UNIVERSITY OF SUSSEX

Firms and Trade in Downturns

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Submitted for the degree of Doctor of Philosophy

Department of Economics

University of Sussex

May 2016

Acknowledgements

Submitting a PhD thesis consists of the very last moment of a long period of maturation and growth, from both a personal and an academic perspective. In my case the gestation lasted over four years and for being at the stage of accomplishing this last step I must extend my gratitude to several people. Working towards the achievement of this Doctorate of Philosophy has been, in fact, a process for which the inputs and the collaboration of several individuals has not only been beneficial, but essential.

I must primarily thank my supervisors, L. Alan Winters and Dimitra Petropoulou, with whom I am deeply indebted for their invaluable and tireless guidance throughout the entire period of my PhD. I enjoyed the privilege to be able to concentrate and work at my thesis with a constant peace of mind, having been able to rely on their support, advice and encouragement at any moment. From both Alan and Dimitra I have received indispensable inputs from which I will benefit for my entire career. I have learnt from them how to approach and interact in the academic environment, how to formulate and address relevant research ideas both theoretically and empirically and, most importantly, how to embrace the profession as an economist in a competent and rigorous way.

I could not have been writing this acknowledgement pages without the key intervention of Pierluigi Montalbano. From Pierluigi I received my first economics lectures, and an excellent supervision for my undergraduate dissertation. His biggest contribution has been, however, to stimulate my interest in this discipline and to stir my studies in direction of the Department of Economics at Sussex. Without his precious advice I would have not pursued this path.

At the Department of Economics at Sussex, I need then to extend my gratitude to many of the faculty members, with whom I had insightful conversations about my work and that contributed to the final thesis in a significant way. Among many, I expressly thank Barry Reilly, Paolo Masella, Ingo Borchert and Michael Gasiorek.

I am also extremely grateful to the Department of Economics at Sussex, for providing me with the financial means needed to sustain my living expenses in Brighton, in addition to attending several international conferences during the past years. The Department extended its financial support even further, funding my research trips to the Statistical Office in Slovenia, where I performed the empirical analysis for this thesis. The roles of Andrew Newell and Richard Dickens, as Heads of Department during my stay at Sussex, were essential for the realization of my projects.

For the data preparation and access in Slovenia, I am grateful to the Statistical Office of the Republic of Slovenia, which hosted me and allowed me to visit the Secure Rooms in which the analysis was carried out.

The years in Brighton have not only been exclusively about work and research, and for the much needed diversion from my thesis I could rely on many good friends whose company and support helped lightening the PhD years. Thanks Amrita, Antonia, Egidio, Elsa, Eva, Gabriele, Hector, Marco, Michela, Nicola, and Yashodhan for the countless reunions, dinners, (long and shorter) trips, sports and all the rest that allowed me to endure over these years in a happy and relaxed state of mind. I found great colleagues in you, but without doubt, I found a group of close friends that will survive our respective PhD journeys.

A special mention goes to Cinzia, my partner in life since three years and who experienced the goods and the bads of a relation with an aspiring PhD. Without her moral support and rational advice I would have struggled a great deal more to complete this work. Pursuing a career as a researcher necessitates having someone like her on one's side.

Finally, this thesis is dedicated to my family. My parents Giuseppe and Christine, together with my brother Flavio, have not only provided me with the means to reach where I am today, but with their unconditional love and trust in my ability they granted me with the essential building block that everyone needs to succeed in life.

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Firms and Trade in Downturns

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Abstract

My research lies at the intersection of international trade and industrial economics. I contribute to the firms and trade literature, both empirically and theoretically, focusing on the impact of the financial crisis of 2008-09 on various dimensions of firms' activities. In particular, I study the response of international trade to the shock, focusing on the reaction of importers to the reduction in demand. Additionally, I explore the impact of the crisis on firms' innovation decisions, together with the implications of this for firms' export participation. I pursue these avenues of research as the Great Recession constituted a large shock, impacting severely various aspects of firms' operations. This allowed me to study the impacts of the fall in demand on trade, and the effects of liquidity scarcity on innovation and exporting.

In Chapter 2 I exploit detailed Slovenian custom data to explore the product dimension of the trade crisis. I find that imports of inputs accounting for a larger share of firms' costs underwent an enhanced reaction during the event. This finding is explained with an inventory adjustment model which predicts a more than proportionate adjustment for high cost-share inputs because of their higher storage costs. In the Chapter 3 and 4, I concentrate on the effects of the 2008 crisis on firms' innovation decisions and selection into exporting. I augment the Melitz and Ottaviano (2008) framework to include process innovation subject to liquidity constraints, and show that a reduction in liquidity for innovation has opposing outcomes on innovators and exporters: innovative activity is reduced but entry into exporting is stimulated by a reduction in the industry-wide degree of competition. Evidence supporting these theoretical predictions is found in an empirical analysis with Slovenian firm level data in Chapter 4.

1 Introduction

The research constituting this thesis is dedicated to the study of the impact of the 2008-2009 financial crisis on various dimensions of firms' activities. The perspective of my analysis places this work at the intersection of international trade and industrial economics. In particular, I focus on the response of international trade to the shock, examining the reaction of importers to the reduction in demand. Additionally, I am also interested in the effects of the crisis on firms' innovation decisions, together with the implications of this for firms' export participation.

The main motivation for placing the lense of my analysis on the Great Recession is that this period constituted a large, arguably exogenous, shock which severely affected firms' operations in numerous ways. This specific event allows me to study the effects of the fall in demand on trade, and the effects of liquidity scarcity on innovation and exporting. More broadly, this thesis contributes to a deeper understanding of the multi-faceted challenges that importers, exporters an innovators face due to imperfections in financial markets.

In Chapter 2, *Product cost-share: a Catalyst of the Trade Collapse,* I exploit detailed custom transaction-level data for Slovenia[1], to explore the product dimension of the trade crisis. Despite a rich literature which studies the dramatic reduction in world trade triggered by the crisis of 2008-09, no work to date has investigated the responsiveness of different intermediates imported by firms according to their share in firms' costs. I uncover a new source of heterogeity in the response of firms to the crisis, namely that imports of higher cost-share inputs underwent a more pronounced reaction in both the downturn and recovery phases of the collapse. I find that a 10 percentage points increase in the cost-share is associated with a 1 percentage point deeper drop of imports in the downturn and a 0.59 percentage point larger rebound in the recovery, accounting for 7.6% and 19% of the average growth in the two sub-periods.

I explain this empirical finding with a simple model of inventory adjustment, based on Arrow *et al.* (1951). This model sees firms optimizing the stock of inventories in an attempt to minimizing storage costs. In a trade crisis, firms may adjust purchases of high cost-share inputs differently from low cost-share inputs if, for instance, in the attempt to retain liquidity firms reduce their working capital targets and destock inventories, with higher cost-

[1] Only a few authors have exploited the Slovenian data (De Loecker 2007, De Loecker & Warzynski 2012 are prominent examples), but the richness of the dataset has hitherto not been fully exploited.

share products being more sensitive to the adjustment. The intuition behind this mechanism is that, regardless of whether the products stored consist of materials for a manufacturer or finished goods for a retailer, higher cost-share products might be stocked in lower amounts if their storage cost is higher than that for lower cost-share products. This leads to a larger adjustment, in proportional terms, to a fall in demand for these inputs[2]. The predictions of the model are supported empirically by estimates from reduced form equations.

Importantly, all these results are robust to controlling for whether transactions are undertaken by independent suppliers (arm's length trade), or whether they are performed within the firm boundaries (intra-firm). Interestingly, I find that for higher cost-share products, intra-firm trade acted as a further accelerating factor. This can be explained again with reference to an inventory mechanism, where multinationals store a lower amount of inventory[3], which is in turn more sensitive to a change in input demand.

Overall, the research in Chapter 2 points to the cost-share of intermediates as a key factor for firms attempting to downsize activity and trade in a recessionary environment.

The contributions of the remaining two substantive chapters of this thesis are tightly knit together. In these, I concentrate on the effects of the 2008 crisis on firms' innovation output and on the interaction of innovation with participation in the export market. Chapter 3, *The Effect of Liquidity Constrained Innovation on Exporting,* explores this topic theoretically, whereas Chapter 4, *From Innovation to Exporting in Times of Crisis: Evidence from Slovenia*, tests empirically the prediction of the theoretical model.

Chapter 3 extends the Melitz-Ottaviano (2008) heterogeneous firms' framework by introducing process innovation, subject to liquidity constraints, on the supply side of the model. Firms pay a fixed cost to access innovation and only those firms with sufficient internal liquidity are able to do so. The most productive firms select into innovation, but there is a set of firms that could profitably innovate and are prevented from doing so due to insufficient internal liquidity. The model shows that if external liquidity is suddently reduced, i.e. liquidity constraints become more binding, access to innovation becomes more selective and the level of product market competition is reduced: this imparts a shock with opposing outcomes to firms at different points of the productivity distribution, which reallocates market shares

[2] This results applies even if demand were to fall by the same proportion on all inputs, e.g., for a manufacturer whose production function is Leontief and uses inputs in fixed proportions, because the adjustment is calculated relative to the amount stored, which is lower for higher cost-share items.

[3] This scenario is plausible if, for instance, multinationals facing higher opportunity cost for storing inventories, or are able to adjust more promptly to shocks because of a more effective management of the information stream.

from firms in the middle range of the productivity distribution to both the most and the least efficient producers. The reduction in innovative activity results, therefore, in more entry into the domestic market and, in a scenario where the shock to innovation is symmetric across trading partners, in a lower productivity threshold to access exporting. In the aftermath of this shock, the model predicts an industry populated by firms that are, on average, less productive and that charge higher prices and higher markups.

This analysis shows how a sudden tightening in external liquidity for innovative firms can provoke a loss in innovation output and efficiency but, at the same time, through its anti-competitive effect, a positive indirect effect on entry into exporting.

These theoretical predictions are tested empirically in the Chapter 4 of the thesis, where I exploit again Slovenian firm level balance sheet data, matched with innovation surveys (CIS) and firm level trade data. Due to the endogenous links and simultaneous determination of the main variables under analysis an indirect test of these proposition is performed. External finance on one side, and innovation and exporting on the other, tend to be subject to both reverse causality and omitted variabale biases; futhermore there is vast literature studying the deep interconnections between exposure to trade and investment in innovation (among many others, Bustos, 2011; Bloom et al., 2015; Becker and Egger, 2013; Damijan et al., 2010). For these reasons the analysis exploits a difference-in-difference strategy, whereby I estimate that in sectors characterized by higher vulnerability to a shock to external finance for innovation, the 2008-09 financial crisis reduced the probability of innovating and increased the probability of exporting, relative to sectors characterised by lower external financing vulnerability. These results are robust to controlling for the availability and use of internal financial resources.

Additionally, firms' markups, computed by exploiting the De Loecker and Warzinsky (2012) procedure, are found to have increased by more in sectors where the reduction in the probability of innovating was larger. It is important to note that conditioning on markups dampens significantly the impact of the shock to innovation on exporting. This supports the rationale that the better exporting perfomance estimated in sectors characterized by higher external financing needs for innovation, was indeed mediated by the anti-competitive effects resulting from the reduction in innovation, that I pick up by controlling for firms' markups.

Finally, the decomposition of the shock across quartiles of the firm size and productivity distributions shows that the negative impact on innovation and the positive impact on exporting were highest in the middle range of the distribution, as predicted by the theoretical framework of Chapter 3.

The rest of this thesis is organised as follows. In the next section, I describe the Slovenian data exploited throughout the thesis. Subsequently, each of the following sections presents a Chapter: Section 2 I is dedicated to *Product cost-share: a Catalyst of the Trade Collapse*; Section 3 consists of the theoretical chapter on *The Effect of Liquidity Constrained Innovation on Exporting* and Section 4 presents *From Innovation to Exporting in Times of Crisis: Evidence from Slovenia*. Section 5 concludes.

1.1 The Slovenian Data

The data that I exploit in this thesis are rich firm level datasets from various Slovenian sources, all strictly protected by statistical confidentiality. In particular, the datasets that I received access to are:

(a.) External Trade data: the Statistical Office (*SURS*) and the Custom Administration (*CARS*) provide transaction-level data, recording all foreign transactions of Slovenian firms, at a monthly frequency, disaggregated at the Combined Nomenclature (CN) 8-digit level. For each shipment I extracted the value of the imported and exported product in EUR currency, the physical quantity in units of output (pieces or kilograms), the *CN* and the Broad Economic Categories (*BEC*) codes, the origin and destination ISO country codes. I obtained data spanning from 2000 to 2012.

(b.) Firm characteristics: the Agency of the Republic of Slovenia for Public Legal Records (*AJPES*) provides balance-sheet and income statements for all Slovenian firms, on a census basis. These data include complete financial and operational information, among which sales; costs of intermediate goods, labour, materials and services; operating profits and losses; the value of total, current and fixed tangible assets (the latter was used as a measure of physical capital); depreciation; short term operating receivables and liabilities; the NACE 4-digit industry code. The time span for balance sheet data is 1994-2012.

(c.) Community Innovation Surveys (CIS): these are biannual surveys investigating the innovative behaviour of enterprises, carried out by EU members on a voluntary basis. In Slovenia the survey is carried out by the Statistical Office *(SURS)*, and data are collected through a combination of a stratified sample for firms between 10-49 employees and a census survey for bigger firms, covering about 2,200 firms in each survey. In the third chapter of this thesis I used the last seven innovation surveys, carried out between 2000 and 2012:

CIS3, Statistical Report on Innovation Activity 2002, CIS4, CIS2006, CIS2008, CIS2010, CIS2012. The CIS is a harmonised survey designed by Eurostat to provide information on the innovativeness of sectors by type of enterprises, on the different types of innovation and on various aspects of the development of an innovation, such as the objectives, the sources of information, the public funding, the innovation expenditures and the obstacles encountered.

The data from all three sources can be matched using a common firm identifier.

