4684***	0.2773***
	(3.821)	(6.084)	(3.105)	(4.949)	(3.858)	(2.964)
Boone Indicator	-0.6865***	0.4046	-0.4618***	-0.3459	-0.4425***	-0.9009***
	(-2.947)	(1.277)	(-3.084)	(-1.384)	(-3.121)	(-3.057)
Lerner Index	-5.1353**	-1.1754	-4.9971***	2.3863	-2.6878	-3.2460***
	(-2.567)	(-0.537)	(-2.633)	(1.213)	(-1.065)	(-2.604)
Boone*Lerner	2.8449*					
	(1.830)					
L. Leverage* Boone*Lerner		-7.6045***				
		(-3.481)				
Retained Earnings			-0.3773***			
			(-3.229)			
R. Earnings *Boone*Lerner			1.6068**			
			(2.494)			
Income Volatility				0.2987**		
				(2.324)		
I. Volatility*Boone*Lerner				-2.4407**		
				(-2.178)		
Business Volatility					-0.0535*	
					(-1.766)	
B. Volatility*Boone*Lerner					0.2441*	
					(1.759)	
Reinsurance						0.1909
						(1.027)
Rein.* Boone* Lerner						-1.9426**
						(-2.285)
Cost of Equity	0.0048	0.0034	0.0117*	0.0005	0.0024	-0.0153
	(0.762)	(0.586)	(1.691)	(0.064)	(0.322)	(-1.204)
Firm Size	0.0388	0.0165	0.0960	0.4058*	0.0795	0.4123**
	(0.346)	(0.161)	(0.853)	(1.677)	(0.673)	(2.045)
Liquidity	0.2350**	0.2396*	0.1853	0.7696**	0.1951*	0.1657*
	(2.366)	(1.795)	(1.378)	(2.273)	(1.742)	(1.721)
Investment Return	2.2865***	0.1574	1.4761***	1.2853***	4.0710*	7.2796***
	(2.617)	(0.256)	(3.093)	(2.839)	(1.729)	(2.633)
Tax Payment	-0.0174	0.0578	0.0094	0.0148	-0.1812	-0.0044
	(-0.154)	(0.414)	(0.089)	(0.122)	(-1.225)	(-0.042)
Interest rate	0.0024	0.0035	0.0152	0.0283	0.0077	0.0129
	(0.109)	(0.123)	(0.486)	(1.244)	(0.216)	(0.442)
Inflation Rate	-0.1101**	-0.1009*	-0.0664	-0.1569**	-0.1464**	0.0397
	(-2.559)	(-1.786)	(-1.128)	(-2.440)	(-2.530)	(0.675)
GDP Growth	0.0078	-0.0100	0.0104	0.0163	0.0059	-0.0063
	(0.513)	(-0.405)	(0.474)	(1.008)	(0.260)	(-0.281)
Stock	0.7415	0.5536	0.0498	3.3237**	1.2360	0.4970
	(1.079)	(1.164)	(0.052)	(2.065)	(1.424)	(0.686)
Constant	0.8287	0.3006	0.9275	-4.6549*	0.0374	-1.8355
	(0.754)	(0.276)	(0.821)	(-1.741)	(0.026)	(-1.078)
Observations	2,634	2,540	2,605	2,743	2,553	2,330
Number of Firms	495	481	493	510	483	452
Number of Instruments	161	186	219	182	174	171
Robust	Yes	Yes	Yes	Yes	Yes	Yes
F-test	13.11***	22***	37.94***	7.618***	7.577***	4.404***
AR(1)	-2.578***	-2.633***	-2.565**	-2.814***	-2.491**	-2.320**
AR(2)	0.715	0.909	-0.199	0.577	0.739	1.050
Hansen Test (P-value)	144.3 (0.55)	180.1 (0.32)	204.5 (0.48)	178.8 (0.25)	165.5 (0.35)	152.3 (0.57)

t-statistics in parentheses； *** p<0.01, ** p<0.05, * p<0.1

Table 3.13: Interacted Effects with Boone * HHI on Capital Structure - GMM

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.4987***	0.5543***	0.3713***	0.4035***	0.2187**	0.2566*
	(4.170)	(4.184)	(3.738)	(2.967)	(2.523)	(1.947)
Boone Indicator	-3.9462**	-0.1458	-0.3605*	0.5337	-1.1315***	-1.5981***
	(-2.384)	(-0.610)	(-1.860)	(0.922)	(-3.019)	(-2.951)
HHI	-0.1084**	0.0027	-0.0058	0.0125	-0.0273**	-0.0361**
	(-2.126)	(0.402)	(-0.911)	(0.802)	(-2.046)	(-2.283)
Boone*HHI	0.0922*					
	(1.919)					
L. Leverage*Boone*HHI		-0.0065**				
		(-2.511)				
Retained Earnings			-0.4952***			
			(-2.650)			
R. Earnings *Boone*HHI			0.0121**			
			(2.008)			
Income Volatility				0.5421***		
				(2.592)		
I. Volatility*Boone*HHI				-0.0153*		
				(-1.832)		
Business Volatility					0.0558	
					(1.367)	
B. Volatility*Boone*HHI					-0.0019*	
					(-1.817)	
Reinsurance						0.2385
						(1.124)
Rein.*Boone*HHI						-0.0131**
						(-2.257)
Cost of Equity	0.0035	0.0413**	0.0003	-0.0040	-0.0041	0.0050
	(0.402)	(2.267)	(0.047)	(-0.782)	(-0.479)	(0.692)
Firm Size	0.3840**	-0.1589	-0.2025	0.3246**	-0.1694	0.1460
	(2.391)	(-0.871)	(-1.014)	(2.156)	(-0.834)	(0.690)
Liquidity	0.7171	0.1519*	0.2907**	0.5148	0.2794	0.4690
	(1.249)	(1.748)	(2.298)	(1.568)	(0.582)	(1.142)
Investment Return	0.0715	0.1243**	0.1225**	0.1227**	0.1169**	0.2183*
	(1.005)	(2.152)	(2.581)	(2.154)	(2.060)	(1.913)
Tax Payment	-0.0105	-0.0780**	0.0107	-0.0110	-0.0526*	0.0029
	(-0.324)	(-2.428)	(0.135)	(-0.630)	(-1.732)	(0.148)
Interest rate	-0.0727*	-0.0179	0.0931***	0.0125	0.0302	-0.0172
	(-1.694)	(-0.451)	(2.842)	(0.471)	(0.525)	(-0.424)
Inflation Rate	-0.2641***	-0.0984	0.0070	-0.1805**	-0.7061***	-0.1451*
	(-2.919)	(-1.238)	(0.069)	(-2.016)	(-3.371)	(-1.694)
GDP Growth	0.0107	-0.0117	-0.0160	0.0155	-0.0140	0.0039
	(0.666)	(-0.890)	(-1.302)	(0.937)	(-0.298)	(0.169)
Stock	-0.9713	-2.4932	-0.3795	0.6425	-0.1126	-2.3669*
	(-0.886)	(-1.560)	(-0.400)	(0.583)	(-0.063)	(-1.814)
Constant	3.6752	3.9300*	3.2896*	-2.7173	6.3923***	4.5988**
	(1.330)	(1.908)	(1.649)	(-1.307)	(2.646)	(2.565)
Observations	4,186	4,519	4,148	4,320	3,975	3,354
Number of Firms	565	616	563	588	560	493
Number of Instruments	115	152	158	168	161	110
Robust	Yes	Yes	Yes	Yes	Yes	Yes
F-test	11.09***	6.596***	5.311***	7.995***	5.254***	4.661***
AR(1)	-3.336***	-3.248***	-3.399***	-3.043***	-3.236***	-2.699***
AR(2)	1.255	1.259	0.554	0.945	0.783	1.289
Hansen Test (P-value)	111.3 (0.23)	156.9 (0.13)	163.4 (0.12)	174 (0.12)	165 (0.14)	99.80 (0.35)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.14: Interacted Effects with Lerner * HHI on Capital Structure - GMM

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.3276***	0.7732***	0.4355***	0.2861**	0.3797***	0.3406***
	(4.957)	(3.896)	(5.263)	(1.983)	(2.907)	(4.241)
HHI	-0.0452**	0.0018	-0.0193**	-0.0036	-0.0296**	-0.0101
	(-2.508)	(0.199)	(-2.097)	(-0.324)	(-2.374)	(-0.868)
Lerner Index	-7.5679***	0.2135	-1.8540*	-0.0856	-4.7660**	-0.1044
	(-2.986)	(0.171)	(-1.840)	(-0.044)	(-2.002)	(-0.068)
Lerner*HHI	0.1957**					
	(2.441)					
L. Leverage*Lerner*HHI		-0.1686**				
		(-2.188)				
Retained Earnings			-0.3389***			
			(-2.879)			
R. Earnings*Lerner*HHI			0.0325**			
			(2.100)			
Income Volatility				0.5594**		
				(2.289)		
I. Volatility*Lerner*HHI				-0.0549*		
				(-1.679)		
Business Volatility					-0.0922**	
					(-2.095)	
B. Volatility*Lerner*HHI					0.0078*	
					(1.912)	
Reinsurance						-0.2898*
						(-1.769)
Rein.*Lerner*HHI						0.0322*
						(1.701)
Cost of Equity	-0.0006	0.0000	0.0042	0.0087	0.0050	0.0051
	(-0.080)	(0.006)	(0.675)	(0.898)	(0.697)	(0.657)
Firm Size	0.4389**	0.1894	0.1909	0.1340	0.2075	0.2090
	(2.234)	(1.170)	(1.265)	(1.005)	(1.091)	(1.377)
Liquidity	0.0795	-0.0381	0.2125**	-0.0160	0.5727*	0.1123
	(0.627)	(-0.310)	(2.144)	(-0.136)	(1.866)	(1.036)
Investment Return	4.6739*	4.5367*	2.3933**	1.2810***	4.7065*	7.7224**
	(1.684)	(1.770)	(1.987)	(3.360)	(1.948)	(2.088)
Tax Payment	0.1264	-0.3435	-0.0467	-0.2865	-0.0746	-0.8054**
	(0.262)	(-0.973)	(-1.006)	(-1.643)	(-0.457)	(-2.305)
Interest rate	-0.0322	0.0321	0.0150	0.0332	-0.0194	-0.0113
	(-0.780)	(1.461)	(0.569)	(1.236)	(-0.494)	(-0.330)
Inflation Rate	-0.0595	-0.0773*	-0.0774	-0.1269*	-0.1278*	-0.1754***
	(-1.050)	(-1.740)	(-1.077)	(-1.920)	(-1.899)	(-2.692)
GDP Growth	-0.0275	-0.0080	-0.0071	0.0059	0.0041	-0.0112
	(-0.864)	(-0.465)	(-0.291)	(0.279)	(0.123)	(-0.416)
Stock	0.2537	0.6239	1.1281*	0.2136	1.5000	1.0084
	(0.331)	(1.011)	(1.903)	(0.311)	(1.235)	(1.205)
Constant	-1.1534	-1.3588	-0.5584	-0.6747	-0.0393	-1.3519
	(-0.709)	(-0.888)	(-0.529)	(-0.483)	(-0.019)	(-0.872)
Observations	2,100	2,634	2,605	2,743	2,553	2,330
Number of Firms	446	495	493	510	483	452
Number of Instruments	131	128	224	193	185	221
Robust	Yes	Yes	Yes	Yes	Yes	Yes
F-test	5.553***	7.472***	8.068***	10.23***	6.691***	5.278***
AR(1)	-2.517**	-2.646***	-2.804***	-2.231**	-2.346**	-2.426**
AR(2)	0.573	0.947	-0.166	0.359	0.619	0.965
Hansen Test	114.7 (0.54)	110.4 (0.58)	222 (0.26)	193.3 (0.21)	181.8 (0.25)	224.1 (0.18)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Section 3.5 Conclusion

The purpose of this chapter is to determine the factors affecting UK insurers' choices of the capital structure. Apart from confirming the influences of insurers' internal factors (behaviours), attention has also been paid to the impacts of market structure (external factors). Although there are several studies concerning the impact of market structure on firms' capital structures in the product market and the banking industry, the literature has not fully developed this issue in the insurance industry. One issue that cannot be avoided is market structure (e.g., competition). Because market structure is complex and cannot be measured directly, this chapter uses three measurements—the Boone indicator, the Lerner index and the HHI—to represent the different concepts of UK market structure in this chapter. Further, the interaction terms between the internal factors and these three indicators (separately) are included in the regressions to determine how the impacts of internal factors change according to varied market structure. First, the market structure measurements show that there are upward trends associated with all three indicators over the study period, implying that increase in the market competition (the Boone indicator) might lead to enhancing insurers' pricing power (the Lerner index) and the degree of market concentration (the HHI).

Second, the summary of the hypotheses and relevant results are shown in Table 3.15. Panel A indicates that both internal factors and external market structure influence insurers' capital structures (the leverage ratio) differently. There is evidence to support both trade-off and pecking-order behaviour, while the pecking-order theory takes the dominant position. This suggests that UK insurers might prefer using internal sources of funding to adjust capital structure towards the target level. Further, Panel B confirms that there are changes in the impacts of insurers' internal decisions or behaviours under different market structures. These results not only suggest that the impacts of internal factors change due to the external pressures but also reveal that different indicators represent different concepts of market structure. Thus, these concepts are not mutually exclusive, and there is overlapping and non-overlapping information shared among the three measurements.

Table 3.15: Summary of Hypotheses and Results

Panel A: Hypotheses 1-4	
Trade-off Theory (Lagged Leverage)	+
Pecking-order Theory (Retained Earnings)	-
Income Volatility	+
Business Volatility	-
Reinsurance	-
Boone Indicator	-
Lerner Index	-
HHI	-
Panel B: Hypothesis – Interactions with Boone	
Lagged Leverage*Boone	-
Retained Earnings*Boone	+
Income Volatility*Boone	-
Business Volatility*Boone	+
Reinsurance*Boone	**?**
Panel C: Hypothesis – Interactions with Lerner	
Lagged Leverage* Lerner	-
Retained Earnings*Lerner	+
Income Volatility*Lerner	-
Business Volatility*Lerner	+
Reinsurance*Lerner	-
Panel D: Hypothesis - Interactions with HHI	
Lagged Leverage* HHI	-
Retained Earnings*HHI	+
Income Volatility*HHI	-
Business Volatility*HHI	-
Reinsurance*HHI	+
Panel E: Hypothesis - Interactions with Boone*Lerner	
Boone*Lerner	+
Lagged Leverage*Boone*Lerner	-
Retained Earnings*Boone*Lerner	+
Income Volatility*Boone*Lerner	-
Business Volatility*Boone*Lerner	+
Reinsurance*Boone*Lerner	-
Panel F: Hypothesis - Interactions with Boone*HHI	
Boone* HHI	+
Lagged Leverage*Boone* HHI	-
Retained Earnings*Boone*HHI	+
Income Volatility*Boone*HHI	-
Business Volatility*Boone*HHI	-
Reinsurance*Boone*HHI	-
Panel G: Hypothesis - Interactions with Lerner*HHI	
Lerner * HHI	+
Lagged Leverage* Lerner * HHI	-
Retained Earnings*Lerner*HHI	+
Income Volatility*Lerner*HHI	-
Business Volatility*Lerner*HHI	+
Reinsurance*Lerner*HHI	+

In addition, Panels E through G show that the impact of market structure on insurers' capital structures is consistent when at least two indicators are combined, suggesting that the interactions between two individual concepts can disclose a relatively complete picture of market structure. Findings from Panels E through G further suggest that the choice of the capital structure depends on both internal factors and external pressures.

In sum, this chapter confirms that both internal behaviours and external pressures arising from market structure influence insurers' capital structures. Other relevant results further reveal the importance of considering the various concepts of market structure. These developments contribute to the current discussion on capital requirements, such as Solvency II. The required amount of capital should not only be based on insurers' internal decisions but should also bear in mind market influences. On the other hand, insurers also must adjust their capital structures or operational decisions to correspond to changes in market structure so that they maintain competitive advantage.

CHAPTER 4: Key Determinants of the UK Non-life Insurer's Financial Soundness: Does Underwriting Cycle Matter?

Abstract

It is essential to ensure that insurers can maintain and enhance their financial soundness, to meet the promised obligations. This chapter addresses the impacts of some particular factors on insurers' financial soundness (stability). Specifically, four factors — performance, leverage position, reinsurance and liquidity — are identified as significant driving forces, as they are the top-four internal issues that potentially relate to insurers' solvency. As one of the special characteristics of the non-life insurance market is the existence of a cyclical pattern, the impacts of the underwriting cycle on insurers' stability have also received particular attention. Furthermore, another main contribution of this research is to disclose the interacted effects on insurers' stability when the interactions between internal factors and external pressures are taken into account. It provides insight as to whether there are any mechanisms through which the external pressures affect insurers' stability indirectly. Therefore, this empirical study focuses on the U.K. non-life market from 1996 to 2017 and is conducted in two steps. First, the second-order autoregressive AR(2) model is used to dete the existence of the underwriting cycle. Second, the OLS fixed-effect model and dynamic GMM estimator are adopted to test the influence of both internal and external factors on insurers' financial stability, (*i.e.* Z-score and its efficiency).

The result from the AR(2) model first confirms the existence of the underwriting cycle in the U.K. non-life market; the length is about five years on average. The finding from the main regression model then discloses the importance of both internal factors (*i.e.* performance, leverage, and reinsurance and liquidity) and the external factor (*i.e.* underwriting cycle) on insurers' financial soundness. An insurer's performance and liquidity risk level are positively related to its soundness, while the firm's leverage level and the market underwriting cycle contain negative influences on stability. The use of reinsurance enhances non-life insurers' soundness in the short-term only. Further, it is reasonable to conclude that the underwriting cycle jointly determines the effect of internal factors on stability. It implies that the underwriting cycles influence insurers' operational strategies and financial health. Last, there is evidence to support the view that competition is one potential driving factor of the underwriting cycle in the non-life market.

Section 4.1 Introduction

During the savings and loan crises in the U.S. in the 1980s, concerns for the financial stability of financial institutions initially received more attention and public scrutiny (Brockett *et al.*, 2004b). Since the famous case of the London Market Excess (LMX) reinsurance spiral in the early 1990s, this concern further infiltrated the insurance industry because it acted as a vita financial intermediary and had systemic relevance within the financial system (Acharya *et al.*, 2009; Cummins and Weiss, 2014; Weiß and Mühlnickel, 2014). As noted, the primary function of the insurance sector is to provide protection and mobilise industries' participation in development by providing additional funding; a healthy and well-developed insurance sector can further enhance stability of financial market (Rothstein, 2011; Lee, 2013; Lee and Chang, 2015; Eling and Jia, 2018). Thus, it is crucial to ensure that an insurer maintain and enhance its financial soundness to meet the promised obligations to policyholders and investors (Brockett *et al.*, 2004b; Zou *et al.*, 2012). The financial crisis that occurred in 2007 has further raised regulatory authorities', researchers', and insurers' concerns regarding the insurer's solvency, *i.e.* the insurer's overall stability (Dhaene *et al.*, 2017).

Investigating the influence of the 2007–2009 financial crisis on the global insurance market, Baluch, Mutenga, and Parsons (2011) point out that, in comparison to the losses in the banking sector, the negative impact of the financial crisis on the insurance sector was much less. However, the severe decline within the insurance sector remained large enough to merit attention (Baluch, Mutenga and Parsons, 2011). The impact of an insurer becoming distressed or insolvent can be extensive, as it becomes more engaged with banks and acts as the ultimate carrier of risks. Das, Davies, and Podpiera (2003) also mention that harmful contagion effects of the failures of insurers might influence the financial system and economy. Baranoff and Sager (2011) further reveal that insurers moved from a finite-risk mode toward an excessive-risk mode during the 2007–2009 financial crisis period, meaning that insurers engaged in an excessive level of risk as they were not able to adjust their risk management strategies according to the increased risk-taking (*e.g.* asset risk).

Previous studies on the financial soundness (or insolvency) of insurance companies mainly follow two paths. One is to predict an insurer's insolvency by using different econometric techniques, such as the neural network models and support vector machines

(Brockett *et al.*, 1994, 2006; Huang, Dorsey and Boose, 1994; Salcedo-Sanz *et al.*, 2004; Ibiwoye, Ajibola and Sogunro, 2012; Benali and Feki, 2015), the logit regression (BarNiv and Hershbarger, 1990; Chen and Wong, 2004; Sharpe and Stadnik, 2007; Cheng and Weiss, 2012b; Zhang and Nielson, 2015), the hazard models (Lee and Urrutia, 1996; Brockett *et al.*, 2006; Dang, 2014; Caporale, Cerrato and Zhang, 2017), the generic programming approach (Salcedo-Sanz *et al.*, 2005), and the CAMEL-S model (Hsiao and Whang, 2009; Yakob *et al.*, 2012). Most studies on these techniques tend to use a large sample size and a massive number of variables (*i.e.* the firm's financial ratios, in most cases) to establish an early warning system. Moreover, a further purpose is to compare the accuracy and effectivity of the forecasted outputs from different approaches.

Analysing the determinants of an insurer's financial instability (or risk-taking) is another line of study in which the sample of insolvent firms is not essential criteria, but the targeted hypotheses are specified. The fundamental idea is that increased incentives to take more risks are expected to increase the likelihood of instability (Ren and Schmit, 2006). In other words, the researcher only considers the impact of some specific factors on the insurer's instability or risk-taking behaviour (see Browne and Hoyt, 1995; Ren and Schmit, 2006; Shim, 2015; Pasiouras and Gaganis, 2013; Mankaï and Belgacem, 2016; Cummins, Rubio-Misas and Vencappa, 2017; Alhassan and Biekpe, 2018; and Eling and Jia, 2018). The advantage of focusing on some particular factors is not only to clarify the potential influences, but also to allow attention to be paid to some specific strategies, behaviours, and movements, which may not have direct impacts on an insurer's soundness.

Regarding the determinates of an insurer's financial soundness, Benali and Feki (2015) analysed insurer solvency in the Tunisian market and found that profit performance, leverage position, and liquidity problems are the top-three issues relevant to insolvent companies. This result is similar to the previous findings of Lee and Urrutia (1996) and Chen and Wong (2004), who applied the logit and hazard models to identify the critical factors on insurer's insolvency prediction.[1] Using a large sample, including data from 515

[1] From Lee and Urrutia's study (1996), the logit model detects four key factors: leverage ratio (the ratio of net premiums written to surplus), profitability (ROE), risky business and long term bond investment. The hazard model detects four additional variables: operating margin, liquidity ratio, rate of growth of surplus, and rate of growth in premiums written. Chen and Wong (2004) found the significant factors for general insurers are investment performance, liquidity, surplus growth, combined growth, operating margin and size.

U.K. general insurers for 30 years, Caporale, Cerrato and Zhang (2017) found that leverage, profitability, liquidity, reinsurance, and organisational form are the driving factors of insolvency risk. Previous studies on the connection between insurers' risk-taking and various corporate governance mechanisms include Cheng (2008), Boubakri (2011), and Ho, Lai and Lee (2013), among others.

Apart from the factors that internally affect an insurer's financial health, exogenous factors — economic and market factors — are also crucial in influencing an insurer's financial health (Brockett *et al.*, 2006; Wang, 2010; Zhang and Nielson, 2015). Focusing on the U.S. market, Browne and Hoyt (1995) confirmed this view by testing the influence of six exogenous variables on a property-liability insurer's insolvency rate. Browne, Carson and Hoyt (1999) further found that interest rate, personal income and real estate returns influence the life-health insurer's stability and insolvency. Chen and Wong (2004) and Caporale, Cerrato and Zhang (2017) also explored the impact of market and economic factors (together with other internal factors) on insurers' health in the Asia market and the U.K. market, respectively. Based on data from 66 countries, Fields, Gupta and Prakash (2012) investigated the effects of external factors (*e.g.* investor protection, government quality and contract enforcement) on an insurer's risk-taking. Specifically, competition was one of the external factors that had essential effects on a firm's soundness in the financial markets (Ren and Schmit, 2006). Its impact has been massively debated and developed by policymakers and academics (Keeley, 1990; Berger *et al.*, 2004; Beck, Demirgüç-Kunt and Levine, 2006; Schaeck, Cihák and Wolfe, 2009; Schaeck and Cihák, 2010; 2014; Cheng and Weiss, 2012; Fields, Gupta and Prakash, 2012; Cummins, Rubio-Misas and Vencappa, 2017; Alhassan and Biekpe, 2018).

With the exception of competition, a unique characteristic of the non-life (general) insurance market is the existence of a cyclical pattern of underwriting results, called underwriting cycles. [1] The underwriting cycle can be defined as repeating, regular phases of soft and hard markets in the non-life sector (Niehaus and Terry, 1993; Harrington and Niehaus, 2000; Weiss, 2007); it is considered to have encompassing influence on an insurer's operations. Insurers act differently in soft and hard markets. For example, in a hard market, insurance coverage is restricted due to the tightened underwriting standards,

[1] Chen, Wong and Lee (1999) state that there are differences between the underwriting cycle and business cycle in the non-life sector. First, the underwriting cycle may not necessarily synchronize with the business cycle. Second, the underwriting cycle occurs more frequently than the business cycle.

and the insurance price is higher due to a lower degree of competition. On the other hand, insurers set a lower price for their products and services due to the relatively high insurance supply in a soft market with intense competition and less stringent underwriting standards.[1]

Thus, the existing underwriting cycle can be seen as one of the external pressures that adds uncertainty to non-life insurers' practices in the form of pricing strategies (*i.e.* premium rate level), claims payments, revenues and profit generation (see Cummins and Outreville, 1987; Eling and Luhnen, 2009; Zhang and Tang, 2012; and Jakov and Žaja, 2014). Elango (2009) illustrates that a larger number of insurers perform closer to the average industry level in a hard market, relative to a soft market. Further, the underwriting cycle is also incorporated into insurers' enterprise risk management and solvency analysis (Kaufmann, Gadmer and Klett, 2001). Malinovksii (2010) presumes that claim size varies at different phases of the insurance cycle. The risk managers should keep this cycle in mind; then they can predict when the underwriting will be tight or loose, and when the external pressure will be increased or reduced. Similar to the underwriting cycle in the insurance market, the business cycle has been widely used to represent a general cyclical pattern appearing in the financial industry. For example, the state of the business cycle can explain an insurer's time-varying relationship between size and growth (Hardwick and Adams, 2002). From non-insurance literature, some studies have investigated the effect of the cyclical pattern on firms' behaviour and reaction to the cycle in various perspectives (see Rampini, 2004; Vander Vennet, De Jonghe and Baele, 2004; Angeletos and Calvet, 2006; Saadaoui, 2014; and Ben Bouheni and Hasnaoui, 2017).

However, compared to the number of studies on the relationship between competition and stability, investigations on the impact of the cyclical pattern on an insurer's financial soundness is relatively limited. Guidara and Lai (2015) state that the actuarial pricing approach is designed to deal with the rates, but the market pricing approach is used to set the selling price, for which external factors (such as the underwriting cycle) need to be considered as well. Simmons and Cross (1986), Jones and Ren (2006) and Jakov and Žaja

[1] In terms of accounting profitability, Trufin, Albrecher and Denuit (2009) define four stages of the underwriting cycle. The first stage is when the insurers remain at a low profitability level for several years. Then, insurers' profitability increases suddenly and rapidly during the second stage. This is followed by a high level of profitability, while it is no longer increasing. During the fourth stage, insurers' profitability starts to decline until it returns to a phase of low profitability.

(2014) suggest that this cycle indirectly influences general insurers' risk-taking behaviours and solvency situations. Browne and Hoyt (1995) also argue that the underwriting cycle can be a significant predictor of insurers' insolvency. From the past few decades, the insolvency rate in the U.K. market has been relatively low compared to the U.S. market. However, this does not necessarily mean the financial stability is high. According to Shiu (2005), U.K. insurers operate in a low solvency environment. Thus, although the cost of financial distress might be less than the cost of insolvency of a troubled firm,[1] the effect of instability is still significant and is a significant concern (Sharpe and Stadnik, 2007).

Weiss (2007) states that regularity is the key reason why this cyclical pattern has piqued the interest of different researchers because this regularity can potentially influence the rationality of insurers' operations.[2] Numerous prior studies have tested its appearance in different insurance markets and tried to explain the presence and causes of the underwriting cycle (see Venezian, 1985; Cummins and Outreville, 1987; Winter, 1994; Doherty and Garven, 1995; Cummins and Danzon, 1997; Lamm-Tennant and Weiss, 1997; Fung *et al.*, 1998; Chen, Wong and Lee, 1999; Harrington, 2004; Meier, 2006a; Leng and Meier, 2006; Meier, 2006b; Lazar and Denuit, 2011; and Zhang and Tang, 2012).

The explanations of the cause of the underwriting cycle follow two leading schools of thought: irrational behaviour hypotheses and rational expectations. The former suggests that the insurance market operates irrationally or imperfectly (Venezian, 1985; Gron, 1994). The relevant hypotheses include the cash-flow underwriting hypothesis (Gron, 1994), the naive rate-making process (Venezian, 1985), the capacity-constraint hypothesis (Winter, 1994), the risky-debt hypothesis (Cummins and Danzon, 1997), and the competitor-driving pricing hypothesis (Berger, 1988; Harrington and Danzon, 1994; Malinovksii, 2010). The assumption that uncontrollable external factors and market

[1] According to Financial Sevices Compensation Scheme, there are 33 insolvent cases have occurred in the non-life sector since 1985. Althrough there are clear differences between insolvency and financial distressed, the terms of "insolvency", "instability" and "financial distressed" are interchangeable, *i.e.* do not distinguish between insolvency and fianncial instability in this chapter.

[2] Weiss (2007) suggests that there are diverse concerns associated with different phases of the cycle for various parties. For example, policyholders and regulators may pay attention to insurers' financial health in the soft market, as a higher insolvency rate is likely to occur in the soft market. In the hard market, the potencial clients may be concerned with the price of insurance coverages, and the manager of the insurance firm may need to strike a balance between the cost of insurance and the ability to write new businesses.

characteristics cause the underwriting cycle is known as the rational expectation, also called the institutional intervention hypothesis (Lamm-Tennant and Weiss, 1997). These factors include: (1) institutional, regulatory, and accounting characteristics, *i.e.* the feature of time-lags (Cummins and Outreville, 1987; Outreville, 1990); (2) pricing policies and regulatory requirements (Winter, 1991a); (3) exogenous shocks related to claim and loss distributions, *e.g.* catastrophic losses (Harrington and Niehaus, 2000); (4) interest rate fluctuations (Doherty and Kang, 1988; Doherty and Garven, 1995; Fung *et al.*, 1998); (5) general business cycle and economic growth (Grace and Hotchkiss, 1995; Chen, Wong and Lee, 1999); (6) the availability of reinsurance and reinsurers' capacity (Meier and Outreville, 2006); (7) internal risk factors (Jakov and Žaja, 2014); and (8) other external uncertainties, *e.g.* the possibility of extreme discontinuities in insurer policy offers (Berger and Cummins, 1992).[1]

Indeed, there is a potential connection between insurers' stability and underwriting cycles. As introduced, the insurers will adjust their premium (price of policies) level corresponding to the cyclical pattern, either increasing or decreasing. Thus, the insurer can strengthen its financial stability (soundness) if it can adjust the premium more efficiently and precisely to reflect the latest market information (Cummins and Outreville, 1987). However, much less is known on the relationship between stability and underwriting cycles. In the previous literature, Nelson (1970) observed that the number of insolvencies in the industry roughly follows the underwriting cycle. Malinovksii (2010) provides some numerical examples to show that there are connections between the insurance cycle and insolvencies of insurers. He further argues that it is essential to recognise the impact of the competition-originated cycle on an insurer's financial health. From earlier, Pentikäinen (1988) and Daykin, Pentikäinen and Pesonen (1996) studied the relationship between the underwriting cycle and the probability of ruin. Wang (2010) reveal that the economic and industry cycles influence the distribution of an insurer's (credit) rating in the U.S. property-liability insurers' rating over the 1995 – 2006 period. The result indicates that insurers usually have better performance in an economic peak year. Regarding the underwriting cycle, Wang (2010) also finds that insurance ratings are more stable in the soft market, and more down-graded in the hard market. Using dynamic

[1] Studies that provide useful summaries on the rationale of the underwriting cycle include Lamm-tennant and Weiss (1997), Chen, Wong and Lee (1999), Harrington (2004), Meier and Outreville (2006), Weiss (2007) and Eling and Luhnen (2009).

financial analysis, Kaufmann, Gadmer and Klett (2001) later studied the relationship between the underwriting cycle and ruin probability. Similarly, Marek and Eling (2012) adopted the Ornstein Uhlenbeck process to confirm the influence of the underwriting cycle on risk and return. The cyclical pattern can also be seen as the periodic risk (see theoretical literature from Asmussen and Rolski, 1994; Dimitrov, Chukova and Garrido, 2000; Morales, 2004; and Lu and Garrido, 2005). Compared to the case of no cyclical pattern, Trufin, Albrecher and Denuit (2009) agree that the underwriting cycle increases the probability of ruin.

The underwriting cycle is an essential topic in research, but somewhat neglected in the U.K. insurance market, one of the most mature and developed insurance markets in the world. The purpose of this chapter is not to seek an explanation as to why the underwriting cycle exists.[1] Instead, the aim is to examine the influence of underwriting cycles on an insurer's strategies, especially within the U.K. context. Specifically, this chapter first contributes to the literature by testing the occurrence of underwriting cycles in the U.K. non-life market. Then, the second step explores a rarely discussed topic: the influence of underwriting cycles on an insurer's soundness (or stability). One particular interest is, therefore, to test whether this cyclical pattern affects the relationship between an insurer's internal factors and its financial soundness; this can be achieved by including an interaction term that is between the proxy of the underwriting cycle and different driving forces.

This chapter mainly contributes to ongoing discussions on insurers' financial soundness (Cummins, Rubio-Misas and Vencappa, 2017; Alhassan and Biekpe, 2018; Eling and Jia, 2018). The main purpose of this chapter not simply identify early warning signs of insurer instability, but also essential to determine some particular driving factor on insurers' financial health. On top of that, the direct and indirect influences of underwriting cycle on insurers' soundness are considered, as the cycle influences the insurers' risk-taking behaviours (Jones and Ren, 2006; Jakov and Žaja, 2014).