Besides these three main Slovenian sources, I also extracted information from the ownership database of ORBIS (Bureau Van Dijk) and Compustat: I will describe these sources in more detail the data sections of the respective chapters to which they relate.

I obtained access to the Slovenian protected microdata by signing a confidentiality agreement, which required that all the analysis needed to be conducted in the Secure Rooms at the Statistical Office of the Republic of Slovenia, in Ljubljana. The benefit of being able to use these extremely rich data came at the cost of having to perform the analysis within a strictly limited time and by using the computers and statistical software provided at the Statistical Office. The time constraint, in particular, forced me to focus the analysis on its main objectives, over five trips to Slovenia. Nonetheless the difficulties and the organizational challenges that accessing the Slovenian data implied, I am extremely grateful to the Department of Economics at the University of Sussex for the financial support provided for my stay in Ljubljana and to the Statistical Office of the Republic of Slovenia for data preparation and access.

2 Product cost-share: a Catalyst of the Trade Collapse

2.1 Introduction

The 2008-2009 great recession was characterized by a dramatic collapse in international trade. This reduction in world trade attracted considerable attention, both because of the unprecedented size of the fall – a 30% reduction from September 2008 to January 2009 with respect to the 3% drop in GDP (Bricongne *et al.* 2012) – and because of its suddenness and homogeneity across OECD countries (Baldwin and Evenett 2009). Levchenko *et al.* (2010) confirm the exceptionality of this episode detecting a 40% shortfall in imports by examining the deviations of the trade time-series from the norm[4]. This unexpected collapse raises important questions and the literature that has emerged points to the decrease in real expenditure, the existence of vertical linkages in production and the tightening of credit supply as the main causes of the event (Bems *et al.* 2012).

This chapter contributes to the understanding of the dynamics of the trade collapse by exploring a new channel: the cost-share of imported products. In order to uncover a source of heterogeneity in the response of firms to the crisis, I examine Slovenian trade and investigate the reaction of different products, depending on their cost-share[5]. My primary aim is not, therefore, to shed light on the root causes of the trade crisis or to quantify their relative importance, but rather to identify a factor that might have amplified the reaction of imports to the demand shock caused by the financial crisis. I find that products' cost-share was associated with an increased responsiveness of trade of intermediate goods, in both the subperiods of the crisis; in other words, imports of inputs accounting for a larger cost share fell more than proportionately in the downturn and rebounded more than proportionately in the recovery. This result is robust to controlling for the impact of firm affiliation. Besides confirming the role of inputs' cost-share as a catalyst of the trade collapse, the study of the role of intra-firm and arm's length trade provides an additional contribution of this paper: intra-firm trade is not observed to perform differently compared to arm's length trade in the crisis. This latter finding differs from the results of Bernard *et al.* (2009), observing intra-firm trade of US firms to be more resilient than arm's length trade during the 1997 East-Asian crisis, and Altomonte *et al.* (2012), estimating an enhanced reaction of trade of French firms in the 2008-09 collapse when shipments took place within firms' boundaries.

I address these questions by studying the trade collapse in a small open economy, Slovenia,

[4] The demand for import as predicted by domestic absorption, domestic price and import prices.

[5] The cost-share variable is computed as the average value of an imported product with respect to firms' costs, as explained in Section 2.5.

using high frequency custom data matched with firm balance-sheet and ownership information. This highly disaggregated dataset allows a detailed examination of the trade crisis[6]. To the best of my knowledge no previous work explores the cost-share hypothesis in the trade collapse, a channel that can induce a higher elasticity of trade flows to a demand collapse and the explanation for which may lie in the dynamics of inventory adjustments.

The literature has investigated both demand and supply side factors in order to explain the collapse. On the demand side, the change in real expenditure is identified as the main factor responsible for the strong reduction in trade (Bems *et al.* 2010, 2011, 2012; Eaton *et al.* 2011, Bussière *et al.* 2013): the asymmetric reduction in expenditure across sectors, largest for the more traded goods, transmitted the demand shock heavily to the border. In the attempt to understand what caused trade to deviate from levels predicted by benchmark theoretical models, authors have studied determinants of the trade wedge[7] (Levchenko *et al.* 2010, Alessandria *et al.* 2011, Bems *et al.* 2012). A standard aggregate CES import demand equation predicts a unit elasticity of trade with respect to a change in aggregate expenditure, and candidates for the larger measured responsiveness of transactions in 2008-09 are durability of goods (Engel and Wang, 2009; Petropoulou and Soo 2011), input linkages across sectors and the adjustment of inventories, especially within Global Value Chains (Alessandria *et al.,* 2010a, 2011; Altomonte *et al.,* 2012). Global Value Chains (henceforth GVCs) are viewed as an important locus of the trade crisis, because of the large fraction of trade originating within them due the worldwide fragmentation of production (Bems *et al.* 2011). Here I analyse a mechanism that can enhance the reaction of trade to a demand shock, within GVCs[8].

On the supply side, the literature mostly points towards the role of the financial shock in impairing firms' production and exporting activities through the constrained access to working capital (Amiti and Weinstein 2011, Bricongne *et al.* 2012, Chor and Manova 2012, Paravisini *et al.* 2012, Behrens *et al.* 2013) and the reduction in trade finance (Korinek *et al.* 2010, Malouche 2011, Coulibaly *et al.* 2011, Antràs and Foley 2014). The first set of studies sought to identify the effect of reduced bank credit on firms' activity by examining pre-crisis financial vulnerability measures (e.g. external financial dependence, payment incidents) to avoid the endogenous link between credit and production decisions: they all find some evidence of harm to firms' activity by the financial shock, with this channel accounting for about 15-20% of the trade collapse. The second group of studies focused instead on the

[6] Only a few studies exploited similarly rich data sources – Bricongne *et al.* (2012) and Altomonte *et al.* (2012) for France; Behrens *et al.* (2013) for Belgium – with no study taking into account Slovenian trade, whose experience might differ from that of the other two countries.

[7] The deviation of the trade time series from the levels predicted by the evolution of domestic demand and prices.

[8] Identified by the role of intermediate goods, for which the main results are found.

importance of bank- versus firm-intermediated trade finance: the general conclusion is in favour of a moderate impact of the reduction in trade finance, especially when intermediated by banks via, for example, letters of credit. However, the case study of Antràs and Foley (2014) finds evidence of exporters relying more on cash-in-advance agreements during the crisis than in normal times, while Coulibaly *et al.* (2011) show that the behavior of firms that were able to switch to between-firm arrangements away from financial credit experienced lower declines in sales. These studies therefore attribute some relevance to firm intermediated finance for understanding the heterogeneity in responses to the financial crisis. In order to insulate the identification of the impact of products' costs-share on trade from the effects of the credit-crunch and the lack of trade finance, a proper set of firm-month-origin fixed effects is exploited in estimation.

My paper adds to this literature by unpacking the dynamics of the trade collapse along its product dimension and observing the responsiveness of shipments depending on products' cost-share. The relevance of the cost-share arises in particular for inputs used by firms in production: in a trade crisis firms may adjust purchases of high cost-share inputs differently from low cost-share inputs if, for instance, in the attempt to retain liquidity firms reduced their working capital targets and destocked inventories, with higher cost-share products being more sensitive to the adjustment. This is the mechanism that I propose as an explanatory factor of the estimated higher responsiveness of higher cost-share inputs' trade.

A secondary contribution of this paper arises from conditioning the main results on the degree of integration of the value chain. The integration via the acquisition of ownership rights creates business groups within which so-called intra-firm trade can be observed, whose dynamics are likely to differ from arm's length trade, consisting of shipments between unaffiliated firms. Multinationals could adjust more promptly to a shock for reasons such as better and faster communication and the overall lower degree of uncertainty, or else groups could show higher resilience - especially at the extensive margin - given the different cost structures and depth of integration pursued to overcome the hold-up problem (Antràs, 2003). The contemporaneous presence of offsetting channels could explain why no significantly different performance between intra-firm and arm's length trade is detected in my estimation.

Finally, the data permit to perform a detailed decomposition of trade margins, separating among the firm-, destination- and product-extensive margin and the intensive margin of Slovenian trade. These four margins are then further decomposed along the intra-firm versus arm's length dimensions, to evaluate the relative contribution of the two organisational modes of cross-border production. To my knowledge, only Bernard *et al.* (2009) separate intra-firm from arm's length trade margins, examining the East-Asian crisis of 1997, whereas no study so far decomposes trade margins considering the role of intra-firm trade in the recent crisis.

The rest of the chapter is organised as follows. Section 2.2 exposes a possible mechanism underlying the unequal trade adjustment of different products. Sections 2.3 and 2.4 present the data and describe the trade collapse for Slovenian firms. In Section 2.5, I discuss the methodology before proceeding to the exposition of the results in Section 2.6. Section 2.7 presents reduced form estimates in support of the main channel hypothesised in Section 2.2. Section 2.8 shows the results from the margin decomposition. Section 2.9 concludes.

2.2 The hypotheses

The magnified movements in international trade following the fall in sales have been explained, among other things, by the severe adjustment of inventory holdings (Alessandria *et al.* 2010a, 2011): following a negative shock to demand which is expected to persist, firms find themselves with an excessive level of inventory and therefore cut back on orders. Moreover, since firms involved in international trade hold larger stocks of inventories than domestic firms do (Alessandria 2010b), the response of trade is larger than that of production. Intuitively, since imports equal sales of imported goods plus inventory investment and both sales and inventory investment decline in a recession, imports are more volatile than sales. This amplification mechanism has the potential to explain the short-run elasticity of imports to demand shocks and the movements in the trade wedge: Alessandria *et al.* (2011) quantify it by arguing that inventory adjustments accounted for about 30% of the wedge measured for the United States and about 20% of the decline of US imports. Production chains can be an ideal locus for examining further aspects of this phenomenon. Concentration of trade relationships and rapid communication among firms along a chain of production may explain the speed of inventory adjustments and why the downsizing of trade was so synchronized and homogenous worldwide.

2.2.1 The cost-share hypothesis

The value of certain imported inputs accounts for a larger share of total costs and this can be a source of heterogeneity in the response of trade to the demand shock, potentially due to inventory adjustments. The cost-share of imported intermediates might lead firms to differentiate inventory management strategies across products: in the attempt of minimizing the cost of running the inventory system, higher purchasing and carrying costs associated with higher cost-share inputs can lead to lower inventories for these products, which therefore present a higher responsiveness to a symmetric demand reduction. This is summarised by Hypothesis 1:

> **Hypothesis 1**: *the responsiveness of trade to a shock to sales is larger for intermediates accounting for a larger share in firm's total costs.*

This hypothesis is supported by a model of inventory management[9]. I exploit the "lot size-reorder point" model, or (S, s) model, originally derived by Arrow *et al.* (1951). This model sees firms optimizing the stock of inventories in the attempt of minimising storage costs. Objective is to derive the optimal quantity S of inventory to order and the optimal reorder point r at which to place the order, given a rate of demand δ and a procurement lead time τ. The reorder point defines the safety stock s, i.e. the amount of inventory on hand when the procurement arrives. With a rate of demand δ, quantity S is depleted in time $T = S/\delta$, which denotes the length of a cycle. Optimal values for S and r minimise the cost of managing the inventory system. Under the assumptions of a fixed ordering cost A, a constant marginal purchasing cost c, a linearly rising marginal cost of sourcing and handling inventories[10] ωS^2 and an instantaneous carrying charge I proportional to the value of the stock cS and the time over which the items remain in inventory, the optimal order quantity S^* is derived. Average inventory, denoted by $\bar{S}^*$can be shown to be:

$$\bar{S}^* = \frac{S^*}{2} = \sqrt{\frac{A\delta}{2\left(cI + 2\delta\omega\right)}} \tag{1}$$

The reorder point r is derived following Hadley and Whitin (1963). If m denotes the largest integer less than or equal to τ/T, then an order is placed when the on-hand inventory reaches:

$$r^* = \delta(\tau - mT) = \delta\tau - mS^*, \tag{2}$$

while the on-hand inventory is exactly zero at the time the order arrives[11].

It follows directly from equation (1) that average inventory $\bar{S}^*$ varies inversely with the square root of the marginal cost c, so that the average inventory for high cost intermediates

[9] The model is fully elucidated in the Appendix; here I provide a summary of the main mechanism.

[10] I refer to marginal cost $\frac{d}{dS}\left(\omega S^2\right) = 2\omega S$ as "sourcing and handling cost"; this could conceivably capture a variety of factors that make the cost of holding inventories rise with the quantity stored. An example could be rising transportation costs, if the distance from suppliers increases when sourcing additional items from alternative locations that are further away. Alternatively, there may be rising labour costs, related to the operations of receiving, inspecting and handling a larger quantity of items. Also storage costs could be convex in the quantity stored (Chazai *et al.* 2008). Finally and more generally, this rising cost could capture a higher degree of complexity in coordinating the management of an increasing quantity of items stored.

[11] This rule ensures the firm has a zero safety stock s, and only if the cycle length T is not an exact multiple of the lead time τ, does the firm place the order just a bit before reaching the zero inventory floor.

is lower than for low cost intermediates. Consider two inputs h and l, where h denotes a high unit-cost intermediate and l denotes a low unit-cost intermediate, such that $c_h > c_l$. It can be shown[12] that although $\bar{S}_h^* < \bar{S}_l^*$, the higher cost input corresponds to a higher value of the stock $\bar{S}_h^* c_h$, such that $\bar{S}_h^* c_h > \bar{S}_l^* c_l$, which in turn implies a higher cost-share $\bar{S}_h^* c_h / \left(\bar{S}_h^* c_h + \bar{S}_l^* c_l\right)$. Intuitively, this is because the elasticity of average inventory quantity to cost is less than 1.

Hypothesis 1 states that a fall in demand induces a larger response of imports of higher cost-share products compared to lower cost-share ones. Since an inventory adjustment corresponds to a change in the flow of imports[13], Hypothesis 1 is confirmed in the model since $\frac{\partial(\bar{S}^* c)/\partial\delta}{\bar{S}^* c}$ is increasing in c. In particular:

$$\frac{\partial\left(\bar{S}^* c\right)/\partial\delta}{\bar{S}^* c} = \frac{1}{2\delta(1+\frac{2\delta\omega}{cI})} \quad \text{and} \quad \frac{\partial}{\partial c}\left(\frac{1}{2\delta(1+\frac{2\delta\omega}{cI})}\right) = \frac{\omega I}{\left(cI+2\delta\omega\right)^2} > 0. \tag{3}$$

The responsiveness of inventory stocks to a demand change increases in the unit-cost of the items, and therefore also in their cost-share. The intuition behind this mechanism is that, regardless of the technology used by firms in production, higher cost-share products[14] are purchased in lower amounts if their storage cost is higher than that for lower cost-share products. This leads to a larger adjustment, in proportional terms, to a fall in demand for these inputs. Notice that this result applies even if demand were to fall by the same proportion on all inputs, e.g., for a manufacturer whose production function is Leontief and uses inputs in fixed proportions, because the adjustment is calculated relative to the amount stored.

Figure 2.1 illustrates the average cost (AC) of running a single item inventory system as a function of the quantity ordered S (convex curves), together with the locus of points mapping the optimal quantity stored S^* as a function of the unit cost c (more vertical curves). A reduction in demand causes the average cost curve to shift inwards (dashed line), such that its minimum is now found at a lower level of S: this determines a reduction in the quantity of inventories ordered.

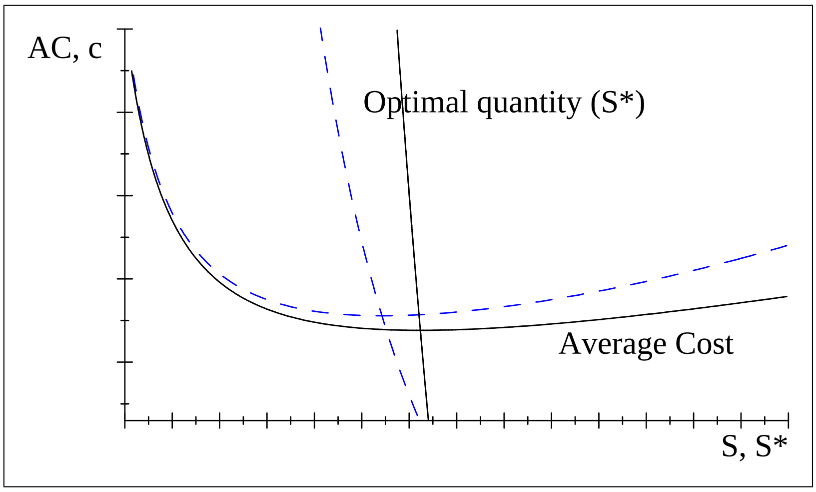
[12] See Appendix for full derivation.

[13] It is straightforward to show that the flow of imports is mononically linked to the average stock of inventories. Consider the accounting equation $M_t = S_t + (I_t - I_{t-1})$, where M_t denotes imports in year t, S_t denotes sales of imported goods, I_t denotes the stock of inventories of imported goods so that $I_t - I_{t-1}$ is inventory investment. An increase in the average stock of inventories I_t, and therefore of inventory investment, leads to an increase in the flow of imports.

[14] I cannot distinguish between price and quantity when measuring the cost-share in the data, hence a high cost-share product could either be a relatively inexpensive product purchased in large amounts, or else a relatively expensive product purchased in small amounts

The optimal quantity curve shows instead two facts: first, that regardless of the demand rate, higher cost items are ordered in lower amounts; secondly and more crucially, that a change in the demand rate causes a change in the slope of the optimal quantity curve, indicating that higher cost items see their optimal quantity reduced in a way which is more than proportionate relative to lower cost items.

Figure 2.1: Average cost of managing the inventory system, and optimal quantity stored.



This more than proportionate adjustment of higher cost-share products "accelerates" the reaction of imports during a crisis, conferring to the cost-share a role of *catalyst* of the collapse. This mechanism can find an explanation in the attempt of firms to absorb shocks to internal liquidity through changes in inventory investment. Carpenter *et al.* (1994) find systematic evidence of this behaviour for three US recessions throughout the 1980s, whereas for the 2008-09 event Udenio *et al.* (2015) confirm that firms' willingness to retain liquidity prompted a reduction in working capital targets, mostly accounted for by inventory liquidation. The downsizing of inventory levels could have therefore been more sensitive to the demand collapse when involving higher-cost share inputs.

The intra-firm versus arm's length effect The responsiveness of different products could potentially differ depending on firm affiliation: due to inventory adjustments, various mechanisms can explain a differential response of intra-firm versus arm's length trade. In the language of the (S, s) model exposed in section 2.1, multinationals might order a lower quantity S of inventories even in good times if they can be assumed to be subject to a higher carrying charge I. The carrying charge mostly captures the cost of capital; i.e. the opportunity cost of investing in inventories rather than in interest bearing assets. It is conceivable that this opportunity cost is larger for firms belonging to groups, because of their greater ability to differentiate their investments of different kinds and their deeper involvement in financial markets. To see this consider that:

$$\frac{\partial\left(\bar{S}^{*}c\right)/\partial\delta}{\bar{S}^{*}c}=\frac{1}{2\delta(1+\frac{2\delta\omega}{cI})}\quad and\quad \frac{\partial}{\partial I}\left(\frac{1}{2\delta(1+\frac{2\delta\omega}{cI})}\right)=\frac{cw}{(cI+2dw)^{2}}>0. \tag{4}$$

Equation (4) shows that, regardless of the unit-cost of the items, the responsiveness of the stock of inventories to a demand shock is increasing in the carrying charge I.

Alternatively, and more simply, intra-firm trade might show a more pronounced reaction to a drop in demand because of the faster and more effective management of the information stream between trade partners belonging to the same business group (Altomonte *et al.*, 2012). Both these mechanisms would lead to an accelerated reaction of international trade during the financial crisis of 2008-09, conferring also to intra-firm trade a role of *catalyst* of the trade collapse.

> **Hypothesis 2:** *intra-firm trade of intermediates accelerates the reaction of trade to a shock to sales, compared to arm's length trade.*

A word of caution is due here: alternative mechanisms that explain a differential reaction between intra-firm and arm's length trade to a demand collapse are conceivable, even though they would be harder to rationalize within the stylized example offered by the (S, s) model[15]. The findings reported in the empirical section are, in fact, consistent with this theoretical framework, but, with the data at hand, other explanations cannot be ruled out.

2.3 Data

The analysis necessitates high frequency transaction-level trade data matched with ownership information. The availability of this kind of data is restricted to a limited set of countries; here I look at Slovenia.

Slovenia is a small, open and fast developing economy, with well-established trade and production relations with the major European countries, besides the group of ex-Yugoslavian economies. The European process of east-west integration triggered the emergence of international networks of production, involving states of Central and Eastern Europe (CEECs) and Western European economies, mainly Germany and Italy. A further statistic confirming the relevance of *GVCs* for this country is that Slovenian trade is dominated by intermediate

[15] If intra-firm trade was more resilent during the trade collapse, as found by Bernard *et al.* (2009) for the East Asian crises of 1997, it would impart an effect of opposite sign, compared to the cost-share hypothesis, to shipments of intermediates in a recessionary environment. Alternatively, the two factors would show a cumulative effect if both the cost-share and firm affiliation acted as *catalysts* during the 2008-09 event. The interaction of the two channels is, therefore, also explored empirically.

goods (72% of imports). Looking deeply at the trade dynamics for this particular country appears therefore of interest. I use matched datasets from three sources:

a. Trade data: the Slovenian Custom Administration (*CARS*) provide transaction-level data, recording all foreign transactions of Slovenian firms, at a monthly frequency, at the CN-8 level. For each shipment I extracted the value of imported and exported product in EUR currency, the physical quantity in units of output (pieces or kilograms), the *CN* and the Broad Economic Categories (*BEC*) codes and origin country codes.

b. Firm characteristics: the Statistical Office (*SURS*) provides balance-sheet and income statements for all Slovenian firms.

c. Ownership: this information is extracted from *ORBIS* (Bureau Van Dijk). This database allows to track the proprietary network of affiliates belonging to the same headquarter and located worldwide, up to the 10th level of subsidiarity[16]. I identify, for each firm, whether it belongs to a Slovenian or a foreign multinational group, or whether it is an independent firm. If transactions are undertaken by independent firms there is no doubt that this is arm's length trade, but shipments by Slovenian affiliates can include both a component of trade with related parties and a component with non-related parties. To solve this problem I follow the approach of Altomonte *et al.* (2012). Bas and Carluccio (2009) show that 88% of trade by affiliates to/from a certain destination/origin is made either by following a pure arm's length or a pure intra-firm strategy, with the remaining 12% following a mixed strategy. I therefore assume that transactions are intra-firm when they are directed to/come from a country where there is a subsidiary belonging to the same business group. On the other hand, if transactions are directed to a country with no co-affiliates, they are certainly going to be arm's length shipments[17].

All data span from 2000 to 2011, except for the ownership information which describes the status of proprietary networks in 2011[18].

[16] These levels are defined depending on the immediate owner of a subsidiary. A firm might in fact own another one while being owned by a headquarter firm at a higher level. The full ownership information used in this paper includes chains up to the 10th level.

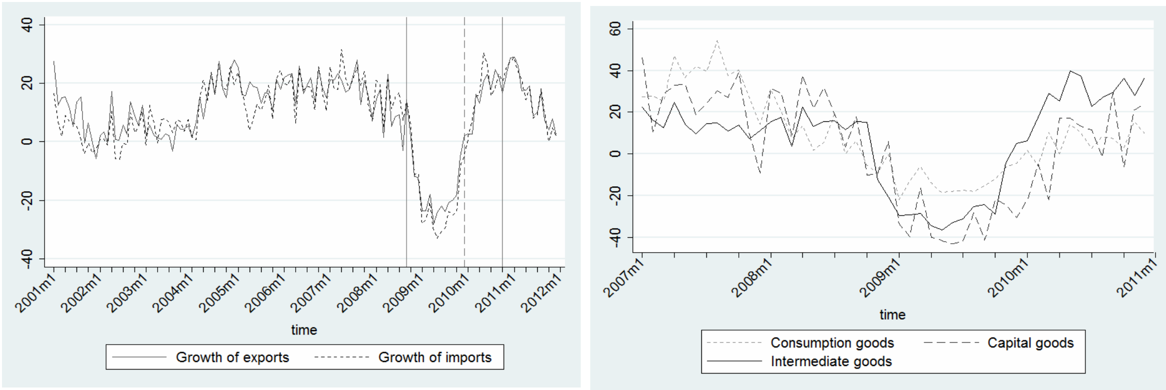
[17] The assumption by which intra-firm and arm's length trade are identified introduces some measurement error. It is asymmetrical (consisting of a fraction of arm's length shipments being wrongly labelled as intra-firm), but it can be argued to be random, causing an attenuation bias in estimation, as I do not have reasons to think of factors causing a systematic misallocation of these shipments. In Appendix I provide figures that provide some insight about the size of the bias.

[18] The reasons for this are outlined in Appendix.

2.4 Slovenian trade in the crisis

Slovenia's economic activity is dominated by small and medium enterprises, whose trade participation is high compared to larger countries[19]. The custom data allow a detailed picture of the impact of the crisis on Slovenian trade to be drawn: the shock had a sudden and deep impact on both exports and imports, with the deepest point reached in mid-2009, but with growth rates remaining negative for over a year and reverting to positive values only in 2010 (left panel of Figure 2.2).

Figure 2.2: Growth of exports and imports 00-07; Growth of imports of consumption, capital and intermediate goods.



The right panel of Figure 2.2 illustrates growth rates of consumption, capital and intermediate goods separately (BEC). Consumption goods showed a higher degree of resilience relative to the other categories; while intermediates dipped less and for a shorter period than capital goods. This visual inspection shows evidence of compositional effects emerging from the heterogeneous response of the three aggregates; however, what is not immediately evident is a preponderant role of intermediates in the collapse. The larger fall of trade in intermediates, to which the literature attributed part of the responsibility in accelerating the trade crisis (Yi 2009) does not immediately appear to be dominant in the Slovenian case.

In estimation the analysis runs from September 2008 to September 2010, with the trough identified at November 2009, as trade kept growing at a negative rate until then. By September 2010 the value of imports had approximately recovered to the pre-crisis level (Figure 2.3, left).

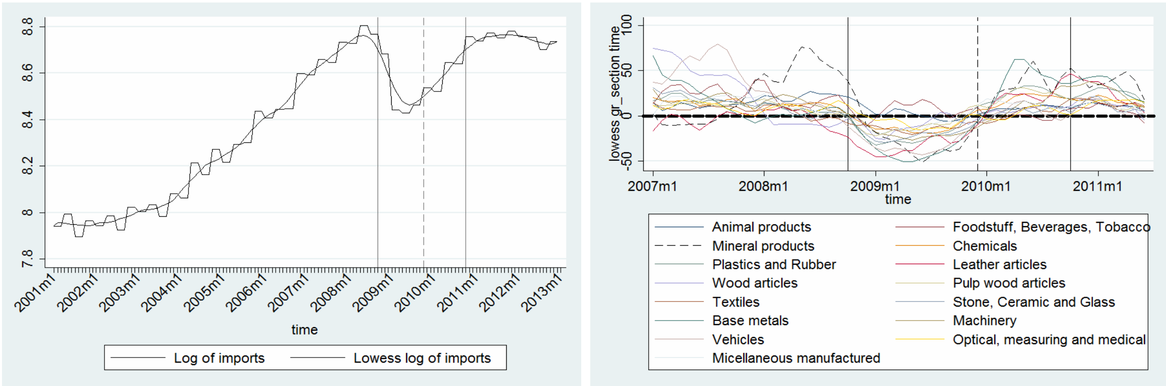
The identification of the cutoff dates according to the Slovenian experience could spur worries of endogeneity if the Slovenian case were somehow affected by peculiar characteristics of Slovenian firms that I cannot control for in the econometric specification[20]. However, these concerns can safely be excluded here for a variety of reasons, the main one being that the

[19] Export participation in the manufacturing sector in 2002 was 48%; the same figure for the US was 18% (Bernard *et al.* 2012).