[1] This chapter does not try to define the factors that influence the underwriting cycle. From previous literature, the results with respect to the cycle lengths or driving factors are not consistent and robust because of the chosen estimation menthods, the variables, or the extent of available data (Meier, 2006b). This is not an issue in this chapter because the primary aim is to test the existence of the cycle and its influences.

Then, several contributions can be made to the literature. Firstly, the question of how the underwriting cycle may interact with insurers' stability has not been well-studied. The relationship will provide insight into how to improve a firm's stability in response to pricing restrictions (caused by underwriting cycle). Furthermore, the potential impacts of underwriting cycle are important for all stakeholders. For example, policyholders are the ultimate beneficiaries, so they are keen to know whether their potential compensation is secure during different phases. They can adjust their purchase decisions according to the market conditions. Investors also need to know the influence of changes in an insurer's stability on the value of their investments due to exogenous factors.

Additionally, it is vital to pay attention to changes in an insurer's financial soundness after changes in an insurer's risk-related behaviour. Thus, it is worth discussing the potential factors that lead to such changes, both internal factors and external pressures. Therefore, the expected results can provide insights to answer the following questions: What are the internal determinants that drive U.K. insurers' stability (soundness)? Do insurers adjust their riskiness in response to external pressures stemming from the underwriting cycle? Are there any mechanisms through which external pressures affect stability, *i.e.* disclosing interacted effects on insurers' stability when considering the interactions between internal factors and external pressures? This chapter contributes to the literature by incorporating the influence of the underwriting cycle on an insurer's financial soundness (stability or risk-taking behaviour), including the interaction term between both internal and external factors in consideration of their joint effects. Answering the abovementioned questions can help regulators endorse supervisions to reduce insolvency risk and promote financial stability in the market.

The rest of this chapter is structured as follows: Section 4.2 develops the hypotheses based on the empirical literature. Section 4.3 presents the methodology adopted to test the existence of the underwriting cycle in the U.K. non-life insurance market; the theoretical model and the variables used to test the hypotheses are then discussed. Section 4.4 presents the empirical results related to the hypotheses. Finally, Section 4.5 presents the conclusion

Section 4.2 Literature Review and Hypotheses Developments

This section discusses the empirical evidence of the determinants of the firm's soundness (stability), *i.e.* both internal and external driving forces, in the insurance industry. Due to inadequate empirical studies on the expected relationship in the insurance market, the discussion is extended to cover studies on risk determinants in the financial market, including evidence from the banking sector.

4.2.1 Insurer's Performance

An insurer's financial soundness is related to its long-term management quality, such as its operational performance. Based on previous studies, the link between a financial firm's performance and its stability is inconclusive. For example, the moral hazard hypothesis (or bad-management hypothesis) assumes that inefficient firms, *i.e.* the underperformers, are more prone to risk-taking than efficient firms (Kwan and Eisenbeis, 1997; Altunbas *et al.*, 2007; Fiordelisi, Marques-Ibanez and Molyneux, 2011). Allen, Carletti and Marquez (2011) confirm that efficient monitoring allows banks to attract better credit risks. Although Altunbas *et al.* (2007) provide some evidence from the sub-group of less efficient banks to support the positive relationship between performance and stability, they also found that banks' inefficiency and risk-taking are negatively related in the full sample (*i.e.* inefficiency reduces banks' risk-taking).

In terms of the insurance business, the fact that inefficient insurers accept an excessive or unexpected amount of risk (*e.g.* inaccurate pricing), taking more risky businesses and making inappropriate investments, can explain the positive relationship (between performance and stability). BarNiv and McDonald (1992) agree that high profitability may indicate a lower risk of being financially distressed. In line with this, Zhang and Nielson (2015) state that profitability (return on equity) is negatively related to insurers' insolvency.

From a cost perspective, Kim *et al.* (1995) used a firm's combined ratio to represent underwriting losses and confirm that there is a positive impact on insurers' insolvency rates. Berger and DeYoung (1997) confirmed that the cost efficiency reduces (enhances) firms' riskiness (soundness). They refer to this relationship as the "cost skimping" hypothesis. In studying the Australian general insurance market, Sharpe and Stadnik (2007) revealed that an insurer with better profitability will have a lower likelihood of experiencing financial instability. However, the authors also found that the combined ratio is negatively related to insurer's insolvency; this result is inconsistent with previous findings by Kim *et al.* (1995) and Chen and Wong (2004), who revealed a positive relationship.

Recently, Schaeck and Cihák (2014) and Cummins, Rubio-Misas and Vencappa (2017) further discovered a competition-efficiency-stability nexus in which efficiency is as a channel through which competition strengthens a firm's stability in banking and insurance markets, respectively. In a later study, using a large sample from the EU between 2006 and 2013, Eling and Jia (2018) illustrated that an insurer's technical efficiency is negatively related to its likelihood of failure. These findings indicate that efficiency (performance) enhances insurers' financial soundness (stability).

In contrast, the profit-incentive hypothesis posits a positive relationship between a firm's performance and risk-taking (Tan and Anchor, 2016). More specifically, efficient insurers should have better financial ability to engage in more risky activities than those inefficient firms (Borde, Chambliss and Madura, 1994). Lee and Urrutia (1996) confirmed this view using data from the U.S. property-liability insurance market. By studying banking across the EU from the mid-1990s to 2008, Poghosyan and Cihák (2009) identified a set of indicators that define distressed banks. Indeed, they found that some distressed banks have better cost performance (low cost). Hu and Yu (2015) noted that Taiwanese insurers' inefficiency is positively related to product risks and negatively to asset risk when different specified risks are considered. These results suggest that efficiency (performance) damages insurers' financial soundness.

As discussed above, the impact of an insurer's performance on its financial soundness is ambiguous. Thus, a hypothesis can be developed as:

H1: *An insurer's performance affects its stability.*

4.2.2 Insurer's Leverage (Capital Structure)

The connection between a firm's capital structure and risk-taking has been well studied in the financial industry. Brunnermeier (2009) argues that more leveraged (less equity) firms are more likely to suffer from loss spirals. Shrieves and Dahl (1992), Jacques and Nigro (1997), Aggarwal and Jacques (2001) and Altunbas *et al.* (2007) argue that the banks that increase equity capital (reduce leverage) increase their risk appetites. This positive relationship between equity and risk-taking can be explained by the regulatory-cost hypothesis, which indicates that financial firms are willing to take more risks to balance the cost raised from the capital requirement. Thus, there is evidence to support a positive relationship between banks' leverage and financial stability.

However, Kwan and Eisenbeis (1997) point out that banks with more equity capital (lower leverage) may have less credit risk. Based on the monitoring theory, Allen, Carletti and Marquez (2011) and Mehran and Thakor (2011) also suggest that holding more capital (less leverage) allows banks to have better screening and monitoring, thereby enhancing financial stability. Further, Caccioli *et al.* (2014) found that there is a critical threshold for leverage, above which banks' financial stability decreases. Focusing on American and European banks between 2001 and 2009, Vazquez and Federico (2015) studied the impact of leverage on financial distress. They found that larger banks with higher leverage are more likely to fail. Thus, there is a potential negative connection between leverage and stability.

Although relevant studies are relatively limited in the insurance market, conflicting results also exist in the insurance world. According to the expected bankruptcy cost argument, insurers that have less equity capital, higher policyholder liabilities or higher leverage are expected to have more difficulty meeting future obligations and be more likely to experience financial distress (Shim, 2010; 2015; Shiu, 2011). This idea is corroborated by Carson and Hoyt (1995), who found that insurers with a low leverage ratio (*i.e.* the ratio of premium written to surplus) are less likely to be insolvent. Chen *et al.* (2009) suggest that more conservative operational strategies (*e.g.* holding less leverage) reduce the operational risk. Weiß and Mühlnickel (2014) indicate that insurers who carry more leverage are more exposed to systemic risk. Similarly, Zhang and Nielson (2015) prove that higher leverage firms tend to have a higher probability of being financially distressed. Recently, Caporale, Cerrato and Zhang (2017) found that highly leveraged insurers have a higher default probability in the U.K. general insurance market. Thus, the evidence from the insurance market supports a negative relationship between leverage and stability.

In comparison, because highly capitalised (low leveraged) insurers have the superior risk tolerance, they may have more of an incentive to write riskier businesses or make more risky investments (Hu and Yu, 2015); these impose further uncertainties on the firm. IN studies analysing the property-casualty insurer in the U.S. market, Cummins and Sommer (1996) and Zou *et al.* (2012) revealed that an insurer's risk position increases when it holds more capital. Nevertheless, Cheng and Weiss (2013), who also studied the connection between insurers' capital and these two specified risks, found the impacts on underwriting and asset risk were both positive in the U.S. property-liability market between 1993 and 2007. Thus, evidence of a positive relationship between an insurer's leverage and its soundness exists.

By decomposing the overall instability into different specified risk factors, Baranoff and Sager (2002; 2003) investigated the interplay between an insurer's capital position and some specified risks (*e.g.* product risk and asset risk) in the U.S. life market. Baranoff and Sager (2002) observed that the capital ratio significantly and negatively influenced a life insurer's product risk, while the positive impact on asset risk was not significant. Later, Baranoff and Sager (2003) further confirmed that the influence of capital on asset risk is insignificant.

Recently, in line with transaction-cost theory and regulatory-cost hypothesis, Hu and Yu (2014; 2015) found that higher capital levels encourage insurers to take more product risks, due to the higher expenses that originate from the regulatory capital requirement. In other words, the higher cost associated with the capital requirement may encourage insurers to make more risky business decisions in order to achieve a higher risk-return. Further, in the same study, the authors also found that capital had a significantly negative effect on asset risk. In terms of leverage, this result lends support to the moral hazard hypothesis, whereby highly leveraged insurers may take more asset risks. Indeed, Hu and Yu's (2014; 2015) findings are contrary to Baranoff and Sager's (2002) evidence; the former suggests that this may be due to the difference in regulatory cultures between the U.S. market and the Taiwanese market. Later, Alhassan and Biekpe (2018) also found that increasing equity (lowering the leverage level) can reduce underwriting risk but damages insurers' overall financial stability.

To sum up, two possible reasons can explain these inconclusive results, as suggested by Tabak, Fazio and Cajueiro (2012). First, operating with a certain level of capital can discipline firms through the capital-at-risk effect (*i.e.* capital is adjusted with respect to a firm's risk-bearings). So, increasing capital (or lowering the leverage) may enhance a firm's financial stability. Second, as holding capital is costly, firms may be more motivated to take extra risk to restore future profit. A higher equity level (lower leverage) may damage a firm's soundness.

Thus, the hypothesis on the impact of the leverage position on an insurer's soundness can be stated as:

H2: *Insurer's leverage position affects its stability.*

4.2.3 Reinsurance

As noted, non-life insurers are riskier than life insurers because of their characteristic short duration of policy life, which is the uncertainty in the claim amount and the timing. It is vital to adopt an effective and efficient risk management system to maintain financial soundness in a non-life insurance company. Reinsurance is a risk-shifting tool that reduces the exposures to underwriting and liquidity risks. Except for holding more capital or liquid assets to maintain solvency, insurers may choose to take reinsurance if the cost of hedging risk is less than the cost of financial distress. The primary objective of using reinsurance is to allow the primary insurer to transfer a certain amount of risk to the reinsurer (Shiu, 2011); this may suggest the usage of reinsurance can enhance an insurer's financial stability (Doherty and Tinic, 1981; Adams, 1996; Liu, Shiu and Liu, 2016). Mayers and Smith (1990) also report that reinsurance can lower the expected costs of financial distress. Moreover, Froot, Scharfstein and Stein (1993) suggest that risk management techniques (*e.g.* reinsurance) can enhance an insurer's market value. Upreti and Adams (2015) underline that reinsurance plays a significant role in helping insurers achieve a larger market share in the U.K. non-life market.

Apart from providing "emergency funding" directly to an insurer when it cannot keep a promise, reinsurance can also influence insurers' stability indirectly via other channels, such as capital and liquidity.[1] For example, according to the renting capital hypothesis,[2] the purchase of reinsurance may allow insurers to expand their underwriting capacity and

[1] Studies of the relationship between reinsurance and insurers' capital structures can be found in MacMinn (1987), Plantin (2006), Shiu (2011), Mankaï and Belgacem (2016) and Sheikh, Syed and Ali Shah (2018). Regarding liquidity, Liu, Shiu and Liu (2016) found that the interplay between insurers' liquidity and the usage of reinsurance was positive. In addition, Rochet and Villeneuve (2011) focused on firms facing cash-flow risks and concluded that the usage of (re)insurance helped firms to maintain liquidity level, stabilize investment spending and lower the cost of capital. These results confirm that insurers can use reinsurance to maintain their capital or liquidity position, which further influences insurers' financial stability.

[2] The rent capital hypothesis assumes that reinsurance may serve as a substitute, to some degree, for equity capital, and can potencially increase the primary insurer's surplus level (Hoerger, Sloan and Hassan, 1990; Adiel, 1996; Chen, Hamwi and Hudson, 2001; Garven and Lamm-Tennant, 2003; Shiu, 2011). The primary insurer may prefer to use reinsurance to transfer its risks if the cost of reinsurance is lower than the cost of issuing equity capital.

maintain capital at a relatively low level without increasing the risk of default (Mankaï and Belgacem, 2016; Caporale, Cerrato and Zhang, 2017).

In addition to the mentioned advantages, Liu, Shiu and Liu (2016) provide two other reasons why general insurers should use reinsurance. First, reinsurance can reduce an insurer’s pre-tax income volatility, and thus, its expected tax payments. Second, reinsurers provide extra information or real services to primary insurers’ operations, thereby maintaining the primary insurer’s financial soundness. Based on U.S. market data from 1980 to 1987, Garven and Lamm-Tennant (2003) also suggest that using reinsurance can mitigate insolvency risk. Looking at the Australian general insurance market, Sharpe and Stadnik (2007) note that insurers’ with more reinsurance expenses tend to be more stable. Studying the relevance between the insurance sector and the financial system in the U.S., Weiß and Mühlnickel (2014) argue that insurers who purchase more reinsurance protections are less likely to become the top systemic risk contributors. After conducting a worldwide study, Fields, Gupta and Prakash, (2012) confirmed that there is a positive relationship between an insurer’s soundness and the use of reinsurance by life insurers, while finding no evidence for non-life insurers. Besides, Kramer (1996) found no evidence to support the idea that reinsurance influences the financial stability of Dutch non-life insurers.

Although the traditional view suggests a positive relationship between the use of reinsurance and an insurer’s stability, an alternative view indicates that an insurer may increase its risk-taking if it depends heavily on a reinsurer’s financial health (Kim *et al.*, 1995; Pottier and Sommer, 1999). This negative relationship can be referred as the moral hazard hypothesis, which implies that the usage of external protections (*e.g.* reinsurance or guaranty funds) may encourage insurers to accept more risks (Lee, Mayers and Smith, 1997). Also, insurers may face more counterparty risk while they are enjoying the benefits of using more reinsurance (Caporale, Cerrato and Zhang, 2017).

Contrary to the Shim's (2015) expectation, he found that insurers with more reinsurance were not necessarily more stable. This finding is consistent with the results of Aunon-Nerin and Ehling (2008), Shiu (2011) and Mankaï and Belgacem (2016), who found that heavy use of reinsurance resulted in higher risk-taking. Caporale, Cerrato and Zhang (2017) studied the U.K. general insurance market, and their findings first suggested that insurers accepting reinsurance had a higher probability of default than those without reinsurance protections, especially when natural disasters occurred. They further argued that the ceded amount was critical because insurers could choose whether they wanted to cede all or part of their businesses (Berger, Cummins and Tennyson, 1992). Recently, Alhassan and Biekpe (2018) confirmed a complex relationship that indicates that taking more reinsurance may increase underwriting risk and reduce an insurer's stability.

The above discussion is inconclusive as to the impacts of the use of reinsurance; therefore, the hypothesis can be stated as:
H3*: Insurer's reinsurance ceded affects its stability.*

4.2.4 Insurer's Liquidity

Apart from holding capital or purchasing (re)insurance to avoid insolvency, a firm's liquidity (or liquidity risk) is related to its solvency in financial institutions. From another perspective, a firm's liquidity position also indirectly influences its stability via performance, capital structure and risk management.[1] Additionally, a strong capital position may not be sufficient to address the financial difficulties raised by liquidity risk; firms that face more short-term obligations are willing to hold liquidity buffers to maintain their financial soundness. Ratnovski (2013) suggests that holding higher liquidity buffers and imposing transparency are two methods of managing liquidity risk (in banking), while Ratnovski also argues that adopting these methods is costly.

In terms of insurance, insurers with more liquid assets are exposed to less liquidity risk. Liquidity risk is defined as the probability that policymakers' need for cash exceeds the amount held by the insurer. The asset-liability mismatch is the primary source of liquidity risk. Insurers should maintain a certain level of liquidity to meet their expected obligations when they are due. Billio *et al.* (2012) not only confirmed the importance of the insurance industry in the financial sector but also pointed out that illiquidity may be one of the sources of systemic risk.

Lee and Urrutia (1996) argue that current liquidity ratio is a significant indicator of financial stability. Benali and Feki (2015) also express that an insurer's ability to meet its

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[1] The relationship between a firm's liquidity and performance can be found in Molyneux and Thornton (1992), Adams and Buckle (2003), Athanasoglou, Brissimis and Delis (2008), Fresard (2010), and Tan (2016). The potencial connections between a firm's liquidity and capital structure can be found in Kim, Mauer and Sherman (1998), Opler (1999), Najjar and Petrov (2011) and Chiaramonte and Casu (2017). Liu, Shiu and Liu (2016) also provide a detailed study on the interlinks between liquidity and reinsurance.

short-term liabilities and obligations is the key to distinguishing solvent and insolvent firms. This is particularly true for non-life insurers. In comparison to life insurers, non-life insurers require more liquidity than life firms due to the short-term nature of its businesses (Fields, Gupta and Prakash, 2012). Thus, the non-life insurers are exposed to more liquidity risks and tend to maintain higher liquidity levels (Liu, Shiu and Liu, 2016).

Myers and Rajan (1998) revealed the strengths and weaknesses of maintaining certain levels of liquidity. From an insurer's point of view, the benefit is that insurers can be in a better position to avoid financial distress during periods of high demand for claims; the drawback is that it makes it hard to commit the firm to another course of action (Najjar and Petrov, 2011). Apart from these two outcomes, Weiß and Mühlnickel (2014) present a third possible consequence of holding more liquid assets. They argue that insurers with more liquid assets may be more likely to be liquidated when the market experiences a downturn.

By investigating credit ratings in the insurance market, Carson and Scott (1997) and Bouzouita and Young (1998) identified a negative correlation between credit rating and liquidity risk. In the same line, Sharpe and Stadnik (2007) studied insurers' financial health in the Australian market and confirmed that holding an adequate level of liquid assets can reduce the likelihood of experiencing financial distress. Later, Zhang and Nielson (2015) found that property-casualty insurers with sufficient cash flow were less likely to become insolvent in the U.S. market. In line with these, Caporale, Cerrato and Zhang (2017) confirmed that a high liquidity ratio (*i.e.* the cash ratio) represents a good claims-paying ability, which is associated with a lower default probability in the U.K. general insurance market.

Further, Fields, Gupta and Prakash (2012) use liquidity ratio (*i.e.* the ratio of liquid asset to net technical reserves) to represent exposure from investments. They provide evidence for the positive relationship between this liquidity ratio and life insurers' risk-taking (or insolvency). Similarly, Mankaï and Belgacem (2016) argue that insurers with more liquid assets may decide to hold less capital and accept more risks.

Similar to the insurance industry, Wagner (2007) also suggests that liquid banks may be riskier. In contrast, using the Net Stable Funding Ratio (NSFR) to represent banks' liquidity, Vazquez and Federico (2015) found that (smaller) banks with weaker liquidity positions were more likely to suffer failures. Chiaramonte and Casu (2017) confirmed a similar result. However, Hong, Huang and Wu (2014) found that liquidity has only limited effects on bank failures. Liu, Molyneux and Nguyen (2012) and Leroy and Lucotte (2017) also found no evidence that a bank's liquidity influences its risk-taking.

Based on the previous findings, the following hypothesis can be developed from the point of liquidity risk:

H4: *Insurer's liquidity risk affects its stability.*

4.2.5 Underwriting cycle on Soundness

Apart from the discussed internal factors, macroeconomic and industry variables also significantly influence insurers' financial soundness (Cheng and Weiss, 2012b). For example, Rampini (2004) identified the business cycle as one of the factors related to firms risk-taking. As one of the special characteristics of the general insurance market, the underwriting cycle potentially affects non-life insurers' financial soundness. Using loss ratio to represent the underwriting cycle, Ren and Schmit (2006) found that the influence of competition and the franchise value on insurers' solvency (risk-taking) are affected by the underwriting cycle.

As mentioned, the non-life market follows a hard and soft market cycle. A period of higher premiums, lower supply of coverages and sizeable underwriting profit characterize the hard market; by a period of lower premiums, a higher level of competition and considerable underwriting losses characterize the soft market (Venezian, 1985; Winter, 1991b). When the premium charged is below the discounted losses and expenses in the soft market, an insurer's likelihood of insolvency increases due to the deterioration of surplus level and reserve inadequacy (Jones and Ren, 2006).

If the industry-wide combined ratio is used to represent the underwriting cycle, a higher ratio would indicate unfavourable underwriting results, which would likely be found in a soft market; a lower combined ratio may indicate a hard market. The financial health of insurers who have excessive risk-taking strategies should be considerably weaker in a soft market (or during a period of peaks in the cycle) because of the combination of a low premium due to competition and high claims due to loose underwriting. Thus, it is reasonable to assume that there is a positive (negative) relationship between insurers' insolvency (soundness) and the industry-wide combined ratio.

Doherty and Garven (1995) suggest that changes in interest rates may influence the value of the capital stock, which may further affect insurers' underwriting and pricing strategies. Fields, Gupta and Prakas (2012) used the lending interest rate to control the underwriting cycle and found evidence that the mean is negatively related to risk-taking, while the variance is positively related. To be more specific, an insurer in the hard market will tend to increase prices and reduce supply levels when its equity decreases due to fluctuation in interest rates in order to maintain its financial stability. Thus, this assumption supports the hypothesised positive relationship between the industry combined ratio (*i.e.* the proxy of the underwriting cycle) and insurers' insolvency. In other words, the insolvency rate will be higher in the soft market, when the industry combined ratio increases or when the underwriting cycle peaks. Browne and Hoyt (1995) confirmed that the industry combined ratio is positively related to the insolvency rate. Sommer (1996) also found that the price of insurance is negatively related to insurers' instability.

Ren *et al.* (2011) studied the impact of the underwriting cycle on insurers' risk-taking from 1960 to 2008. They found that insurers tend to reduce (enhance) the amount of investment risk taken in the hard (soft) market,[1] while insurers face higher insolvency risks in the hard market than in the soft market. Furthermore, a difference of reaction to the underwriting cycle between stock and mutual insurers with respect to investment risk was found. For example, stock firms actively adjust their investment risk across the underwriting cycle (Ren *et al.*, 2011). Zhang and Nielson (2015) also demonstrated a significant relationship between the underwriting cycle and insurers' financial performance and insolvency. The authors confirmed the underwriting cycle hypothesis; that is, the probability of instability increases when the industry has poor underwriting results on average due to the higher competition in the soft market.

Cheng and Weiss (2012) also found that insolvency propensity is significantly related to the underwriting cycle. However, in contrast with others, their results indicate that there may be more insurer insolvencies in the hard market, *i.e.* when the supply of insurance is

[1] Ren *et al.*'s (2011) results indirectly indicate that an insurer seeks an optimal level of stability by balancing underwriting risk and investment risk. Staking and Babbel (1995) and Cummins and Sommer (1996) also achieved a similar conclusion by studying the relationship between investment risk and underwriting risk directly.

low, as there is a negative link between industry-wide combined ratio and insurers' insolvency. Thus, these results partial support Ren *et al.*'s (2011) findings.

In addition to the direct impacts on insurers' stability, the underwriting cycle may influence insurers' soundness indirectly. For example, Huang and Eling (2013) state that non-life insurers in the BRIC bloc of countries would have a lower level of efficiency when the overall market condition is favourable. In line with this, Eling and Schaper (2017) found that insurance market conditions are one of the driving factors of efficiency in the European market. Further, the underwriting cycle also influences insurers' M&A and IPO decisions, as suggested by Chamberlain and Tennyson (1998) and Yu *et al.* (2004).

Cummins and Danzon (1997) provide evidence that insurers are willing to raise capital in hard markets. Moreover, Gron and Lucas (1998) argue that insurers should be more comfortable raising capital in hard markets, as the capital market provides positive and favourable feedback to insurers' financing decisions. Regarding insurers' capital adjustments, Guidara and Lai (2015) found that the adjustment is higher in a soft market. In banking studies, Delechat *et al.* (2012) also found a potential connection between the credit cycle (business cycle) and liquidity buffer. Brei and Gambacorta (2016) also state that the business cycle influences the bank capital ratio.

As discussed by Cummins *et al.* (2008), the event of losses that lead to a capital shortage, re-evaluation of pricing strategies or re-assessment of risk management can trigger a hard phase. In order to adapt to the new surroundings, insurers may choose to reduce coverage capacity, to accept a higher level of insolvency or to transfer the risk to reinsurers. The underwriting cycle characterizes both primary insurers and reinsurers equally because they share unexpected losses from the same sources (Meier and Outreville, 2006). Thus, the cost of reinsurance will be higher in the hard market, while it is less costly in the soft market. Thus, the underwriting cycle will potentially influence a primary insurer's decision to use reinsurance.

In summary, the direct impact of the underwriting cycle is explicit, as most of the findings from previous studies indicate that insurers may face higher insolvency risks in a soft market. Thus, the hypothesis can be developed as:

H5a: *The underwriting cycle directly affects an insurer's stability.*

An indirect impact can also be expected, as the underwriting cycle may influence other risk management decisions, such as capital structure, reinsurance and liquidity. Thus, another hypothesis can be stated as:

H5b: *The interaction between underwriting cycle and firm-specific factors affects an insurer's stability.*

Section 4.3 Data and Methodology

This section describes the empirical approach employed to examine the discussed hypotheses. In order to test the influence of the underwriting cycle on insurers' financial stability, test on determining whether the cycle exists in the UK non-life insurance market is first performed. After establishing the presence of the underwriting cycle in the UK non-life market, the discussed hypotheses will be tested by using the different estimation models. The database used in this chapter is built on information from financial statements of individual insurers, which included the balance sheet and the income statement, collected from Orbis, Fame and ISIS (or Insurance Focus), and provided by Bureau van Dijk. The World Bank database is the main source for those macro-economic data. The sample only covers the non-life insurers in the UK market from 1996 to 2017 [1]. There is no required data for all years; therefore, unbalanced panel data is accepted. To ensure all monetary values are directly comparable, we deflate each year's value by the consumer price index to the base year 2015.

4.3.1 Determine the Presence of the Underwriting Cycle in the UK Market

From previous studies, various methodologies can be used to test the existence of underwriting cycle[2], for example, direct observation by using charts (Elango, 2009), the spectral analysis/cointegration techniques (Grace and Hotchkiss, 1995; Meier, 2006a; Venezian and Leng, 2006), Christiano-Fitzgerald filter analysis (Zhang and Tang, 2012), vector autoregressive (VAR) processes (Chung *et al.*, 1994; Fung *et al.*, 1998), financial models, *etc*. Among these different methods, the second-order autoregressive AR(2) process is the one that has been widely used to determine the presence of the underwriting cycle and the length of the cycle, see studies from Venezian (1985), Cummins and Outreville (1987), Lamm-tennant and Weiss (1997), Chen, Wong and Lee (1999), Fenn

[1] According to Outreville, (1990) and Eling and Luhnen, (2009), at least 12 years of data are required to determine the underwriting cycle.

[2] Meier, (2006a) provides a good discussion on different methods used to detemine the underwriting cycle.

and Vencappa (2005) Leng and Meier (2006), Meier and Outreville (2006), Lazar and Denuit (2011), Zhang and Tang (2012) and Bruneau and Sghaier (2015), among others.

Venezian's (1985) model assumes that insurers may use past loss level to predict their future losses, which can be further used to set premiums; and this is further confirmed by Lamm-tennant and Weiss (1997). Thus, the second-order autoregression model and the parameters needed to measure the length of the cycle can be obtained by estimating the following model[1] with ordinary least squares:

$$\Pi_t = \alpha_0 + \alpha_1\Pi_{t-1} + \alpha_2\Pi_{t-2} + \omega_t$$

Equation (4.1)

where ω_t is a random error term, the parameter α_1 and α_2 are used to calculate the length of the cycle period. An underwriting cycle will be present if $\alpha_1 > 0$, $\alpha_2 < 0$ and $\alpha_1^2 + 4\alpha_2 < 0$, then the length of the cycle period can be expressed as follows in Equation (4.2):

$$Period\ (P) = 2\pi\ /\cos^{-1}(\alpha_1/2\sqrt{-\alpha_2})$$

Equation (4.2)

Regarding Π_t, it represents the insurer's underwriting performance at year *t*. There are various variables can be chosen. For example, Cummins and Outreville (1987) use the ratio of premiums-to-claims represents the underwriting profit in the U.S. market. Chen, Wong and Lee (1999) and Trufin, Albrecher and Denuit (2009) apply the second-order autoregression model and use the ratio of premiums-to-claims to estimate the presence of the underwriting cycle in Asia non-life market and Canadian motor insurance market, respectively. The ratio of premiums-to-claims, which can be seen as the inverse loss ratio, that is a price indictor[2]. Besides, Lamm-tennant and Weiss (1997) use two ratios - the underwriting results (profits) or the loss ratio[3] - to estimate the cycle period; and they find significant results from both models. By using the loss ratio, Meier (2006b) test the

[1] The AR(2) analysis may be misleading if the underlying variable Π_t is not stationary. Thus, the Augmented Dickey-Fuller test (Dickey and Fuller, 1979) and Phillips-Perron test (Phillips and Perron, 1988) are used to examine whether the variable is stationary, *i.e.* there is no unit root. If the variable has a unit root (*i.e.* it is non-stationary), the variable is expressed as a form of first differences. Following Eling and Luhnen (2009), a time trend may be included in the equation, to reflect control for the downward trend in expenses over time. However, Eling and Luhnen (2009) state that the results from model with trend and without trend are not significantly different; the same conclusion applied to model with level series or differenced series. Then, the Akaike Information Criterion (AIC) is used to determine the number of lags for the lagged terms, and to confirm that the underlying variable Π_t satisfies a AR(2) process.

[2] The inverse loss ratio represents the unit price for each unit of claim paid from an insurer.

[3] The underwriting results is defined as underwriting profit divided by premium earned. The loss ratio is expressed as the ratio of losses incurred to premium Written.

existence of the cycle in Switzerland, the U.S. and Japan. Later, Eling and Luhnen (2009) choose the loss ratio to study the underwriting cycle in German property-liability market, and find the cycle length is about 5.3 years on average. Similar to the loss ratio, Browne and Hoyt (1995), Grace and Hotchkiss (1995) and Bruneau and Sghaier (2015) use industry combined ratio to indicate the underwriting cycle[1]. A high combined ratio means an unfavourable underwriting result, which is likely to be found in a soft market.

By focusing the UK market, Fenn and Vencappa (2005) use a dynamic model to confirm that the existence of a second-order autoregressive structure to economic loss ratio in the motor insurance line, and the cycle length is between eight to nine years[2]. Thus, following Fenn and Vencappa's (2005) UK study, the AR(2) model can be rewritten as[3]:

$$Loss\ Ratio_t = \alpha_0 + \alpha_1 Loss\ Ratio_{t-1} + \alpha_2 Loss\ Ratio_{t-2} + \omega_t$$

Equation (4.3)

4.3.2 Empirical Models and Estimation Techniques

At the second step, in order to estimate the effects of both internal and external factors on the insurer's financial stability (Tabak, Fazio and Cajueiro, 2012; Shim, 2015), and to test the hypotheses described in section 4.2, a baseline model is formulated as below:

$$\begin{aligned} Stability_{\ i,t} = {} & \alpha_0 + (\alpha_1)Performance_{i,t} + (\alpha_2)Leverage_{i,t} + (\alpha_3)Reinsurance_{i,t} \\ & + (\alpha_4)Liquidity_{i,t} + (\alpha_5)Underwriting\ Cycle_{i,t} + (\lambda_n)Interactions_{i,t,n} \\ & + (\phi_m)Controls_{i,t,m} + \varepsilon_{i,t} \end{aligned}$$

Equation (4.4)

where *Stability* represents an insurer's financial health or soundness or the risk-taking at the aggregated level at time *t*. *Performance*, *Leverage*, *Reinsurance* and *Liquidity* are the key variables used to test the Hypotheses 1-4, while *Underwriting Cycle* is the external factor that is used to test Hypothesis 5a. The $Interactions_{i,t,n}$ show the interacted terms between the underwriting cycle and the *nth* regressor[4]. The purpose of including the

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[1] The combined ratio is equal to (Incurred Claims + Expenses) / Gross Premium Written.

[2] From the other earlier literature, the average cycle length across different countries is about five to eight years, see, Venezian (1985), Simmons and Cross (1986), Cummins and Outreville (1987), Lamm-tennant and Weiss (1997) and Chen, Wong and Lee (1999).

[3] In this chapter, the aim is only to test whether the underwriting cycle appear in the UK market. So, the second order autoregression model remain in a simplest form, excluding other independent variables. Here, the panel data approach is taken as it combines advantages from both time series and cross-sectional approaches, such as: it does not only identifies the dynamic short-run features of the individual firm, but also identidy the differentiations of the short-run features among different firms.

[4] Regressors includes internal factors, *i.e.*, *Performance*, *Leverage*, *Reinsurance* and *Liquidity*.

interaction terms is to exam the joint effect on the insurer's financial soundness. To be more specific, the interaction term is of key interest as the significant coefficient (λ_n) should be indicative of either the potential effect of the underwriting cycle on the relationships between financial stability and four regressors, or the joint effect of the cycle and four regressors on the insurer's stability. Similar approaches, in which the interaction term between the cyclicality and another regressor is involved to determine the joint impact, can be found from Dionne and Wang (2013), Saadaoui (2014) and Ben Bouheni and Hasnaoui (2017). $Controls_{i,t,m}$ is a set of control variables. α_0 and ε_{it} are the constant term and error term, respectively. The detail of definition for each of the variables will be decribed in the next section.