[20] I could be introducing a selection bias and reduce the degree of exogeneity of the shock.

timing used in estimation is highly compatible with the evolution of merchandise trade at the world level during the same period (Asmundson *et al.* 2011). Secondly, I estimate all regressions with firm-month-origin fixed effects, thereby controlling for any firm and origin specific unobservable shock, which is common across products imported by each firm from each country in each month. Finally, given its economic size, Slovenia could not affect the evolution of the financial and subsequent trade crisis. The shock can thus be considered largely exogenous to Slovenia.

Figure 2.3: Value of total Slovenian imports in logs 00-12; Growth of imports by CN categories, 00-11.



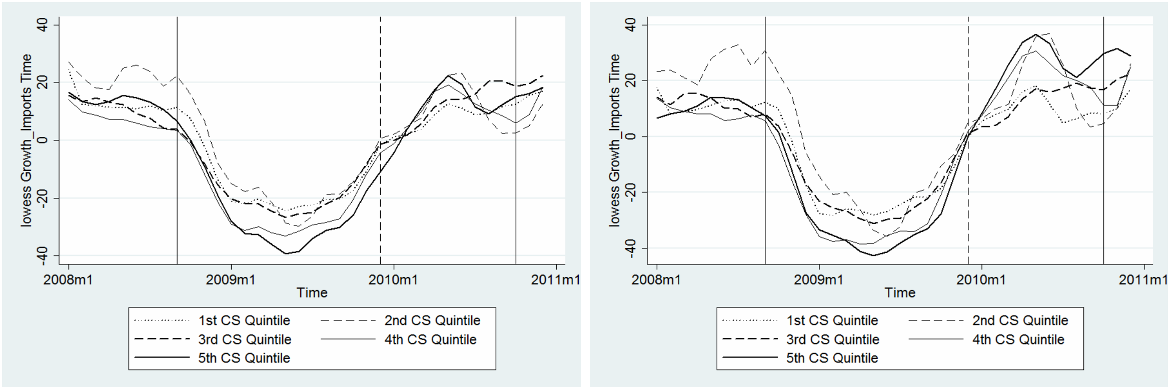
The synchronicity of the 2008-09 collapse further supports the choice of confining the analysis to the above described dates: the behaviour of aggregate imports is the outcome of the coincident path of fall and rebound of the various product categories over the crisis (Figure 2.3, right). Disentangling the experience of the collapse across goods accounting for different shares in firms' costs, this synchronicity is observed again (Figure 2.4). It is reassuring that the crisis cutoff dates were similar across various segments of the cost-share distribution: this suggest that the impact of the cost-share on trade detected in estimation is not due to a different timing of reaction for different products (i.e. longer/shorter downturn and recovery) but to a deeper trough of the crisis, as one would expect to be caused by a catalyst of the collapse.

The right panel of Figure 2.4 is particularly eloquent in terms of the key finding of this paper: for intermediates it is immediately evident that higher cost-share products (5th CS quintile) experienced a larger fall over the downturn and a correspondingly higher rebound in the recovery.

Limiting the data between September 2008 and September 2010 leads to the identification of a final sample of 8,498 firms importing 8,733 different products from 227 origins.

Of interest for this work is also firm ownership and the decision of a firm to relocate part of the production abroad with the establishment of affiliates, or to licence an unaffiliated supplier outside its boundary of activity to source intermediate inputs[21].

Figure 2.4: Growth of imports for quintiles of the cost-share distribution, all goods (left) and intermediates (right).



Panel A of Table 2.1 reports the import activity of firms belonging to multinationals[22] regardless of the sender of the shipments. Firms belonging to groups perform 37.2% of import transactions, corresponding to 64% of the total value of flows, despite them being only 15% of importers. In terms of a comparison with previous findings, the UNCTAD (2000) report estimates that, at the world level, intra-firm trade accounts for one third of total trade, while another third is accounted for by transactions that see multinationals at one of the two sides of the exchange, bringing the percentage of transactions operated by groups to about 60% of the total value.

Table 2.1: Activity of multinationals and intra-firm trade in Slovenia, 2007-10.

Firms		Number Transactions		Value transactions*	
Panel A: activity of multinationals					
Groups	Not in groups	Groups	Not in groups	Groups	Not in groups
1,444	8,301	2,567,242	4,319,398	47,135	25,814
Panel B: Intra-firm trade					
Intra Firm	Arm's Length	Intra Firm	Arm's Length	Intra Firm	Arm's length
998	9,574	1,308,626	5,578,014	32,799	40,151

Source: AJPES, CARS, SURS and author's calculations.

*Note: value of transactions is in millions of Euros.

A comparison with country-level figures, most of which focus on U.S. firms, is influenced by the peculiar structure of the Slovenian trade: participation to trade is high in Slovenia and it is a less concentrated activity relative to larger countries. This explains the larger figure reported by Bernard *et al.* (2009) for the US – 90% of US trade being mediated by

[21] Being aware of the imperfect match of the ORBIS data for 2011 with the firm level data for years before 2011, I matched the ownership information to trade data from 2007 onwards only, to reduce the likelihood of wrongly identifying a firm as belonging to a group in case the status of affiliation changed over time

[22] With domestic or foreign headquarter, where the threshold for ownership was set at 50.01%.

multinationals, compared to the about 60% measured for Slovenia – where there is a lower export participation by smaller and independent firms.

Exploiting also the information about the origin of shipments and matching this with the map of network affiliation allows to identify intra-firm trade. These are transactions operated by firms belonging to groups and originating from destinations with firms belonging to the same group. The share of intra-firm imports in total trade is 44.96%: over the four years this share remained constant.

2.5 Empirical strategy

To assess the role of products' cost-share as a catalyst of the trade collapse, the growth rate of imports at the firm-product-origin level is regressed against a number of controls. Using monthly growth rates spurs worries of attrition bias[23]; furthermore, using standard growth rates would not allow to take into account the extensive margin variation, since all firm-product-origin triplets that are not observed between two consecutive periods (i.e. the same month of two consecutive years) would be dropped from the analysis.

To cope with this, I follow the approach of previous studies[24] and use mid-point growth rates, computed on the single flow $M_{kic,t}$ defined as the import flow M of each CN-8 product k, by a Slovenian firm i, from a given origin c in month t. The mid-point growth rate serving as dependent variable is:

$$mp_{kic,t}{=}\frac{M_{kic,t}-M_{kic,t-12}}{0.5\left(M_{kic,t}+M_{kic,t-12}\right)}. \tag{5}$$

However, all the results are also presented exploiting as dependent variable the log change of imports: $\Delta\ln(M_{kic,t}) = \ln(M_{kic,t}) - \ln(M_{kic,t-12})$. This provides considerable robustness to the results as it shows that the transformation by which the mid-point growth rates are computed does not affect findings; furthermore, it reassures about the stability of the findings when investigating only the intensive margin of imports and, finally, it provides more directly interpretable coefficients[25].

In addition to import values, I also present estimates using the growth rates (mid-point and log-change) of import volumes and unit values (value/volume). This allows me to evaluate how much of the effects that I estimate are a consequence of the change in the quantity shipped or of the change in prices over the crisis.

To explore the rationale that a larger share in firms' costs can generate an accelerated

[23] Non-random entries and exits over the the crisis would bias estimates if one were to use standard growth rates.

[24] Davies and Haltiwanger (1992), Buono *et al.* (2008), Bricongne *et al.* (2012)

[25] Since the mid-point growth rate is by contruction bound between -2 and 2, the interpretation of the coefficients is more direct when exploiting the log-difference as dependent variable.

reaction of trade in a recessionary environment, the cost-share (henceforth CS) variable is constructed using:

$$CS_{kj}^{\text{costs}} = \frac{1}{YN} \sum_{y=2000}^{2007} \sum_{i=1}^{N} \left(\frac{\sum_{t=1}^{12} im_{kic,yt}}{C_{iy}} \right), \tag{6}$$

where im_{kict} denotes the value of product k imported by firm i, from origin c, in month t. N denotes the number of firms, Y the number of years, C costs of goods, materials and services. The cost-share of the imported product (6) has a sectoral dimension j since each product k might present a specific relevance depending on the sector j where the firm operates. The firm level cost-share is therefore averaged over all firms within each sector, with the resulting measure being specific for each of the 8,733 products in each of the 462 NACE 4-digit sectors. Using all years available in the data up to the year before the crisis (2007) allows me to compute a possibly exogenous time invariant value of how much, on average, each imported product is worth in firms' costs.

I also compute an alternative cost-share measure, to show that the cross-product heterogeneity unveiled by the CS variable does not strictly depend on the aggregate against which the value of the product is measured, i.e. costs. The sales-based measure is given by:

$$CS_{kj}^{\text{sales}} = \frac{1}{YN} \sum_{y=2000}^{2007} \sum_{i=1}^{N} \left(\frac{\sum_{t=1}^{12} im_{kic,yt}}{S_{iy}} \right), \tag{7}$$

where S denotes total sales. (7) can be seen as a measure of intensity of use of a product as an input since it approximates an input-output (IO) requirement coefficient, i.e. the technical coefficient of use of inputs in downstream industries[26]. Furthermore, the cost-share variables (6 and 7) are re-computed using only the last two years preceding the crisis, to reassure that the measure can be considered a stable product characteristic over time.

Table 2.2 presents some core statistics relating to the cost-share variables:

Table 2.2: Cost-share variables

	Unique values	Mean	Std.
Cost-Share (w.r.t. costs)	142,817	0.041	0.989
Cost-Share (w.r.t. sales)	142,817	0.031	0.682
Cost-Share (w.r.t. costs - only last 2 years)	121,597	0.030	0.145
Cost-Share (w.r.t. sales - only last 2 years)	121,565	0.024	0.257

Source: SORS, AJPES and author's calculations.

The main equation estimated by OLS is:

$$g_{kic,t} = \beta_0 + \beta_1 CS_{kj} + \beta_2 Int_{kic,t} + \beta_3 (CS_{kj} * Int_{kic,t}) + \gamma_{ic,t} + \varepsilon_{kic,t}, \tag{8}$$

[26] A similar measure constructed with the US BEA Input-Output tables was used by Levchenko *et al.* (2010): they constructed a measure of *downstream vertical linkages,* by computing the average use of a commodity in all downstream industries.

where $g_{kic,t}$ denotes either the mid-point growth rate of imports (5) or the log-change of imports of product k received by firm i from origin c in month t; CS_{kj} denotes the cost-share variable, $Int_{kic,t}$ denotes a binary variable identifying intermediates; $\gamma_{ic,t}$ denotes firm-origin-month fixed effects. β_3 tests the hypothesis that relatively higher cost-share intermediates were subject to larger adjustments in the crisis.

Estimation of (8) circumscribes the analysis of the collapse to a full cycle of downturn plus recovery. The role of catalysts of the trade crisis could however emerge more neatly when observing the dynamics within the cycle, rather that the growth of trade over the entire span of the event. The impact of the cost-share has therefore also been separated between the downturn and the recovery phases. If the cost-share imparts a larger reaction to trade, this should be evident with a deeper trough, i.e. a larger fall in the downturn coupled with larger rebound in the recovery - as descriptively shown in Figure 2.4, right panel.

Specification (9) controls for the within cycle dynamics:

$$g_{kic,t} = \alpha_0 + \alpha_1 \Omega + \alpha_2 \Omega * recovery + \varepsilon_{kic,t} \tag{9}$$

where Ω denotes the right hand side of equation (8) and *recovery* is a binary variable picking up shipments after November 2009, identified as the trough of the crisis. The effect of the cost-share as a catalyst is identified by a negative β_3 in downturn and a positive one in the recovery.

To verify that the effect of the cost-share is robust across different degrees of integration of the value-chain (i.e. intra-firm against arm's length trade), I employ specification (10), where I interact the effect of the CS with the effect of firm-ownership: this identifies whether the adjustment differed depending on the relative cost-share of products, when they are traded within the firm boundaries.

$$\begin{aligned} g_{kic,t} = {} & \beta_0 + \beta_1 CS_{kj} + \beta_2 IF_{ki,t} + \beta_3 Int_{kic,t} + \beta_4 \left(CS_{kj} * Int_{kic,t}\right) + \beta_5 \left(IF_{ki,t} * Int_{kic,t}\right) \\ & + \beta_6 \left(CS_{kj} * IF_{ki,t}\right) + \beta_7 \left(CS_{kj} * IF_{ki,t} * Int_{kic,t}\right) + \gamma_{i,t} + \varepsilon_{kic,t} \end{aligned} \tag{10}$$

The right hand side of equation (10) is also interacted with the recovery dummy, as shown in (9). In (10) I can only exploit firm-month fixed effects because for each firm the IF indicator does not vary within origin.

It is to be observed that the firm-origin-month fixed effects account for a great deal of unobserved confounding factors and that I am only exploiting within firm-origin-month cross-product variation in estimation. Any demand or supply shock that had aggregate, firm or origin specific effects in any time period is thereby controlled for: these include the change in real expenditure (Levchenko *et al.*, 2010; Behrens *et al.,* 2013), the credit-crunch (Chor and Manova, 2012) and the reduction in the availability of firm intermediated trade finance (Korinek *et al.,* 2010, Coulibaly *et al.,* 2011), other than firm constant and firm time varying characteristics such as size, capital intensity, employment and productivity. Standard errors are always clustered at the firm level[27].