Then, the main regression model, Equation (4.4), is estimated using both the OLS fixed effect estimation[1] and the dynamic panel Generalized Method of Moments (GMM) model. The former not only represents the long-term relationship, but also eliminate the impact of time-invariant effect and to capture unobserved firm-specific characteristics (heterogeneity across firms). The two-step SYS-GMM[2] is then used to estimate the dynamic features of the model. In addition to that, the econometric issue that can not be addressed by the OLS estimation is the potential endogeneity. In the above model, there are high odds that some of the independent and control variables may influence the underwriting cycle, *i.e.* independent variables are endogenously determined. Then, the use of the GMM model can wipe out inconsistent and biased estimates of the coefficients.

4.3.3 Data: Dependent and Independent variables and other Control Variables

Dependent variables: Financial Soundness (Stability)

Z-score is a well-known accounting measurement that is widely used as the proxy of the financial institution's soundness. Following insurance literature from Shim (2011), (2015), Pasiouras and Gaganis (2013), Mühlnickel and Weiß (2015), Cummins, Rubio-Misas and Vencappa (2017) and Alhassan and Biekpe (2018) and baking studies from

[1] The null hypothesis of Hausman's (1978) test is rejected, suggesting that the fixed effect estimator is prefered.

[2] A System-GMM was modified by Arellano and Bover (1995) and Blundell and Bond (1998) based on Arellano and Bond's (1991) model, and it allows more instruments to be introduced and improve efficiency of estimation. Because the SYS-GMM estimations assume that the first differences of instrument variables are uncorrelated with the fixed effects, and both lagged levels and lagged value of the difference are included in the estimation. The two-step estimations are more efficient than one-step, because the "Windmeijer finite-sample correction" to the two-step standard errors is applied.

Mamatzakis and Bermpei (2014), Kabir and Worthington (2017) and Leroy and Lucotte (2017), the financial stability can be measured as:

$$\mathrm{Z-score}_{it} = \left(ROA_{it} + \frac{Equity_{it}}{Total\ Asset_{it}}\right) / \sigma ROA_{it}$$

Equation (4.5)

where ROA_{it} is insurer *i*'s the return on asset at time *t*. σROA_{it} represents the standard deviation of the return on asset, and a three-year rolling window is used to calculate this standard deviation. Therefore, the z-score is a function of the insurer's profitability, the variation in profitability, and the equity capital available to sustain the variation. In other words, this Z-score represents the number of standard deviations of an insurer's return (ROA) that the insurer must decrease to deplete its capital (Cummins, Rubio-Misas and Vencappa, 2017). Therefore, the relationship between the Z-score and an insurer's likelihood of default is inversed. The higher the Z-score indicates that the lower the probability of default, and the higher the stability.

Independent variables

Based on the hypothesis developed in Section 4.2, five key variables are required to be defined: performance, leverage, reinsurance, liquidity and the underwriting cycle.

Performance variable

As discussed by Eling and Jia (2018), an insurer's efficiency is a good predictor of business failure. So, the efficiency is used to represent the insurer's performance, and to reflect its relative position in the market. The Equation (A4.1), in Appendix 4, can be adopted to estimate this measurement, but with Total Profit[1] as the dependent variable.

Leverage variable

In this chapter, following Shim (2015) and Alhassan and Biekpe (2018), the ratio of net premium written to surplus is adopted to represent an insurer's leverage position, because it not only represents the capital structure but also indicates insurer's leverage risk. A higher ratio assumes that the insurer faces more leverage risk.

Reinsurance variable

Similar to Garven and Lamm-Tennant (2003), Cole and McCullough (2006), Powell and Sommer (2007) and Mankaï and Belgacem (2016) and Alhassan and Biekpe (2018),

[1] Total profit is the simple operating profit, profit before tax, presented in financial statement.

the reinsurance ratio is measured as reinsurance ceded divided by the gross premiums underwritten.

Liquidity variable

Following Zhang and Nielson (2015) and Mankaï and Belgacem (2016), the ratio of liabilities to liquid assets shows the insurer's liquidity risk. A larger ratio indicates a higher level of liquidity risk in the insurance company.

Underwriting Cycle variable

Regarding the proxy of the underwriting cycle, the industry-wide loss ratio is adopted (Browne and Hoyt, 1995; Cheng and Weiss, 2012b), as this ratio is consistent with the discussion in Section 4.3.1. A higher industry-wide ratio indicates unfavourable underwriting results, which will be likely found in a soft market; then a lower ratio may indicate a hard market. Thus, it is reasonable to assume a negative relationship between industry-wide loss ratio and an insurer's stability

Control variables

Both firm characteristics and environmental factors are included as control variables. Among internal factors, *firm size* is one of the concerns when examing the financial firm's stability. For example, the large scale represents that the insurer has a better diversification ability and higher franchises values (Sharpe and Stadnik, 2007). Some other studies also find that smaller insurers are more likely to suffer insolvency issues, because the regulators are less likely to liquidate larger firms, see, BarNiv and Hershbarger (1990), Cummins, Harrington and Klein (1995), Adams and Buckle (2003), Chen and Wong (2004) and Kleffner and Lee (2009). However, the potential effect of size on financial stability is still ambiguous. Shim (2011), Weiß and Mühlnickel (2014), Guidara and Lai (2015) and Cummins, Rubio-Misas and Vencappa (2017) find that firm size negatively connects to financial soundness. And, the negative relationship is also found in banking literature, (chaeck and Cihák (2010) reveal that size is inversely related to stability. Alhassan and Biekpe (2018) also reveal that the effects of size on both underwriting risk and z-score are positive and significant; this indicates that larger firms tend to take more underwriting risks, while being characterised by greater stability. Here, the natural logarithm of total assets represents the insurer's size.

Further, Shim (2015) and Eling and Jia (2018) confirms that there is a non-linear (inverted U-shape) relationship between insurer's size and its financial soundness; it implies that an extreme increase in firm size may erode the insurer's financial stability. Therefore, *the square of firm size* is included to control for the potential non-linear relationship.

Premium growth, measures the rate of market penetration, has been widely used to determine/represent the insurer's financial condition (either stability or insolvent) in insurance literature, see Kim *et al.* (1995), Chen and Wong (2004) and Kleffner and Lee (2009). In general, the growth represents that the insurer is in a soundness condition. However, rapidly writing more new business may indicate a substantial potential future loss, and an unexpected growth may also indicate that there is a potential mispricing pricing issue (Niehaus and Mann, 1992; Caporale, Cerrato and Zhang, 2017). Borde, Chambliss and Madura (1994), Lee and Urrutia (1996) and Chen and Wong (2004) use the rate of growth of gross premium to indicate the insurer's instability, because they believe that rapid growth of business should attribute to the loose of underwriting standards, and then further lead to financial instability. However, Sharpe and Stadnik (2007) find no significant evidence on this relationship in the Australian market. Then, this measurement can be defined as (gross premium written in year *t* – gross premium written *t-1*) / gross premium written in year *t-1*.

Following Eling and Marek (2014) and Eling and Jia (2018), *business volatility* is also included to control for the long-term fluctuations in the insurer's business results. The standard deviation of the return on equity with a 3-year rolling window is used to capture the uncertainties of return at the aggregated level (Pasiouras and Gaganis, 2013).

Organisational form is also controlled as following Cummins and Sommer (1996), who exam the impact of agency theory on the insurer's risk-taking. They argue that a larger separation between manager and policyholders (or owners) in mutual firms leads to lower the risk-taking. A similar view is also confirmed by Lee, Mayers and Smith (1997), who suggests that incentives to increase risk are better controlled in a mutual firm. Later, Ho, Lai and Lee (2013), Shim (2015) and Eling and Jia (2018) all confirm that mutual insurers are more stable than stock insurers. From previous literature, two main reasons are given. First, the incentive conflict is better controlled in mutual insurers (Lee, Mayers and Smith, 1997). Second, Eling and Jia (2018) suggest that mutual insurers are more willing to maximise the policyholders' interest, and then less likely to take more risks (Lamm-

Tennant and Starks, 1993). Thus, a dummy variable, which equals to one for stock firms, is included to control for organisational form. A negative coefficient can be expected.

In line with the fact that changes of macroeconomic factors may directly affect firm's risk-taking (Browne, Carson and Hoyt, 1999; Chen and Wong, 2004; Wang, 2010; Zhang and Nielson, 2015; Caporale, Cerrato and Zhang, 2017), change in interest rate and GDP growth are included as exogenous control variables.

Section 4.4 Results and Discussions

Table 4.1 shows the descriptive statistics of the firm-specific and market-specific variables used to test hypotheses 1 to 5. Table 4.2 presents the correlation between the discussed variables. Apart from the correlation between two variables related to firm size, the highest correlation coefficient of 0.51 is between the underwriting cycle and interest rate change. The second-highest correlation coefficient (-0.41) is between business volatility and two stability variables. These may lead to a potential issue of multicollinearity. The variance inflation factor (VIF) analysis was computed for all independent variables. The highest individual score is 1.58 for the underwriting cycle, and the overall score is 1.14; these scores are well below the commonly accepted threshold value of 10 (Kennedy, 1998). Thus, multicollinearity is unlikely to be a severe issue in this study. It is safe to assume that interest rate and competition are potential driving factors of the underwriting cycle in the non-life market because of the significant correlation coefficients among the variables.

[Table 4.1: Descriptive Statistics insert here]

[Table 4.2 Correlation Coefficient Matrix insert here]

Table 4.1 Descriptive Statistics

Variables	Function	Observations	Mean	Median	Standard Deviation	Min	Max
Stability	Independent Variable	6499	3.0563	1.0559	21.6536	-42.0766	1089.7417
Stability Efficiency	Independent Variable (Robust Test)	3612	0.3668	0.3699	0.1049	0.0229	0.6705
Performance	Hypothesized Variable	4001	0.4533	0.4718	0.1075	0.0029	0.8243
Leverage	Hypothesized Variable	5559	2.1814	0.8264	3.9984	0.0000	19.0833
Reinsurance	Hypothesized Variable	5910	0.3822	0.2512	0.3689	0.0009	1.6000
Liquidity Risk	Hypothesized Variable	7365	6.7925	1.7862	16.1980	1.0142	85.6310
Underwriting Cycle	Hypothesized Variable	21954	3.4311	3.4277	0.5146	2.5166	4.0692
Competition	Hypothesized Variable (Robust Test)	19890	0.4171	0.4311	0.2500	-0.2452	0.7937
Firm Size	Control Variable	8062	7.4163	7.4820	2.0608	2.9848	11.4692
Squared Firm Size	Control Variable	8062	59.2471	55.9797	30.4660	8.9092	131.5432
Premium Growth Rate	Control Variable	2512	-1.7213	-1.7898	1.8929	-8.7130	10.9893
Business Volatility	Control Variable	6998	2.2268	2.2941	1.6309	-31.6820	5.1468
Stock	Control Variable	18162	0.4484	0.0000	0.4973	0.0000	1.0000
Interest Rate Change	Control Variable	21953	2.2536	0.0000	4.9193	-0.9655	28.0000
GDP Growth	Control Variable	21954	2.1403	2.4560	1.6295	-4.1878	4.0382

Notes: *Stability* is measured by Z-score, which is (Return on Asset + Equity to Asset Ratio) / Standard Deviation of ROA. A higher Z-score value corresponds to the lower probability of insolvency and higher level of stability. *Stability Efficiency* is an alternative proxy of the insurer's financial soundness, and make robustness check on the discussed hypotheses, and it is estimated by using Stochastic Frontier Analysis. *Performance* is the insurer's profit efficiency, which is also found by adopting Stochastic Frontier Analysis. *Leverage* is the ratio of net premium written to surplus. *Reinsurance* is the ratio of reinsurance ceded to gross premium written. *Liquidity Risk* is the ratio of liability to liquid asset; a larger value indicates the insurer may face liquidity issues. The industry-wide loss ratio represents the underwriting cycle in the non-life market; a higher ratio potentially implies a soft market condition. As another proxy of underwriting cycle, the intensity of c*ompetition* is measured by the Boone indicator. Chapter three provides details on how to capture the Boone index. *Firm Size* is the natural logarithm of the insurer's total assets. *Premium Growth Rate* is defined as (gross premium written in year *t* – gross premium written *t-1*) / gross premium written in year *t-1*. *Business Volatility* is the standard deviation of the return on equity with a 3-year rolling window, and captures the uncertainties of return at the aggregated level. In addition, a dummy variable, which equals to one for *STOCK* firms, is also included in the dynamic GMM models. Two macroeconomic factors - *Interest Rate Change* and *GDP Growth* - are collected from World-Bank database. To mitigate the confounding effects of outliers, some firm-specific variables are winsorized at 3% level at each tail, and further take natural logarithm to ensure the distribution is normally skewed.

Table 4.2 Correlation Coefficient Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Stability	1.00														
2. Stability Efficiency	0.42*	1.00													
3. Performance	0.11*	0.30*	1.00												
4. Leverage	-0.03	-0.06	-0.02	1.00											
5. Reinsurance	-0.05	0.13*	0.10*	0.00	1.00										
6. Liquidity Risk	0.06	0.05	0.03	-0.00	-0.02	1.00									
7. Underwriting Cycle	-0.16*	-0.04	0.07	0.01	-0.01	0.04	1.00								
8. Competition	0.00	0.01	0.04	0.04	-0.01	-0.04	0.17*	1.00							
9. Firm Size	0.05	-0.35*	0.00	0.00	-0.11*	0.04	-0.04	0.03	1.00						
10. Squared Firm Size	0.05	-0.38*	-0.01	-0.00	-0.13*	0.04	-0.04	0.03	0.99*	1.00					
11. Premium Growth Rate	0.00	-0.02	0.02	-0.05	-0.09*	0.10	0.14*	0.02	0.15*	0.15*	1.00				
12. Business Volatility	-0.41*	-0.41*	0.05	0.07	-0.08	-0.05	0.15*	-0.08	-0.10*	-0.11	0.01	1.00			
13. Stock	0.11*	0.11*	0.01	-0.09*	0.09*	0.03	0.02	0.03	0.16*	0.17*	0.02	-0.32*	1.00		
14. Interest Rate Changed	0.03	0.04	-0.01	-0.01	-0.05	-0.02	-0.51*	-0.18*	0.03	0.03	-0.05	-0.07	-0.01	1.00	
15. GDP Growth	0.06	0.00	-0.06	0.01	-0.00	0.01	-0.39*	0.18*	-0.02	-0.01	-0.08	-0.14*	0.04	0.20*	1.00

Notes: The highest correlation coefficient is -0.51, observed between Underwriting Cycle and Interest Rate Change, raising the potential issue of multicollinearity.
The variance inflation factor (VIF) analysis is computed for all the independent variables.
The highest individual score is 1.58 from Underwriting Cycle, and the overall score is 1.14.
These are well below the commonly accepted threshold value of 10 (see, (Kennedy, 1998)). Thus, multicollinearity is unlikely to be a serious issue in this study.
A positive Boone Indicator is adopted by timing the negative β with -1. Thus, a larger value of this positive Boone indicator denotes that the market is more competitive.
* represent statistical significance at 5% level at least.

4.4.1 The Length of the Underwriting Cycle in the Non-life Market

As discussed, one of the main contributions of this chapter is to determine the impact of the underwriting cycle on insurers' financial soundness (stability). Therefore, the first step is to confirm the existence of the underwriting cycle in the non-life market. Following Venezian (1985) and Lamm-Tennant and Weiss (1997), the AR(2) model (*e.g.* Equation 4.1 and 4.3) — most widely used method — was adopted to measure the length of the underwriting cycle, if it exists.

The model found the coefficient of lagged-one loss ratio (0.257) and the coefficient of lagged-two variable (-0.1847). Both coefficients are significant and conform to the requirements discussed in Section 4.3.1. Equation 4.2 can be used to calculate length; the length of the underwriting cycle is about five years (actually, 4.95 years) in the U.K. non-life market. This result is mainly consistent with the previous findings for various countries (see Lamm-Tennant and Weiss, 1997; Chen, Wong and Lee, 1999; and Eling and Luhnen; 2009). However, compared to Fenn and Vencappa's (2005) investigation for the U.K. market, the resulted length is shorter than the length of eight to nine years observed by them, *i.e.* half of their estimated length. One possible reason for this is that Fenn and Vencappa (2005) split the non-life market into several sub-markets, and each of the sub-markets had a longer underwriting cycle. Another reason could be that the resulted cycle lengths may have varied due to the length of the investigation period (Eling and Luhnen, 2009). Last, Fenn and Vencappa (2005) studied the market from 1985 to 2002, while the present study focuses on the market from 1996 to 2017. A short length may indicate that the U.K. insurers adapt to the market more effectively due to the technique development.

4.4.2 Panel Estimation

By following Goddard, Molyneux and Wilson (2004) and Mamatzakis and Bermpei (2016), the main regression model is estimated using both OLS fixed effect estimation and the dynamic panel Generalized Method of Moment (GMM) model. The former not only eliminate the impact of time-invariant effect and to capture unobserved firm-specific characteristics (heterogeneity across firms), but also represents the long-run relationship. The GMM model is used to address the potential endogeneity issue that may arise in the OLS estimation; meanwhile, it can be used to further estimate the dynamic features of the model, which is the short-run relationship. Therefore, a comprehensive story, in which variabilities existed between the long-run relationship and the short-run relationship are considered, can be provided by comparing the results from these two models.

As the existence of the underwriting cycle has been determined in the U.K. non-life market, estimating the main model, *i.e.* Equation 4.4, can verify the discussed hypotheses; this section presents the results. To be specific, reviewing the results shown in Tables 4.3 and 4.4, in which the estimated results reveal the impacts of individual hypothesised factors — performance, leverage, reinsurance, liquidity risk and the underwriting cycle — on insurers' financial soundness (stability), can verify Hypothesis 1 to Hypothesis 5a. Tables 4.5 and 4.6 disclose the impacts of the interactions between individual factors and the underwriting cycle on financial stability. Last, Tables 4.7 to 4.9 present the results of the robustness checks.

4.4.2.1 Performance, Leverage, Reinsurance, Liquidity Risk and the Underwriting Cycle

Tables 4.3 and 4.4 present the results for the OLS fixed-effect and the GMM dynamic panel regressions, respectively. Regarding the impact of performance, Hypothesis 1 is valid because of the significant and positive coefficient shown in Model 1 and Model 6. The positive result indicates that the insurers that have better profitability may face a lower likelihood of being financially distressed. This result remains consistent in both the long-run model (*i.e.* the fixed model) and the short-run model (*i.e.* the GMM dynamic model). It is also in line with the previous findings of BarNiv and McDonald (1992), Sharpe and Stadnik (2007) and Eling and Jia (2018). Thus, it is reasonable to conclude that performance (profit efficiency) enhances insurers' financial soundness in the U.K. non-life market.

To verify Hypothesis 2, which discusses the impact of an insurer's leverage on its soundness, the ratio of premium written to surplus represents the insurer's leverage position. As discussed in Chapter 3, the definition of leverage is ambiguous in the insurance market. On the one hand, it related to the funds raised from both shareholders and debtholders; on the other hand, the policyholders are the dominant supplier of insurance leverage (Cummins and Lamm-Tennant, 1994; Pope and Ma, 2008). Therefore, the advantage of using the ratio of premium written to surplus is that it allows us to explain the insurer's capital structure from the point of the insurer's underwriting ability. For example, a larger ratio indicates that the insurer may issue too many policies or businesses compared to its underwriting ability (*i.e.* the equity level). In line with the expected bankruptcy cost argument, the results from Model 2 show that the leverage negatively influences insurers' stability, and the impact remains significant in both Tables 4.3 and 4.4. It indicates that an insurer who faces higher leverage has an increased probability of being insolvent when the firm writes a number of businesses beyond its underwriting ability. Carson and Hoyt (1995), Shiu (2011), Shim (2010; 2015) and Caporale, Cerrato and Zhang (2017) share similar conclusions.

Concerning the hypothesis on the relationship between the use of reinsurance and insurers' stability, the results from Model 3 vary between the long-run model (Table 4.3) and the short-run model (Table 4.4). Specifically, the results from Table 4.3 indicate that using more reinsurance may damage an insurer's financial health in the long-run, though the coefficient is not significant. In the dynamic model, by contrast, Model 3 confirms the significant and positive impact of using reinsurance on stability. These results suggest that the insurer can treat reinsurance as essential protection to enhance the firm's stability in the short-run. The positive influence has been widely accepted (see Adams, 1996; Garven and Lamm-Tennant, 2003; Sharpe and Stadnik, 2007; Liu, Shiu and Liu, 2016; and Mankaï and Belgacem, 2016). Although the harmful impact of reinsurance in the OLS fixed-effect model is not significant, Kim *et al.* (1995), Lee, Mayers and Smith (1997) and Pottier and Sommer (1999) provide some explanation for the negative relationship between the use of reinsurance and stability.

Surprisingly, Model 4 from Tables 4.3 and 4.4 suggests that the insurer who accepts more liquidity risk is less likely to become insolvent. This is inconsistent with both the expectation of Hypothesis 4 and the previous findings of Carson and Scott (1997), Bouzouita and Young (1998), Sharpe and Stadnik (2007) and Caporale, Cerrato and Zhang (2017).

As noted in the introduction, determining the impact of the underwriting cycle on insurers' soundness (*i.e.* Hypothesis 5a) is one of the most important contributions of this study. The industry-wide loss ratio represents the underwriting cycle from the point of an insurer's underwriting profits or losses. A higher ratio indicates that the market is soft, while a negative or decreased ratio represents a hard market. In line with Hypothesis 5a, the results (see, Models 5 and 6 in both Tables 4.3 and 4.4) show that the coefficients of underwriting cycle (*i.e.* the industry-wide loss ratio) are significant and negative. This confirms that insurers tend to be riskier in the soft market (as the industry-wide loss ratio increased), as discussed in Section 4.2.5.

Among the above discussions, one question needs to be addressed regarding the positive impact of liquidity risk on insurers' stability, as most of the previous findings support a negative one. In order to address this issue, following Schaeck and Cihák (2010) and Cummins, Rubio-Misas and Vencappa's (2017) procedures, we established the impacts of the critical factors on the three different components of the Z-score; Appendix 4, Tables A4.1 to A4.3, show the estimated results. Model 4 in Tables A4.1 and A4.3 indicates that the insurer who has more liquidity risk may generate higher returns and is willing to hold more capital. Thus, these connections may further contribute to a positive influence on the insurer's stability.

In addition, the results (Model 1) also reveal that well-performed firms tend to have a higher return on asset (ROTA) and a larger standard deviation of return (S.D. ROTA). The former is positively related to Z-score, while the latter has negative influences; thus, both can enhance financial stability. High leveraged insurers usually face more instability issues, mainly because they have a lower level of ROTA and hold less capital (see Models 2 and 6). Last, Model 5 discloses that the insurers tend to generate fewer returns with bearing less return uncertainty. Such behaviours also enhance insurers' soundness in the soft market.

Table 4.3: Individual effects on Financial Stability -OLS

VARIABLES	(1) H1 Stability	(2) H2 Stability	(3) H3 Stability	(4) H4 Stability	(5) H5 Stability	(6) H1-5 Stability
Performance	8.1690***					9.3119***
	(4.512)					(4.570)
Leverage		-0.0015***				-0.0012***
		(-3.568)				(-2.690)
Reinsurance			-0.8639			-2.0069
			(-0.706)			(-0.704)
Liquidity Risk				0.0386***		0.0359***
				(17.354)		(9.423)
Underwriting Cycle					-1.8151*	-2.6537*
					(-1.801)	(-1.916)
Firm Size	5.0629	14.3291***	14.1530***	11.7208***	11.6621***	4.3153
	(1.184)	(3.270)	(3.202)	(2.938)	(2.841)	(0.869)
Squared Size	-0.3156	-0.7615***	-0.7480***	-0.6107***	-0.6065***	-0.2756
	(-1.235)	(-3.338)	(-3.197)	(-2.878)	(-2.795)	(-0.941)
Premium Growth Rate	0.0435	0.0661	0.0624	0.0546	0.0780	0.0413
	(0.571)	(1.057)	(1.090)	(0.965)	(1.351)	(0.492)
Business Volatility	-2.8064***	-2.7525***	-2.3462***	-2.2572***	-2.2764***	-3.1368***
	(-6.315)	(-7.129)	(-6.130)	(-6.352)	(-6.403)	(-6.163)
Interest Rate Change	0.0972	0.0532	0.0551	0.0563	-0.0087	0.0030
	(1.413)	(0.833)	(0.989)	(1.007)	(-0.160)	(0.032)
GDP Growth	-0.0633	-0.0042	-0.0174	-0.0022	-0.0753	-0.2343*
	(-0.586)	(-0.046)	(-0.217)	(-0.028)	(-0.840)	(-1.797)
Constant	-13.0358	-55.8794***	-56.1157***	-46.2305**	-38.9998*	1.2339
	(-0.733)	(-2.670)	(-2.680)	(-2.469)	(-1.941)	(0.059)
Observations	666	859	950	994	1,007	583
Number of Insurers	325	377	390	413	423	285
Adjusted R-squared	0.254	0.250	0.209	0.204	0.208	0.291
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	8.43***	9.87***	8.09***	5978.07***	7.99***	207787***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4.4: Individual effects on Financial Stability - GMM

VARIABLES	(1) H1 Stability	(2) H2 Stability	(3) H3 Stability	(4) H4 Stability	(5) H5 Stability	(6) H1-5 Stability
Lagged Stability	0.1928**	0.2020**	0.1947**	0.2218***	0.2905*	0.2082**
	(2.396)	(2.516)	(2.257)	(2.629)	(1.958)	(2.568)
Performance	6.8163***					9.1620***
	(3.974)					(3.932)
Leverage		-0.0023***				-0.0005
		(-4.009)				(-1.454)
Reinsurance			0.0924**			4.1985
			(2.339)			(1.372)
Liquidity Risk				0.0310***		-0.0045
				(2.608)		(-0.083)
Underwriting Cycle					-2.2437*	-3.3969*
					(-1.760)	(-1.679)
Firm Size	2.5570	4.9316	3.5102	6.1666	5.1561	-4.0256
	(0.376)	(0.667)	(0.319)	(0.840)	(0.432)	(-0.639)
Squared Size	-0.1487	-0.3055	-0.2155	-0.3600	-0.3777	0.2348
	(-0.387)	(-0.719)	(-0.359)	(-0.862)	(-0.558)	(0.677)
Premium Growth Rate	0.1644***	0.1178*	0.1153**	0.1014*	0.2810**	0.2911**
	(3.051)	(1.802)	(2.058)	(1.846)	(2.581)	(2.557)
Business Volatility	-2.7853***	-2.5680***	-2.6449***	-2.7111***	-2.4058***	-1.9758***
	(-4.932)	(-6.366)	(-4.561)	(-5.481)	(-3.600)	(-3.997)
Stock	-2.0021**	-0.9758*	-1.8823***	-1.7138**	5.7449	-1.4716**
	(-2.395)	(-1.754)	(-2.704)	(-2.465)	(0.644)	(-2.154)
Interest Rate Change	-0.0174	-0.0392	0.0598	0.0610	-0.1098	-0.2972*
	(-0.275)	(-0.647)	(0.523)	(0.595)	(-1.121)	(-1.676)
GDP Growth	-0.1116	-0.0043	-0.0557	-0.0676	-0.0023	-0.1615
	(-0.732)	(-0.052)	(-0.486)	(-0.493)	(-0.011)	(-1.133)
Constant	-3.6619	-10.7096	-4.4924	-16.2694	-2.8740	31.5020
	(-0.124)	(-0.347)	(-0.093)	(-0.521)	(-0.056)	(1.059)
Observations	594	767	847	884	895	519
Number of Insurers	293	339	347	371	379	256
Number of Instruments	101	125	87	85	42	120
Robust	Yes	Yes	Yes	Yes	Yes	Yes
F-test	17.77***	7.991***	3.830***	69.53***	8.984***	51.53***
AR(1)	-1.836*	-1.833*	-1.839*	-1.895*	-1.981**	-1.828*
AR(2)	-0.824	-0.687	-1.198	-1.192	-0.799	-0.499
Hansen/Sargan Test (P-value)	87.13 (0.56)	117.4 (0.42)	78.25 (0.44)	76.72 (0.42)	31.42 (0.50)	94.35 (0.78)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4.4.2.2 Interaction with the Underwriting Cycle: Industry-wide Loss Ratio

Another main contribution of this study is to determine the joint effects of interactions between internal factors and external pressure on insurers' soundness. The findings in Tables 4.5 and 4.6 provide evidence that the underwriting cycle can influence an insurer's operational strategies and financial soundness. To be specific, Table 4.5 shows the OLS fixed-effect model, and Table 4.6 shows the estimations from the dynamic panel model. The former represents the long-term effect, and the latter shows the short-term effect.

Concerning the interaction term of performance * underwriting cycle (see Models 1 and 5), the coefficient is negative. This implies that well-performed insurers may easily suffer instability issue in the soft market, especially in the short-run (because the coefficient is only significant in Table 4.6). There are two reasonable explanations for this negative impact. First, the majority of the market players will suffer underwriting losses in the soft market. This is the nature of the soft phases. In other words, a relatively well-performed insurer may still face more underwriting losses in the soft market, compared to the hard market. Second, these relatively well-performing insurer firms may believe that they have an advantage in executing high-risk strategies when the external environment is unfavourable, such as investing in risky assets, writing more risky businesses or adopting loose monitoring standards.

The impact of the interaction, which is between leverage and the underwriting cycle, on a firm's stability is positive, while it is only significant in the dynamic model, as presented in Models 2 and 5. The results suggest that highly leveraged insurers tend to have a lower insolvency risk in the soft market. This contradicts the observed negative coefficients of two individual variables, *i.e.* leverage and the underwriting cycle. However, it is not surprising to have such a positive joint effect. According to the expected bankruptcy cost argument, highly leveraged firms are expected to be riskier. The managers in such firms may need to take the initiative and adjust the operational strategies to maintain stability when the market condition is unfavourable, for example, in the soft market. In simpler terms, managers in highly leveraged firms already pay sufficient attention to the status of the market and their firm's health. A similar interpretation can also be applied to discuss the circumstances which have left insurers with a higher level of liquidity risk, as the coefficients of interaction terms of "liquidity risk * underwriting cycle" are positive and significant in both long-run and short-run (see Model 4).

In addition, Model 3 shows the coefficients of the interaction term "reinsurance * underwriting cycle" are also positive and significant in both long-term and short-term cases. This implies that the use of reinsurance can enhance an insurer's stability in a soft market. The positive coefficients also contradict the negative coefficients of two individual variables. Thus, this further confirms that insurers pay particular attention to the harmful effects raised by external market conditions.

Table 4.5: Interacted Effects with Underwriting Cycle on Financial Stability -OLS

VARIABLES	(1) H5b Stability	(2) H5b Stability	(3) H5b Stability	(4) H5b Stability	(5) H5b Stability
Profit Efficiency	52.5501				63.1340
	(1.329)				(1.432)
Performance * Underwriting Cycle	-11.7777				-14.2805
	(-1.152)				(-1.253)
Leverage		-0.1741			-0.1795
		(-1.197)			(-0.707)
Leverage * Underwriting Cycle		0.0446			0.0464
		(1.187)			(0.703)
Reinsurance			-31.1721*		-42.9121*
			(-1.851)		(-1.698)
Reinsurance * Underwriting Cycle			8.1974*		10.9999
			(1.779)		(1.635)
Liquidity Risk				-3.2831	-8.6551**
				(-1.525)	(-1.969)
Liquidity Risk * Underwriting Cycle				0.9496*	2.3273**
				(1.794)	(2.154)
Underwriting Cycle	3.1157	-2.1307**	-5.0333***	-2.6359**	-1.3808
	(0.647)	(-2.170)	(-2.902)	(-2.352)	(-0.257)
Firm Size	3.5978	14.5491***	15.7174***	11.3136***	5.3350
	(0.841)	(3.123)	(3.313)	(2.856)	(1.111)
Squared Size	-0.2215	-0.7694***	-0.8585***	-0.5882***	-0.3706
	(-0.837)	(-3.191)	(-3.407)	(-2.840)	(-1.267)
Premium Growth Rate	0.0638	0.0855	0.0785	0.0659	0.0148
	(0.825)	(1.331)	(1.326)	(1.171)	(0.176)
Business Volatility	-2.8197***	-2.7710***	-2.3546***	-2.2623***	-3.1302***
	(-6.439)	(-7.193)	(-6.291)	(-6.383)	(-6.304)
Interest Rate Change	0.0076	-0.0148	-0.0254	-0.0043	-0.0201
	(0.101)	(-0.233)	(-0.441)	(-0.075)	(-0.201)
GDP Growth	-0.1696	-0.0905	-0.1170	-0.0763	-0.2854**
	(-1.417)	(-0.895)	(-1.294)	(-0.842)	(-2.068)
Constant	-19.2238	-48.9834**	-42.2988**	-34.7124*	-5.0168
	(-0.907)	(-2.192)	(-2.017)	(-1.728)	(-0.192)
Observations	666	859	950	994	583
Number of Insurers	325	377	390	413	285
Adjusted R-squared	0.268	0.257	0.237	0.214	0.315
Fixed effects	Yes	Yes	Yes	Yes	Yes
F-test	8.11***	7.46***	7.35***	7.13***	8.103***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4.6: Interacted Effects with Underwriting Cycle on Financial Stability -GMM

VARIABLES	(1) Performance Stability	(2) Leverage Stability	(3) Reinsurance Stability	(4) Liquidity Risk Stability	(5) All Stability
Lagged Stability	0.1847**	0.1194*	0.1818***	0.2157***	0.1999*
	(2.510)	(1.769)	(2.650)	(3.136)	(1.775)
Profit Efficiency	77.8206*				138.5053**
	(1.933)				(2.037)
Performance * Underwriting Cycle	-18.1537*				-32.9593*
	(-1.749)				(-1.864)
Leverage		-0.4984**			-2.8486*
		(-2.194)			(-1.765)
Leverage * Underwriting Cycle		0.1281**			0.7406*
		(2.179)			(1.765)
Reinsurance			-21.2372**		-25.4913
			(-1.994)		(-0.705)
Reinsurance * Underwriting Cycle			5.3930**		8.4814
			(1.996)		(0.893)
Liquidity Risk				-11.6770*	1,909.80
				(-1.759)	(0.660)
Liquidity Risk * Underwriting Cycle				2.8279*	-469.3388
				(1.729)	(-0.660)
Underwriting Cycle	7.3020	-2.9381*	-2.4452*	3.3674***	8.8057
	(1.487)	(-1.822)	(-1.701)	(3.251)	(1.083)
Firm Size	-2.1063	7.2725	4.9338	1.9404	-9.3241*
	(-0.449)	(0.909)	(0.662)	(0.379)	(-1.901)
Squared Size	0.1219	-0.3361	-0.2507	-0.1084	0.5008*
	(0.459)	(-0.765)	(-0.600)	(-0.371)	(1.694)
Premium Growth Rate	0.1727*	0.1029	0.0363	0.2669***	0.3057***
	(1.885)	(1.466)	(0.541)	(5.766)	(3.136)
Business Volatility	-2.3919***	-2.4022***	-2.2129***	-1.7707***	-2.0413***
	(-6.914)	(-3.168)	(-5.499)	(-6.525)	(-4.735)
Stock	-1.4317**	-2.0151**	-1.3628**	-0.8487*	-2.7013
	(-2.315)	(-1.994)	(-2.549)	(-1.707)	(-0.443)
Interest Rate Change	-0.1938	-0.1193**	-0.0499	0.4739***	-0.3872**
	(-1.229)	(-1.984)	(-0.682)	(3.066)	(-1.997)
GDP Growth	-0.0370	-0.1066	-0.0031	0.0190	-0.3142
	(-0.327)	(-0.845)	(-0.041)	(0.253)	(-1.315)
Constant	-14.4692	-16.6678	-5.7518	-15.7639	9.1497
	(-0.477)	(-0.471)	(-0.189)	(-0.746)	(0.267)
Observations	594	767	847	884	358
Number of Insurers	293	339	347	371	188
Number of Instruments	153	102	156	122	137
Robust	Yes	Yes	Yes	Yes	Yes
F-test	8.544***	2.553***	6.020***	79.22***	101.9***
AR(1)	-1.694*	-1.701*	-1.833*	-1.825*	-1.664*
AR(2)	-0.760	-0.803	-1.229	-1.223	-0.403
Hansen/ Sargan Test (P-value)	131.2 (0.71)	86.49 (0.59)	136.6 (0.66)	104.8 (0.62)	123.2 (0.38)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4.4.3 Sensitivity and Robustness Check

4.4.3.1 Competition as an alternative proxy of the Underwriting Cycle

As discussed in both the introduction and hypotheses development sections, one theory suggests that destructive competition may be one factor that causes the presence of the underwriting cycle (Berger, 1988; Harrington and Danzon, 1994; Malinovksii, 2010; Malinovskii, 2014). Although, Fenn and Vencappa (2005) emphasize that it is difficult to explain why insurers choose to compete and collaborate at a point in time (*i.e.* generally five to eight years apart), it cannot be disclaimed that the strength of competition varies across the underwriting cycle (Malinovskii, 2014). To be more specific, a lower degree of competition can be observed in the hard market, while the competition is more intensive in the soft market. Thus, in this section, competition is treated as a proxy for the underwriting cycle for robustness and sensitivity tests; the aim is to examine whether the competition can represent some features of the underwriting cycle. If the effects of interactions between competition and those internal factors are similar (or identical) to the impacts observed in the previous sections, then it is reasonable to claim that competition can represent the underwriting cycle.

Apart from treating competition as a driving force of the underwriting cycle in the non-life market, there are differences between these two external factors. The impact of competition on stability itself is also a critical question in the financial industry. Although the effect of market competition on firms' stability has been well discussed in the banking industry, it has yet to reach a consensus. While the debate of whether the effect of competition on stability in the banking sector is beneficial or harmful continues, the same question has also been raised in the insurance market. Compared to the massive investigations into banking, relevant studies on the insurance market are limited. Two conflicting hypotheses describe the potential relationships: the competition-fragility hypothesis and the competition-stability hypothesis. The former represents a traditional view that assumes there is a negative relationship between competition and stability.[1] In

[1] Alhassan and Biekpe (2018) summarise three transmission mechanisms to explain the negative relationship as applied to insurance market. First, increasing competition makes it difficult for insurers to monitor claim behaviours and pricing policies (*i.e.* increasing the future uncertainties), due to the high frequency of policyholders switching insurance suppliers in a competitive market. Second, supervision of an insurer's risk-taking behviours will be affected by the increased competition (Allen and Gale, 2004). Finally, as stemming from Keeley (1990), profit-maximisation is one of an insurer's main incentives for excessive risk-taking in a competitive market.

other words, increasing competition erodes a firm's charter values or profitability and contributes to higher instability because of the incentives for excessive risk-taking behaviours (Keeley, 1990).

Rhoades and Rutz (1982) and Demsetz, Saidenberg and Strahan (1996) express a similar view that firms with higher market power would tend to reduce risk-taking. Repullo (2004) also states the view that more competition leads to more risk-taking in the absence of regulation. Later, several international studies found evidence to support a negative relationship between competition and stability in banking sectors (Beck, Demirgüç-Kunt and Levine, 2006; Yeyati and Micco, 2007; Turk-Ariss, 2010). Further, when considering the impact of banking stability on the economy, Fernández, González and Suárez (2016) used a large amount of data from 110 countries and found that the banking stability contributed more to stabilising economic volatility in a less competitive market. Chiaramonte and Casu (2017) state that banks had a lower risk of insolvent in a concentrated market when they used the data from EU-28 member states from 2004 to 2013. By investigating a sample of European-listed banks for the same period, Leroy and Lucotte (2017) confirmed the competition-fragility view at firm-level, while they also suggest that competition may improve financial stability by reducing systemic risk at the macro-level.[1]

On the other hand, the competition-stability hypothesis indicates that competition can enhance firms' stability. Uchida and Tsutsui (2005), Schaeck, Cihák and Wolfe (2009), Allen, Carletti and Marquez (2011), Liu, Molyneux and Nguyen (2012) and Schaeck and Cihák (2010; 2014) provide evidence that supports this stability-enhancing effect in the banking sector. Using the Boone indicator to represent the market competition, Schaeck and Cihák (2010) further confirmed that competition might enhance banks' soundness via efficiency. Soedarmono and Tarazi (2016) suggest that banks in the Asia-Pacific region may face higher credit risk and income volatility when they have more market power (*i.e.* potentially operate in a less competitive market). This confirms the previous findings of Soedarmono, Machrouh and Tarazi (2011; 2013). Recently, Clark, Radić and

[1] These conflicted results can be explained by the different features of the risk indicators, such as the individual stability that can be refered to as internal risk, while systemic risk corresponds with externalized risk. Leroy and Lucotte (2017) provide a detailed explaination regarding the dual relationship between competition and stability.

Sharipova (2018) further confirmed this positive relationship in the Commonwealth of Independent State (CIS).

In terms of the insurance industry, the rationale may be that insurers in a more competitive market tend to monitor its risk-taking (*e.g.* an insurer's underwriting process) more efficient and careful than those in a less competitive market. Then, greater competition may increase a firm's stability as it boosts insurers to increase monitoring and improve its selection of policyholders. Moreover, the reduction in competition may lead to an adverse-selection of high-risk policyholders and the moral hazard problem, as the dominant insurers charge a higher premium (Alhassan and Biekpe, 2018). Fields, Gupta and Prakash (2012) state that higher barriers (lower competition) increase both life and non-life insurers' risk-taking (*i.e.* instability). Thus, increasing competition may enhance an insurer's financial soundness (Boyd and Nicoló, 2005). Consistent with the competition-stability hypothesis, Cheng and Weiss (2012) used the logistic model to confirm that the probability of insolvent is high in a more concentrated market. Using data from 1999 to 2011 in ten EU life insurance markets, Cummins, Rubio-Misas and Vencappa (2017) also found that competition enhances insurers' soundness.

Further, by using both concentration ratio and the Lerner index to represent market competition, Fu, Lin and Molyneux (2014) found that higher concentration (less competition) and lower market power (stemming from intensive competition) lead to higher instability in the banking sector. This confirms the Martinez-Miera and Repullo (MMR) hypothesis that indicates a non-monotonic relationship,[1] which can be referred to as the third view of the connection between competition and a firm's risk-taking (Berger, Klapper and Turk-Ariss, 2009; Martinez-Miera and Repullo, 2010; Jiménez, Lopez and Saurina, 2013). Using the Lerner index and Z-score, Alhassan and Biekpe (2018) found evidence that supports the MMR hypothesis, which suggests an inverted U-shaped relationship between competition and insurers' solvency in the non-life insurance market in South Africa. Therefore, due to the unique feature of the non-life market and the inconclusive results raised in the previous literature, it is worth re-examing the relationship between competition and financial stability at the first step.

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[1] The direction of the net marginal effect between competition and stability defines the non-linear relationship as either a U-shape or an inverted U-shape (Alhassan and Biekpe, 2018).

In this section, the Boone indicator is used to capture the impact of competition on insurers' stability. One of the advantages of using this measurement is that it further considers the competition-efficiency-stability nexus; the nexus suggests that efficiency is the channel through which competition enhances stability (Schaeck and Cihák, 2010; 2014). This confirms the importance of a firm's efficiency to enhancing its stability.

Models 1 and 2 from Table 4.7 study the impact of competition on insurers' soundness (*i.e.* Z-score). Model 1 first confirms that intensive competition will damage a firm's stability. This result not only confirms the competition-fragility view but also discover an impact that is observable from the underwriting cycle (*i.e.* the insurers are less stable in the soft market, see Tables 4.3 and 4.4). Furthermore, the results shown in Model 2 support the MMR hypothesis, which indicates there is a non-linear relationship between competition and stability. Specifically, the results suggest a U-shaped relationship, which implies that an extreme increase in market competition can enhance the financial stability of an insurer. This contradicts to the inverted U-shaped relationship found by Alhassan and Biekpe (2018).

Table 4.7: Robustness - Competition on Financial Stability - GMM

VARIABLES	(1) R1: Competition Stability	(2) R2: Competition^2 Stability	(3) R1: Competition Stability Efficiency	(4) R2: Competition^2 Stability Efficiency
Lagged Stability	0.1698**	0.1946*	0.3005***	0.3009***
	(2.255)	(1.827)	(7.279)	(5.376)
Competition	-1.7856*	-3.5890*	-0.0249*	-0.0546*
	(-1.657)	(-1.802)	(-1.757)	(-1.685)
Competition^2		4.3647*		0.0773*
		(1.927)		(1.839)
Firm Size	2.9200	3.9696	0.1209	0.1719**
	(0.464)	(0.835)	(1.489)	(2.202)
Size^2	-0.1909	-0.2535	-0.0087*	-0.0118**
	(-0.500)	(-0.937)	(-1.789)	(-2.561)
Premium Growth Rate	-0.0835	-0.0078	0.0016	0.0013
	(-0.399)	(-0.084)	(0.792)	(1.109)
Business Volatility	-2.5789***	-2.4083***	-0.0452***	-0.0249***
	(-6.018)	(-4.759)	(-6.640)	(-2.848)
Stock	-1.4258*	0.9223	-0.0030	0.0170
	(-1.891)	(0.367)	(-0.241)	(1.393)
Interest Rate Change	-0.0562	-0.0293	0.0021	0.0016
	(-0.766)	(-0.464)	(1.361)	(0.911)
GDP Growth	0.0514	0.0252	-0.0020	-0.0009
	(0.657)	(0.350)	(-0.895)	(-0.341)
Constant	-0.4835	-7.0706	-0.0018	-0.2708
	(-0.020)	(-0.335)	(-0.006)	(-0.844)
Observations	895	873	489	489
Number of Insurers	379	367	246	246
Number of Instruments	85	87	83	66
Robust	Yes	Yes	Yes	Yes
F-test	8.278***	3.894***	16.01***	9.741***
AR(1)	-1.762*	-1.871*	-1.844*	-1.679*
AR(2)	-0.996	-1.111	-1.036	-0.485
Hansen/ Sargan Test (P-value)	70.34 (0.63)	77.39 (0.43)	68.43 (0.63)	51.01 (0.63)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4.8 shows the results of the joint impacts on insurers' stability when the interaction terms "internal factors * competition" are included. By comparing these results with the findings from Table 4.6, it is easy to test whether competition is an essential factor of the underwriting cycle. As expected, it is safe to conclude that the competition is a good representative of the underwriting cycle because the impacts raised by the interaction terms are identical in both Tables 4.6 and 4.8.

Table 4.8: Robustness - Interaction effects with Competition on Financial Stability - GMM

VARIABLES	(1) Performance Stability	(2) Leverage Stability	(3) Reinsurance Stability	(4) Liquidity Risk Stability	(5) All Stability
Lagged Stability	0.1445**	0.1177*	0.2034***	0.2743***	0.1846*
	(2.122)	(1.711)	(2.905)	(2.724)	(1.924)
Competition	8.0619*	-1.7486*	-0.2506	-1.5755	-11.3466
	(1.902)	(-1.757)	(-0.531)	(-1.428)	(-1.371)
Profit Efficiency	19.6685***				6.4893
	(3.532)				(0.822)
Performance * Competition	-20.6268**				6.2318
	(-2.195)				(0.468)
Leverage		-0.0459**			-0.1596
		(-2.067)			(-0.841)
Leverage * Competition		0.0886**			0.2081
		(2.389)			(0.843)
Reinsurance			0.0415*		-6.3847
			(1.687)		(-1.095)
Reinsurance * Competition			0.5293**		11.9135*
			(2.044)		(1.665)
Liquidity Risk				-1.2804**	-74.1945*
				(-2.277)	(-1.770)
Liquidity Risk * Competition				12.0100*	965.7323*
				(1.759)	(1.786)
Firm Size	1.1899	7.2395	0.7076	0.4873	-7.3010
	(0.183)	(0.830)	(0.148)	(0.062)	(-1.163)
Size^2	-0.0044	-0.3742	-0.0217	0.0896	0.4227
	(-0.012)	(-0.773)	(-0.080)	(0.185)	(1.132)
Premium Growth Rate	0.1026	0.1161	0.0728	0.2553***	0.2770***
	(1.287)	(1.649)	(1.261)	(4.160)	(3.246)
Business Volatility	-2.3700***	-2.1731***	-2.0497***	-1.7919***	-3.0700***
	(-3.752)	(-4.974)	(-7.147)	(-3.969)	(-7.284)
Stock	-2.3463**	-1.4826	-1.4027***	4.5842	-6.4646
	(-2.212)	(-0.827)	(-2.808)	(0.903)	(-1.178)
Interest Rate Change	-0.1558	0.1172*	0.0088	0.0801	-0.0087
	(-1.226)	(1.730)	(0.211)	(0.806)	(-0.060)
GDP Growth	0.0945	-0.0076	-0.0384	-0.1404	-0.1098
	(0.682)	(-0.067)	(-0.614)	(-1.179)	(-0.627)
Constant	-9.1185	-25.3421	2.9788	-7.4310	43.1370
	(-0.314)	(-0.658)	(0.142)	(-0.230)	(1.372)
Observations	594	721	798	862	519
Number of Insurers	293	320	327	359	256
Number of Instruments	101	121	140	86	116
Robust	Yes	Yes	Yes	Yes	Yes
F-test	4.010***	9.020***	7.126***	9.703***	2089***
AR(1)	-1.709*	-1.681*	-1.892*	-1.745*	-1.745*
AR(2)	-0.851	-0.916	-1.347	-1.119	0.308
Hansen/ Sargan Test (P-value)	85.30 (0.59)	102.1 (0.67)	121.7 (0.64)	72.12 (0.54)	82.18 (0.88)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Except for using competition to represent the underwriting cycle, those impacts raised by the interactions can also be explained from a competition perspective. In other words, the results from Table 4.8 suggest that better-performing insurers are riskier in the competitive market, as such firms have incentives to use riskier strategies in order to maintain their market shares. In contrast, insurers who bear more leverage risk, liquidity risk or use more reinsurance have a lower likelihood of being insolvent in the competitive market, as they should have already paid attention to the harmful effects originating from competition.

4.4.3.2 Z-score Efficiency as the proxy of the Insurer's Soundness (Stability)

Apart from using competition to represent the underwriting cycle, an alternative measurement — Z-score efficiency — is used to represent financial soundness. In the original model, Equation 4.4, the Z-score considers the insurers' stability from the point of return. However, there is a potential limitation of using the Z-score to represent financial soundness, as it is not able to reflect an individual firm's position relative to its counterparts (Fang, Hasan and Marton, 2011). This is especially true when the competition is considered because one of the outcomes of intensive competition the forced exit of inefficient firms from the market. Therefore, the stability efficiency variable, which can overcome this limitation, is adopted here to identify an insurer's stability. Tabak, Fazio and Cajueiro (2012), Tan (2016) and Tan and Floros (2018) present a similar approach. Equation (A4.1), in Appendix 4, shows the detail of the mathematical model used to estimate the z-score efficiency.

First, Models 3 and 4 from Table 4.7 study the impact of competition on insurers' stability efficiency. Consistent with the prior findings, the competition-fragility hypothesis and the MMR hypothesis are both confirmed. Then, Table 4.9 shows the desired impacts of the interaction terms on insurers' stability efficiency. The estimated results are almost identical to the prior results; this further identifies the robustness and unbiasedness of the main conclusions. It is worth noting that, due to the nature of stability efficiency, the results not only reveal the potential driving forces of a firm's stability but also discover its financial health position relative to its counterparts in the market. Specifically, the results of Model 1 indicate that better-performing insurers take a relatively high insolvency risk in a competitive market compared to other insurers.

Similarly, insurers with more leverage risk, liquidity risk or use of more protections are more stable than others (see Models 2 to 5).

Table 4.9: Robustness - Interaction effects with Competition on Stability Efficiency - GMM

VARIABLES	(1) Performance Stab. Efficiency	(2) Leverage Stab. Efficiency	(3) Reinsurance Stab. Efficiency	(4) Liquidity Risk Stab. Efficiency	(5) All Stab. Efficiency
Lagged Stability Efficiency	0.3132***	0.2673**	0.4053***	0.3415***	0.3266***
	(3.550)	(2.579)	(3.620)	(4.311)	(4.314)
Competition	0.1965**	-0.0505***	-0.0433*	-0.0077	0.0154
	(1.970)	(-3.022)	(-1.797)	(-0.482)	(0.212)
Profit Efficiency	0.5019***				0.2642***
	(4.690)				(4.352)
Performance * Competition	-0.4271**				0.0162
	(-2.071)				(0.120)
Leverage		-0.0050*			0.0019
		(-1.800)			(0.850)
Leverage * Competition		0.0065*			-0.0025
		(1.885)			(-0.849)
Reinsurance			-0.0095		0.0319
			(-1.146)		(0.813)
Reinsurance * Competition			0.0983*		-0.0954*
			(1.665)		(-1.672)
Liquidity Risk				-0.0828*	-0.3064**
				(-1.854)	(-2.118)
Liquidity Risk * Competition				1.0779*	4.0011**
				(1.858)	(2.125)
Firm Size	0.1778	0.1436	0.0933	0.1836**	0.0913
	(1.550)	(1.080)	(1.326)	(2.075)	(1.547)
Squared Size	-0.0111*	-0.0087	-0.0067*	-0.0126**	-0.0062*
	(-1.663)	(-1.193)	(-1.680)	(-2.466)	(-1.899)
Premium Growth Rate	0.0016*	0.0014	0.0017*	0.0042***	-0.0007
	(1.817)	(1.648)	(1.661)	(4.552)	(-0.899)
Business Volatility	-0.0391***	-0.0388***	-0.0414***	-0.0404***	-0.0355***
	(-5.652)	(-4.572)	(-5.166)	(-7.269)	(-7.061)
Stock	0.0666	-0.0897	0.0419	0.0264	0.0051
	(1.209)	(-1.649)	(0.895)	(0.713)	(0.136)
Interest Rate Change	-0.0004	0.0006	0.0024	0.0031**	0.0012
	(-0.447)	(0.269)	(1.444)	(2.201)	(1.103)
GDP Growth	-0.0051**	-0.0022	-0.0032	-0.0044*	-0.0027
	(-2.228)	(-0.661)	(-1.229)	(-1.828)	(-1.187)
Constant	-0.6020	-0.1302	0.0065	-0.3010	-0.1157
	(-1.267)	(-0.211)	(0.020)	(-0.828)	(-0.417)
Observations	468	444	474	489	426
Number of Insurers	241	226	236	246	211
Number of Instruments	106	102	121	149	151
Robust	Yes	Yes	Yes	Yes	Yes
F-test	15.61***	11.29***	9.563***	4142***	3288***
AR(1)	-1.677*	-1.658*	-1.902*	-2.141**	-1.686*
AR(2)	-0.977	-0.921	-1.287	-1.159	-1.381
Hansen/ Sargan Test (P-value)	92 (0.539)	81.04 (0.739)	115.2 (0.324)	127.9 (0.698)	141.3 (0.295)

t-statistics in parentheses

4.4.4 The Impact of Control Variables

In line with Shim (2015) and Eling and Jia (2018), there is evidence to support an inverted U-shaped relationship between an insurer's firm size and its financial soundness, though this relationship is only significant in the long-term models. Inconsistent with previous studies (see Lee and Urrutia, 1996; and Chen and Wong, 2004), the impact of a premium growth rate on stability is significant and positive in the short-term; this implies that a higher premium growth enhances a firm's stability in the short-term. Regarding business volatility, the results confirm that it negatively and significantly influences insurers' health in both the long- and short-term. Finally, stock insurers are found to be less stable. This result is in line with those of Ho, Lai and Lee (2013) and Shim (2015).

4.4.5 The Validity of Models

The F-test and the value of adjusted R-squared verify the validity of the OLS fixed-effect model. The GMM dynamic models are required to meet the assumptions of overidentification restrictions and no second-order correlations. As expected, all the GMM models are valid because both the Hansen test (or Sargan test) and the AR(2) test are insignificant.

Section 4.5 Conclusion

The main purpose of this chapter is to study the driving forces that influence insurers' financial soundness in the U.K. non-life market. Although there are many studies concerning this issue in the banking industry, the literature has not been as developed in the insurance industry. Notably, the influence of the underwriting cycle is neglected in the U.K. market. By applying one of the most widely used methods, *i.e.* the AR(2) model, we achieved results that confirm the existence of the underwriting cycle in the U.K. non-life market; the length is about five years on average.

By focusing the period from 1996 to 2017, the results of regressions confirm that both internal factors (*i.e.* performance, leverage, reinsurance and liquidity) and external factors (*i.e.* the underwriting cycle) are essential, though some of the impacts may vary between the long- and short-term. Apart from investigating the individual influences, the interaction terms, which are between the internal factors and the proxy of the underwriting cycle, are included in the regressions to answer how the impacts of internal factors vary according to changes in market conditions, *i.e.* the soft market or the hard market. The findings show that the underwriting cycle influences insurers' operational strategies and financial health. The impacts of internal factors on stability need to be jointly determined with the underwriting cycle.

Table 4.10 presents the summary of all hypotheses and relevant results. Panel A indicates that individual factors influence insurers' financial soundness (Z-score) differently. Panel B shows the impacts on insurers' Z-scores, after jointly considering the internal factors and the underwriting cycle, *i.e.* including the interaction terms. The results indicate that the underwriting cycle does influence insurers' operational strategies, and managers in the insurance companies have already paid attention to the harmful effects the originate from such a cyclical pattern. Panels C and D present the results from the robustness and sensitivity tests. The competition is used to represent the underwriting cycle in the former, while the Z-score is replaced by z-score efficiency (stability efficiency) to represent insurers' soundness in the latter panel. As shown, the impacts of interaction terms on stability are identical in all three models (Panels B to D). Thus, from one side, it is safe to believe that competition is one of the potential driving factors of the underwriting cycle. This research has potential public implications. For example, insurers may need to adjust their underwriting and managerial strategies to achieve efficient and effective operations, in response to different phases of the underwriting cycle. For regulators, legislators and consumer groups, this research provides some understanding of how to maintain stability in the insurance market and may help clarify insurers' health positions. Further, it points out the importance of external pressure on insurers' stability.

Table 4.10: Summary of Hypotheses and Results

Panel A: Hypotheses 1-5	Results
Hypothesis 1: Performance	+
Hypothesis 2: Leverage	-
Hypothesis 3: Reinsurance	+
Hypothesis 4: Liquidity Risk	+
Hypothesis 5a: Underwriting Cycle	-
Robust Test: Competition	-
Robust Test: Squared Competition	+
Panel B: Hypothesis 5b – Interactions with Underwriting Cycle	
Performance * Underwriting Cycle	-
Leverage * Underwriting Cycle	+
Reinsurance * Underwriting Cycle	+
Liquidity Risk * Underwriting Cycle	+
Panel C: Robustness – Interactions with Competition	
Performance * Competition	-
Leverage * Competition	+
Reinsurance * Competition	+
Liquidity Risk * Competition	+
Panel D: Robustness - Impacts on Stability Efficiency	
Performance * Competition	-
Leverage * Competition	+
Reinsurance * Competition	+
Liquidity Risk * Competition	+

CHAPTER 5: Conclusion

There is a notable link between an economy's financial development and insurance market growth. Financial developments involve the effort of protecting a population's properties against unexpected events; such events are hard to avoid and may lead to losses. For this reason, the insurance concept was developed as a means of protection against such undesirable events or losses. The existing literature has indicated that the insurers are not only exposed to systemic risks but also significantly influence the stability of the financial system. Thus, because of the insurance-specific characteristics, its importance and stabilisation, analysing the insurance industry is crucial for different stakeholders – with the expectations of stabilising the financial system, preventing unexpected losses and enhancing economic health. The UK insurance industry has been chosen because it is one of the most advanced/developed insurance markets in the global market. In particular, three vital factors – performance, capital structure and soundness (stability) – which are insurers' fundamental concerns, have been studied in this thesis.

This thesis contributes to the ongoing discussions on insurers' performance, capital structure and financial soundness (stability). Specifically, it aims to determine the impacts of risk-related practices on these vital concerns, with further consideration of the external influences.

To be more specific, Chapter 1 provides an overview of the UK insurance market in terms of operational performance, from 1996 to 2017. Two performance indicators – efficiency and productivity – are estimated by the SFA. By identifying insurers' performance, two questions have been answered: (1) How well is the firm being operated? And (2) How has the market evolved over time? The main findings show no significant improvement on efficiencies from the past 20 years. Compared with the best-practice player, most of the UK insurers may increase their cost efficiency and profit efficiency by 40% and 70%, respectively. Thus, it is reasonable to state that they have put more efforts on cost management than on profit generation. Regarding the sub-markets, the life insurers always demonstrate the lowest performance compared with the others. Besides, the UK insurers suffer productivity declines on the average level, and the main driving force is the decrease in the markup ability.

Chapter 1 mainly contributes to ongoing discussions on insurer's performance (Eling and Luhnen, 2010a; Eling and Luhnen, 2010b; Bertoni and Croce, 2011). First, the UK insurance industry is an important contributor to economic growth both in the country itself and worldwide, and is ranked as the largest across the EU and the third-largest in the world. However, in contrast to the number of studies related to the US market or the EU market, the number of studies that focus on the UK market is relatively low. Therefore, it is essential to fill the gap and draw a full picture of this important market. Second, it is the first and most comprehensive study to investigate the UK insurance market. In order to obtain a more accurate overview of insurers' performance, this chapter encompasses various aspects, which are generally covered in three areas: (1) different performance indicators - efficiency and productivity; (2) types of insurers - life, non-life and composite insurers; (3) types of ownership - stocks and mutual insurers. Third, in comparison to other performance studies related to the UK market, the sample used in this chapter can be considered the largest, and its acquired data are also the most recent and the widest in coverage regarding time.

It is thus essential to gain insights into the driving forces behind the insurers' performance. Chapter 2 explores the relation between risk-related activities (risk-taking and risk management) and the insurers' performance in the UK market over the 1996–2013 period. Both cost and profit efficiencies represent insurers' performance from two different perspectives. The findings confirm that both risk-taking and risk management practices significantly affect the insurers' performance. Indeed, the significant effects of the interactions between risk-taking and risk management activities on the insurers' performance are also proven, indicating the joint impacts on the insurers' performance.

This chapter mainly contributes to ongoing studies on revealing the determinants of insurer's efficiency (Lin, Wen and Yang, 2011; Biener, Eling and Wirfs, 2016; Bikker, 2016; Eling and Schaper, 2017). Firstly, this study investigates the impact of both risk-taking behaviours and risk management activities on the insurers' performance, but most of the extant studies only focus from one perspective (Lin, Wen and Yang, 2011; Biener, Eling and Wirfs, 2016). Secondly, it is the first study to consider the interaction effects between different insurers' risk-taking behaviours and risk management activities. It is worth to determine such impacts, because insurers' risk-taking behaviours and risk management activities are often jointly considered. Third, this chapter responds to measurement issues and employs product risk, diversification strategy and pricing risk as underwriting risk measures. This provides more detailed information on insurers' underwriting strategies. Fourth, it is vital to consider the impact on both cost and profit efficiencies, as two efficiencies capture different information. Overall speaking, the findings can help insurers devise appropriate strategies combining both business and operational activities at the aggregated level to improve performance. Regulators can also use the results to establish regulations or standards related to insurers' business and operational activities.

Chapter 3 determines the factors affecting the insurers' capital structure in the UK market, concerning both internal and external factors. By focusing on the UK insurance market from 1998 to 2017, the results not only confirm the significant influences of the targeted factors but also reveal that different market structure indicators represent various concepts of the market. Furthermore, by having internal behaviours and external pressures interact, the results suggest that the impact of internal behaviours on the capital structure varies according to the changes in the market structure.

Several contributions can be made to the literature (Campello, 2003; Shiu, 2011; Cheng and Weiss, 2012; Altuntas, Berry-Stölzle and Wende, 2015; Dhaene *et al.*, 2017). Firstly, in contrast to the banking studies on capital structure, there is relatively little investigation on determinants of insurers' capital structure. Secondly, the impact of market structure (e.g., competition) on an insurer's capital structure is ambiguous. It is important to fill the gap. Therefore, the main contribution of this study is to determine how market structure affects UK insurers' capital structure directly and indirectly—for example, considering the individual effect of market structure and its interactions with firm-specific characteristics on the UK insurance market's capital structure. Third, this chapter responds to measurement issues and employs Boone indicator, Lerner Index and HHI as market structure measures. By implying three different indicators, it provides a comprehensive picture of market structure in the UK insurance industry.

It is important to ensure that the insurers maintain the ability to meet their obligations and further enhance their soundness (stability). Thus, Chapter 4 determines the influence of performance and risk-related practices on the soundness (stability) of general insurers, paying particular attention to the impact of the underwriting cycle. The results confirm the existence of the underwriting cycle, with a five-year duration in the UK market. Furthermore, evidence supports the argument that the underwriting cycle influences insurers' operational strategies and further affects their financial health. Then, the impacts of internal factors on stability need to be jointly determined with the underwriting cycle. Lastly, by using competition to represent the underwriting cycle, it is reasonable to confirm that competition is a potential driving force behind the underwriting cycle because they have identical impacts on the insurers' soundness.

This chapter mainly contributes to ongoing discussions on insurers' financial soundness (e.g., Cummins, Rubio-Misas and Vencappa, 2017; Alhassan and Biekpe, 2018; Eling and Jia, 2018). Firstly, the question of how the underwriting cycle may interact with insurers' stability has not been well-studied. The relationship will provide insight into how to improve a firm's stability in response to pricing restrictions (caused by underwriting cycle). Additionally, it is vital to pay attention to changes in an insurer's financial soundness after changes in an insurer's risk-related behaviour. This chapter contributes to the literature by incorporating the influence of the underwriting cycle on an insurer's financial soundness (stability or risk-taking behaviour), including the interaction term between both internal and external factors in consideration of their joint effects. Answering the abovementioned questions can help regulators endorse supervisions to reduce insolvency risk and promote financial stability in the market.

Apart from the abovementioned specific contribution, this study also generally contributes to the literature from the following perspectives:

1. The UK market has its specific features and research contributions. However, relatively few studies have focused on the unitary UK market.
2. This thesis can claim that its study sample is the largest in quantity, and its acquired data also provide the most recent and the second widest coverage in terms of the study period (from 1996-2017).
3. It is beneficial to research on the UK insurance market to provide a clear indication of the standard and a potential benchmark to its counterparts, such as

developed markets (*e.g.*, the US or the German market) or emerging markets (*e.g.*, the Chinese market).

4. The obtained results can constitute a reference for regulatory purposes, such as setting guidelines for insurers' behaviours, promoting competition, and so on.

This thesis has provided comprehensive results on the effect of various risk-related factors (risk-taking behaviours or risk-management activities) on the UK insurer's performance, capital structure and financial soundness However, there remain some limitations and challenges for future research. First, this study focus only on the UK insurance market, it will be interesting to test whether similar or different conclusion will be existed in other countries, for example, the US market or the Chinses market, the former has a totally different feature from the UK market, and the latter is one of the high growth emerging markets. Further comparisons can be beneficial to understanding the similarities or differences. Second, although the most recent information used in this thesis is from 2017, it is not able to fully catch the impact of Solvency II, which is launched in 2016, on the insurance market. It will be reasonable to collect more data and make further time series analysis. Moreover, due to data limitation, the solvency capital requirement and minimum capital requirement (from Solvency II), which are better indicators of capital structure/requirement and insolvency risk, are not available to use. Additionally, due to data availability, it is not possible to make further analysis of the impact of BREXIT on the UK insurance market. However, it is crucial to make such analysis as it will be meaningful for future market developments, but it requires new data to be collected.

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Appendix

Appendix 1

<u>*Summary of different topics of efficiency studies*</u>

Distribution System:

By considering the influence of 'distribution systems', the degree of efficiency in various distribution channels can be compared. According to (Berger, Cummins and Weiss (1997), an insurance package could be promoted in two ways: either directly by insurers to customers (a direct issue) or indirectly via third-party independent agencies (an indirect issue).

Under the indications of the product-quality hypothesis,[1] although service intensity and quality could be effectively leveraged within the process of issuing an insurance package via third-party independent distribution channels (agencies), a consideration of additional cost is also required (Berger, Cummins and Weiss, 1997). Conversely, even if there is no cost efficiency advantage in promoting an insurance package via third-party independent distribution channels (in comparison to direct channels), its advantage in terms of profit efficiency (again in comparison to direct channels) is clear.