Table 2.3: Descriptive statistics of main variables - Chapter 1

	Imports								
	Entire sample			Downturn			Recovery		
	Obs.	Mean	Std.	Obs	Mean	Std.	Obs.	Mean	Std.
Dep. var. - mid point growth rate (value)	5,672,551	-0.075	1.697	3,395,569	-0.079	1.695	2,276,982	-0.067	1.701
Dep. var. - mid point growth rate (quantity)	5,454,565	-0.056	1.683	3,294,607	-0.059	1.688	2,159,958	-0.051	1.675
Dep. var. - mid point growth rate (unit value)	5,454,565	-0.046	1.632	3,294,607	-0.035	1.629	2,159,958	-0.063	1.636
Dep. var. - log change (value)	1,784,484	-0.068	1.452	1,095,030	-0.130	1.458	689,454	0.030	1.436
Dep. var. - log change (quantity)	1,780,387	-0.088	1.607	1,092,570	-0.153	1.161	687,817	0.015	1.588
Dep. var. - log change (unit value)	1,780,387	0.020	0.803	1,092,570	0.023	0.812	687,817	0.015	0.788
Intermediates (binary indicator)	5,672,551	0.515	0.499	3395569	0.512	0.499	2,276,982	0.512	0.499
Intra-Firm (binary indicator)	5,672,551	0.173	0.377	3395569	0.172	0.377	2,276,982	0.174	0.378

Source: SORS, AJPES and author's calculations.

2.6 Results

This section presents the estimates of the behaviour of Slovenian importers in the crisis, separating the impact of the shock according to the cost-share of products and the type of firm affiliation.

2.6.1 The cost-share of intermediates, a *catalyst* of the collapse.

Table 2.4 reports the results from estimating specifications (8) and (9) for the value (Panel A), quantity (Panel B) and unit-values (Panel C) of imports. In columns (1)-(6) the dependent variable is the mid-point growth rate (5), which allows to take into account every single shipment at the product-firm-origin level of disaggregation, even if discontinued with respect to the same month of the previous year. In columns (7)-(12) I instead exploit standard growth rates defined as the log-difference of the shipment: this implies that only product-firm-origin triplets that are present in at least two consecutive time periods (the same month of two consecutive years) are included in the analysis. In other words, using standard growth rates only exploits the intensive margin of trade, with the mid-point growth rate picking up a great deal more data points given the relevance of extensive margin changes at this level

[27] Clustering at the NACE 4-digit sector level leaves the results unchanged.

of disaggregation. Despite this difference, the results are strikingly similar across the two variables.

Table 2.4: The Cost-Share as a Catalyst of the Collapse

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Mid-Point Growth Rates						**Standard Growth Rates (Log-change)**					
PANEL A: Imports - Values												
CS	-0.004***		-0.004***	-0.004***		-0.004***	-0.002		-0.002	-0.002		-0.001
	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.004)		(0.004)
Int		0.027***	0.034***		0.030***	0.046***		0.008**	0.010**		0.013**	0.016***
		(0.004)	(0.004)		(0.005)	(0.006)		(0.004)	(0.004)		(0.006)	(0.006)
Int*CS			-0.003			**-0.049*** **			-0.029*			**-0.100*** **
			(0.015)			**(0.017)**			(0.015)			**(0.027)**
CS*Rec				-0.000		-0.001				-0.000		-0.002
				(0.001)		(0.002)				(0.007)		(0.007)
Int*Rec					-0.008	-0.029***					-0.011	-0.016*
					(0.006)	(0.007)					(0.009)	(0.009)
Int*CS*Rec						**0.117*** **						**0.159*** **
						(0.024)						**(0.043)**
PANEL B: Imports - Quantity												
CS	-0.004***		-0.004***	-0.004***		-0.004***	-0.002		-0.002	-0.001		-0.000
	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.004)		(0.003)
Int		0.024***	0.032***		0.026***	0.043***		0.000	0.000		0.004	0.006
		(0.005)	(0.005)		(0.006)	(0.006)		(0.005)	(0.005)		(0.006)	(0.006)
Int*CS			-0.009			**-0.041** **			-0.019			**-0.065** **
			(0.016)			**(0.019)**			(0.016)			**(0.026)**
CS*Rec				-0.000		-0.001				-0.001		-0.003
				(0.002)		(0.002)				(0.006)		(0.006)
Int*Rec					-0.006	-0.027***					-0.009	-0.013
					(0.006)	(0.007)					(0.010)	(0.009)
Int*CS*Rec						**0.081*** **						**0.103*** **
						(0.025)						**(0.039)**
PANEL C: Imports - Unit Values												
CS	-0.003***		-0.004***	-0.003***		-0.003***	-0.000		-0.000	-0.001		-0.000
	(0.001)		(0.001)	(0.001)		(0.001)	(0.000)		(0.000)	(0.001)		(0.001)
Int.		0.030***	0.037***		0.036***	0.049***		0.009**	0.009***		0.009**	0.010**
		(0.004)	(0.004)		(0.005)	(0.006)		(0.003)	(0.003)		(0.004)	(0.004)
Int*CS			0.025**			**0.014**			-0.010			**-0.035*** **
			(0.011)			**(0.012)**			(0.009)			**(0.012)**
CS*Rec				-0.000		-0.000				0.001*		0.001
				(0.001)		(0.001)				(0.001)		(0.001)
Int*Rec					-0.012*	-0.031***					-0.002	-0.003
					(0.006)	(0.007)					(0.006)	(0.006)
Int*CS*Rec						**0.023**						**0.056*** **
						(0.018)						**(0.018)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	5380701	5672551	5380701	5380701	5672551	5380701	1750854	1784484	1750854	1750854	1784484	1750854

Note: Standard errors clustered at the firm level in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Hypothesis 1 is confirmed very strongly in Table 2.4: for imports of intermediates, products' cost-share worked as a catalyst of the collapse. Starting from columns (1) and (7), on average and over the entire period of the crisis, imports of products accounting for a larger share in firms' costs grew less, but significantly so only for the mid-point growth rate. Over the entire cycle one would not expect a differential behaviour across products if the cutoff dates were identified precisely; however, as evident in Figure 1.4, the path of shipments at different quintiles of the *CS* distribution is rather heterogeneous in the recovery, making it difficult to pin down the end of the cycle with precision.

In contrast, the path of intermediates is more homogenous, and this is mirrored in the coefficient on the interaction *Int.*CS* in columns (3) and (9): a higher *CS* did not imply a stark difference for imports of intermediates when no distinction is made between the downturn and the recovery.

Observing the within collapse dynamics is more directly informative of the role of the *CS* as a catalyst of the crisis. For this purpose in columns (4)-(6) and (10)-(12) I separate the impact of the *CS* on undifferentiated products and on intermediates between the downturn and the recovery period. The overall negative performance of higher *CS* products found in column (1), is the outcome of a more pronounced fall in the downturn, with no significant difference detected in the recovery (column 4).

For intermediates instead, for both mid-point and standard growth rates and for both the value and the quantity of trade (column 6 and 12), the *CS* acted as a strong catalyst, accelerating the drop of imports in the downturn, with a significant and large rebound in the recovery. Firms reacted to the shock reducing purchases of inputs accounting for a larger share of their costs more than proportionately in the first period of crisis, and then increased them when the cycle picked up, again more than proportionately. This larger responsiveness could possibly be due to larger inventory adjustments by firms trying to downsize the stock of relatively high cost-share intermediates, in an attempt to raise liquidity in a recessionary period[28]. The differential impact of the crisis across products highlights a relevant role for the cost-share in explaining part of the trade collapse. For mid-point growth rates, a 10 percentage points increase in the cost-share (two and a half times the mean, but only about one tenth of a standard deviation) corresponds to a 0.49 percentage point larger fall of trade in the downturn and a 0.68 percentage point larger growth in the recovery (-0.049 + 0.177), accounting for 6.8% and 10% of the average growth in the two subperiods. For standard growth rates, a 10 percentage points increase in the cost-share lead to a 1 percentage point

[28] A more formal explanation for this mechanism is left to be explained in section 2.7.

faster drop in the downturn and a 0.59 percentage point faster rebound in the recovery, accounting for 7.6% and 19% of the average growth in the two subperiods. Finally, notice that the positive coefficients of the intermediate dummy in the downturn (columns 5 and 11) increase by 25-50% when controlling for the cost-share of products, whereas the coefficients in the recovery phase become more negative and acquire significance. In both subperiods of the event it therefore appears that higher-cost share intermediates performed in a way which is opposite to lower cost-share intermediates.

Table 2.5: The Cost-Share as a Catalyst of the Collapse - CS^{sales}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rates				Standard Growth Rates (Log-change)			
PANEL A: Imports - Values								
CS	-0.006***	-0.005***	-0.006***	-0.005***	-0.003	-0.002	-0.004	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)
Int		0.035***		0.046***		0.010**		0.016***
		(0.005)		(0.006)		(0.004)		(0.006)
Int*CS		-0.027*		**-0.086*** **		-0.077***		**-0.164*** **
		(0.015)		**(0.032)**		(0.018)		**(0.046)**
CS*Rec			0.000	-0.001			0.001	-0.002
			(0.002)	(0.002)			(0.010)	(0.010)
Int*Rec				-0.029***				-0.018**
				(0.007)				(0.009)
Int*CS*Rec				**0.116** **				**0.289*** **
				(0.054)				**(0.076)**
PANEL B: Imports - Quantity								
CS	-0.006***	-0.006***	-0.006***	-0.006***	-0.003	-0.002	-0.002	-0.000
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.005)	(0.005)
Int		0.032***		0.043***		0.002		0.006
		(0.005)		(0.006)		(0.005)		(0.006)
Int*CS		-0.031**		**-0.075** **		-0.061***		**-0.127*** **
		(0.016)		**(0.028)**		(0.023)		**(0.035)**
CS*Rec			0.000	-0.000			-0.001	-0.003
			(0.002)	(0.002)			(0.009)	(0.010)
Int*Rec				-0.026***				-0.014
				(0.007)				(0.009)
Int*CS*Rec				**0.084* **				**0.218*** **
				(0.045)				**(0.062)**
PANEL C: Imports - Unit Values								
CS	-0.005***	-0.005***	-0.005***	-0.005***	-0.000	0.000	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Int		0.036***		0.049***		0.009***		0.010**
		(0.004)		(0.006)		(0.003)		(0.004)
Int*CS		0.025**		**0.029**		-0.016		**-0.037* **
		(0.012)		**(0.019)**		(0.013)		**(0.021)**
CS*Rec			0.000	-0.000			0.002*	0.001
			(0.001)	(0.001)			(0.001)	(0.001)
Int*Rec				-0.030***				-0.003
				(0.007)				(0.006)
Int*CS*Rec				**-0.007**				**0.071* **
				(0.029)				**(0.037)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5388408	5388408	5388408	5388408	1749482	1749482	1749482	1749482

Note: Standard errors clustered at the firm level in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.5 presents the results from estimating the same specifications of Table 2.4 replacing the cost-share in terms of costs (6) with the cost-share variable computed in terms of sales (7).

The two measures have a somewhat different interpretation because equation (7) represents rather an average *intensity of use* of a product across firms in an industry. Despite this, it is noticeable that the main results are fully confirmed when exploiting the cost-share in terms of sales: this suggests that the findings are stable regardless of the main aggregate - costs or sales - against which the value of inputs is measured.

In conclusion, for both Table 2.4 and 2.5, I present also the results from estimating the impact of the *CS* on the growth of the quantity of shipments (mass in kg or units) and the growth of unit-values (value/quantity). Comparing the coefficients across the three panels within the tables allows to disentangle whether the results are due to a change in the quantity shipped, or to changes in prices over the crisis. The literature so far pointed towards the change in quantity as the main driver of the collapse, with prices only playing a marginal role (Bricongne *et al.,* 2012; Behrens *et al.,* 2013): the same conclusion is confirmed in this work.

The effects of the *CS* on the value of trade are detected also when only quantity changes are observed. For unit-values instead, proxying the price of products, in the mid-point growth rate regressions all the relevant coefficients are insignificant. In the regressions exploiting the log-change of imports, given that unit-values equal the ratio between values and quantity, the coefficients are, by construction, equal to the difference between the coefficient for import values and the coefficient for import quantities. All together, these results hint at the fact that price changes are not significantly associated with the effects under examination in this work.

Stability of the cost-share measures over time As a robustness check for the main results shown in the previous section, I recomputed the *CS* measures (6) and (7) using only the last two years of data preceding the trade crisis, i.e. 2006 and 2007, rather than all available years in the data. This reduces the number of observations since products that are not imported in the 2006-07 period do not enter the calculation of the *CS* measures, while the measures become less dispersed (e.g. the standard deviation for (6) falls from 0.98 to 0.14), providing a further robustness check[29].

All the main coefficients remain statistically significant with their size increasing between 20% and 100%. These results provide robustness for the main findings of Table 2.4, considering also that they are obtained from a measure whose variability is reduced in a significant

[29] Here I show the table for the CS in terms of cost; the table for the CS in terms of sales is in Appendix.

way.

Table 2.6: The Cost-Share as a Catalyst of the Collapse - Only 2006-07 for CS calculation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rates				Standard Growth Rates (Log-change)			
PANEL A: Imports - values								
CS	-0.044***	-0.036***	-0.041***	-0.030***	-0.070***	-0.063**	-0.097**	-0.065**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.027)	(0.031)	(0.006)	(0.036)
Int		0.034***		0.044***		0.008*		0.015**
		(0.005)		(0.006)		(0.004)		(0.006)
Int*CS		-0.050**		**-0.095*** **		-0.021		**-0.124** **
		(0.025)		**(0.030)**		(0.046)		**(0.059)**
CS*Rec			-0.020	-0.040			0.131**	0.031
			(0.026)	(0.037)			(0.057)	(0.068)
Int*Rec				-0.027***				-0.016**
				(0.007)				(0.009)
Int*CS*Rec				**0.152** **				**0.212** **
				(0.058)				**(0.093)**
PANEL B: Imports - quantity								
CS	-0.046***	-0.037***	-0.042***	-0.031***	-0.052**	-0.041	-0.068*	-0.042
	(0.015)	(0.012)	(0.013)	(0.008)	(0.025)	(0.027)	(0.038)	(0.029)
Int.		0.032***		0.041***		0.001		0.006
		(0.005)		(0.006)		(0.005)		(0.006)
Int*CS		-0.058**		**-0.089*** **		-0.031		**-0.101* **
		(0.026)		**(0.028)**		(0.040)		**(0.052)**
CS*Rec			-0.025	-0.038			0.078	0.013
			(0.028)	(0.037)			(0.049)	(0.066)
Int*Rec				-0.025***				-0.013
				(0.007)				(0.009)
Int*CS*Rec				**0.110* **				**0.151* **
				(0.056)				**(0.086)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5267877	5267877	5267877	5267877	1734962	1734962	1734962	1734962

Note: Standard errors clustered at the firm level in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

2.6.2 A firm level cost-share measure

The results presented in Tables 2.4, 2.5 and 2.6 explore the trade adjustment of products accounting for a different share of firms' costs (or firms' sales), where the *CS* measure is specific for each CN-8 product in each NACE (4-digit) sector.

In order to explore the *CS* heterogeneity further, an attempt has been made to compute the *CS* measure at an even finer level of disaggregation, making the *CS* ratio product-firm specific, rather than product-industry specific[30]. The main results (Table 2.14) are broadly confirmed, with the *CS* of imported products being associated with a larger response of imports in both the subperiod of the crisis. One noticeable difference, relative to the main results of Tables 2.4 and 2.5, is that when exploiting the firm-product level *CS* measure this accelerating impact appears to be driven by non-intemerdiate products. However, when

[30] Full details about the CS measures and the results are provided in Appendix.

analysing only the subsample of intermediates (Table 2.15) a sign pattern compatible with the *CS* acting as a catalyst of the collapse is detected again.

Despite the similarity of results between the product-industry and the product-firm *CS* measures, the variable that is preferred in terms of the main finding of this paper remains the product-industry measure. This is because it can be better interpreted as a stable characteristic of the product and it is less likely to be determined by idiosyncratic firm-level features. Overall, it is reassuring to find that products' *CS* is associated with an enhanced trade adjustment across such a large variety of amendments of the *CS* measure.

2.6.3 Unpacking the CS effect across the intra-firm versus arm's length trade dymension of the collapse.

Conditioning on firm ownership, the main result about the impact of product CS on trade is upheld. This is a key finding emerging from disentangling the intra-firm versus arm's length dimension of the trade collapse. Regardless of whether transactions are operated by related parties - intra-firm trade (IF), or unrelated parties - arm's length trade (AL), shipments of inputs accounting for a larger CS underwent a larger adjustment both during the downturn and the recovery phase of the crisis.

Furthermore, controlling for the type of firm affiliation, other than strenghtening the main finding of this chapter, allows to uncover a secondary mechanism that characterized the trade adjustment: *IF* trade might have worked as an additional catalyst of the trade collapse for higher *CS* products, while there appears to be no difference between the response of IF and AL trade when no distinction is made across products.

In Table 2.7 the impact of the *CS* is interacted with that of firm affiliation, as shown in specification (10). In columns (3), (4), (7) and (8) the analysis contrasts the two subperiods of the crisis and reveals the two key findings: first, the accelerating effect of the *CS* on imports of intermediates, discussed in the previous sections, is fully robust to controlling for the impact of firm affiliation (*Int*CS* and *Int*CS*Rec* coefficients in columns 4 and 8); second, *IF* trade might have worked as an additional catalyst of the trade collapse for higher *CS* products. This latter finding appears strongly in columns (3) and (7), with higher *CS* products experiencing a larger fall in the downturn coupled with a larger rebound in the recovery. However, this effect does not look to be specific to trade of intermediates, at least not in the downturn, where the negative coefficient on *IF*CS* is unchanged (or even becomes larger) when controlling for the impact on intermediates (columns 4 and 8). In other words, while for both *IF* and *AL* trade the reaction of higher *CS* inputs was larger than that of lower CS inputs, the difference between *IF* and *AL* trade consists of an enhanced reaction for higher *CS* consumption and capital goods, relative to lower *CS* ones. In the recovery instead, the positive rebound of higher *CS* products traded *IF* (relative to *AL* imports) appears to be driven by intermediates. In Table 2.7 this is evident for the mid-point growth rate regressions, however, when the alternative *CS* measure is exploited (Table 2.7B in Appendix) the positive rebound for *IF* imports of higher *CS* intermediates is found for both the mid-point and the standard growth rate[31][32].

Table 2.7: Firm affiliation and cost-share.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
IF	-0.012	-0.00690	0.007	0.009	-0.013	-0.005	-0.008	-0.013
	(0.022)	(0.024)	(0.029)	(0.030)	(0.010)	(0.012)	(0.013)	(0.016)
CS	-0.005***	-0.005***	-0.005***	-0.005***	-0.003*	-0.002	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.016)	(0.002)	(0.002)	(0.004)	(0.003)
IF*CS	-0.014**	-0.021***	**-0.018*** **	**-0.018*** **	-0.031	-0.133*	**-0.147** **	**-0.211** **
	(0.006)	(0.05)	**(0.004)**	**(0.003)**	(0.026)	(0.078)	**(0.063)**	**(0.086)**
Int		0.029***		0.035***		0.008*		0.009
		(0.004)		(0.005)		(0.004)		(0.006)
Int*IF		-0.013		-0.008		-0.015		0.006
		(0.018)		(0.024)		(0.012)		(0.015)
Int*CS		-0.007		**-0.040** **		-0.041**		**-0.111*** **
		(0.015)		**(0.019)**		(0.019)		**(0.026)**
Int*CS*IF		0.076**		0.038		0.152*		0.175
		(0.036)		(0.061)		(0.084)		(0.113)
IF*Rec			-0.040	-0.035			-0.013	0.022
			(0.035)	(0.036)			(0.021)	(0.024)
CS*Rec			0.001	0.000			-0.001	-0.003
			(0.001)	(0.002)			(0.006)	(0.006)
IF*CS*Rec			**0.077** **	-0.288*			**0.248** **	0.252
			(0.037)	(0.162)			**(0.098)**	(0.194)
Int*Rec				-0.015*				-0.000
				(0.008)				(0.009)
Int*IF*Rec				-0.016				-0.055**
				(0.024)				(0.022)
Int*CS*Rec				**0.087*** **				**0.162*** **
				(0.026)				**(0.044)**
Int*CS*IF*Rec				**0.347** **				-0.154
				(0.175)				(0.225)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5380701	5380701	5380701	5380701	1750854	1750854	1750854	1750854

Note: Standard errors clustered at the firm level in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The availability of *IF* and *AL* dummies, allows to perfom an additional simple excercise, i.e. to estimate whether *IF* trade exhibited a differential response relative to *AL* trade on

[31] Tables 2.7, 2.7B (in Appendix) and 2.8 show the results for nominal imports. For the sake of brevity I do not show the tables for quantity, but results are extremely similar to those for the value of imports.

[32] Over the entire cycle (columns 1,2 5 and 6) it appears that higher *CS* products grew less when traded intra-firm compared to when traded at arm's length, with this effect being driven by consumtion and capital goods rather than intermediates, which instead show a better performace (*Int*CS*IF* coefficients). These effects are larger when the standard growth rate is used as dependent variable, but they are estimated more precisely when exploiting the mid-point growth rate.

average, without exploiting the *CS* margin. Table 2.8 shows the results from these regressions, which do not reveal a statistically different response between the two organisational modes.

Table 2.8: Intra-firm versus arm's length trade.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
IF	-0.009	-0.001	0.009	0.015	-0.014	-0.008	-0.012	-0.019
	(0.021)	(0.023)	(0.029)	(0.029)	(0.010)	(0.012)	(0.013)	(0.017)
Int		0.022***		0.021***		0.007		0.005
		(0.004)		(0.005)		(0.004)		(0.006)
IF*Int.		-0.017		-0.014		-0.010		0.013
		(0.016)		(0.022)		(0.010)		(0.015)
IF * Rec.			-0.044	-0.039			-0.003	0.030
			(0.033)	(0.035)			(0.020)	(0.024)
Int* Rec				0.005				0.006
				(0.008)				(0.010)
IF*Int*Rec				-0.008				-0.061***
				(0.023)				(0.022)
FEs.	yes	yes	yes	yes	yes	yes	yes	yes
N	5672551	5672551	5672551	5672551	1784484	1784484	1784484	1784484

Note: Standard errors clustered at the firm level; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

IF trade is not observed to have affected the reaction of trade in the crisis differently from *AL* trade, when the effect is averaged over all products, or when separating the effect for intermediates; neither over the entire cycle (columns 1, 2, 5 and 6), nor when separating the effect over the downturn and the recovery (columns 3,4, 7 and 8). Only for standard growth rates it appears that, in the recovery, there was a negative premium for shipments of intermediates when taking place intra-firm relative to arm's length: too little to conclude anything in favour of an accelerating or dampening impact of *IF* trade overall.

Summarizing the findings of this section, the role of product CS as a catalyst of the collapse is upheld when controlling for firms' affiliation. Furthermore, *IF* trade did not affect the reaction of trade differently from *AL* trade when the impact is averaged over all products, or when products' CS is not controlled for. The only margin along which some action is detected is when contrasting the performace of shipments accounting for a larger share of firms' costs between the two subperiods of the crisis. These results suggest that *IF* trade might have deepened the collapse of imports, relative to *AL* trade. There appears, therefore, to be a cumulative effect imparted by the *CS* and firm affiliation, with the difference that for both *IF* and *AL* trade the *CS* impacted trade of intermediates (and this results is robust to controlling for firm ownership), whereas the differential impact of *IF* with respect to *AL* trade is mostly evident for capital and consumption goods in the downturn and for intermediates in the recovery.

Several factors can explain why the analysis of *IF* against *AL* trade failed to show well defined results. First, all regressions are run with firm-month fixed effects; so there is likely to be little within firm-month variation to be estimated from between *IF* and *AL* trade. Secondly, the identification of *IF* and *AL* transactions suffers from measurement error: as explained in Section 3, the misallocation of a fraction of shipments from *AL* to *IF* trade causes the coefficients on these variables to be biased towards zero, again preventing the detection of a significant impact. In this case, however, it can be argued that this limitation works against my identification strategy and that the differences I detect between *IF* and *AL* trade would just be stronger if I could separate the two groups more precisely. Lastly, even though the stylized (S, s) model offers a simple rationale to expect a larger reaction of *IF* trade, the presence of alternative mechanisms of opposite sign is well possible in a trade crisis[33]. In case offsetting mechanisms were at work, this can further explain why only a mild gap is uncovered between the response of one trading mode with respect to the other.

Importantly, heterogeneity across the *CS* of imported products seems to be the relevant margin of intervention of firms when attempting to downsize activity in a recessionary environment: the accelerating impact of the *CS* persists when controlling for the effect of firm affiliation and it is the only margin along which a differential impact between *IF* and *AL* trade is detected, possibly because of a different inventory mangement strategy, or more simply a differential potential to quickly adjust to a shock.

2.6.4 A *bullwhip* effect triggered by the adjustment of intermediates?

The cost-share of imported products imparted to imports of intermediates a more than proportionate response to the change in demand in the 2008-09 collapse, in both the downturn and in the recovery phase. This deeper trough experienced by intermediates hints at a U-shaped reaction for these goods over the crisis. If this path can find an explantion in the dynamics of inventory adjustments by firms along a value chain[34], this U-shaped reaction recalls what the value chain literature defines the *bullwhip* effect (Forrester, 1961), a response induced by demand variability, which is lowest for the most downstream product along a chain of production, and highest for the most upstream producers. Escaith *et al.* (2010) argue that the greater the distance between a firm and the final consumer, the more demand uncertainty the firm faces and the greater its inventory holdings. A demand shock leads downstream firms to reduce orders and run down inventories in expectation of lower future demand: this is reflected in an amplified shock for upstream firms, which are forced to hold more inventories. During the recovery phase the opposite should be observed, with a more

[33] IF trade of US firms was reported to be more resilient than AL trade during the East Asian crises of 1997 (Bernard *et al.* 2009).

[34] This channel is going to be analysed in Section 2.7.

than proportional increase of shipments along the chain when inventory stocks go back to the pre-shock level.

The results of Table 2.4 do not show the existence of a *bullwhip* effect for all intermediate products. In columns (5) and (11) I expressly control for this effect, which would result in a negative coefficient on the intermediate dummy in the downturn, coupled with a positive one in the recovery. There appears instead to be a faster growth of intermediates' imports in the downturn, with no significant difference in the recovery. On the other side, importantly, the bullwhip effect emerges when controlling for the *CS* of intermediates: the faster fall in the downturn coupled with the faster rebound in the recovery found for inputs accounting for a larger *CS*, consists in a result corresponding to a bullwhip effect. The additional accelerating impact exerted on trade of high-*CS* products by *IF* trade contributes to strengthen the finding that, within GVCs, the relevant source of cross-product heterogeneity acting as a catalyst of the trade collapse is the relative *CS* of the items imported by firms.

2.7 Empirical tests of the inventory mechanism

In this section I provide evidence in support of the channel hypothesised as a determinant of the enhanced trade adjustment of higher *CS* products and the larger reaction of *IF* relative to *AL* trade.

Hypotheses 1 and 2 relate the trade adjustment to the management of inventories. In order to test their implications about the relevance of products' cost-share and firm affiliation in determining the stock of inventories (i.e. a higher *CS* corresponding to a higher value of the stock and *IF* trade firms accumulating less inventories than *AL* trade firms) and the inventory adjustment (i.e. a higher *CS* leading to a larger adjustment and IF trade adjusting more than *AL* trade), I would ideally need inventory data at the level at which I measure the cost-share (CN-8 product level). Additionally, to observe the adjustment over the crisis these data would need to be at a monthly frequency. Having inventory data only at the firm level, at a yearly frequency, an empirical test of the hypotheses can be approached only indirectly. Because of this weakness of the data and in order to provide more robustness to the inventory adjustment channel, I pursue two alternative strategies.