Similarly, Brockett *et al.* (1998, 2004b, 2004a), Carr, Cummins and Regan (1999) and Klumpes (2004) further argue that more efficiency can be observed from the independent distribution system in comparison to direct systems. Apart from these findings, Ward (2002) also confirmed that more efficiency could be generated by using a singular distribution system, in comparison to using multi-distribution channels. The recent study of bancassurance, Fiordelisi and Ricci, (2010) consider from the perspectives of ownership and distribution channels separately. They found that captives (controlled by the bank) and joint ventures (50-50) outperform independent companies.

Intercountry Comparisons:

By using country-specific macro factors to compare efficiency scores in different insurance markets, differences across countries can be determined.

Based on investigations of efficiency in Nigeria (Barros and Obijiaku, 2007), Malaysia (Mansor and Radam, 2000) and Australia (Worthington and Hurley, 2002), substantial international differences in average efficiency are detected. In addition, according to Diacon, Starkey and O'Brien (2002), apart from the appearance of varied average efficiency among countries, the general tendency is towards decreasing average efficiency among EU-15s from 1996 to 1999. Kasman and Turgutlu (2011) draw a similar conclusion by studying 22 EU non-life markets, with their results indicating that cost inefficiency exhibited an upwards trend in most countries over the 1995–2002 period, after the implementation of 'one single market' (deregulation in the EU zone).

Moreover, bsed on the investigation of EU-14s from 1997-2006 by Zanghieri (2009),

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[1] Berger, Cummins and Weiss (1997) developed two hypotheses: the market imperfection hypothesis and the product quality hypothesis. Under the market imperfection hypothesis, the existence of the surviving independent financial advisers is due to market imperfection. It is assumed that efficient firms will expect to earn higher risk-adjusted profit than the inefficient firms Alternatively, under the product-quality hypothesis, independent financial advisers offer a high cost for producing 'higher quality' products or great service intensity.

it is worth mentioning that country-specific factors could be regarded as a strong mediator in influencing efficiencies. Zanghieri also argues that different firm-specific factors, such as size, would drive efficiency results differently for life and non-life businesses.

Recently, Eling and Schaper (2017) study the impact of changing environmental factors, i.e., factors not under the control of managers, on a firm's performances, and further emphasise the importance of considering such external factors. They further confirm that business environments, such as general economic, regulation and stock market performance, and insurance market conditions are important drivers of efficiency in 14 EU life markets from 2002 to 2013.[1] A similar conclusion is made in an earlier study from Huang and Eling (2013), who focused on non-life markets in the BRIC countries (Brazil, Russia, India and China).

Regulation Changes and External Pressures:

By investigating the impact of external factors (i.e., regulatory factors, business environment factors) on a firm's performance (see, Chen and Wong (2004), Pope and Ma (2008) and Klein and Wang (2009)), two goals can be achieved: (1) Regulators and supervisors can impose new rules based on firms' performance; and (2) Firms need to adjust internal controls in a new regulatory environment. Since 1994, EU insurance companies have faced a few dramatic regulatory reforms, such as the deregulation in 1994, the reinsurance directive issued in 2007 and the Solvency II in 2016. One of the motivations for the deregulation reform is to enhance the degree of competition, and thus further encourage insurers to boost their production and efficiency.

Cummins and Rubio-Misas (2006) indicated that increased competition in the domestic market was one of the most significant characteristics of deregulation. Deregulation puts pressure on domestic firms to innovate due to competition and to introduce new technologies to improve the firm's cost position. For example, in Spain, the number of firms declined by 35%, while firm size increased by 275%; meanwhile, the unit product price declined as well during the 1989–1998 period (Cummins and Rubio-Misas, 2006).

By using data collected from Germany and the UK for the 1991-2002 period, Hussels and Ward (2007) hypothesis that efficiency enhancement would appear due to deregulation in Europe. However, they find no clear evidence to support their hypothesis. That said, the hypothesis was strongly accepted by Turchetti and Daraio (2004), in the Italian insurance market from 1982 to 2000, and in Austria from 1994 to 1999 (Ennsfellner, Lewis and Anderson, 2004). Yet, Mahlberg and Url (2000) find that the deregulation could lead to a decreasing tendency towards efficiency. Kasman and Turgutlu (2011) also point out that cost efficiency exhibits downwards trend in the EU-22's non-life market after the implementation of 'one single market (deregulation in the EU zone)'. Similarly, in the US market, as emphasised by Ryan and Schellhorn (2000), no efficiency changes are detected under the circumstances of the implementation of risk-based capital requirements.

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[1] Different environmental factors contribute to efficiency differently. For example, economic maturity and capital market performance are positive drivers; regulation (restricted capital requirements) and unemployment are negatively related to efficiencies; inflation and interest rate levels have negative impacts on technical efficiency but positive impacts on cost efficiency. (Eling and Schaper, 2017)

The liberalisation of the EU insurance sector resulted in an increasing number of mergers and acquisitions, about which Cummins and Weiss (2004) reported that there were 2595 M&As involved in the EU market from 1990 to 2002. Since M&As could also stimulate market competition, which would in turn further influences the degree of efficiency as defined by Cummins, Tennyson and Weiss (1999) and Cummins and Xie (2008), M&As could be regarded as a beneficial strategy (*e.g.* value-enhancing) for both the acquiring and target firms. In addition, according to Fenn *et al.* (2008), the adoption of acquisitions and mergers could lead to efficiency gains under the liberalisation of the EU market. However, it was suspected by Klumpes (2007) that acquiring companies would achieve greater efficiency, whereas target companies would not gain such benefits in the EU market. As stated by Kim and Grace (1995), even though target firms are shown to lack efficiency in doing business, their efficiency as a whole could be enhanced when combined with the acquiring firm in the US life market. However, Shim (2011) also find that the acquirer's performance decreased and earning volatility increased after the M&As.

From the most recent study, by Eling and Schaper (2017), the impact of several different external factors on life insurers' efficiencies were detailed more comprehensively. Three central dimensions constituting the business environment were outlined – general economic, capital market and insurance market condition – in which seven sub-factors are involved.[1] To be more precise, both economic maturity and stock market performance had a positive impact on efficiency, whereas unemployment and regulation were negative contributors.

Organizational Form, Corporate Governance Issues:

This application is aimed at comparing the degree of efficiency among companies associated with different features. For example, extensive discussions and academic research have given particular attention to insurers' ownership structure issues, *e.g.* Mayers and Smith (1981, 1986, 1988), Lamm-Tennant and Starks (1993), Pottier and Sommer (1997) and Brockett *et al.* (2004b). One of the key reasons for such interest in insurers' ownership structures is that certain ownership structure has an advantage in controlling particular types of conflicts among owners, managers and policyholders (Mayers and Smith, 1981). In supporting the managerial discretion hypothesis,[2] Pottier and Sommer (1997) state that stock insurers are more prevalent in group businesses than in their mutual counterparts.

As reviewed by Cummins, Weiss and Zi (1999), most professionals admitted that mutual firms are generally less efficient in comparison to stock firms, and this assertion is also forwarded by Brockett *et al.* (2004b) and Diboky and Ubl (2007). Diboky and Ubl (2007) show that hybrid forms (i.e. stock firms owned by a mutual) are inferior to pure stock firms in the German life market, in terms of comparing efficiency scores. A similar conclusion is reached by Lai and Limpaphayom (2003), who find that no significant difference in terms of ROA performance between mutual and stock firms; and yet Keiretsu insurers outperformed in Japan non-life market. Furthermore, Jeng, Lai and McNamara (2007) indicate that efficiency enhancements could also be identified after de-mutualisation. However, in the case of US and German markets, exceptions also existed

[1] The seven sub-factors are as followed: economic maturity, unemployment, information, interest rate level, stock market performance, competition and regulation (capital adequacy) (Eling and Schaper, 2017).

[2] The managerial discretion hypothesis predicts that different ownership structures may have certain comparative advantages in particular lines of business.

(Greene and Segal, 2004; Luhnen, 2009). As suggested by Greene and Segal (2004), equivalent efficiency and profitability are found in both stock and mutual insurers. Also, Biener, Eling and Wirfs (2016) find no evidence to support the notion that stock insurers are more efficient in Swiss life and non-life markets.

Apart from ownership form issues, many researchers have made varied considerations from different corporate governance perspectives. Size is one of the factors that plays a crucial role, such as scale-efficient firm operates at a constant return to scale (CRS); meanwhile, scale-inefficient firms operate at either an increasing return scale (IRS) or a decreasing return scale (DRS). For example, Worthington and Hurley (2002), Canton *et al.* (2005), Cummins and Xie (2013) and Alhassan and Biekpe (2015) all provide evidence that size has a significant impact on a firm's efficiency and CRS – especially, a non-linear effect of size is found.[1] This implies that larger insurers should downsize to improve efficiency, while policymakers should encourage consolidation among small- and medium- -size firms. Instead, Grace and Timme (1992) and Yuengert (1993) find that larger-size insurers operated at CRS rather than at DRS.

Other corporate governance factors, such as the age of the firm, the reinsurance ceded and the insurer's leverage, are found to be negatively related to its technical efficiency by Alhassan and Biekpe (2015). Their leverage-related findings are in line with Jensen and Meckling's (1976) 'conflict of interest' hypothesis[2] and Biener, Eling and Wirfs' (2016) results in Swiss insurance market. However, these last results were inconsistent with those of Adams and Buckle (2003) and Luhnen (2009) and the 'free-cash flow' hypothesis suggested by Jensen (1986), who claimed that high leverage induced better management efficiency.[3]

Board characteristics have also been studied, by Hardwick, Adams and Zou (2011) who find that different board members would have different impacts on efficiency; Bahloul, Hachicha and Bouri (2013) conclude that the optimal power of the CEO would allow the insurance firm to be more productive and more efficient.

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[1] The convex relationship arose from both Cummins and Xie (2013) and Alhassan and Biekpe (2015) because the coefficient of the linear term is negative, and the quadratic term of size is positive. This also refers to a non-linear 'U-shaped' relationship between a firm's size and its efficiency, and Worthington and Hurley (2002) also confirm this result. Canton *et al.* (2005) provide a possible explanation for this U-shape: that differences in managerial inability across smaller firms are limited due to limited types of issued products. The largest firms face more competition, which forces them to become more efficient.

[2] Two types of conflicts occur in the insurance company: owner-manager conflict and owner-policyholder conflict. The former arises because the manager may not always act in the best interest of shareholders, while the latter arises because policyholders' claims to an asset have priority over shareholders' rights. Jensen and Meckling (1976) suggest that the optimal capital structure should be determined by the trade-off between these two conflicts. This implies that higher leverage leads to lower performance due to the conflict between owners and policyholders. Cummins and Nini (2002) provide a detailed study of optimal capital structures in the US property-liability insurance market.

[3] According to Jensen (1986) 'control hypotheses (free-cash flow hypothesis)', debt creation enables managers to effectively bond their promise to pay out future obligations. If the firm does not maintain their promise to make payments (interests or principles), then the debtholder may take the firm into bankruptcy court. And should this action happen before shareholders receive their dividends, then the debt reduce the cash flow available for spending at the discretion of managers.

Last but not least, an insurer's business strategies, i.e., business scope, product/ geographical diversification,[1] and other underwriting risks, have also been given attention as one of the driving factors of performance improvement. Luhnen (2009), Cummins *et al.* (2010) and Shim (2011) find that insurers writing more specialised business should be more cost efficient than those with more diversified businesses, a result supported by the strategic focus hypothesis. Cummins and Zi (1998) also suggest that the most internationally diverse insurers suffer diseconomies. In contrast to above, product or geographic diversifications are found to be positively connected to efficiency Mahlberg and Url (2003), Cummins and Xie (2013) and Alhassan and Biekpe (2015).
Moreover, Ansah-Adu, Andoh and Abor (2011) and Alhassan, Addisson and Asamoah (2015) confirm that life insurers exhibit higher efficiency scores compared to non-life insurers.

Other Applications:
The mentioned studies focus on the influence of both external and internal on a firm's efficiency. Inversely, an insurer's operational and management quality (*i.e.* efficiency or productivity) also contributes significantly to a firm's behaviours (Miller, 1996), which can in turn be used as potential predictors of business failures. For example, Siems (1992), Psillaki, Tsolas and Margaritis (2010) and Li, Crook and Andreeva (2014) use efficiency as a failure predictor, and revealing that management quality is critical to business failures. Wheelock and Wilson (2000) and Luo (2003) further demonstrate that more efficient banks are less likely to fail. Eling and Jia (2018) also confirm a similar result between efficiency and business failure from the EU insurance industry. By revealing such a relationship, both managers and supervisors can identify potential insolvency at an earlier stage and have more time to take further actions.

<u>Mathematical (In)efficiency Models</u>
As we mentioned in literature review section, different developments/assumptions of efficiency estimation are used in this study, and detail of each assumption is discussed here. In this research, (in)efficiency is estimated econometrically by using a Stochastic Frontier Analysis (SFA). The advantage is that both random error and inefficiency are combined in a composited error term (Berger and Humphrey, 1997).

An early study from Schmidt and Sickles (1984), assume that inefficiency is individual-specific and time invariant; therefore, the model could be defined as a distribution free model:

$$y_{it} = f(\mathbf{x}_{it}; \boldsymbol{\beta}) + \varepsilon_{it}$$

where $f(\mathbf{x}_{it}; \boldsymbol{\beta})$ stands for a linear function of the variables in the vector x_{it}, y_{it} can be treated as cost, profit, revenue in this study, and $\varepsilon_{it} = v_{it} - u_i$, here, v_{it} is the error term and u_i is the time-invariant inefficiency of individual i. The model can be estimated assuming either u_i is a fixed parameter or a random variable. Therefore, we could have model 1 and model 2 as followed.

Model 1: Fixed-Effect Model (Schmidt and Sickles, 1984)

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[1] The conglomeration and strategic focus hypotheses explain the relationship between product diversification and efficiency. The conglomeration hypothesis predicts diversified insurers to be more efficient, while the strategic focus hypothesis, on the other hand, indicates a negative relationship.

$$\begin{aligned} y_{it} &= \beta_0 + x_{it}\beta + v_{it} - u_i \\ &= \alpha_i + x_{it}\beta + v_{it} \end{aligned}$$

where $\alpha_i = \beta_0 - u_i$, and α_i, i=1,…,N, are assumed to be fixed parameters, once the α_i are available, the estimated value of u_i (inefficiency) can be obtain by:

$$u_i = \max(\alpha_i) - \alpha_i \geq 0, \qquad i = 1, \ldots, N$$

, and the firm-specific efficiency can be obtained from exp (-u_i).

Model 2: Random-Effect Model (Kumbhakar, 1987)

In this RE model, it is possible to assume that α_i is random and uncorrelated with the repressors. There are two different methods to estimate the (in)efficiency. Whereas one method is to estimate it by the generalized least squares (GLS) technique; the other is to impose distribution assumptions on random components. Then, it could be estimated the parameters by the maximum likelihood (ML) method (Pitt and Lee, 1981). Once the parameters are estimated, the inefficiency term could be calculated by Jondrow *et al.'s* (1982) function, and efficiency term can be estimated by Battese and Coelli's (1988) function (Kumbhakar, 1987). The Pitt and Lee (1981)'s MLE model is used in this paper as follow:

$$\begin{aligned} y_{it} &= f(\mathbf{x_{it}}; \boldsymbol{\beta}) + \varepsilon_{it} \\ y_{it} &= \beta_0 + x_{it}\beta + v_{it} - u_i \\ &= \alpha_i + x_{it}\beta + v_{it} \end{aligned}$$

where $\varepsilon_{it} = v_{it} - u_i$ and $v_{it} \sim N(0, \sigma_u^2)$ and $u_i \sim N^+(\mu, \sigma_u^2)$. If μ is equal to 0, the above estimation of inefficiency u_i would follow either half-normal or truncated-normal destruction. By following approach from Pitt and Lee (1981) and Kumbhakar and Lovell (2000), the likelihood function would be obtained as follow:

$$\ln L_i = \text{constant} + \ln\Phi\left(\frac{\mu_{i*}}{\sigma_*}\right) + \frac{1}{2}\ln(\sigma_*^2) + \frac{1}{2}\left\{\frac{\sum_t \varepsilon_{it}^2}{\sigma_v^2} + \left(\frac{\mu}{\sigma_u}\right)^2 - \left(\frac{\mu_{i*}}{\sigma_*}\right)^2\right\} - T\ln(\sigma_v) - \ln(\sigma_u) - \ln\Phi(\frac{\mu}{\sigma_u})$$

where

$$\mu_{i*} = \frac{\mu\sigma_v^2 - \sigma_u^2 \sum_t \varepsilon_{it}}{\sigma_v^2 + T\sigma_u^2} \qquad \text{and} \qquad \sigma_*^2 = \frac{\sigma_v^2\, \sigma_u^2}{\sigma_3^2 + T\sigma_u^2}$$

Thus, the MLE of the parameters is obtained by maximizing the log-likelihood function, and then inefficiency of each firm can be obtained from following equation (Jondrow *et al.*, 1982):

$$E(u_i|\varepsilon_i) = \mu_{i*} + \sigma_* \left[\frac{\emptyset(-\frac{\mu_{i*}}{\sigma_*})}{1 - \Phi(-\frac{\mu_{i*}}{\sigma_*})}\right]$$

and the efficiency can be computed by Battese and Coelli's (1988) function:

$$E(\exp(-u_i)|\varepsilon_i) = \exp\left(-\mu_{i*} + \frac{1}{2}\sigma_*^2\right)\frac{\Phi\left(\frac{\mu_{i*}}{\sigma_*} - \sigma_*\right)}{\Phi\left(\frac{\mu_{i*}}{\sigma_*}\right)}$$

Model 3: Time-Varying Models (Kumbhakar, 1990)

By following Kumbhakar (1990)'s time varying development, the following generic formulation is used to create the framework:

$$y_{it} = f(x_{it}; \beta) + \varepsilon_{it}$$
$$\varepsilon_{it} = v_{it} - u_{it}$$
$$u_{it} = G(t)u_i$$
$$v_{it} \sim N(0, \sigma_u^2) \quad \text{and} \quad u_i \sim N^+(\mu, \sigma_u^2)$$

, where G(t)>0 stands for the function of time (t), then $u_{it} \geq 0, u_i \geq 0$. Thus, the inefficiency u_{it} changes over time and across individual. There are two components from the above equation u_{it}: one is non-stochastic time component G(t), the other is a stochastic component u_i. And there are different assumptions on G(t), non-stochastic time component, the assumption made by Kumbhakar (1990) is considered, as it has two parameters in the G(t) function and it is more flexible than Battese and Coelli (1992) and Kumbhakar and Wang's (2005) model. Kumbhakar's (1990) assumption is made as

$$G(t) = [1 + \exp(\gamma_1 t + \gamma_2 t^2)]^{-1}$$

where $\gamma_1$and γ_2 are coefficients of time dummy. If $\gamma_1 = \gamma_2 = 0$, this model is reduced to the time-invariant random effect model (Model 2).

Again, the likelihood function can be obtained from Kumbhakar and Lovell's (2000) approach and the equation should be the same as in Model 2, but with different mean (μ_{i*}) and variance (σ_*^2) equations:

$$\mu_{i*} = \frac{\mu\sigma_v^2 - \sigma_u^2 \sum_t G(t)\varepsilon_{it}}{\sigma_v^2 + \sigma_u^2 \sum_t G(t)^2} \quad \text{and} \quad \sigma_*^2 = \frac{\sigma_v^2 \sigma_u^2}{\sigma_v^2 + \sigma_u^2 \sum_t G(t)^2}$$

Once the parameter estimates are obtained, inefficiency of each firm can be obtained from Jondrow *et al.'s* (1982) approach and efficiency obtained from Battese and Coelli's (1988) approach as shown in model 2.

Model 4: Persistent Inefficiency model (Kumbhakar and Heshmati, 1995)

Mundlak (1961) states that identifying the level of persistent inefficiency is important, because it reflects the effects of input like operational style, which is unlikely to be changed over short term. Thus, Kumbhakar and Heshmati's (1995) model districts between the persistent and residual component of inefficiency, the former varies across firm but not over time, while the latter is time-varied. Their model is shown bellowed:

$$y_{it} = f(\mathbf{x}_{it}; \boldsymbol{\beta}) + \varepsilon_{it}$$
$$\varepsilon_{it} = v_{it} - u'_{it}$$
$$u'_{it} = u_{it} + \tau_i$$

where ε_{it} is composited error term, v_{it} is statistical noise, u'_{it} is the overall inefficiency, and τ_i represents the persistent inefficiency (varied by firms, but unlikely to change over time) and u_{it} is the time varying inefficiency. Both fixed-effect and random-effect model can be estimated, and the estimation process and further detail can be found in Kumbhakar and Heshmati (1995).

Model 5: Model with separate Firm Effects, Persistent Inefficiency and Time-Varying Inefficiency (Kumbhakar, Lien and Hardaker, 2014)

This final model summaries some of the features or overcome some of the limitations of the previous models, is developed by Kumbhakar, Lien and Hardaker (2014). The model is specified as:

$$\mathrm{y}_{it} = \mathrm{f}(\mathbf{x}_{it}; \boldsymbol{\beta}) + \mu_i + v_{it} - \mathrm{u}_{it} - \tau_i$$

where μ_i is the heterogeneity effect which vary across firms only, v_{it} is the random shock (or statistical noise), u_{it} is time-varying inefficiency and τ_i represents the persistent inefficiency.

Colombi, Martini and Vittadini (2011) pointed out that ML method based on distributional assumptions on these components can be used to estimate this model. Multistep procedure is applied as followed:

1. Rewrite the above equation as

   $$y_{it} = \alpha_0^* + f(x_{it}; \beta) + \alpha_i + \varepsilon_{it}$$

   where $\alpha_0^* = \alpha_0 - E(\tau_i) - E(u_{it})$; $\alpha_i = \mu_i - \tau_i + E(\tau_i)$;
   and $\varepsilon_{it} = v_{it} - u_{it} + E(u_{it})$.
   Both α_i and ε_{it} have zero mean and constant variance.
2. Estimated β by using standard random effect panel regression; and the predicted value of both α_i and ε_{it} would be given.
3. By using $\varepsilon_{it} = v_{it} - u_{it} + E(u_{it})$, the time varying inefficiency u_{it}, can be estimated as predicted ε_{it} is obtained from step 2.
4. Here, $E(u_{it}) = (\sigma_u\sqrt{2/\pi})$; and both approaches from Jondrow *et al.* (1982) and Battese and Coelli (1988) can be used to find inefficiency and efficiency score, respectively.
5. τ_i can be estimated by a similar method as in step 3 and 4, but with $\alpha_i = \mu_i - \tau_i + E(\tau_i)$ and $E(\tau_i) = (\sigma_u\sqrt{2/\pi})$.
6. The overall efficiency score is obtained from the product of time-varying efficiency and persistent efficiency.

Approaches used to select output vectors in financial services industry:

Three principal approaches used to measure outputs in financial services: the user-cost approach (Hancock, 1985), the intermediation approach (Brockett *et al.*, 1998), and the value-added approach (Berger and Humphrey, 1992), to be specific:

- **The user-cost method:** Hancock (1985) refers to when the product is considered to be a financial output, if the financial returns (costs) on an asset (a liability) is more (less) than the opportunity cost of funds; otherwise, it is treated as a financial input. This measurement is based on determining the output's (or input's) net contribution to the revenues of the financial firm. However, Cummins and Weiss (2011) mention that this approach is especially problematical for insurance industry because it is difficult to estimate the precise data on product revenues and opportunity costs for insurers, as the data are not available in the insurance industry (insurance policies are priced implicitly.). From Eling and Luhnen's (2008) survey study, they conclude that none of the recent studies uses this approach due to the mentioned difficultlies.

- **The intermediation approach** views that the insurance company could be regarded as a financial intermediary where insurers are borrowing funds (premium) from policyholders, investing the funds in capital markets to generate returns, and then using this income to pay out claims, benefits, taxes and other costs (Brockett *et al.*, 1998). Thus, in this approach, inputs are borrowed funds and outputs are assets. Eling and Luhnen (2008) also mention that only a few studies employ this approach and taking return on investment (ROI), liquid assets to liability, and solvency scores and some investment-related measurements as outputs, see, Brockett *et al.*(2004b, 2005), Lin, Wen and Yang (2011) and Yaisawarng, Asavadachanukorn and Yaisawarng (2014). However, Cummins and Weiss (2011) point out this approach would not be optimal for insurance industry as insurers provided many services in addition to financial intermediation. Ignoring the distinction among insurers' businesses will prove a less accurate result.

- **The value-added approach** was first introduced by Berger and Humphrey (1992). Later, Cummins and Weiss (2011) suggest this approach as being the most appropriate method for studying insurance efficiency. This approach considers all assets and liabilities categories of having some output characteristics, and it counts outputs as important variables if those outputs contribute a significant added value based on operating cost allocation (Berger *et al.*, 2000); otherwise, the others are treated as unimportant outputs, intermediate products, or inputs, depending on their other characteristics. Eling and Luhnen (2010) summarised that 80 of the 95 studies apply this method, e.g. Berger and Humphrey (1992), Yuengert (1993), Cummins and Turchetti (1996), Cummins and Zi (1998), Cummins, Tennyson and Weiss (1999), Cummins, Weiss and Zi (1999), Ward (2002), Cummins *et al.* (2010) and Cummins and Xie (2013).

Details of the Insurer's Principal Services

The insurers usually provide three principal services, which can be used to define the measurable proxies of insurers' outputs:

- **Risk-pooling and risk-bearing:**
  Insurers collect premiums from the pool of policyholders and redistribute most of the funds to those policyholders who suffer losses. Zanghieri (2009) indicates that risk pooling and risk bearing function could be seen as the insurer providing a mechanism for policyholders, who are exposed to insurable accidents or contingencies, and to engage in risk reduction through pooling them together. Cummins and Weiss (2011) also state that insurers create added value by supplying underwriting, acturical and other operating expenses incurred in the risk pool, and by holding further equity capital to cushion unexpected loses.

- **Financial intermediation:**
  Insurers invest the collected premiums in capital markets or traded securities that are not available to most of the individual policyholders, and return the capital

plus interest payment at a pre-specified date or when the claims are due (Cummins and Weiss, 2011).

- **'Real' financial services relating to insured losses:**
  According to Zanghieri (2009), insurers provide some services related to loss precention, financial advice, pension and benefit schemes to policyholders. This service is closely related to the risk-pooling and risk-bearing activities, which also exploit insurers' expertise in risk management and finance.

Test for the existence of efficiency convergences

The existence of efficiency convergences is tested by applying the concept of both σ-convergence and β-convergence.[1]

Estimating Efficiency Convergence

The tendency for insurers to achieve an identical level of efficiency over time is defined as efficiency convergence. In line with Alhassan and Biekpe (2015), the growth theory of convergence suggested by Barro and Sala-i-Martin (1990, 1991) and Sala-i-Martin (1996) is adopted to exam the rate of efficiency convergence. The β-convergence and σ-convergence are the most widely used concepts in the classical literature; β-convergence refers to the ability of inefficient firms to become efficient or improve their efficiency for those efficient one, and σ-convergence refers to the reduction in the dispersion of efficiency over time. According to Sala-i-Martin (1996), both β- and σ-convergence are related, and evidence of β-convergence is a necessary condition for σ-convergence. Therefore, β-convergence need to be confirmed first, and estimated by employing Casu and Girardone (2009) and Alhassan and Biekpe's (2015) dynamic regression model:

$$\Delta y_{i,t} = \alpha + \delta\Delta y_{i,t-1} + \beta \ln y_{i,t-1} + \varepsilon_{i,t} \ ,$$

Equation (1.7)

where $y_{i,t}$ is the efficiency score for insurer *i* at time *t*; $y_{i,t-1}$ is the efficiency score for insurer *i* at time *t*-1; $\Delta y_{i,t} = \ln y_{i,t} - \ln y_{i,t-1}$; α is the constant term and $\varepsilon_{i,t}$ is the time-varying error term; δ is the coefficient of the lagged depend variable; β is the coefficient of interest that represents the rate of efficiency convergence. The β-convergence is occurred if the value of β is negative, it indicates the catch-up existed; and the higher absolute value of β means a faster speed of convergence. After confirming β-convergence, the model for σ-convergence is as followed:

[1] The concept is first developed and used by Barro and Sala-i-Martin (1990, 1991). This concept has been applied by many banking studies (see example, (Weill, 2009; Casu and Girardone, 2010; Zhang and Matthews, 2012)), and a few insurance studies, such as (Alhassan and Biekpe, 2015).

$$\Delta E_{i,t} = \alpha + \varphi \Delta E_{i,t-1} + \sigma \ln E_{i,t-1} + \varepsilon_{i,t}$$

Equation (1.8)

where $\Delta E_{i,t} = E_{i,t} - E_{i,t-1}$, in which $E_{i,t} = \ln y_{i,t} - \ln \bar{y}_t$ and $E_{i,t-1} = \ln y_{i,t-1} - \ln \bar{y}_{t-1}$. Similarly, $\Delta E_{i,t-1} = E_{i,t-1} - E_{i,t-2}$. $y_{i,t-1}$ is the efficiency score for insurer *i* at time *t*-1; $\bar{y}_t$ and $\bar{y}_{t-1}$ are the average efficiency scores for the market at time *t* and *t*-1, respectively. α and $\varepsilon_{i,t}$ remains as defined before; and the coefficient of dynamic variables $\Delta E_{i,t-1}$ is φ. σ is the parameter that the rate of convergence from $y_{i,t}$ to $\bar{y}_t$. Both Equations (1.7) and (1.8) are estimated using the system generalised method of moments (Arellano and Bover, 1995; Blundell and Bond, 1998) with forward orthogonal and Windmeijer finite-sample correction (Windmeijer, 2005).

Result of Efficiency Convergence

To test the existence of β-convergence and σ-convergence, Equations (1.7) and (1.8) are estimated by the dynamic GMM technique. Table 1.8 presents the estimation results. Columns (1) and (2) show whether the convergences exist in cost behaviours, while Columns (3) and (4) focus on profit behaviours. As discussed, β-convergence is a necessary condition for σ-convergence. Furthermore, the results shown in Table 1.8 confirm the existence of β-convergence and σ-convergence in both cost and profit behaviours. Comparing Columns (1) and (3) shows that the speed of convergence in cost performance is faster than the catch-up in profit performance since the absolute value of β is more significant in the cost function. These results indicate that a cost-inefficient insurer spends less time on becoming a cost-efficient firm compared with a profit-inefficient insurer. Then, the results presented in Columns (2) and (4) suggest that insurers are more comfortable with converging their profit performance to the industry level because the value of σ in the profit function is larger than in the cost function.