2.7.1 Frequency of shipments as a proxy for inventory adjustments

The change in the frequency of shipments at the transaction level can be an indication that firms are changing the stock of inventories of a certain product (Chen and Juvenal, 2015). With transaction level data, I can compute the growth of the frequency of imports of each product, in each sector, in each month[35].

As in the main specifications of this work, both the mid-point growth rate and the log-change of the frequency of shipments at the product-sector-month level has been computed. These have then been exploited to replace the growth of imports on the left-hand-side of specifications (8), (9) and (10) to test whether higher *CS* products underwent larger inventory adjustments and whether *IF* trade lead to a faster adjustment of trade relative to *AL* trade.

Table 2.9 shows the results of these regressions, for both the CS^{costs} and the CS^{sales} measures.

Table 2.9: Frequency of shipments - Inventory adjustment. Cost-share.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Mid-Point Growth Rates						Standard Growth Rates (Log-change)					
PANEL A: Frequency of shipments. CS^{costs}												
CS	-0.002***		-0.002***	-0.002***		-0.002***	-0.000		-0.000	-0.001*		-0.001
	(0.003)		(0.003)	(0.004)		(0.003)	(0.000)		(0.000)	(0.000)		(0.001)
Int		0.017***	0.022***		0.017***	0.031***		0.007***	0.007***		0.006***	0.007***
		(0.002)	(0.003)		(0.003)	(0.004)		(0.002)	(0.002)		(0.002)	(0.002)
Int*CS			-0.007			**-0.035***			-0.022**			**-0.025****
			(0.011)			**(0.018)**			(0.001)			**(0.012)**
CS*Rec				0.000		-0.001				0.002**		0.002**
				(0.000)		(0.001)				(0.001)		(0.001)
Int*Rec					0.000	-0.021***					0.017	0.001
					(0.004)	(0.005)					(0.004)	(0.004)
Int*CS*Rec						**0.069*****						**0.005**
						(0.020)						**(0.010)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	5313521	5578068	5313521	5313521	5578068	5313521	837575	856555	837575	837575	856555	837575
PANEL B: Frequency of shipments. CS^{sales}												
CS	-0.003***		-0.002***	-0.003***		-0.002***	-0.001		-0.000	-0.002***		-0.001*
	(0.000)		(0.000)	(0.000)		(0.000)	(0.001)		(0.000)	(0.001)		(0.001)
Int.		0.018***	0.022***		0.017***	0.031***		0.007***	0.008***		0.006***	0.008***
		(0.002)	(0.002)		(0.003)	(0.004)		(0.002)	(0.002)		(0.002)	(0.002)
Int*CS			-0.001			**-0.056****			-0.055**			**-0.058***
			(0.016)			**(0.028)**			(0.028)			**(0.031)**
CS*Rec				0.000		0.000				-0.003**		-0.003***
				(0.000)		(0.001)				(0.006)		(0.001)
Int*Rec					0.000	-0.021***					0.017	0.001
					(0.004)	(0.005)					(0.004)	(0.004)
Int*CS*Rec						**0.095*****						**0.006**
						(0.041)						**(0.013)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	5309737	5578068	5309737	5309737	5578068	5309737	837032	856555	837032	837032	856555	837032

Note: Standard errors clustered at the firm level in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

What emerges is that the growth of the frequency of shipments is significantly associated with the *CS* of products. In particular, shipments of intermediates accounting for a higher

[35] It has also been experimented with the computation of this variable at the firm level, but the level of product disaggregation and the monthly frequency do not allow to have meaningful variation when disaggregating the growth of the frequency by products, sector, and firms.

CS contracted more in the downturn and grew back more in the recovery phase. For standard growth rates this result is found also without distinguishing between the end use of products (column 10). The findings in Table 2.9 mirror therefore closely those of Table 2.4 and 2.5: if the change in the frequency of shipments can be considered a good proxy for inventory adjustments, it can be inferred that the accelerating impact of product's cost-share in the trade collapse was likely driven by a reduction in the stock of inventories in the downturn and to a corresponding increase in the recovery.

Table 2.10: Frequency of shipments - Inventory adjustment. Firm affiliation and CS^{costs}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
IF	0.024	-0.008	0.011'	0.011	-0.002	0.004	0.000	0.006
	(0.058)	(0.080)	(0.007)	(0.010)	(0.005)	(0.006)	(0.001)	(0.007)
CS	-0.002***	-0.002***	-0.002***	-0.002***	-0.001***	-0.001***	-0.002***	-0.001***
	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
IF*CS	-0.012**	-0.015***	**-0.013*** **	**-0.013*** **	-0.020	-0.187***	**-0.039**	**-0.228** **
	(0.004)	(0.03)	**(0.002)**	**(0.001)**	(0.024)	(0.051)	**(0.035)**	**(0.056)**
Int		0.022***		0.031***		0.008*		0.007**
		(0.003)		(0.011)		(0.002)		(0.0029)
Int*IF		-0.001		-0.003		-0.010**		-0.011*
		(0.009)		(0.011)		(0.005)		(0.005)
Int*CS		-0.004		**-0.037** **		-0.024**		**-0.026***
		(0.009)		**(0.015)**		(0.010)		**(0.014)**
Int*CS*IF		0.035		0.026		0.204***		0.236***
		(0.025)		(0.043)		(0.055)		(0.064)
IF*Rec			-0.021	-0.019			-0.004	-0.006
			(0.017)	(0.020)			(0.021)	(0.011)
CS*Rec			0.000	-0.000			0.002**	-0.002**
			(0.001)	(0.000)			(0.001)	(0.001)
IF*CS*Rec			**0.021**	-0.276*			**0.042**	0.132'
			(0.029)	(0.155)			**(0.029)**	(0.088)
Int*Rec				-0.021***				-0.004
				(0.006)				(0.005)
Int*IF*Rec				0.004				0.003
				(0.016)				(0.009)
Int*CS*Rec				**0.089*** **				**0.006**
				(0.020				**(0.014)**
Int*CS*IF*Rec				**0.276**				-0.113
				(0.163)				(0.091)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5313521	5313521	5313521	5313521	837575	837575	837575	837575

Note: Standard errors clustered at the firm level in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.10 I control for the impact of IF trade[36]. Again, conditioning on firm ownership leaves the impact of the CS unaltered. Focusing on the gap between IF and AL trade shows that the effect of *IF* trade on the change in the frequency of shipments is less clearcut than the effect detected on the growth of trade. Most of the coefficients in Table 2.10 take the same

[36] Table 2.10 shows the results for the CS^{costs} variable, Table 2.10B in Appendix shows the results for CS^{sales}. Furthermore, I only present the estimates where the effect of *IF* and the *CS* are interacted, given that in isolation *IF* shows no impact in the crisis (Table 2.8). When exploiting the change in frequency of shipments as dependent variable this result is confirmed.

sign as those in Table 2.8, but the deepening impact of IF trade on the frequency of imports of higher CS product is not always statistically significant at the conventional levels (columns 3, 4, 7 and 8). Hence, I cannot draw strong conclusions about the channel driving the effect of IF relative to AL trade; however more evidence in support of the inventory adjustment channel is provided in Section 2.7.2.

2.7.2 Reduced form estimation of inventory adjustments at the firm level

A second way in which I attempt to support the rationale of hypotheses 1 and 2 is by attempting a reduced form estimation of the main results of the (S, s) model exposed in Section 2.

As I am limited by the lack of inventory data at the level at which I measure the CS (CN-8), and in order to be able to run a firm level regression, I average up to the firm level the CS of the products that a firms imports over a year: $CS_{it} = \frac{1}{K}\sum_{k=1}^{K} CS_{kj}$ where CS_{it} is the CS of firm i in year t[37]. According to equation (1) the average stock of inventory is negatively related to the unit-cost of the item, but positively to the cost-share (equation (81) in appendix). Taking (1) to the data leads to a specification of this form:

$$N_{it} = \beta_0 + \beta_1 CS_{it} + \beta_2 S_{it} + \gamma_i + \eta_t + \delta_1 t + \delta_2 t^2 + \varepsilon_{it} \tag{11}$$

where N denotes the stock of inventories, CS denotes the firm level cost-share ratio, S denotes sales, γ_i and η_t denote firm and year fixed effects, t and t^2 denote a linear and a quadratic time trend[38], i and t index firms and years. Firm fixed effects capture factors that can be considered firm specific and constant over time, like the ordering cost A, the complexity coefficient ω and the carrying charge I; any time varying factor common across firms that determines a change in these costs (e.g. interest rates) is captured by the time fixed effects.

β_1 and β_2 capture the contemporaneous impact of the CS and sales on inventories: the CS should be positively associated with the value of the stock, whereas sales could come with a negative coefficient if contemporaneous sales are different from firms' expectations and inventories act like a buffer stock. In order to take into account firms' expectations and the adjustment of inventories due to sales and the average cost-share, specification (11) can

[37] The product level CS_{kj} does not present a time index because the CS is constructed to be time-invariant. The firm level CS_{it} has instead been calculated averaging the product level cost-share for each firm, year by year, over the products imported. This approach for the firm level CS has been chosen for two reasons:

a. it seems realistic to think that the average CS of the stock of inventories of a firm changes from year to year, depending on the adjustments performed by the firm.

b. preserving a time dimension allows the use of firm fixed effects in estimation.

[38] Since the average stock of inventories (1) is a function of the square root of demand and the cost-share, linear and quadratic time trends are consistent with targets that increase with time and its square root.

be amended in this way:

$$N_{it} = \beta_0 + \beta_1 CS_{it} + \beta_3 CS_{it-1} + \beta_3 S_{it} + \beta_4 S_{it-1} + \gamma_i + \eta_t + \delta_1 t + \delta_2 t^2 + \varepsilon_{it} \quad (12)$$

Concerning hypothesis 2 and the unequal inventory management strategy between IF and AL trade firms, an indirect test has been attempted by exploting specification (13):

$$N_{it} = \beta_0 + \beta_1 Group_i + \beta_2 S_{it} + \beta_3 S_{it-1} + \sum_r \beta_r X_{i,t} + \eta_t + \delta_1 t + \delta_2 t^2 + \varepsilon_{it} \quad (13)$$

where *Group* denotes a dummy variable taking value 1 if the firm belongs to a multinational group, S denotes sales and X denotes a vector of firm level controls[39] included because, as the *Group* dummy time-invariant, it is not possible to exploit firm fixed effects likewise in the above specifications.

Table 2.11 provides the results of the estimation of (11) and (12), for both CS measures. The data are taken from firms' balance sheet information (AJPES), for all years between 2000 and 2011. The inventory and sales variables are scaled by firms's value of total assets.

Table 2.11: Inventories as a function of the CS.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CS^{costs}				CS^{sales}			
CS_firm(t)	0.00051**		**0.00078*** **	**0.00054*** **	0.00087**		**0.00165*** **	**0.00137*** **
	(0.00021)		**(0.00014)**	**(0.00018)**	(0.00044)		**(0.00031)**	**(0.00040)**
CS_firm$(t-1)$		-0.00032***	**-0.00059*** **	**-0.00045*** **		-0.00048***	**-0.00101*** **	**-0.00066*** **
		(0.00010)	**(0.00011)**	**(0.00017)**		(0.00014)	**(0.00019)**	**(0.00028)**
Sales(t)	-0.00026+	-0.00023+	-0.00023+	-0.00024+	-0.00016***	-0.00023+	-0.00022+	-0.00024+
	(0.00018)	(0.00016)	(0.00016)	(0.00017)	(0.00005)	(0.00017)	(0.00016)	(0.00018)
Sales$(t-1)$		0.00022	0.00027+	0.00034+		0.00022	0.00027+	0.00033+
		(0.00021)	(0.00021)	(0.00024)		(0.00021)	(0.00021)	(0.00024)
CS_firm(t)*Crisis				**0.00014**				**-0.00083**
				(0.00040)				**(0.00080)**
CS_firm$(t-1)$*Crisis				**-0.00103*** **				**-0.00027**
				(0.00056)				**(0.00098)**
Trends	yes	yes	yes	yes	yes	yes	yes	yes
Firm. FE	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Constant	0.192***	0.192***	0.192***	0.188***	0.185***	0.192***	0.192***	0.188***
	(0.00127)	(0.00133)	(0.00133)	(0.00133)	(0.00121)	(0.00133)	(0.00127)	(0.00133)
N	110169	81448	81020	86734	110115	81434	80999	86705

Note: Standard errors clustered at the firm level in parentheses; + p < 0.2, ' p < 0.15,* p < 0.1, ** p < 0.05, *** p < 0.01.

The contemporaneous average firm-level CS ratio is always found to be positively associated with the stock of inventories, as expected. It also emerges that contemporanous sales

[39] The controls are capital intensity, skill intensity, number of employees and TFP, computed by use of the Levinsohn and Petrin (2003) estimator.

are negatively associated with the value of the inventory stock: this seems compatible with the classical interpretation that sees inventories as a buffer against unexpected increases in sales, in order to avoid stockout costs (Hadley and Whitin 1963, Abel 1985, Carpenter *et al.,* 1994, 1998). The optimal stock (equation 1 in the model) increases with sales; hence in columns (2) and (6) I attempt to control for the adjustmet induced by the *CS*, replacing the contemporaneous *CS* with its one year lag: conditional on sales (or past sales), a past higher average *CS* induces firms to adjust inventory holdings to a lower level in order to minimise carrying costs: this explanation is compatible with the negative coefficient estimated for the lagged *CS* ratio. In columns (3) and (7) I control for all factors jointly: all coefficients take the expected signs, including the sales variables, whose level of significance does however not reach the conventional levels.

Lastly, in order to control whether the inventory adjustment behaviour was enhanced during the trade collapse, in columns (4) and (8) I interact the firm level *CS* and its one year lag with a dummy picking up the difference between these coefficients for all the other years and 2009.

The contemporanous *CS* doesn't show a significant difference during the crisis, but the lagged *CS* is associated with a negative premium for the crisis year (signifcant only for the *CS* in terms of firms' costs). This suggests that if firms tend to respond to a higher *CS* by reducing the stock of inventories, they did so more strongly during the trade collapse.