Tables 1.8 Test for β-convergence and σ- convergence

VARIABLES	(1) β-converg. (Cost) Δy_{it}	(2) σ-converg. (Cost) $\Delta E_{i,t}$	(3) β-converg. (Profit) Δy_{it}	(4) σ-converg. (Profit) $\Delta E_{i,t}$
$\Delta y_{i,t-1}$	0.4546*** (3.179)		0.1432** (2.261)	
$lny_{i,t-1}$	-0.6174** (-2.369)		-0.2889** (-2.265)	
$\Delta E_{i,t-1}$		0.3534** (2.218)		-0.4593*** (-4.271)
$lnE_{i,t-1}$		0.0314** (2.306)		0.2858*** (4.284)

Constant	-0.3421**	0.1172***	-0.3576**	0.5178***
	(-2.455)	(2.700)	(-2.044)	(4.780)
Observations	965	316	961	622
Number of Firms	252	140	254	178
Number of Instruments	66	45	119	82
Robust	Yes	Yes	Yes	Yes
F-test	5.187***	5.703***	2.804*	14.24***
AR(1)	-2.312**	-0.628	-2.948***	-2.471**
AR(2)	0.978	0.269	-1.042	0.161
Hansen (p-value)	63.14 (0.472)	48.95 (0.214)	135.4 (0.105)	82.29 (0.378)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A1.1 Cost Efficiency from Different Models for All Insurers

Year	SS84 FE	KUM87	KUM90	KH95	KLH14
1996	0.0414	0.6206	0.6846	0.0332	0.6193
1997	0.0412	0.6240	0.6622	0.0330	0.6204
1998	0.0426	0.6127	0.6303	0.0345	0.6243
1999	0.0419	0.6231	0.6258	0.0341	0.6295
2000	0.0449	0.6047	0.5915	0.0360	0.6120
2001	0.0506	0.5623	0.5372	0.0410	0.6022
2002	0.0487	0.5669	0.5336	0.0387	0.5986
2003	0.0496	0.5695	0.5317	0.0392	0.6018
2004	0.0486	0.5716	0.5243	0.0382	0.5955
2005	0.0529	0.5667	0.5194	0.0424	0.5997
2006	0.0556	0.5544	0.5044	0.0442	0.5937
2007	0.0552	0.5435	0.4937	0.0440	0.5913
2008	0.0524	0.5828	0.5429	0.0403	0.6119
2009	0.0537	0.5640	0.5274	0.0410	0.6024
2010	0.0519	0.5522	0.5223	0.0413	0.5990
2011	0.0557	0.5602	0.5401	0.0442	0.5927
2012	0.0521	0.5541	0.5432	0.0408	0.5876
2013	0.0521	0.5482	0.5517	0.0403	0.5810
2014	0.0507	0.5632	0.5855	0.0414	0.6107
2015	0.0514	0.5623	0.6089	0.0418	0.6102
2016	0.0524	0.5484	0.6273	0.0420	0.5917
2017	0.0600	0.5353	0.6545	0.0482	0.5711
Average	**0.0500**	**0.5669**	**0.5597**	**0.0407**	**0.6001**

Table A1.2 Profit Efficiency from Different Models for All Insurers

Year	SS84 FE	KUM87	KUM90	KH95	KLH14
1996	0.0153	0.4309		0.0087	0.2469
1997	0.0142	0.4210		0.0090	0.2654
1998	0.0138	0.4140		0.0086	0.2611
1999	0.0122	0.3739		0.0069	0.2147
2000	0.0120	0.3493		0.0071	0.2172
2001	0.0127	0.3638		0.0068	0.2198
2002	0.0131	0.3885		0.0075	0.2308
2003	0.0137	0.4020		0.0079	0.2419
2004	0.0180	0.4937		0.0108	0.3054
2005	0.0172	0.4705		0.0106	0.3051
2006	0.0179	0.4911		0.0110	0.3165
2007	0.0194	0.4980		0.0122	0.3274
2008	0.0205	0.4733		0.0124	0.3027
2009	0.0177	0.4726		0.0108	0.3081
2010	0.0217	0.4829		0.0132	0.3066
2011	0.0183	0.4563		0.0100	0.2715
2012	0.0187	0.4731		0.0116	0.3059
2013	0.0192	0.4769		0.0115	0.3006
2014	0.0227	0.4731		0.0134	0.2913
2015	0.0234	0.4817		0.0127	0.2708
2016	0.0231	0.4857		0.0144	0.3124
2017	0.0243	0.4768		0.0154	0.3166
Average	**0.0175**	**0.4631**		**0.0112**	**0.2908**

Figure A1.1: Cost Efficiency from Different Models

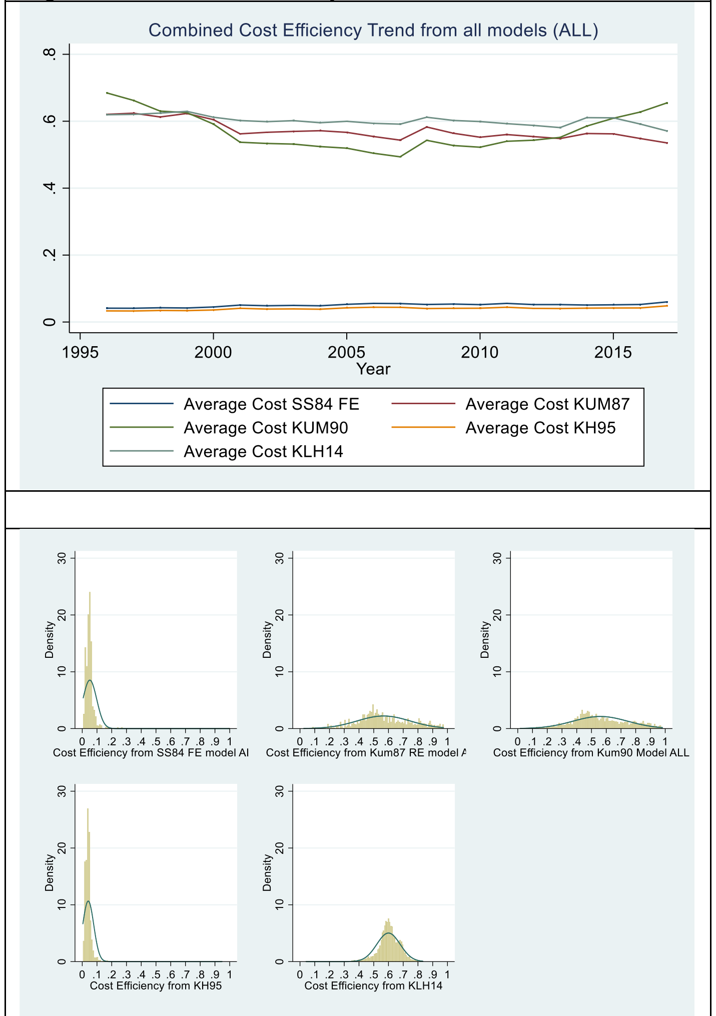


Figure A1.2: Profit Efficiency from Different Models

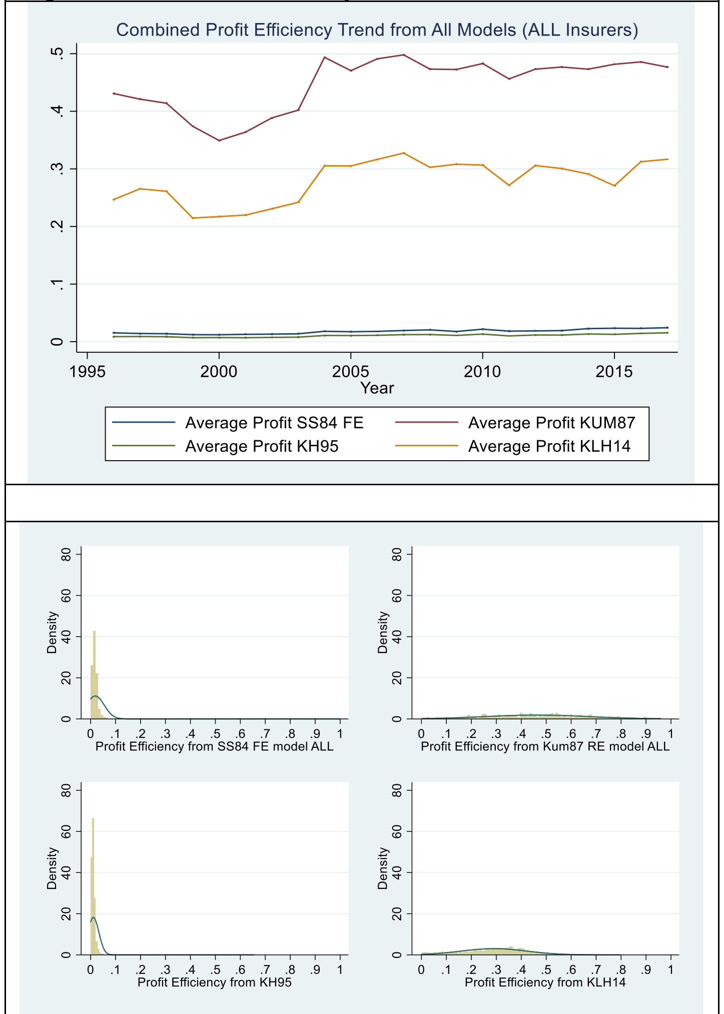
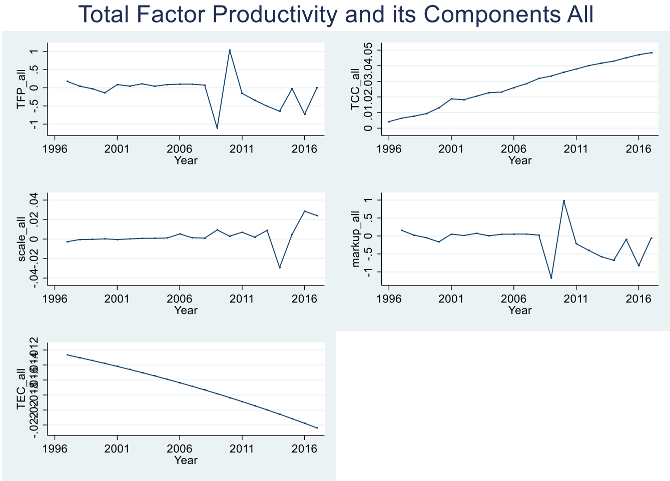


Figure A1.3: Total Productivity and its Components



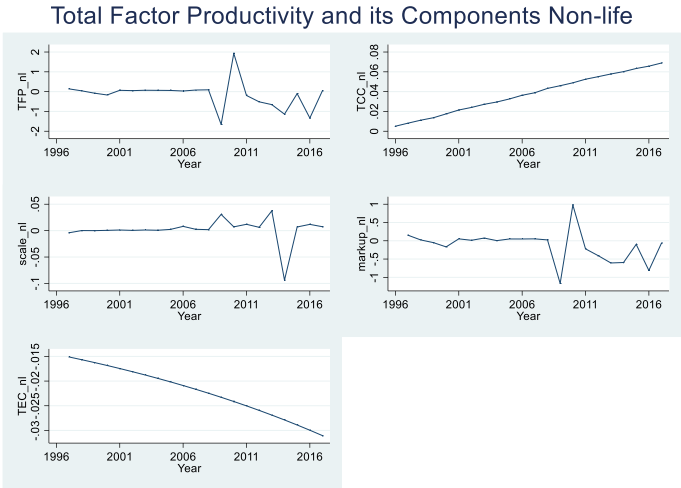
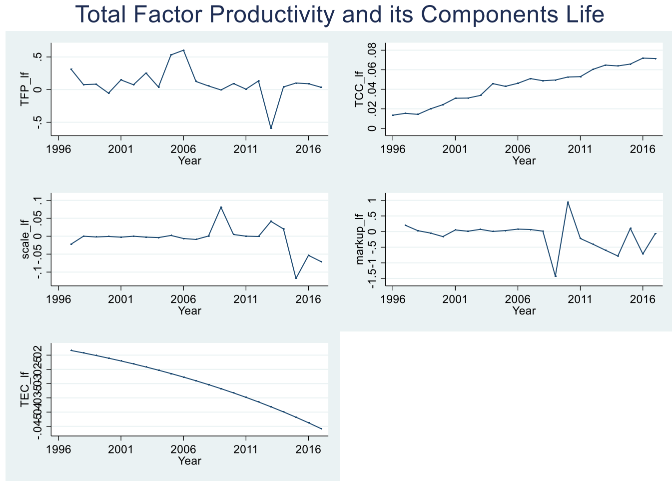


Figure A1.3: Total Productivity and its Components (continued)



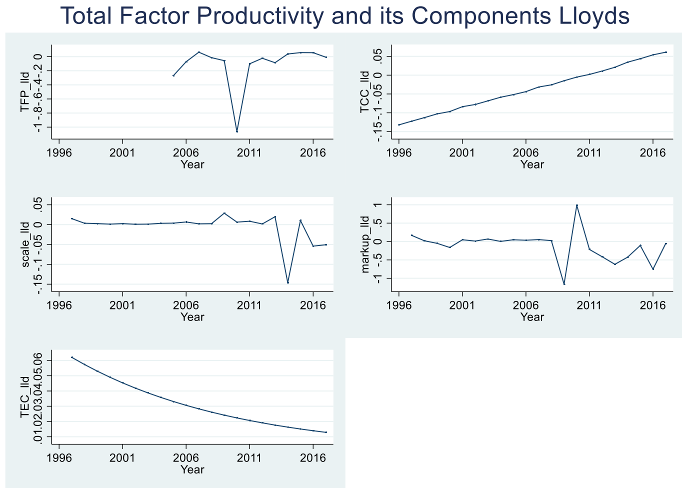
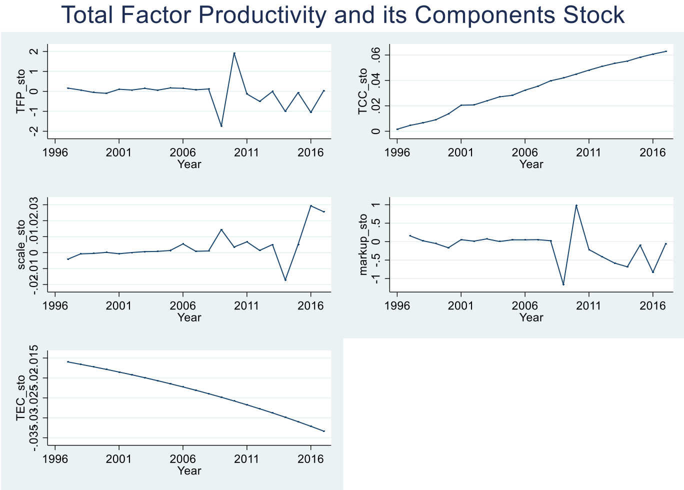
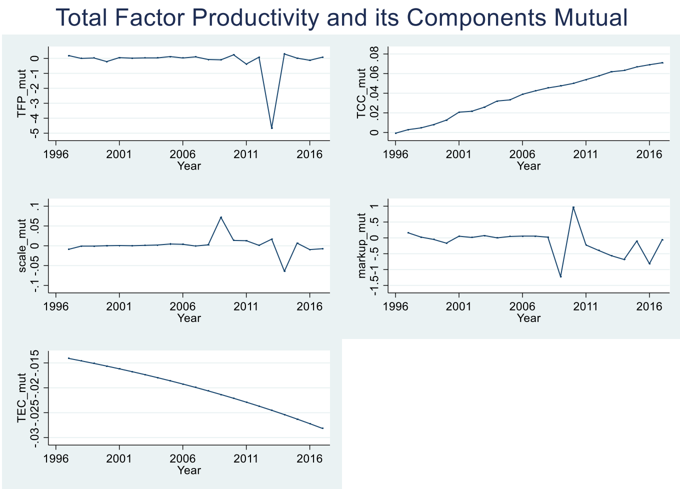


Figure A1.3: Total Productivity and its Components (continued)





Appendix 2

Dynamic Panel Threshold Model

The dynamic panel threshold model is used to provide a robustness check of the individual effectiveness arising from different strategies and risk management activities. The results from the threshold analysis further suggest that taking risks and protections below or beyond a certain level leads to inefficient operations.

As a further step to test the hypotheses 1-6, by following Mamatzakis and Bermpei's (2014) banking study, the panel GMM-threshold model that is originated from Kremer, Bick and Nautz (2013) is introduced to have robustness check. This approach further allows for the regime changes of the individual vital variables, which affect the insurer's cost and profit performances. The adopted threshold model takes the following form:

$$eff_{i,t} = \theta_i + \lambda_1 I(q_{i,t} \leq \gamma) m_{i,t} + \delta_1 I(q_{i,t} \leq \gamma) + \lambda_2 I(q_{i,t} \geq \gamma) m_{i,t} + \varepsilon_{i,t} \tag{A2.1}$$

where $eff_{i,t}$ stands for both cost and profit efficienies, while θ_i is the firm-specific fixed effect and $\varepsilon_{i,t}$ is the error term. I is the indication function that specified the regimes, in which $q_{i,t}$ is the interested threshold variables, they are the level of underwrting risk, invetsment risk, capital holdings and reinsurance purchased; and γ indicates the threshold value which classified the obeservations into two categories: high and low regimes, in which the observations is above a threshold value and below the threshold, respectivly. λ_1 and λ_2 represents the regression coefficients of the threshold variable in different regimes that are estimated with the usage of the GMM estimator (Arellano and Bover, 1995). By extending Hansen's (1999) threshold model, the term of regime dependent intercept, δ_1, is included in Kremer, Bick and Nautz's (2013) model in order to mitigate the inconsistent estimating for the value of threshold and and its coefficients magnitudes of two regimes (Bick, 2010). $m_{i,t}$ is a vector of explanatory variables that include firm-specific and business environment factors, in which a subset of variables can be treated as exogenous variables that are uncorrelated to error term, and another subset of endogenous variables, which is correlated to error term. The advantage of using this GMM-threshold model is to consider endogeneity issues to avoid serial correlation in the transfomed errors (Arellano and Bover, 1995). To be more specific, the orthogonal deviations transformation for the error term is adopted, in which the average of all future observations of a variable is subtracts.

The estimation follows steps as; first, following Caner and Hansen (2004), a reduced form regression for endogenous variables as a function of instruments is estimated. The predicted values are then replacing the endogenous variables in Equation (A2.1); in the second step, Equation (A2.1) is estimated via ordinary least squares for a fixed threshold value γ when the predicted values are used. Finanlly, the estimator of the threshold value is selected by the minimizayion of the concerntrated sum of squared errors, i.e., $\hat{\gamma} = argimS_n(\gamma)$[1]. Once the $\hat{\gamma}$ is found, the regression coefficients, λ_1 and λ_2 for two regimes, can be estimated by GMM estimator (Caner and Hansen, 2004).

[1] Following (Hansen, 1999; Caner and Hansen, 2004), in order to determining the 95% confidence interval of the threshold value, the critical value is given by $\Gamma = \{\gamma : LR(\gamma) \leq C(\alpha)\}$, where $C(\alpha)$ is the asymptotic distribution of the likelihood ratio statistic $LR(\gamma)$ at 95% level. And this LR is adjusted to control for the number of time period used for each cross section (Hansen, 1999).

Threshold Estimations for Individual Factors

As mentioned above, the dynamic panel threshold model is applied to make a robustness check of the individual vital factors—the risk-taking factors and risk management factors. The results of the threshold estimation for each of the six key factors are presented in Tables A2.1 to A2.7. The lowercase letters *a* and *b* in the headings of each table represent the cost model and profit model, respectively. To maintain an adequate number of observations, these models do not control for business type or organisational form.

Product Risk Threshold Variable

In Table A2.1a, the threshold value for product risk is found to be 34.9%. This indicates that an insurer, with risky business accounting for more than 35% of its total business, would damage its cost structure. Further, more than 2/3 of the observations are located in the higher regime—insurers with risky business accounting for more than 35% of their total business amount, facing a significant negative impact of -0.05. Insurers located in the lower regime receive a much less significant adverse impact of -0.009. Indeed, these negative impacts align with the previous findings. Surprisingly, no significant impact arising from greater product risk is found in the profit function (Table A2.1b).

Business Diversificant as Threshold Variable

In line with the previous finding indicating that business diversification should enhance insurers' cost efficiency, the results shown in Table A2.2a confirm this positive impact. Although insurers enjoy the benefits of business diversification on cost performance, it will have less of an effect on cost structure if the insurer issues more than five lines of business. Regarding the profit model (Table A2.2b), the positive impact on profit performance remains as expected in both regimes, but the significant result is only found in the higher regime, in which insurers usually write more than four lines of business.

Area Diversificant as Threshold Variable

The evidence of two regimes is found in both the cost model (Table A2.3a) and the profit model (Model A2.3b). From the cost model, the different magnitudes of the significant, negative impact are found in both regimes. This implies that having businesses in more than one geographic market hurts the insurers' cost performance, while the magnitude of the negative effect is reduced when the number of geographic markets increases. From the profit table, two significant, opposite effects are observed in the different regimes. The insurer will enjoy the benefit of geographic diversification when it has businesses in more than three geographic markets; otherwise, geographic diversification may be too costly and followed by decreasing profit. Also, more than half of the observations enjoy the benefit of geographic diversification on improving profit performance.

Pricing Risk as Threshold Variable

An existing threshold splits the sample into two regimes, in both the cost model (Table A2.4a) and the profit model (Table A2.4b). The expected, positive impact of pricing risk on cost performance is found in both regimes. On the other hand, two opposite impacts are revealed in the regimes of the profit model—the positive associated with insurers facing a lower level of pricing risk and the negative confirmed for insurers taking greater pricing risk (as shown in the higher regime). However, there are two cautions: (i) the desired impact is only significant when insurers take a higher level of pricing risk (high regime) in both models; and (ii) the desired impact in the higher regime is also much stronger than the observed impact in the lower regime. Fortunately, more than 50% of the observations are located in the higher regime.

Investment Risk as Threshold Variable

An investment risk threshold value of 0.0038 splits the sample into (i) insurers who take low investment risks and face a much stronger adverse effect on cost performance and (ii) insurers who take high investment risks and bear a smaller negative impact on cost performance. Also, from the observation allocation numbers (Table A2.5a), two-thirds of the observations are located in the regime with a higher level of investment risk indicating that insurers enjoy the weakened damage effect resulting from taking additional risk.

The results of the profit model (Table A2.5b) indicate that insurers accepting a certain amount of investment risk, with a ceiling of 0.0018, enjoy a much stronger, significant benefit on improving profit efficiency. It is worth noting that only 13% of the observations are located in the low regime.

Capital as Threshold Variable

Regarding the capital level, the results from the threshold model indicate that an insurer holding a limited amount of capital can significantly enhance its cost efficiency, while a reverse effect can be seen if the amount of capital is beyond a certain amount (Table A2.6a). Even though the negative effect on cost efficiency is insignificant, it is still necessary to be cautious because the adverse magnitude is much larger than the benefit of holding capital. From the profit table (Table A2.6b), a consistently positive result is confirmed in both regimes, while it is only significant in the higher regime. It may be said, then, that holding capital can effectively improve an insurer's profit efficiency because almost all observations are located in the significant, higher regime.

Reinsurance as Threshold Variable

Tables A2.7a and A2.7b present the results of the threshold analysis for the cost model and the profit model, respectively. The positive coefficient (the benefit) shown in the cost table and the negative coefficient (the adverse impact) presented in the profit model confirm the findings from previous sections. To be specific, the result from the cost table indicates that an insurer using more reinsurance can significantly improve its cost efficiency because the magnitude of the significant beneficial effect is more abundant in the higher regime than the insignificant effect in the lower regime. Although the impact of using reinsurance is negative on profit performance, this adverse impact is smaller when using more reinsurance (higher regime) than using less reinsurance (lower regime). However, the result is only significant in the lower regime, and the two-thirds of observations are located in this group.

Table A2.1a: Product Risk on Cost Efficiency		
Product Risk as Threshold Variable		
Threshold Estimate		
Product Risk	3.5525 (34.9)	
95% Confidence Interval	3.3569 (28.7)	3.5946 (36.4)
	Estimates	**SE**
Impact of Product Risk		
Product Risk Less	-0.0091**	0.004245
Product Risk Greater	-0.051382***	0.019025
Impact of Covariance		
Business Diversification	-0.002023	0.005439
Area Diversification	-0.006732***	0.002286
Pricing Risk	0.008268***	0.002397
Investment Risk	-0.549201**	0.248754
Firm Size	-0.248034*	0.146341
Square of Firm Size	0.015028*	0.009143
Liquidity	0.009617***	0.003003
Market Share	-0.341762	2.312255
Stock Market Return	-0.000115	0.000135
GDP per Capita	-0.00001***	0.000003
Unemployment Rate	-0.003714**	0.001591
Inflation Rate	0.000326	0.002111
δ	-0.169467**	0.071606
Observation	634	
Low Regime	229	
High Regime	405	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.1b: Product Risk on Profit Efficiency		
Product Risk as Threshold Variable		
Threshold Estimate		
Product Risk	2.8391 (17.1)	
95% Confidence Interval	1.9315 (6.9)	4.1912 (66.1)
	Estimates	**SE**
Impact of Product Risk		
Product Risk Less	0.001674	0.005447
Product Risk Greater	0.012172	0.010397
Impact of Covariance		
Business Diversification	0.013633**	0.006403
Area Diversification	0.003473	0.005054
Pricing Risk	-0.000366	0.00203
Investment Risk	-0.087751	0.293754
Firm Size	0.104671**	0.050977
Square of Firm Size	-0.00634**	0.003112
Liquidity	-0.033612**	0.015498
Underwriting Income	0.023806***	0.003263
Stock Market Return	0.00105***	0.000264
GDP per Capita Growth	-0.007459***	0.001823
Unemployment Rate	-0.009657***	0.002918
Inflation Rate	-0.008045**	0.004028
Concentration	0.521934**	0.170265
δ	0.056564	0.038617
Observation	860	
Low Regime	110	
High Regime	750	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.2a: Business Diversification on Cost Efficiency		
Business Diversification as Threshold Variable		
Threshold Estimate		
Business Diversification	1.0334 (5)	
95% Confidence Interval	-0.0233 (3)	1.0429 (6)
	Estimates	**SE**
Impact of Business Diversification		
Business Diversification Less	0.023086***	0.00768
Business Diversification Greater	0.014316*	0.00827
Impact of Covariance		
Product Risk	-0.011833***	0.00328
Area Diversification	-0.004672**	0.002114
Pricing Risk	0.007024***	0.002231
Investment Risk	-0.23693	0.220061
Firm Size	-0.027086	0.037103
Square of Firm Size	0.001421	0.002078
Liquidity	0.009307***	0.002858
Market Share	-3.625668***	1.230576
Stock Market Return	-0.00023**	0.000103
GDP per Capita	-0.000009***	0.000003
Unemployment Rate	-0.003775**	0.001627
Inflation Rate	-0.001055	0.001725
δ	0.02275*	0.01364
Observation	**634**	
Low Regime	**447**	
High Regime	**187**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.2b: Business Diversification on Profit Efficiency		
Business Diversification as Threshold Variable		
Threshold Estimate		
Diversified Business	0.4679 (4)	
95% Confidence Interval	0.0020 (3)	1.3085 (6)
	Estimates	**SE**
Impact of Business Diversification		
Business Diversification Less	0.056456	0.03824
Business Diversification Greater	0.0156*	0.009078
Impact of Covariance		
Product Risk	0.062142**	0.024748
Area Diversification	0.001141	0.005186
Pricing Risk	-0.004428	0.002786
Investment Risk	0.03222	0.484041
Firm Size	0.15625**	0.069507
Square of Firm Size	-0.009205**	0.004059
Liquidity	-0.001781	0.004997
Underwriting Income	0.027067***	0.00374
Stock Market Return	0.000893***	0.00029
GDP per Capita Growth	-0.006577***	0.001982
Unemployment Rate	-0.007775**	0.00304
Inflation Rate	-0.008431*	0.004702
Concentration	0.579531***	0.196318
δ	0.003852	0.017119
Observation	**860**	
Low Regime	**346**	
High Regime	**514**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.3a: Area Diversification on Cost Efficiency

Area Diversification as Threshold Variables		
Threshold Estimate		
Area Diversification	-0.6385 (1)	
95% Confidence Interval	-0.6515 (1)	0.4541 (3)
	Estimates	**SE**
Impact of Area Diversification		
Area Diversification Less	-0.154809***	0.034273
Area Diversification Greater	-0.009229***	0.002574
Impact of Covariance		
Product Risk	-0.011606***	0.00367
Business Diversification	0.006494*	0.003939
Pricing Risk	0.007007***	0.001998
Investment Risk	-0.434577**	0.208553
Firm Size	-0.033535	0.032975
Square of Firm Size	0.001636	0.001795
Liquidity	0.008962***	0.002668
Market Share	-4.465176**	1.795616
Stock Market Return	-0.000303***	0.000094
GDP per Capita	-0.000015***	0.000003
Unemployment Rate	-0.004096***	0.001502
Inflation Rate	0.00062	0.001883
δ	-0.130992***	0.027808
Observation	**634**	
Low Regime	**239**	
High Regime	**395**	

*** p<0.01, ** p<0.05, * p<0.1

Table A2.3b: Area Diversification on Profit Efficiency

Area Diversification as Threshold Variables		
Threshold Estimate		
Area Diversification	0.1652 (3)	
95% Confidence Interval	-0.7646 (1)	0.8316 (4)
	Estimates	**SE**
Impact of Area Diversification		
Area Diversification Less	-0.055281***	0.015756
Area Diversification Greater	0.011635*	0.006821
Impact of Covariance		
Product Risk	-0.003385	0.003826
Business Diversification	0.013226**	0.006413
Pricing Risk	0.000213	0.002055
Investment Risk	-0.186651	0.294571
Firm Size	0.100487**	0.048579
Square of Firm Size	-0.006073**	0.002996
Liquidity	-0.037153**	0.016732
Underwriting Income	0.02414***	0.003302
Stock Market Return	0.000933***	0.000267
GDP per Capita Growth	-0.006501***	0.001838
Unemployment Rate	-0.007227**	0.002963
Inflation Rate	-0.007366*	0.004027
Concentration	0.520684***	0.172896
δ	-0.010871	0.010458
Observation	**860**	
Low Regime	**379**	
High Regime	**481**	

*** p<0.01, ** p<0.05, * p<0.1

Table A2.4a: Pricing Risk on Cost Efficiency		
Pricing Risk as Threshold Variables		
Threshold Estimate		
Pricing Risk	-2.5060 (0.0816)	
95% Confidence Interval	-2.9922 (0.0505)	-1.5532(0.2116)
	Estimates	**SE**
Impact of Pricing Risk		
Pricing Risk Less	0.00005	0.00393
Pricing Risk Greater	0.015217***	0.004042
Impact of Covariance		
Product Risk	-0.011744***	0.004372
Business Diversification	0.002627	0.005157
Area Diversification	-0.005782**	0.002371
Investment Risk	-0.594494**	0.239491
Firm Size	-0.280821**	0.139846
Square of Firm Size	0.017236**	0.008772
Liquidity	0.010452***	0.003051
Market Share	-0.965763	2.270777
Stock Market Return	-0.000117	0.000137
GDP per Capita	-0.00001***	0.000003
Unemployment Rate	-0.004272***	0.001635
Inflation Rate	0.000722	0.002095
δ	-0.02962**	0.01307
Observation	**634**	
Low Regime	**246**	
High Regime	**388**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.4b: Pricing Risk on Profit Efficiency		
Pricing Risk as Threshold Variables		
Threshold Estimate		
Pricing Risk	-2.1735 (0.1138)	
95% Confidence Interval	-3.8114 (0.0221)	-1.4312 (0.2390)
	Estimates	**SE**
Impact of Pricing Risk		
Pricing Risk Less	0.002839	0.004357
Pricing Risk Greater	-0.006285**	0.002789
Impact of Covariance		
Product Risk	-0.00486	0.004063
Business Diversification	0.044186**	0.018842
Area Diversification	-0.002198	0.004968
Investment Risk	-0.081904	0.29817
Firm Size	0.090228	0.055418
Square of Firm Size	-0.005751**	0.003284
Liquidity	-0.002775	0.004599
Underwriting Income	0.02501***	0.003209
Stock Market Return	0.001041***	0.000256
GDP per Capita Growth	-0.007055***	0.001654
Unemployment Rate	-0.007311***	0.002602
Inflation Rate	-0.003782	0.004578
Concentration	0.385433**	0.190163
δ	0.006838	0.013685
Observation	**860**	
Low Regime	**386**	
High Regime	**474**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.5a: Investment Risk on Cost Efficiency

Investment Risk as Threshold Variables		
Threshold Estimate		
Investment Risk	0.0038	
95% Confidence Interval	0.0011	0.0091
	Estimates	**SE**
Impact of Investment Risk		
Investment Risk Less	-2.992999*	1.779581
Investment Risk Greater	-0.63781***	0.232237
Impact of Covariance		
Product Risk	-0.011115***	0.003567
Business Diversification	0.004684	0.004441
Area Diversification	-0.00733***	0.002383
Pricing Risk	0.005035	0.00346
Firm Size	-0.031918	0.035644
Square of Firm Size	0.001478	0.002002
Liquidity	0.009014***	0.002782
Market Share	-3.190873***	1.221209
Stock Market Return	-0.000309***	0.000111
GDP per Capita	-0.000007***	0.000003
Unemployment Rate	-0.002125	0.001525
Inflation Rate	-0.000957	0.001845
δ	-0.004337	0.005301
Observation	**634**	
Low Regime	**217**	
High Regime	**417**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.5b: Investment Risk on Profit Efficiency

Investment Risk as Threshold Variables		
Threshold Estimate		
Investment Risk	0.0018	
95% Confidence Interval	0.0010	0.0087
	Estimates	**SE**
Impact of Investment Risk		
Investment Risk Less	26.293563**	10.272085
Investment Risk Greater	0.071299	0.292259
Impact of Covariance		
Product Risk	-0.000903	0.004778
Business Diversification	0.012183*	0.006474
Area Diversification	0.004145	0.004945
Pricing Risk	-0.000936	0.002096
Firm Size	0.042432	0.055267
Square of Firm Size	-0.003485	0.003193
Liquidity	0.001861	0.004614
Underwriting Income	0.047945***	0.009983
Stock Market Return	0.000654**	0.000315
GDP per Capita Growth	-0.005272***	0.001844
Unemployment Rate	-0.005765***	0.002802
Inflation Rate	-0.007295*	0.003842
Concentration	0.668683***	0.178102
δ	-0.01009	0.01233
Observation	**860**	
Low Regime	**108**	
High Regime	**752**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.6a: Capital on Cost Efficiency		
Capital as Threshold Variable		
Threshold Estimate		
Capital	-1.2011 (0.3001)	
95% Confidence Interval	-3.6052 (0.0272)	-0.9782 (0.3760)
	Estimates	**SE**
Impact of Capital		
Capital Less	0.009167***	0.002826
Capital Greater	-0.021258	0.01994
Impact of Covariance		
Product Risk	-0.010312***	0.003432
Business Diversification	0.004199	0.004556
Area Diversification	-0.004601**	0.002348
Pricing Risk	0.007955***	0.002423
Investment Risk	-0.389132*	0.204699
Firm Size	-0.04994	0.040026
Square of Firm Size	0.002743	0.002156
Liquidity	0.009088***	0.00268
Market Share	-3.357168***	1.213
Stock Market Return	-0.000169	0.000105
GDP per Capita	-0.000015***	0.000004
Unemployment Rate	-0.00584***	0.001769
Inflation Rate	0.00602**	0.00285
δ	0.020252	0.022591
Observation	**634**	
Low Regime	**357**	
High Regime	**277**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.7b: Capital on Profit Efficiency		
Capital as Threshold Variable		
Threshold Estimate		
Capital	-4.1006 (0.0166)	
95% Confidence Interval	-4.1006 (0.0166)	-2.8411 (0.05836)
	Estimates	**SE**
Impact of Capital		
Capital Less	0.009425	0.007768
Capital Greater	0.023954***	0.00725
Impact of Covariance		
Product Risk	-0.003314	0.003782
Business Diversification	0.012282*	0.006413
Area Diversification	0.003966	0.005046
Pricing Risk	-0.000786	0.002077
Investment Risk	-0.122376	0.296159
Firm Size	0.10424**	0.050502
Square of Firm Size	-0.00608**	0.003103
Liquidity	-0.041379**	0.016435
Underwriting Income	0.022267***	0.00337
Stock Market Return	0.001052***	0.000271
GDP per Capita Growth	-0.007344***	0.001878
Unemployment Rate	-0.011163***	0.002923
Inflation Rate	-0.007476*	0.003979
Concentration	0.543122***	0.170802
δ	-0.015486	0.041735
Observation	**860**	
Low Regime	**48**	
High Regime	**812**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.7a: Reinsurance on Cost Efficiency		
Reinsurance as Threshold Variable		
Threshold Estimate		
Reinsurance	-0.8068 (0.4463)	
95% Confidence Interval	-2.4860 (0.0832)	-0.4397 (0.6443)
	Estimates	**SE**
Impact of Reinsurance		
Reinsurance Less	0.000531	0.00179
Reinsurance Greater	0.016494**	0.006466
Impact of Covariance		
Product Risk	-0.01074***	0.003569
Business Diversification	0.003672	0.004386
Area Diversification	-0.005198**	0.002097
Pricing Risk	0.005692**	0.002251
Investment Risk	-0.372013*	0.198396
Firm Size	-0.015184	0.034296
Square of Firm Size	0.000911	0.001875
Liquidity	0.008032***	0.002743
Market Share	-4.348***	1.225755
Stock Market Return	-0.000227**	0.000105
GDP per Capita	-0.000009***	0.000003
Unemployment Rate	-0.004104***	0.001512
Inflation Rate	0.0001	0.001763
δ	-0.026537***	0.005796
Observation	**634**	
Low Regime	**360**	
High Regime	**274**	
*** p<0.01, ** p<0.05, * p<0.1		

Table A2.7b: Reinsurance on Profit Efficiency		
Reinsurance as Threshold Variable		
Threshold Estimate		
Reinsurance	0.5628	
95% Confidence Interval	-0.0227	0.5628
	Estimates	**SE**
Impact of Reinsurance		
Reinsurance Less	-0.001171***	0.000347
Reinsurance Greater	-0.000608	0.000703
Impact of Covariance		
Product Risk	-0.000521	0.004028
Business Diversification	0.010941*	0.006213
Area Diversification	0.000536	0.004801
Pricing Risk	-0.006261	0.005136
Investment Risk	0.078021	0.286927
Firm Size	0.104048**	0.04953
Square of Firm Size	-0.00654**	0.003072
Liquidity	-0.000537	0.004648
Underwriting Income	0.025917***	0.003426
Stock Market Return	0.000795***	0.000283
GDP per Capita Growth	-0.005491***	0.00166
Unemployment Rate	-0.006623**	0.002517
Inflation Rate	-0.008779**	0.003922
Concentration	0.432027**	0.171757
δ	-0.023613***	0.008115
Observation	**860**	
Low Regime	**615**	
High Regime	**245**	
*** p<0.01, ** p<0.05, * p<0.1		

Appendix 3

Introduction on Financial Reforms in the EU

The concept of ‘single passport,’ namely the Third Generation Insurance Directive, was implemented in 1994. It allows insurers from EU member countries to conduct business across all EU countries. The main object is to increase competition by removing entry barriers. According to Fenn *et al.* (2008), a huge wave of mergers and acquisitions (M&As) has appeared in the EU insurance industry—2,595 M&As from 1990 to 2002 (Cummins and Weiss, 2004). From 2003 to 2014, there were 2,142 M&As in the EU market, of which 697 were from the UK market.

The Financial Conglomerates Directive (Directive 2002/87/EC) was introduced in 2002, and EU countries were asked to incorporate the directive into national law by 2004. The objective is to enhance effective supervision via setting up a regulatory board framework for financial conglomerates, such as, banking groups and insurance groups. The overall aim is to achieve greater financial stability and consumer protection.

The Reinsurance Directive was approved in 2005 by the European Parliament and implemented by 2007. This directive allows reinsurers to have their head office in one of the member countries for writing reinsurance business across the EU. Thus, both primary insurers and reinsurers may benefit from the enhanced ability to diversify into a broad range of activities.

Discussions on Various Measurements on market Structure

The structural method, such as Herfindahl-Hirschman Index (Herfindahl, 1950; Hirschman, 1980) and N-firm Concentration Ratio, is widely used to test Structure-Conduct-Performance (SPC) hypothesis that implies a close relationship between market power and firm’s performance (Bain, 1951). These methods gauge the degree of competition by determining the level of concentration (Degryse, Kim and Ongena, 2009).

Besides, the N-firm concentration ratio only represents the market shares of the N largest firms but ignores the other smaller firms in the market, while HHI does consider the entire players in the market. As argued by (Al-Muharrami, Matthews and Khabari, 2006), HHI attaches the importance to the larger firms relative to the smaller one; it means this index still takes into account the relative size of the firms in the market.

By investigating the degree of competition via different approaches in the U.S. banking, Bolt and Humphrey (2015) reveal the reason of regulators use HHI to represent competition was that it could be predictive of high prices in a concentrated sector, while the authors also questioned that how well the structural methods can capture competition.

Although concentration is a reasonable proxy for competition when the SPC hypothesis is supported, Claessens and Laeven (2004) and Sekkat (2009) still questioned that it was an unreliable indicator of competition because the highly competitive behaviour could be observed in a concentrated market (e.g., Shaffer, 1993; Shaffer and DiSalvo, 1994; ten Raa and Mohnen, 2008). In an early study from Berger (1995a), the author already pointed that the concentration measurement (HHI) only focused on market share while it neglected the effect of firm’s efficiency (Efficiency-Structure hypothesis, see Demsetz (1973)). As suggested by Bolt and Humphrey (2015), the competition would be understated if the higher concentration (higher HHI) was achieved by better management that could be lowering the overall costs.

Due to the above shortcomings associated with structural models, the non-structural models, so-called New Empirical Industrial Organisation (NEIO) approaches, are more preferred to indicate competition as they involve considering a firm's conduct/behaviour to analyse the market. The Lerner index (Lerner, 1934), the Panzar-Rosse *H* statistic (Panzar and Rosse, 1987), and the Boone indicator (Boone, 2008) have been widely adopted to determine the degree of competition in the financial industry (see, Bikker and Haaf, 2002; Claessens and Laeven, 2004; Bachis, Diacon and Fenn, 2007; Berger, Klapper and Turk-Ariss, 2009; Beck, De Jonghe and Schepens, 2013a; Alhassan and Biekpe, 2016; Cummins, Rubio-Misas and Vencappa, 2017).

Lerner index, so-called price-cost margin, usually captures information on a firm's profit-maximising behaviour that is at the time when the firm sets the output price higher than the marginal cost. Thus, the larger(smaller) the distance between price and marginal cost, the weaker(intenser) the competition associated with the market (Lerner, 1934). Specifically, this markup (the difference between price and marginal cost) is used to identify the monopoly pricing power. However, there are drawbacks suffered by using this approach. First, this method is mainly criticized by the fact that it is a proxy for pricing power instead of measuring competition (Beck, De Jonghe and Schepens, 2013a). Then, the availability of price information on inputs and outputs is a challenge. Third, there is a possibility that the index can be negative (Agoraki, Delis and Pasiouras, 2011; Soedarmono, Machrouh and Tarazi, 2011; Coccorese, 2014), then it might be somewhat misleading as the fact that market power cannot be negative in the long term (e.g., it's unlikely to have the price below marginal cost in long-run). However, being a time-varying and individual-based index is superior (Leroy and Lucotte, 2017).

In line with the former, the P-R *H* statistic can also be derived from the profit-maximising condition. This method assumes that the market power of firms is based on the extent to which the degree of changing in input prices are reflected in revenue earned (Vesala, 1995). It is estimated by using a reduced-form revenue function with different choices of the dependent variables (a vector of input prices) and control variables, and the *H* statistic is obtained by summing up the coefficient (elasticity) concerning input prices. Besides, there are two shortages associated with P-R model. First, to apply this methodology, a long-run equilibrium, which is the zero profit constraint holds, need to be achieved in the market (Bikker and Haaf, 2002; Schaeck and Cihák, 2014; Mulyaningsih, Daly and Miranti, 2015). Nevertheless, this criteria is hard to achieve because of the market entry and exit (Claessens and Laeven, 2004; Tan, 2016). Second, as criticized by Bikker, Shaffer and Spierdijk (2012), *H* statistic provides a less informative and non-ordinal result that indicates a monopoly behaviour; meanwhile, both revenue and price functions are used to estimate the *H* statistic while they do not provide the same estimations (also see, Gischer and Stiele (2009)). Last, van Leuvensteijn *et al.* (2011) further argues that there are uncertainties associated with this estimation because it is hard to predict *H* statistic via the static model.

Besides, under Demsetz's (1973) efficiency-structure hypothesis, Boone (2008) developed a theory that suggested output was reallocated from less efficient towards more efficient firm, and expected that the impact of competition on firm's performance should be varied by the extent to which firms' efficiency level. Explicitly, the author assumed that efficient firms, who should receive superior performance, could be more beneficial in a competitive market. In another word, the inefficient firm would be punished more harshly in such condition. Meanwhile, this effect is amplified when there are more intense competitive pressures (Stiroh, 2000). As noticed by Schaeck and Cihák (2014), advantages of using Boone indicator as the measurement of competition can be summarised as, first, it overcomes drawbacks associated with traditional concentration that captured only the outcomes of competition, whereas the Boone index measures the conducts among banks in a competitive environment [1]. Second, it represents the reallocation effect, which is one of the features of strengthening competitive pressure. Third, if comparing to P-R *H* statistic, the assumption of long-run equilibrium is not required. Moreover, the Boone indicator does not suffer from the problem of overlooking product substitutability that is pointed out by Vives (2008).[2] However, the main weakness associated with this method is that the assumption of constant marginal cost may not be valid in the real world (Schaeck and Cihák, 2014).

[1] For example, competition can force firms to exit the market via failure or merger that leads to an increased in the level of concentration. In such a case, the concentration measurement only captures the result of competition, but not the degree of competition (even underestimate the degree of competition).

[2] Changes in the level of competition can be commonly achieved by, changes in entry barriers (such as, the decline in entry costs or eliminate entry requirements), enhanced interactions among firms (such as competitive strategies) and close product substitutes. Vives (2008) questioned the suitability of using Lerner index to measure competition as its connection with the degree of product substitutability is ambiguous. On the other hand, Boone (2008) confirms that the more efficient firms are beneficial under these conditions.

Table A3.1: Individual Factor Effects on Change in Leverage – OLS

	(1)	(2)	(3)
	Boone	Lerner	HHI
VARIABLES	**Change in Leverage**	**Change in Leverage**	**Change in Leverage**
Lagged Leverage	0.3371	0.0503	0.3378
	(1.296)	(0.178)	(1.291)
Retained Earning	-2.0082*	-1.0969	-1.9842*
	(-1.747)	(-1.190)	(-1.734)
Boone Indicator	0.7241		
	(0.134)		
Lerner Index		-23.2934	
		(-1.212)	
HHI			0.0286
			(0.156)
Income Volatility	0.1480	-1.3428	0.1280
	(0.171)	(-1.063)	(0.146)
Business Volatility	-0.1905	0.2848	-0.1858
	(-0.458)	(1.472)	(-0.444)
Reinsurance	-1.4028*	-1.6378**	-1.3997*
	(-1.822)	(-2.137)	(-1.824)
Cost of Equity	-0.0081	0.0415	-0.0080
	(-0.168)	(0.860)	(-0.169)
Firm Size	4.5168	8.4563	4.5590
	(1.210)	(1.076)	(1.186)
Liquidity	-0.2110	-0.4511	-0.1708
	(-0.335)	(-0.525)	(-0.297)
Investment Return	1.9149***	0.9714	1.9246***
	(2.697)	(0.030)	(2.597)
Tax Payment	-0.0644	-1.2521	-0.0627
	(-0.136)	(-1.116)	(-0.132)
Interest rate	-0.2385	-0.9108	-0.2290
	(-0.366)	(-0.978)	(-0.375)
Inflation Rate	0.1014	-0.3965	0.0178
	(0.057)	(-0.312)	(0.015)
GDP Growth	-0.5991*	-0.9098	-0.6138*
	(-1.800)	(-1.546)	(-1.708)
Constant	-46.1854	-73.5391	-46.7618
	(-1.250)	(-1.065)	(-1.185)
Observations	993	651	993
Number of Firms	389	288	389
Adjusted R-squared	0.010	0.017	0.010
Fixed effects	Yes	Yes	Yes
F-test	2.26	0.68	2.321

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Tables A3.2: Summary of Economic Impact

Variable	Observations	Mean
Panel A: Market Structure – Boone Indicator		
Economic Impact of Leverage (Boone)	27,302	**0.045573**
Economic Impact of Retain Earnings (Boone)	27,302	**0.157241**
Panel B: Market Structure – Lerner Index		
Economic Impact of Leverage (Lerner)	27,302	**0.003396**
Economic Impact of Retain Earnings (Lerner)	27,302	**0.052224**
Panel C: Market Structure – HHI		
Economic Impact of Leverage (HHI)	27,302	**0.046252**
Economic Impact of Retain Earnings (HHI)	27,302	**0.15426**

Notes: According to (Cheng and Weiss, 2012a), the trade-off theory is more important than pecking order theory if the economic impact of leverage is larger than the economic impact of retained earnings; otherwise, the pecking order theory dominants the trade-off theory.
Across all three models, the economic impact of retained earnings is larger than the economic impact of leverage. Thus, it is reasonable to assume that the pecking order theory dominants the trade-off theory in the UK insurance market during the study period.

Table A3.3: Interacted Effects with Boone*Lerner on Capital Structure - OLS

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.2791***	0.4803***	0.3075***	0.2757***	0.2745***	0.2042***
	(4.559)	(6.466)	(3.921)	(4.360)	(4.457)	(3.464)
Boone Indicator	-0.4639*	0.0959	-0.4251***	-0.1719	-0.4419***	-0.2540*
	(-1.855)	(0.779)	(-3.155)	(-1.276)	(-3.267)	(-1.901)
Lerner Index	-1.4141	0.1289	-1.0484	0.5170	-1.3736*	-1.4335**
	(-0.690)	(0.207)	(-1.498)	(0.412)	(-1.737)	(-2.035)
Boone*Lerner	0.3972					
	(0.203)					
L. Leverage*Boone*Lerner		-3.7574***				
		(-3.425)				
Retained Earnings			-0.1713**			
			(-2.500)			
R. Earnings*Boone*Lerner			0.4531			
			(1.184)			
Income Volatility				0.1924***		
				(2.611)		
I. Volatility*Boone*Lerner				-1.1622**		
				(-2.124)		
Business Volatility					-0.0967*	
					(-1.657)	
B. Volatility*Boone*Lerner					0.2335*	
					(1.795)	
Reinsurance						-0.2122***
						(-3.309)
Rein.*Boone*Lerner						0.3901
						(1.338)
Cost of Equity	0.0115**	0.0114**	0.0113**	0.0122**	0.0117**	0.0134*
	(2.299)	(2.256)	(2.363)	(2.383)	(2.302)	(1.912)
Firm Size	-0.0467	-0.0531	-0.0457	-0.0473	-0.0558	-0.0066
	(-0.352)	(-0.424)	(-0.342)	(-0.369)	(-0.401)	(-0.069)
Liquidity	0.0204	0.0293	0.0115	0.0158	0.0153	-0.0089
	(0.476)	(0.692)	(0.252)	(0.360)	(0.315)	(-0.166)
Investment Return	2.7571***	2.6950***	2.7636***	2.6276***	3.1366***	7.7724***
	(2.880)	(2.774)	(2.790)	(2.870)	(2.662)	(2.657)
Tax Payment	-0.0273	0.0041	-0.0111	-0.0261	-0.0402	-0.0355
	(-0.446)	(0.072)	(-0.197)	(-0.442)	(-0.623)	(-0.817)
Interest rate	0.0148	0.0148	0.0266	0.0109	0.0111	-0.0064
	(0.718)	(0.733)	(1.301)	(0.544)	(0.523)	(-0.255)
Inflation Rate	-0.1045**	-0.0749**	-0.0936**	-0.1065**	-0.0996**	-0.0955**
	(-2.388)	(-2.015)	(-2.216)	(-2.449)	(-2.297)	(-2.221)
GDP Growth	-0.0006	-0.0028	-0.0024	0.0025	-0.0050	0.0047
	(-0.034)	(-0.158)	(-0.141)	(0.149)	(-0.282)	(0.236)
Constant	2.0511**	1.5166	1.9543*	1.4585	2.2126*	1.0878
	(1.979)	(1.473)	(1.766)	(1.501)	(1.852)	(1.159)
Observations	2,749	2,749	2,715	2,743	2,667	2,330
Number of Firms	511	511	508	510	499	452
Adjusted R-squared	0.180	0.212	0.209	0.184	0.192	0.166
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	7.5	9.1	6.98	7.5	5.29	7.173

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A3.4: Interacted Effects with Boone*HHI on Capital Structure - OLS

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.2801***	0.4738***	0.2954***	0.2817***	0.1809***	0.1876***
	(3.682)	(4.466)	(3.521)	(3.630)	(2.619)	(3.150)
Boone Indicator	0.7284	-0.1119	-0.5506***	0.0865	-0.4613**	-0.4150*
	(0.752)	(-0.639)	(-2.923)	(0.348)	(-2.391)	(-1.954)
HHI	0.0253	0.0000	-0.0098	0.0039	0.0017	0.0060
	(0.891)	(0.006)	(-1.182)	(0.438)	(0.266)	(0.851)
Boone*HHI	-0.0370					
	(-1.198)					
L. Leverage*Boone*HHI		-0.0076***				
		(-4.025)				
Retained Earnings			-0.2803***			
			(-3.035)			
R. Earnings*Boone*HHI			0.0042			
			(1.402)			
Income Volatility				0.3666***		
				(3.244)		
I. Volatility*Boone*HHI				-0.0083**		
				(-2.176)		
Business Volatility					-0.0698**	
					(-2.546)	
B. Volatility*Boone*HHI					0.0007	
					(1.413)	
Reinsurance						-0.3444***
						(-3.461)
R.*Boone*HHI						0.0007
						(0.393)
Cost of Equity	-0.0078	-0.0087*	-0.0067	-0.0075	-0.0071	-0.0053
	(-1.440)	(-1.665)	(-1.222)	(-1.348)	(-1.349)	(-0.833)
Firm Size	-0.2503*	-0.2641*	-0.2371	-0.2740*	-0.3837**	-0.3707**
	(-1.710)	(-1.864)	(-1.600)	(-1.855)	(-2.375)	(-2.034)
Liquidity	0.0579	0.0632	0.0525	0.0726	0.0388	-0.0245
	(0.999)	(1.154)	(0.889)	(1.337)	(0.591)	(-0.343)
Investment Return	0.1145***	0.1139***	0.1130***	0.1156***	0.1071***	0.2404***
	(2.730)	(2.755)	(2.703)	(2.748)	(2.627)	(6.098)
Tax Payment	-0.0164	-0.0139	0.0037	-0.0152	-0.0139	-0.0155
	(-1.009)	(-0.868)	(0.253)	(-1.032)	(-0.910)	(-1.329)
Interest rate	0.0941***	0.0965***	0.1047***	0.0902***	0.1029***	0.0557**
	(3.848)	(3.989)	(4.317)	(3.647)	(3.911)	(2.072)
Inflation Rate	-0.1605**	-0.1259*	-0.1508**	-0.1514**	-0.1272*	-0.1358**
	(-2.113)	(-1.901)	(-2.003)	(-2.106)	(-1.763)	(-1.965)
GDP Growth	-0.0174	-0.0218	-0.0199	-0.0144	-0.0271*	-0.0037
	(-1.134)	(-1.430)	(-1.302)	(-0.860)	(-1.694)	(-0.206)
Constant	3.3320*	3.8994***	4.3484***	3.4109**	5.5693***	4.5569***
	(1.881)	(3.100)	(3.390)	(2.506)	(3.992)	(3.081)
Observations	4,519	4,519	4,471	4,495	4,151	3,665
Number of id	616	616	613	615	587	548
Adjusted R-squared	0.162	0.179	0.173	0.172	0.137	0.190
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	7.43	8.02	7.43	8.66	6.14	12.02

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A3.5: Interacted Effects with Lerner*HHI on Capital Structure - OLS

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.2803***	0.5139***	0.3088***	0.2767***	0.2753***	0.2062***
	(4.535)	(4.924)	(3.919)	(4.336)	(4.436)	(3.510)
HHI	0.0063	0.0169*	0.0039	0.0084	0.0040	0.0112
	(0.599)	(1.728)	(0.536)	(0.983)	(0.517)	(1.330)
Lerner Index	-0.8775	0.2583	-1.4061**	-0.5297	-1.6650**	-1.4308**
	(-0.557)	(0.439)	(-2.405)	(-0.993)	(-1.986)	(-2.115)
Lerner*HHI	-0.0110					
	(-0.300)					
L. Leverage*Lerner*HHI		-0.1006**				
		(-2.312)				
Retained Earnings			-0.2407***			
			(-2.782)			
R. Earnings*Lerner*HHI			0.0268*			
			(1.883)			
Income Volatility				0.1452**		
				(2.160)		
I. Volatility*Lerner*HHI				-0.0113		
				(-0.905)		
Business Volatility					-0.1120*	
					(-1.683)	
B. Volatility*Lerner*HHI					0.0077*	
					(1.725)	
Reinsurance						-0.2269***
						(-3.170)
Rein.*Lerner*HHI						0.0127
						(1.339)
Cost of Equity	0.0113**	0.0128**	0.0111**	0.0118**	0.0115**	0.0133*
	(2.240)	(2.467)	(2.307)	(2.308)	(2.253)	(1.887)
Firm Size	-0.0875	-0.0874	-0.0817	-0.0886	-0.0987	-0.0511
	(-0.640)	(-0.634)	(-0.594)	(-0.659)	(-0.686)	(-0.516)
Liquidity	0.0049	0.0144	-0.0049	0.0009	-0.0012	-0.0293
	(0.110)	(0.339)	(-0.105)	(0.020)	(-0.024)	(-0.522)
Investment Return	2.7555***	2.7342**	2.7820***	2.7249***	3.1330***	7.9349***
	(2.745)	(2.582)	(2.777)	(2.727)	(2.626)	(2.662)
Tax Payment	-0.0380	-0.0106	-0.0201	-0.0395	-0.0502	-0.0401
	(-0.618)	(-0.173)	(-0.348)	(-0.633)	(-0.773)	(-0.988)
Interest rate	0.0320	0.0335	0.0431*	0.0283	0.0282	0.0099
	(1.463)	(1.479)	(1.863)	(1.292)	(1.220)	(0.376)
Inflation Rate	-0.0084	-0.0106	0.0031	-0.0104	-0.0064	-0.0093
	(-0.210)	(-0.278)	(0.075)	(-0.264)	(-0.159)	(-0.247)
GDP Growth	0.0026	-0.0009	0.0011	0.0080	-0.0018	0.0064
	(0.157)	(-0.050)	(0.064)	(0.475)	(-0.106)	(0.324)
Constant	1.6247	1.1171	1.6213	1.2663	1.9234	0.6810
	(1.481)	(0.975)	(1.456)	(1.049)	(1.605)	(0.766)
Observations	2,749	2,749	2,715	2,743	2,667	2,330
Number of Firms	511	511	508	510	499	452
Adjusted R-squared	0.176	0.198	0.206	0.177	0.189	0.164
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	7.43	7.4	6.97	6.88	4.98	7.269

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Further sensitivity and robustness check: the Non-linear Relationship-the Square of Market Structure: Boone², Lerner² and HHI²

For further sensitivity and robustness check, two more issues are considered. First, as discussed in the literture section, both Pandey (2004) and Berger, Klapper and Turk-Ariss (2009) found a non-linear relationship between market structure (*i.e.* market power) and the firm's capital structure. The former comfirmed that there was a cubic relationship, and an inverted U-shape was suggested by the latter. Then, testing the existence of the non-linear relationship and the combined impact with other factors on the insurer's capital stucture is also essential.

Secondly, many authors have studied the impact of organisational form on the firm's capital stucture. For example, Cheng and Mary A Weiss (2012) identify the assumption of the presence of differences in behaviours that related to firms' capital structure adjustments, between mutual and stock insurers. Harrington and Niehaus (2002) suggest that mutual insurers had less access to the capital market, and that it is more costly to raise capital (*i.e.* equity) than holding capital. Thus, it is reasonable to expect that holding capital is less costly in mutual firms.[1] On the other hand, based on Mayers and Smith's (1981, 1986) agency theory, Mayers and Smith (2005) argue that it is harder to exert control over managers effectively in the mutual firm; then, Cheng and Mary A Weiss (2012) further assume that the cost of holding capital should be less in stock firms. In addition, Adams, Hardwick and Zou (2008) suggest that the usage of reinsurance would also be different between two organisational forms due to the ability to raise capital.[2] Thus, the issue of organisational forms is worth to be controlled.

Based on the findings from Pandey (2004) and Berger, Klapper and Turk-Ariss (2009) and the above discussions on the organisational form , Equation 3.12 can be re-written as:

$$\begin{aligned} Leverage_{\ i,t} = (1-\delta)\left[Leverage_{\ i,t-1}\right] + (\delta\alpha_1)Market\ Structure_{i,t} \\ + (\delta\alpha_2)Market\ Structure^2_{i,t} + (\delta\alpha_3)Retained\ Earning_{i,t} \\ + (\delta\alpha_4)Volatility_{i,t} + (\delta\alpha_5)Reinsurance_{i,t} + (\delta\lambda_n)Interactions_{i,t,n} \\ + (\delta\rho_n)Interactions''_{i,t,n} + (\delta\phi_m)Controls_{i,t,m} + Stock + \varepsilon_{i,t} \end{aligned} \quad (3.13)$$

where, the $Market\ Structure^2_{i,t}$ is the square of market strcture proxies (*i.e.* Boone Indicator, Lerner Index and HHI). And $Interactions''_{i,t,n}$ denotes the interaction terms between the square of these proxies and the *nth* regressor. Then, the potencial non-linear impact can be tested by adding these variables. Moreover, a dummy variable *Stock*, which indicates stock type insurers by assigned a value of 1, is also included for sensitivity and robustness check.

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[1] Based on Harrington and Niehaus's (2002) logic, the cost of holding capital is lower than the cost of raising capital for mutual firms. Meanwhile, for stock insurers, the cost of raising capital is lower than the cost of holding. Thus, it is impossible to assume that the cost of holding for mutual is higher than the cost of holding for stock insurers, because the mutual raising cost can not be higher than stock raising the cost, under Harrington and Niehaus's (2002) logic.

[2] Mayers and Smith (1990), Wells, Cox and Gaver (1995) and Cummins *et al.* (2008) provided studies on the discrepancy in purchasing reinsurance between stock and mutual insurers. Mayers and Smith (1990) found evidence that mutual firms reinsured more businesses than stock insurers. In contrast, Cole and McCullough (2006) and Cummins *et al.* (2008) supported that stock insurers would like to utilize more reinsurance.

The estimation results in Tables A3.7 to A3.9 present the non-linear relationships between market structure and insurers' leverage ratios, as discussed by Pandey (2004), Berger, Klapper and Turk-Ariss (2009) and Guney, Li and Fairchild (2011). Separately including the interaction terms for the level of market structure and the square of market structure (from various concepts) allows this study to test whether the non-linear relationship may affect insurers' leverage levels via different channels (or behaviours). It also allows the researchers to determine whether the impacts of the variables of interest (or the interested behaviours) would change due to this non-linear relationship. Although, the results are estimated by both the OLS fixed effect and the dynamic GMM approach, the discussions are mainly focusing on the dynamic model.

In Table A3.7b, the result of Model 1 indicates that the relationship between competition and leverage ratio appears to be inverse U-shaped, implying that insurers are willing to accept more leverage (e.g., business leverage) when market competition becomes intensive. However, up to a certain point, insurers begin reducing their leverage ratios by either taking less leverage or generating more equity, if the competition becomes too strong in the market. Further, Models 2 and 5 indicate that insurers, who already hold a massive amount of leverage or issue more risky businesses, will increase their leverage to a certain level corresponding to the level of increased competition. They will then adjust their leverage ratios downwards to maintain stability in fiercer competition. Conversely, insurers with more retained earnings, income volatilities and reinsurance protection will reduce their leverage to a certain point, then increase it after the inflexion, corresponding to rising market competition (see Models 3, 4 and 6 from Table A3.7b).

The coefficients of the Lerner index, the square of the Lerner index and their interaction terms are statistically significant across all models in Table A3.8b, indicating that the impacts of pricing power (market power) on capital structure are non-linear. Thus, Model 1 reveals that insurers may tend to reduce leverage use when they start to gain pricing power, while they will increase their leverage when their pricing power moves beyond a certain level. Considering this non-linear impact together with insurers' behaviours, Models 3, 5 and 6 show that insurers start to increase their leverage ratios if they have more retained earnings, risky businesses and reinsurance protections at the time they start developing pricing power; however, these insurers prefer reducing the leverage amount when their pricing power is further strengthened. An opposite pattern, which is a U-shaped relationship, can be found in Models 2 and 4, suggesting that insurers who hold higher past leverage and carry more income volatilities are willing to lessen their leverage until their pricing power increases to one inflexion point. Soon after their pricing power is beyond the inflexion point, they start expanding their leverage.

Finally, regarding the impacts of market concentration on insurers' capital structure, the associated parameters are negative at the level term and positive at the squared term (Model 1), indicating that this is a significant, U-shaped relationship. This implies that insurers operating in a more concentrated market are willing to have a higher leverage ratio than those in a less concentrated market. The non-linear U-shaped relationship is also confirmed in cases of retained earnings and reinsurance (see Models 2, 3 and 6 in Table A3.9b). This implies that insurers with a higher level of past leverage, massive retained earnings or more reinsurance reduce leverage ratios when the market is becoming concentrated, while they decide to accept more leverage to maximise their output levels if the market is relatively more concentrated. Notably, insurers, who accept more uncertainties from both investment and business activities (Models 4 and 5), enlarge their leverage when the concentration level is low; then, they might reduce leverage again when the market becomes more concentrated.

Therefore, the above findings support Pandey's (2004) and Berger, Klapper and Turk-Ariss's (2009) suggestions, indicating that market structure has a non-linear impact (through various concepts) on firms' capital structures. However, Soedarmono, Machrouh and Tarazi (2013) do not find any evidence for this non-linear relationship. It is also worth noting that non-linear relationships are more significant in the short-run than in the long-run. However, most of the significant effects are consistent in both models. Further, the inconsistent results across Tables A3.7 to A3.9 confirm two previously proved findings: (1) three individual concepts (or three measurements) represent different information about market structure; and (2) the impact of market structure has different impacts on insurers' capital structures via various channels. Finally, regarding the differences between two organisational forms, the impacts of the main variables remain consistent and valid in all models, after controlling for organisational form, but there are no strong, significant coefficients associated with the dummy variable of stock insurers. Moreover, it is safe to assume that there are no distinct differences between the two organisational forms in the UK insurance market concerning their capital structure choices.

Table A3.6: Summary of Non-linear Relationship	
Panel A: Hypothesis – Interactions with Boone Squared	
$Boone^2$	**Inverse U**
Lagged Leverage*$Boone^2$	**Inverse U**
Retained Earnings*$Boone^2$	**U-Shape**
Income Volatility*$Boone^2$	**U-Shape**
Business Volatility*$Boone^2$	**Inverse U**
Reinsurance*$Boone^2$	**U-Shape**
Panel C: Hypothesis – Interactions with Lerner Squared	
$Lerner^2$	**U-Shape**
Lagged Leverage* $Lerner^2$	**U-Shape**
Retained Earnings*$Lerner^2$	**Inverse U**
Income Volatility*$Lerner^2$	**U-Shape**
Business Volatility*$Lerner^2$	**Inverse U**
Reinsurance*$Lerner^2$	**Inverse U**
Panel D: Hypothesis - Interactions with HHI Squared	
HHI^2	**U-Shape**
Lagged Leverage* HHI^2	**U-Shape**
Retained Earnings*HHI^2	**U-Shape**
Income Volatility*HHI^2	**Inverse U**
Business Volatility*HHI^2	**Inverse U**
Reinsurance*HHI^2	**U-Shape**

Table A3.7a: Interacted Effects with Boone^2 on Capital Structure - OLS

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage	(7) Leverage
Lagged Leverage	0.1934***	0.3489***	0.2940***	0.2817***	0.1793***	0.1858***	0.1873**
	(3.059)	(3.809)	(3.510)	(3.641)	(2.606)	(3.132)	(1.965)
Boone Indicator	-0.2452	-0.5102*	0.2977	0.9286	0.0815	-1.1492**	0.9312
	(-0.697)	(-1.891)	(0.879)	(1.246)	(0.226)	(-2.277)	(0.752)
Boone^2	-0.1416	0.3796	-0.8265**	-0.5447	-0.5545	0.6727	-0.0606
	(-0.394)	(1.618)	(-2.209)	(-0.897)	(-1.419)	(1.588)	(-0.063)
Lagged Leverage*Boone		0.4201**					0.2039
		(2.481)					(1.063)
Lagged Leverage*Boone^2		-0.6337***					-0.2451
		(-3.467)					(-1.157)
Retained Earnings	-0.1227**		-0.1621*				-0.0664
	(-2.578)		(-1.794)				(-0.661)
Retained Earnings*Boone			-0.6375**				-0.4768*
			(-2.357)				(-1.857)
Retained Earnings*Boone^2			0.7172***				0.4747**
			(2.726)				(2.287)
Income Volatility	0.1592**			0.4493***			0.5932**
	(2.462)			(2.992)			(2.547)
Income Volatility*Boone				-0.3534			-0.9176
				(-0.852)			(-1.532)
Income Volatility*Boone^2				-0.0697			0.3667
				(-0.200)			(0.787)
Business Volatility	-0.0367**				-0.0784***		-0.0732
	(-1.982)				(-2.795)		(-1.506)
Business Volatility*Boone					0.0233		0.1277
					(0.431)		(1.106)
Business Volatility*Boone^2					0.0138		-0.0909
					(0.319)		(-1.147)
Reinsurance	-0.2795***					-0.2729***	-0.2487***
	(-4.019)					(-2.771)	(-2.622)
Reinsurance*Boone						-0.5052**	-0.3848**
						(-2.419)	(-2.031)
Reinsurance*Boone^2						0.5050**	0.4065**
						(2.376)	(1.984)
Cost of Equity	-0.0041	-0.0075	-0.0061	-0.0071	-0.0068	-0.0050	-0.0031
	(-0.635)	(-1.511)	(-1.113)	(-1.291)	(-1.294)	(-0.784)	(-0.477)
Firm Size	-0.4184**	-0.2574*	-0.2377	-0.2738*	-0.3798**	-0.3712**	-0.4137**
	(-2.191)	(-1.848)	(-1.598)	(-1.851)	(-2.324)	(-2.021)	(-2.273)
Liquidity	0.0040	0.0615	0.0504	0.0736	0.0383	-0.0196	0.0109
	(0.065)	(1.170)	(0.856)	(1.347)	(0.585)	(-0.276)	(0.180)
Investment Return	0.2381***	0.1147***	0.1140***	0.1159***	0.1077***	0.2405***	0.2406***
	(6.288)	(2.761)	(2.751)	(2.752)	(2.632)	(6.093)	(6.686)
Tax Payment	-0.0031	-0.0123	0.0108	-0.0141	-0.0140	-0.0156	0.0012
	(-0.316)	(-0.769)	(0.695)	(-0.967)	(-0.915)	(-1.332)	(0.118)
Interest rate	0.0488*	0.0896***	0.0884***	0.0757***	0.0792***	0.0408	0.0494*
	(1.751)	(3.360)	(3.183)	(2.670)	(2.913)	(1.484)	(1.772)
Inflation Rate	-0.1412**	-0.0794	-0.1232	-0.1142	-0.1368*	-0.1518**	-0.1241**
	(-2.263)	(-1.228)	(-1.577)	(-1.503)	(-1.906)	(-2.336)	(-2.052)
GDP Growth	0.0040	-0.0132	-0.0063	-0.0045	-0.0147	0.0020	-0.0013
	(0.184)	(-0.778)	(-0.354)	(-0.240)	(-0.843)	(0.101)	(-0.059)
Constant	4.9411***	3.8012***	3.8708***	3.2189***	5.5965***	4.9384***	3.9616**
	(2.989)	(3.274)	(3.192)	(2.645)	(3.923)	(3.145)	(2.565)
Observations	3,511	4,519	4,471	4,495	4,151	3,665	3,511
Number of Firms	533	616	613	615	587	548	533
Adjusted R-squared	0.210	0.191	0.174	0.173	0.138	0.192	0.220
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	13.87***	8.3***	6.55***	6.55***	5.58***	11.69***	10.06***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A3.7b: Interacted Effects with Boone^2 on Capital Structure - GMM

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage	(7) Leverage
Lagged Leverage	0.1975***	0.3097*	0.4530***	0.4989***	0.3994***	0.1618**	0.8357***
	(2.820)	(1.809)	(4.558)	(4.707)	(3.054)	(2.195)	(2.920)
Boone Indicator	0.7774*	-1.0253*	0.2296	5.0109***	0.1794	-1.8766*	0.0448
	(1.921)	(-1.960)	(0.970)	(2.728)	(0.287)	(-1.900)	(0.013)
Boone^2	-0.8398*	0.9059**	-0.5437**	-2.4879**	-1.1454*	1.2599	2.1010
	(-1.799)	(2.051)	(-2.047)	(-2.253)	(-1.733)	(1.572)	(0.760)
L. Leverage*Boone		1.0131**					-1.5965**
		(2.188)					(-1.986)
L. Leverage*Boone^2		-1.1482***					1.0673*
		(-2.783)					(1.778)
Retained Earnings	-0.6618***		-0.1811**				-0.0069
	(-3.250)		(-2.017)				(-0.029)
R. Earnings*Boone			-0.4735*				-1.1253*
			(-1.830)				(-1.693)
R. Earnings*Boone^2			0.5471*				0.9433*
			(1.941)				(1.885)
Income Volatility	0.2588**			1.2261***			1.2989**
	(2.095)			(3.614)			(1.998)
I. Volatility*Boone				-2.3748***			0.0519
				(-2.748)			(0.031)
I. Volatility*Boone^2				1.0056*			-1.3077
				(1.841)			(-1.037)
Business Volatility	0.0134				-0.1501		0.1033
	(0.344)				(-1.521)		(0.695)
B. Volatility*Boone					0.4126*		-0.1606
					(1.846)		(-0.487)
B. Volatility*Boone^2					-0.2424*		0.0134
					(-1.695)		(0.056)
Reinsurance	-0.5390***					-0.2720*	0.3852
	(-3.293)					(-1.658)	(1.474)
Rein.*Boone						-0.9914**	-1.7720**
						(-2.161)	(-2.513)
Rein.*Boone^2						0.9643**	1.2590**
						(2.265)	(2.297)
Cost of Equity	0.0100	-0.0005	0.0266**	-0.0069	-0.0037	0.0047	0.0082
	(1.165)	(-0.076)	(2.254)	(-1.101)	(-0.485)	(0.575)	(1.076)
Firm Size	-0.2990	-0.2318	0.0689	0.3243**	0.3817***	-0.2752	0.1008
	(-1.065)	(-1.307)	(0.396)	(2.207)	(2.694)	(-0.871)	(0.545)
Liquidity	0.0768	0.1094	0.6389	0.1091	0.1698	0.3670	-0.1178
	(0.638)	(1.323)	(1.048)	(0.938)	(1.407)	(0.438)	(-0.773)
Investment Return	0.2927***	0.1213***	0.0277	0.1823**	0.1343*	0.2674***	0.3139***
	(6.987)	(2.590)	(0.413)	(2.196)	(1.694)	(4.636)	(8.552)
Tax Payment	0.0412	-0.0123	0.0395	-0.1151	0.0012	-0.1760	0.0419**
	(1.642)	(-0.111)	(0.623)	(-0.777)	(0.066)	(-0.726)	(2.185)
Interest rate	0.0020	0.0685**	-0.0302	0.0053	-0.0340	-0.0556	-0.0074
	(0.036)	(2.336)	(-0.811)	(0.208)	(-0.567)	(-1.063)	(-0.160)
Inflation Rate	0.0672	0.0387	-0.0593	-0.0295	-0.2218*	-0.2542*	-0.0782
	(0.643)	(0.507)	(-1.157)	(-0.611)	(-1.961)	(-1.684)	(-1.209)
GDP Growth	0.0413	-0.0037	0.0006	0.0025	0.0497	-0.0369	0.0295
	(1.137)	(-0.286)	(0.038)	(0.210)	(1.647)	(-1.019)	(1.169)
Stock		-0.7949	-0.3124	-0.0675	-0.2601	-1.5099	0.1185
		(-1.105)	(-0.214)	(-0.271)	(-0.825)	(-1.000)	(0.364)
Constant	2.2883	3.3555**	1.0609	-4.1850***	-0.8057	5.7260*	-2.5980
	(1.060)	(2.191)	(0.505)	(-2.820)	(-0.712)	(1.802)	(-1.500)
Observations	3,354	4,186	4,471	4,495	3,821	3,665	3,189
Number of Firms	503	565	613	615	534	548	476
Instruments	204	160	125	165	136	111	202
Robust	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	11.52***	8.699***	6.340***	11.04***	8.247***	8.714***	8.178***
AR(1)	-3.058***	-3.345***	-3.727***	-3.363***	-3.076***	-2.935***	-3.237***
AR(2)	0.606	1.472	0.797	0.977	1.070	1.035	-0.449
Hansen Test	197.6 (0.30)	155.6 (0.26)	107 (0.54)	143.5 (0.61)	130.9 (0.23)	105.1 (0.23)	168.2 (0.63)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A3.8a: Interacted Effects with $Lerner^2$ on Capital Structure - OLS

VARIABLES	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage	(7) Leverage
Lagged Leverage	0.2397***	0.8328***	0.3075***	0.2757***	0.2734***	0.2047***	0.7213***
	(3.766)	(4.119)	(3.915)	(4.358)	(4.423)	(3.468)	(4.886)
Lerner Index	-5.0219***	-1.7178	-5.1887***	0.7182	-5.7275***	-3.8569	4.3211
	(-2.713)	(-1.076)	(-3.083)	(0.425)	(-3.271)	(-1.632)	(1.512)
$Lerner^2$	8.3861**	0.1202	9.0126***	-2.7183	9.9618***	4.7716	-11.3515*
	(2.347)	(0.040)	(2.863)	(-0.810)	(3.038)	(1.090)	(-1.674)
L. Leverage*Lerner		-11.1046***					-9.5466***
		(-2.985)					(-2.985)
L. Leverage*$Lerner^2$		41.7744**					37.4161**
		(2.503)					(2.429)
Retained Earnings	-0.1210**		-0.3009**				-0.0860
	(-2.468)		(-2.136)				(-0.773)
R. Earnings*Lerner			2.0188				-0.4714
			(1.471)				(-0.403)
R. Earnings*$Lerner^2$			-2.7585				2.6519
			(-1.255)				(1.238)
Income Volatility	0.0934**			0.3342***			0.3156**
	(2.009)			(2.649)			(2.248)
I. Volatility*Lerner				-3.1498**			-2.5417
				(-2.274)			(-1.435)
I. Volatility*$Lerner^2$				6.3569**			3.1177
				(2.200)			(0.936)
Business Volatility	-0.0167				-0.1631*		-0.1073**
	(-0.884)				(-1.754)		(-2.199)
B. Volatility*Lerner					0.7580*		0.8570**
					(1.834)		(2.185)
B. Volatility*$Lerner^2$					-0.8028**		-1.3360*
					(-1.986)		(-1.778)
Reinsurance	-0.1505**					-0.2819**	-0.1527
	(-2.462)					(-2.546)	(-1.412)
Rein.*Lerner						1.8902	0.2209
						(1.433)	(0.191)
Rein.*$Lerner^2$						-6.2126	-0.6390
						(-1.611)	(-0.203)
Cost of Equity	0.0133**	0.0128**	0.0118**	0.0129**	0.0122**	0.0136*	0.0143**
	(1.994)	(2.365)	(2.431)	(2.491)	(2.339)	(1.924)	(2.158)
Firm Size	-0.0255	-0.0877	-0.0761	-0.0859	-0.0877	-0.0408	-0.0504
	(-0.261)	(-0.722)	(-0.561)	(-0.645)	(-0.615)	(-0.423)	(-0.533)
Liquidity	-0.0262	0.0122	-0.0067	-0.0014	0.0063	-0.0136	-0.0251
	(-0.480)	(0.294)	(-0.146)	(-0.033)	(0.130)	(-0.252)	(-0.489)
Investment Return	7.8003***	2.4107***	2.7967***	2.6851***	3.1141***	7.5754***	7.2746***
	(2.657)	(2.869)	(2.758)	(2.690)	(2.623)	(2.615)	(2.770)
Tax Payment	-0.0307	0.0130	-0.0198	-0.0276	-0.0442	-0.0359	-0.0098
	(-0.764)	(0.252)	(-0.326)	(-0.456)	(-0.692)	(-0.882)	(-0.247)
Interest rate	0.0124	0.0272	0.0396*	0.0232	0.0285	0.0057	0.0106
	(0.472)	(1.367)	(1.817)	(1.127)	(1.324)	(0.225)	(0.436)
Inflation Rate	-0.0256	-0.0143	-0.0129	-0.0319	-0.0193	-0.0334	-0.0216
	(-0.718)	(-0.435)	(-0.373)	(-0.939)	(-0.551)	(-0.942)	(-0.642)
GDP Growth	0.0079	0.0110	0.0005	0.0069	-0.0052	0.0052	0.0142
	(0.402)	(0.579)	(0.031)	(0.405)	(-0.297)	(0.261)	(0.749)
Constant	0.9608	1.8354*	1.9701*	1.4598	2.2461*	1.2315	0.4540
	(1.036)	(1.849)	(1.799)	(1.258)	(1.878)	(1.252)	(0.483)
Observations	2,281	2,749	2,715	2,743	2,667	2,330	2,281
Number of Firms	447	511	508	510	499	452	447
Adjusted R-squared	0.191	0.225	0.208	0.183	0.193	0.166	0.225
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	5.46	10.13	6.65	6.72	4.66	6.33	6.194

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A3.8b: Interacted Effects with Lerner^2 on Capital Structure - GMM

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Leverage	Leverage	Leverage	Leverage	Leverage	Leverage	Leverage
Lagged Leverage	0.3601***	0.9794***	0.3208*	0.3722***	0.3683***	0.3064***	1.1579***
	(4.300)	(3.067)	(1.742)	(5.242)	(4.884)	(3.587)	(2.897)
Lerner Index	-9.3230***	-9.2908*	-11.3370***	6.9829	-7.6461***	-0.6268	12.2907*
	(-2.969)	(-1.956)	(-2.700)	(1.624)	(-3.217)	(-0.134)	(1.694)
Lerner^2	19.4512***	6.9451	18.5188*	-13.0141	14.9491***	0.6110	-37.1639*
	(3.156)	(1.007)	(1.748)	(-1.493)	(2.969)	(0.071)	(-1.902)
LLeverage*Lerner		-15.2712**					-15.2413**
		(-2.184)					(-2.205)
LLeverage*Lerner^2		91.7649**					64.0929**
		(2.165)					(2.032)
Retained Earnings	-0.2011*		-0.7951***				0.4129**
	(-1.842)		(-2.811)				(2.043)
REarnings*Lerner			7.2581**				-7.4372**
			(2.199)				(-2.374)
REarnings*Lerner^2			-16.0847*				18.8054**
			(-1.895)				(2.511)
Income Volatility	0.2172**			0.7232***			0.5643**
	(2.141)			(3.061)			(2.283)
IVolatility*Lerner				-6.0435***			-5.1963*
				(-2.648)			(-1.816)
IVolatility*Lerner^2				10.5902**			9.8629
				(2.012)			(1.525)
Business Volatility	-0.0340				-0.1400**		-0.0629
	(-1.353)				(-2.040)		(-0.894)
BVolatility*Lerner					0.7678**		0.4138
					(2.038)		(0.687)
BVolatility*Lerner^2					-1.1038**		-0.2371
					(-2.131)		(-0.246)
Reinsurance	-0.3488***					-0.4563*	0.2026
	(-2.866)					(-1.745)	(0.895)
Rein.*Lerner						6.4390**	-4.4208
						(2.241)	(-1.484)
Rein.*Lerner^2						-18.5788**	11.5211
						(-2.280)	(1.429)
Cost of Equity	0.0075	0.0008	0.0183**	0.0036	-0.0049	-0.0013	0.0083
	(1.001)	(0.142)	(2.102)	(0.467)	(-0.657)	(-0.167)	(1.045)
Firm Size	0.3008*	0.1285	0.2583*	0.0491	0.3972**	0.3120*	-0.0438
	(1.816)	(1.348)	(1.679)	(0.303)	(2.045)	(1.949)	(-0.301)
Liquidity	0.1414	0.0735	0.1654	0.3315	0.5645	0.0800	-0.0647
	(1.379)	(0.986)	(1.532)	(1.002)	(1.470)	(0.667)	(-0.368)
Investment Return	-1.2311	1.8547***	1.8238***	3.8970***	3.5596*	7.8500**	2.5611
	(-0.743)	(2.772)	(4.535)	(4.149)	(1.695)	(2.461)	(1.104)
Tax Payment	0.2252	-0.0215	0.0349	-0.1725	-0.0005	-0.1113	-0.0180
	(0.841)	(-0.359)	(0.291)	(-0.322)	(-0.004)	(-1.419)	(-0.394)
Interest rate	0.0022	0.0402*	0.0316	0.0156	0.0324	0.0400	0.0039
	(0.050)	(1.690)	(0.638)	(0.406)	(0.628)	(0.858)	(0.121)
Inflation Rate	0.0555	0.0367	-0.0656	-0.0120	0.1608*	0.0664	-0.0223
	(0.716)	(0.699)	(-1.086)	(-0.240)	(1.859)	(0.766)	(-0.417)
GDP Growth	0.0145	0.0094	-0.0522	0.0174	-0.0238	-0.0584	0.0118
	(0.413)	(0.373)	(-1.247)	(0.942)	(-0.598)	(-1.510)	(0.479)
Stock		0.5405	0.7002	0.9167	1.1134	1.4508	0.6029
		(0.889)	(0.793)	(0.962)	(0.735)	(1.537)	(0.801)
Constant	-2.1637	-0.1403	-0.8207	-1.3152	-2.6754	-3.2341**	-0.6813
	(-1.368)	(-0.150)	(-0.550)	(-0.761)	(-1.148)	(-2.321)	(-0.445)
Observations	1,748	2,749	2,715	2,743	2,667	2,330	2,281
Number of Firms	385	511	508	510	499	452	447
Instruments	184	225	198	135	220	250	302
Robust	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	10.63***	10.04***	66***	8.949***	5.324***	5.748***	4.501***
AR(1)	-2.313**	-2.918***	-2.110**	-2.683***	-2.639***	-2.326**	-2.573**
AR(2)	0.173	0.752	-0.541	0.576	0.641	0.954	0.470
Hansen Test	191 (0.11)	223.2 (0.25)	182.5 (0.48)	119.3 (0.48)	208.2 (0.40)	247.6 (0.26)	273.3 (0.52)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A3.9a: Interacted Effects with HHI^2 on Capital Structure - OLS

VARIABLES	(9) Leverage	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.1962***	0.1003	0.2967***	0.2849***	0.1822***	0.1905***	0.7920
	(3.082)	(0.104)	(3.517)	(3.632)	(2.616)	(3.178)	(0.946)
HHI	-0.0145	0.0137	0.0346	-0.1952	-0.0138	0.0863	0.0086
	(-0.242)	(0.218)	(0.517)	(-1.370)	(-0.169)	(0.782)	(0.050)
HHI^2	0.0003	-0.0002	-0.0006	0.0024	0.0002	-0.0010	-0.0001
	(0.362)	(-0.193)	(-0.669)	(1.338)	(0.215)	(-0.684)	(-0.038)
Lagged Leverage*HHI		0.0144					-0.0381
		(0.257)					(-0.816)
Lagged Leverage*HHI^2		-0.0003					0.0006
		(-0.331)					(0.972)
Retained Earnings	-0.1338***		2.7494				0.5445
	(-2.710)		(1.626)				(0.642)
Retained Earnings*HHI			-0.1639*				-0.0366
			(-1.738)				(-0.809)
Retained Earnings*HHI^2			0.0022*				0.0005
			(1.736)				(0.819)
Income Volatility	0.1684***			-1.7210			-1.0946
	(2.610)			(-1.037)			(-0.765)
Income Volatility*HHI				0.0987			0.0664
				(1.115)			(0.851)
Income Volatility*HHI^2				-0.0012			-0.0008
				(-1.086)			(-0.813)
Business Volatility	-0.0410**				0.0679		0.5403*
	(-2.199)				(0.335)		(1.833)
Business Volatility*HHI					-0.0064		-0.0311**
					(-0.615)		(-2.026)
Business Volatility*HHI^2					0.0001		0.0004**
					(0.641)		(2.089)
Reinsurance	-0.2826***					-1.1227	-1.2955
	(-4.021)					(-1.045)	(-1.229)
Reinsurance*HHI						0.0401	0.0497
						(0.717)	(0.904)
Reinsurance*HHI^2						-0.0005	-0.0006
						(-0.690)	(-0.821)
Cost of Equity	-0.0046	-0.0091*	-0.0073	-0.0083	-0.0077	-0.0061	-0.0041
	(-0.717)	(-1.653)	(-1.338)	(-1.509)	(-1.455)	(-0.959)	(-0.636)
Firm Size	-0.4517**	-0.2693*	-0.2486*	-0.2843*	-0.4021**	-0.4026**	-0.4513**
	(-2.425)	(-1.873)	(-1.692)	(-1.924)	(-2.526)	(-2.224)	(-2.418)
Liquidity	-0.0022	0.0614	0.0483	0.0775	0.0358	-0.0290	-0.0049
	(-0.035)	(1.037)	(0.804)	(1.392)	(0.534)	(-0.402)	(-0.081)
Investment Return	0.2331***	0.1143***	0.1131***	0.1156***	0.1068***	0.2353***	0.2325***
	(6.167)	(2.792)	(2.764)	(2.779)	(2.666)	(5.950)	(6.168)
Tax Payment	-0.0016	-0.0160	0.0065	-0.0187	-0.0150	-0.0167	-0.0027
	(-0.160)	(-0.982)	(0.416)	(-1.186)	(-0.976)	(-1.374)	(-0.249)
Interest rate	0.0728**	0.1160***	0.1281***	0.1046***	0.1195***	0.0711**	0.0717**
	(2.488)	(4.826)	(5.286)	(4.275)	(4.407)	(2.583)	(2.442)
Inflation Rate	-0.0453	-0.0345	-0.0350	-0.0550	-0.0382	-0.0439	-0.0515
	(-0.916)	(-0.667)	(-0.692)	(-1.082)	(-0.722)	(-0.869)	(-0.989)
GDP Growth	0.0054	-0.0101	-0.0136	-0.0011	-0.0210	0.0040	0.0051
	(0.277)	(-0.625)	(-0.835)	(-0.058)	(-1.319)	(0.221)	(0.252)
Constant	4.8699**	3.3663**	2.9225	7.2941***	5.4414**	2.7261	4.5063
	(2.543)	(2.394)	(1.510)	(2.638)	(2.507)	(0.962)	(1.163)
Observations	3,511	4,519	4,471	4,495	4,151	3,665	3,511
Number of Firms	533	616	613	615	587	548	533
Adjusted R-squared	0.208	0.160	0.170	0.166	0.135	0.187	0.209
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	13.93	7.11	7.32	8.6	6.17	9.91	9.423

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A3.9b: Interacted Effects with HHI^2 on Capital Structure - GMM

VARIABLES	(6) Leverage	(1) Leverage	(2) Leverage	(3) Leverage	(4) Leverage	(5) Leverage	(6) Leverage
Lagged Leverage	0.2407***	5.4956**	0.3432***	0.2235***	0.5880***	0.5046***	8.7402*
	(3.138)	(2.061)	(3.268)	(2.814)	(4.984)	(4.837)	(1.802)
HHI	-0.1090*	0.2541	0.2484	-1.0666*	-0.2969**	-0.4949**	-1.3018*
	(-1.819)	(1.461)	(1.182)	(-1.930)	(-2.094)	(-2.482)	(-1.663)
HHI^2	0.0013*	-0.0036	-0.0031	0.0136**	0.0036**	0.0061**	0.0146
	(1.704)	(-1.520)	(-1.206)	(1.988)	(2.065)	(2.369)	(1.488)
L. Leverage*HHI		-0.2775*					-0.4877*
		(-1.789)					(-1.769)
L.Leverage*HHI^2		0.0039*					0.0065*
		(1.794)					(1.675)
Retained Earnings	-0.3511**		4.9098**				-0.7954
	(-1.997)		(2.195)				(-0.235)
R. Earnings*HHI			-0.2838**				0.0364
			(-2.341)				(0.198)
R. Earnings*HHI^2			0.0038**				-0.0004
			(2.397)				(-0.168)
Income Volatility	0.4614***			-9.0182			-14.4273***
	(3.757)			(-1.577)			(-2.832)
I. Volatility*HHI				0.5013*			0.7497***
				(1.682)			(2.854)
I. Volatility*HHI^2				-0.0066*			-0.0091***
				(-1.744)			(-2.773)
Business Volatility	-0.1933**				-1.0134*		0.1291
	(-1.971)				(-1.841)		(0.177)
B. Volatility*HHI					0.0516*		-0.0106
					(1.788)		(-0.285)
B. Volatility*HHI^2					-0.0006*		0.0002
					(-1.759)		(0.323)
Reinsurance	-0.2908**					4.3457**	2.1936
	(-2.416)					(2.191)	(0.629)
Rein.*HHI						-0.2186**	-0.1478
						(-2.138)	(-0.831)
Rein.*HHI^2						0.0027**	0.0019
						(2.003)	(0.804)
Cost of Equity	0.0051	-0.0085	0.0248	0.0075	-0.0288	-0.0086	-0.0324**
	(0.695)	(-1.583)	(1.482)	(0.798)	(-1.560)	(-0.630)	(-1.986)
Firm Size	-0.0176	0.4195*	-0.3512*	0.3581***	0.1343	-0.0914	-0.1172
	(-0.137)	(1.953)	(-1.879)	(3.102)	(0.695)	(-0.629)	(-0.373)
Liquidity	-0.0057	-0.1171	0.0796	0.1929	0.1454	0.1093	0.2659
	(-0.030)	(-0.281)	(0.914)	(1.302)	(1.053)	(0.882)	(1.480)
Investment Return	0.2343***	0.0403	0.1153**	0.0975	0.2625**	0.3036***	0.3198***
	(2.866)	(0.301)	(2.275)	(1.575)	(2.359)	(6.325)	(6.461)
Tax Payment	0.0617	-0.2756	0.0931	-0.0435	0.0085	0.0030	0.0037
	(0.758)	(-1.003)	(0.968)	(-1.069)	(0.342)	(0.333)	(0.025)
Interest rate	-0.0201	0.0250	0.1027**	0.0322	0.0624	0.0518	0.0407
	(-0.566)	(1.063)	(2.494)	(0.818)	(1.344)	(1.143)	(0.689)
Inflation Rate	-0.0624	-0.0100	-0.0648	-0.2108**	-0.0021	0.0644	-0.0885
	(-1.380)	(-0.234)	(-0.699)	(-2.345)	(-0.025)	(0.780)	(-0.850)
GDP Growth	0.0209	0.0102	0.0011	0.0128	-0.0152	0.0013	0.0181
	(1.039)	(0.731)	(0.040)	(0.428)	(-0.710)	(0.062)	(0.374)
Stock		0.9301	1.1232	0.3088	0.0487	0.2384	0.6361
		(1.033)	(0.600)	(0.346)	(0.145)	(0.761)	(1.212)
Constant	2.2964	-8.1871**	-2.0853	18.0616*	5.6421	11.0125***	28.5189*
	(1.371)	(-2.398)	(-0.517)	(1.663)	(1.474)	(2.682)	(1.787)
Observations	3,511	4,519	4,471	4,495	3,821	3,354	3,511
Number of Firms	533	616	613	615	534	493	533
Instruments	183	87	151	161	152	131	349
Robust	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test	4.885***	16.09***	4.343***	6.121***	8.671***	14.91***	6.166***
AR(1)	-3.023***	-3.938***	-3.250***	-3.198***	-3.171***	-3.217***	-1.786*
AR(2)	0.480	1.424	0.434	0.664	1.208	1.496	-0.0449
Hansen Test	188.9 (0.12)	85.30 (0.135)	151.3 (0.16)	165.3 (0.18)	147.9 (0.23)	120.5 (0.34)	329.4 (0.38)

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Appendix 4

Table A4.1: Individual effects on Z-score components ROTA-OLS

VARIABLES	(1) Performance ROTA	(2) Leverage ROTA	(3) Reinsurance ROTA	(4) Liquidity Risk ROTA	(5) Underwriting Cycle ROTA	(6) All ROTA
Profit Efficiency	19.5360***					17.7573***
	(8.627)					(8.965)
Leverage		-0.0063***				-0.0060***
		(-5.742)				(-13.110)
Reinsurance			-6.5901			-4.7241
			(-1.501)			(-1.558)
Liquidity Risk				0.0137**		0.0192***
				(2.039)		(5.388)
Underwriting Cycle					-2.9708*	-1.4573
					(-1.848)	(-1.414)
Firm Size	0.9126	-15.1894	-19.3051	-12.9604	-12.7843	-18.1301**
	(0.062)	(-0.641)	(-0.875)	(-0.645)	(-0.644)	(-1.979)
Squared Size	-0.1452	0.7871	1.0337	0.6991	0.6883	0.8666*
	(-0.183)	(0.581)	(0.816)	(0.602)	(0.600)	(1.702)
Premium Growth Rate	-0.0042	0.2204**	0.2394**	0.2104**	0.2419**	-0.0137
	(-0.065)	(2.210)	(2.482)	(2.283)	(2.575)	(-0.193)
Business Volatility	0.7715	-0.5177	-0.6997*	-0.3614	-0.3945	0.4870
	(1.635)	(-1.053)	(-1.759)	(-0.857)	(-0.941)	(1.286)
Interest Rate Change	0.1609*	0.1099	0.0329	0.1516	0.0426	0.0503
	(1.709)	(0.836)	(0.278)	(1.349)	(0.347)	(0.508)
GDP Growth	-0.0789	0.0187	-0.0219	-0.0378	-0.1554	-0.2067*
	(-0.763)	(0.115)	(-0.135)	(-0.264)	(-1.072)	(-1.895)
Constant	-0.8508	75.2824	94.0345	61.4069	72.1715	94.5699**
	(-0.013)	(0.758)	(1.002)	(0.735)	(0.858)	(2.361)
Observations	666	859	952	996	1,009	583
Number of Insurers	325	377	391	413	423	285
Adjusted R-squared	0.219	0.011	0.024	0.007	0.011	0.281
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	14.94***	5.83***	1.86***	20.53***	1.93***	571879***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A4.2: Individual effects on Z-score components SD ROTA -OLS

VARIABLES	(1) Performance SD ROTA	(2) Leverage SD ROTA	(3) Reinsurance SD ROTA	(4) Liquidity Risk SD ROTA	(5) Underwriting Cycle SD ROTA	(6) All SD ROTA
Profit Efficiency	3.0428*					0.8300
	(1.897)					(0.608)
Leverage		-0.0018				-0.0063***
		(-0.552)				(-33.435)
Reinsurance			-2.0459			-0.1168
			(-0.865)			(-0.054)
Liquidity Risk				-0.0044		-0.0029
				(-0.954)		(-0.788)
Underwriting Cycle					-2.3442**	-1.1375
					(-2.266)	(-1.443)
Firm Size	2.9006	-8.6711	-12.1276	-8.7077	-5.2654	-4.2133
	(0.374)	(-0.786)	(-1.123)	(-0.870)	(-0.838)	(-0.604)
Squared Size	-0.1958	0.4944	0.6563	0.4720	0.2729	0.1877
	(-0.454)	(0.763)	(1.042)	(0.804)	(0.725)	(0.474)
Premium Growth Rate	0.0292	0.0487	0.0644	0.0669	0.0851	0.0688
	(0.490)	(0.759)	(0.786)	(0.845)	(1.059)	(1.039)
Business Volatility	1.6255***	1.8680***	1.5424***	1.6404***	1.6208***	1.4395***
	(5.545)	(6.736)	(6.385)	(6.392)	(6.441)	(5.557)
Interest Rate Change	0.1797**	0.0770	0.0477	0.0918	0.0149	0.1453
	(2.083)	(0.963)	(0.552)	(1.152)	(0.191)	(1.543)
GDP Growth	-0.0174	0.0501	-0.1537	-0.1472	-0.2442	-0.0862
	(-0.200)	(0.480)	(-0.718)	(-0.731)	(-1.159)	(-1.196)
Constant	-11.3342	36.1461	55.5983	39.1297	33.8573	26.4079
	(-0.333)	(0.807)	(1.226)	(0.956)	(1.260)	(0.881)
Observations	666	860	955	998	1,012	583
Number of Insurers	325	377	393	414	424	285
Adjusted R-squared	0.176	0.066	0.051	0.049	0.052	0.175
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	6.92***	9.65***	10.91***	20.2***	11.29***	1234***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A4.3: Individual effects on Z-score components CAPITAL -OLS

VARIABLES	(1) Performance CAPITAL	(2) Leverage CAPITAL	(3) Reinsurance CAPITAL	(4) Liquidity Risk CAPITAL	(5) Underwriting Cycle CAPITAL	(6) All CAPITAL
Profit Efficiency	0.0369					-0.0047
	(0.539)					(-0.100)
Leverage		-0.0001***				-0.0002**
		(-3.560)				(-2.272)
Reinsurance			-0.0416			-0.1102**
			(-1.287)			(-2.277)
Liquidity Risk				0.0002*		0.0002
				(1.687)		(0.403)
Underwriting Cycle					0.0553**	-0.0059
					(2.301)	(-0.303)
Firm Size	-0.1117	-0.0610	0.0410	-0.0257	-0.0411	-0.0386
	(-0.611)	(-0.581)	(0.393)	(-0.255)	(-0.444)	(-0.399)
Squared Size	0.0020	-0.0020	-0.0073	-0.0037	-0.0029	-0.0024
	(0.199)	(-0.324)	(-1.212)	(-0.629)	(-0.542)	(-0.432)
Premium Growth Rate	-0.0016	-0.0000	0.0000	-0.0004	-0.0009	-0.0012
	(-1.422)	(-0.046)	(0.022)	(-0.297)	(-0.753)	(-0.938)
Business Volatility	-0.0168**	-0.0210***	-0.0207***	-0.0212***	-0.0211***	-0.0094*
	(-2.185)	(-3.341)	(-3.387)	(-3.526)	(-3.561)	(-1.748)
Interest Rate Change	-0.0013	-0.0015	-0.0008	-0.0013	0.0003	-0.0004
	(-0.812)	(-1.158)	(-0.660)	(-1.105)	(0.195)	(-0.260)
GDP Growth	-0.0038	-0.0058***	-0.0044**	-0.0051***	-0.0027	-0.0050**
	(-1.617)	(-3.356)	(-2.318)	(-2.678)	(-1.400)	(-1.992)
Constant	1.1143	1.0350**	0.5230	0.8156*	0.6724	0.8933**
	(1.364)	(2.369)	(1.168)	(1.895)	(1.639)	(2.106)
Observations	666	860	952	996	1,009	583
Number of Insurers	325	377	391	414	424	285
Adjusted R-squared	0.127	0.209	0.129	0.150	0.168	-0.703
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
F-test	5.13***	9.37***	5.76***	6.31***	7.35***	4.982***

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Measurement of Stability Efficiency

The stability efficiency can be estimated by using Kumbhakar, Lien and Hardaker's (2014) Stochastic Frontier Analysis, as followed:

$$\ln Z - score_{it} = \alpha_0 + \sum_{g}^{2} \alpha_g \ln Q_{igt} + \sum_{j}^{3} \beta_j \ln P_{ijt} + \frac{1}{2}\left[\sum_{g}^{2}\sum_{k}^{2} \alpha_{gk} \ln Q_{igt} \ln Q_{ikt} + \sum_{j}^{3}\sum_{h}^{3} \beta_{jh} \ln P_{ijt} \ln P_{iht}\right] + \sum_{g}^{2}\sum_{j}^{3} \delta_{gj} \ln Q_{igt} \ln P_{ijt} + \mu_1 T + \frac{1}{2}\mu_2 T^2 + \sum_{g}^{2} \rho_g T \ln Q_{igt} + \sum_{g}^{2} \rho_g T \ln Q_{igt} + \sum_{j}^{3} \xi_j T \ln P_{ijt} + \mu_i + v_{it} - \tau_{it} - \mathrm{u}_{it}$$

Equation (A4.1)

where, $Z - score_{\mathrm{it}}$ represents insurer's stability at time t. The term μ_i is the heterogeneity effect, which vary across firms only; v_{it} is the random shock (or statistical noise) and τ_i represents the persistent inefficiency. u_{it} is time-varying inefficiency, which is the stability inefficiency. Consistence with value-added approach and insurance litertures (Cummins, Rubio-Misas and Zi, 2004; Hao and Chou, 2005; Cummins and Rubio-Misas, 2006; Yaisawarng, Asavadachanukorn and Yaisawarng, 2014), the outputs, Q_{igt}, is defined as net claims paid (claims incurred net of reinsurance) and total investment; and P_{ijt} measures the three input prices, i.e. labor, capital and technical reserves. The time trend variable (T) captures the changes over time in technology. The procedure amounts to using one of the input prices (e.g., P_{3it}) to normalized Z-score and other input price. Equation (A4.1) is in the translog form , and both Jondrow *et al.* (1982) and Battese and Coelli (1988)'s methods can be used to find the stability inefficiency and stability efficiency score, respectively.