Table 2.12: Inventories and firm affiliation.

	(1)	(2)
Group	**-0.025*** **	**-0.023*** **
	(0.005)	**(0.005)**
$\text{Sales}_{(t)}$	0.002	0.002
	(0.001)	(0.001)
$\text{Sales}_{(t-1)}$	0.004*	0.004*
	(0.002)	(0.002)
Group*Crisis		**-0.006** **
		(0.003)
Trends	yes	yes
Firm. FE	no	no
Firm Controls	yes	yes
Year FE	yes	yes
Constant	0.247***	0.247***
	(0.0068)	(0.0068)
N	23849	23849

Note: Standard errors clustered at the firm level in parentheses; p < 0.1, ** p < 0.05, *** p < 0.01.

Table 2.12 presents the results from estimating specification (13). In line with hypothesis 2, firms belonging to multinational groups are found to accumulate a lower stock of inventories, on average, relative to independent firms. Furthermore, the interaction between the group and the crisis dummy shows an additional negative coefficient, confirming the possibility that firms trading intra-firm might have undertaken larger inventory adjustments during the crisis.

The results in Table 2.11 and 2.12 appear to broadly endorse the (S, s) model and the predictions of hypothesis 1 and 2. Despite the evident caveats arising from the data structure available to test these propositions, there is some - admittedly rudimentary - evidence in support of the inventory adjustment channel as an explanation of the role of the CS heterogneity in accelerating the trade collapse. A higher average CS of imported products is associated with a higher value of inventories, and firms whose average CS of imported products is higher appear to reduce their inventory holdings, after controlling for their level of sales: this mechanism could help explaining the accelerating impact of the CS on imports of intermediates estimated in Tables 2.4 and 2.5, and its role as a catalyst of the trade collapse.

Also the IF versus AL hypothesis obtains support in this section: a sizeable gap is detected in the amount of inventories that affiliated and unaffiliated firms carry, with a further premium during the crisis year.

2.8 Intensive and extensive margin of trade in the crisis

The literature attributed the largest fraction of the variation in trade during the crisis to adjustments at the intensive margin, mainly performed by large exporters (Bricongne *et al.* 2012, Wagner 2012, Behrens *et al.* 2013). The availability of monthly transaction level data allows to perform a detailed intensive/extensive margin decomposition, and to separate the extensive margin further along the firm, destination and product dimensions. One of the novelties of this work consists in the possibility of decomposing these four margins further, distinguishing between IF and AL trade.

The results of section 2.6 and hypothesis 2 point in direction of a differential reaction during a trade collapse depending on the ownership structure linking agents of international trade. Further in support of a differential impact of shocks between IF and AL trade, there are the different cost structures relating to the two organisational modes as well as the so-called hold-up problem[40] (Antràs, 2003; Antràs and Helpman, 2004; Nunn and Trefler, 2013). With respect to trade margins, deeper integration leading to the establishment of multinationals, due to the presence of sunk costs and market rigidities, could imply that in a trade crisis

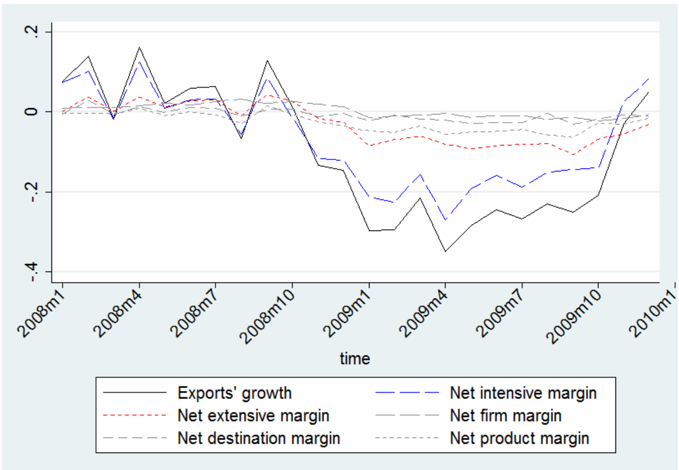
[40] A main determinant of intra-firm trade vs outsourcing has been shown to be the share of inputs provided by the headquarter firm relative to the share of inputs provided by the subsidiaries. In case the bargaining between the parties of an outsourcing agreement breaks down after investment in inputs and production by the two parties took place, the degree of control on the outside options is what induces the firm providing the larger share of inputs to integrate with the foreign supplier in order to minimise losses. (Antràs 2003, Nunn and Trefler 2013).

adjustments along the intensive margin are preferable to extensive margin adjustments. If some adjustment along the extensive margin is required, then this could be preponderant for arm's length trade. For example, Bernard *et al.* (2009) measure a larger negative extensive margin adjustment for arm's length compared to intra-firm trade during the East-Asian crisis of 1997.

The margin decomposition, distinguishing between intra-firm and arm's length transactions, is a further dimension of heterogeneity in the collapse explored in this work. Bernard *et al.* (2009) is to my knowledge the only paper to date performing such a decomposition, analysing US trade during the 1993-2003 period. The decomposition applied here is based on Bricongne *et al.* (2012)[41]: for each month I measure the intensive margin and the three extensive margins (firm, destination and product margins), separating then these further between *IF* and *AL* transactions. The net margins are given by the sum of the positive and negative contributions[42].

During the crisis the adjustment of Slovenian trade took place mostly at the intensive margin, with this fraction of the overall variation possibly also underestimated because of the high level of data disaggregation and frequency. From Figure 2.5 it also is evident that the firm and destination extensive margins play a smaller role compared to the product margin: this confirm the similarity of the Slovenian experience to what the literature showed for France, Belgium and Germany.

Figure 2.5: Net firm, destination and product extensive margin adjustments, 2007-2011.



[41] Since the methodology is borrowed from Bricongne *et al.* (2012) I specify the details in Appendix.

[42] Notice that while the entirety of the empirical analysis in this chapter exploited data on imports, for the margin analysis I am showing results obtained with data on exports. The reason is that, being the margin decomposition computationally intensive, especially when disaggregating the margins across IF and AL transactions I could not perform the analysis with the import data. In the Slovenian trade data, the import data include a much larger amount of observations relative to the export data, reason why the application of the Bricongne et al. (2012) methodology on imports was not possible with the computer at hand in the Secure Rooms at the Statistical Office in Ljubljana.

The complete decomposition is presented in Table 2.13, where the margins' contributions are averaged over the main periods characterising the event[43].

Table 2.13: Net intensive and extensive margin adjustments, 2007-2011, in %.

	Pre-crisis Jan 07 - Dec07		Downturn Sep 08 - Nov 09		Recovery Dec 09 - Sep 10		Post-crisis Oct 10 - Dec 11	
	IF	AL	IF	AL	IF	AL	IF	AL
Firm								
Entry	0.49	3.78	0.40	2.95	0.62	2.92	0.43	3.51
Exit	-0.07	-1.84	-0.91	-3.26	-0.44	-3.34	-0.29	-2.80
Net Firm	0.42	1.94	-0.51	-0.29	0.17	-0.41	0.13	0.70
Destination								
Entry	1.95	5.66	1.46	4.72	1.91	5.88	2.11	5.71
Exit	-1.14	-4.75	-1.99	-5.93	-1.57	-4.87	-1.61	-4.21
Net Dest	0.81	0.90	-0.53	-1.21	0.33	1.01	0.49	1.50
Product								
Entry	4.91	8.92	2.98	4.83	9.03	6.31	6.20	6.49
Exit	-4.61	-8.24	-4.82	-7.38	-8.54	-6.89	-5.80	-5.83
Net Prod	0.30	0.67	-1.83	-2.55	0.49	-0.57	0.40	0.65
Total Extensive								
Pos	7.36	18.3	4.85	12.51	11.5	15.1	8.74	15.7
Neg	-5.83	-14.8	-7.73	-16.57	-10.5	-15.1	-7.70	-12.8
Net Ext	1.53	3.52	-2.88	-4.05	1.00	0.00	1.04	2.86
Total Intensive								
Pos	13.3	10.6	9.01	8.04	13.8	12.3	12.0	13.0
Neg	-8.81	-8.17	-17.3	-15.4	-7.33	-9.34	-7.99	-8.13
Net Int	4.49	2.43	-8.36	-7.39	6.47	3.04	4.09	4.95
Tot. Exp	6.02	6.00	-11.2	-11.4	7.48	3.06	5.13	7.82

Source: CARS, SURS and author's calculations.

In the pre-crisis period, the contributions of intensive and extensive margins are about similar. During the downturn the intensive margin absorbed over double the share of the overall fall in trade compared to the extensive margin; with also the subsequent recovery being dominated by an increase in the value of continuing links rather the creation of new ones. It is the product margin that contributed the most to the extensive margin variation: this is represented by discontinued shipments of products by incumbents within destinations that continued to be served with other products. This is a within firm-destination margin that might appear of secondary importance – and certainly not evident in more aggregate data – which could however represent a first order issue in the light of new findings of the heterogeneous firms trade literature: importing firm's productivity can be harmed in case firms are no longer able to source inputs that are not perfectly substitutable in the production process (Gopinath and Neiman, 2014); or else, exporters might have suffered in case they

[43] Table 2.13 includes the figures underlying figure 2.5. For each sub-period the margins are evaluated separating the contributions to *IF* and *AL* trade, but summing horizontally the within sub-period margins the aggregate figures represented in figure 2.5 are obtained.

were unable to find buyers for the varieties they produce following importers willingness to concentrate purchases from the suppliers best suiting their preferences (Ottaviano *et al.* 2014).

The existing literature on the trade crisis has not explored the disaggregation of trade margins taking into consideration whether shipments are between related parties or not. In all sub-periods, except for the recovery, the contribution of the extensive margin to the overall variation in AL trade exceeds the contribution to the variation in IF trade. A significative comparison can be made especially in the first two sub-periods, because both before the crisis and in the downturn the overall variation is split roughly equally between the two organisational modes, but it is evident that the composition of this variation differs between IF and AL trade: intensive margin changes are prevalent for IF trade; extensive margin changes prevail for AL trade. Once a firm is integrated with the foreign supplier, in a crisis it might be preferable to reduce the value of the shipments, rather than severing the offshoring link. This could find an explanation in the different cost structures relating to these different modes of cross border production, with larger sunk costs and lower variable cost associated to IF trade; or else, in the reasons why firms decide to acquire the ownership of the foreign supplier, rather than subscribing an outsourcing agreement. The literature triggered by Antràs (2003) explained that intra-firm imports increase in the share of non-contractible inputs provided by the headquarter firm: once investment in customised inputs took place, a firm will have losses if the agreement breaks down. Therefore, the larger this investment the more likely the acquisition of control over the supplier.

This interdependence between the two ends of the production chain could be another reason why intensive margin adjustments were larger for IF trade. Outsourcing contracts, on the other hand, might be less negotiable in case production needs to be cut: this could reduce the extent of intensive margin changes, while increasing the extensive margin share in case a firm defaults on its obligations altogether. A further difference between IF versus AL trade arises when looking at the stability of the extensive margin links over time: even though the net contribution do often not show a stark difference between IF and AL trade – especially for the firm and destination margins –, the creation and destruction of links that went into the creation of the net variation show a much higher variability of AL compared to IF transactions. The channels leading to this different behaviour might again derive from the explanations pushed forward above, and find theoretical support in the property rights approach to organisational modes.

2.9 Conclusion

This work addresses the impact of the 2008-09 financial crisis on international trade by analysing high frequency transaction level data matched with firm balance-sheet and ownership information. The main contribution of this paper consists of the identification of a new channel that accelerated the reaction of trade flows to the shock. The share of imported intermediates in firms' costs was identified as a catalyst of the trade collapse, because shipments of higher cost-share inputs fell more than proportionately compared to lower cost-share inputs in the downturn, and rebounded faster in the recovery. This larger responsiveness in both sub-periods of the event suggests that the trough of the collapse was indeed deeper for transactions involving higher *CS* products. This result is robust to expoiting only the intensive margin variation of trade; or to the amendment of the cost-share measure (from the share in total costs to the share in total sales).

Notwithstanding being unable to identify the exact source of this behaviour, this phenomenon appears compatible with the hypothesis that firms adjusted more promptly the inventory stock of higher CS inputs, in the attempt to react to the reduced actual and expected level of demand. Inventory adjustments have been shown to be among the causes of the large elasticity of trade to the demand variation in 2008-09 (Alessandria *et al.* 2011): if, plausibly, firms attemped to offset the shock to internal liquidity caused by the demand collapse by reducing the amount of inventories carried, the optimisation of inventory stocks could have been more prompt for higher *CS* intermediates, leading to the larger estimated reaction for these goods. A simple (S, s) type model with fixed ordering costs, constant marginal purchasing costs and rising marginal handling costs gives theoretical support to this intuition.

The degree of integration of GVCs was also examined, with the role of intra-firm trade being analysed from several perspectives. Overall, *IF* trade was not seen as performing differently from AL trade. Despite this, firm affiliation could have acted as a further accelerating factor in a trade crisis for transactions involving relatively high *CS* products. The lower degree of uncertainty and the more rapid and effective communication characterizing business relations between parties related by ownership rights, could lead to a more effective management of inventory stocks both in good and in bad times: the size of the inventory buffer is likely to be smaller, but the reaction in case the stock needs to be downsized could be stronger in proportional terms, with this responsiveness being even larger for high cost-share products. This hypothesis could explain why a larger adjustment was measured in both the downturn and the recovery for imports of higher *CS* products when involving related parties, relative to AL trade. This result is mostly driven by consumption and capital goods. The reaction of IF trade differed from AL trade also with respect to trade margins: possibly due to the different cost structures relating to the two organisational modes and the ease of adjustment of offshoring (IF) versus outsourcing (AL) agreements, the share of intensive margin relative to extensive margin adjustments was seen to be larger for IF trade; conversely, the share of extensive margin variation was larger for AL trade.

In conclusion, although the precise mechanisms by which the *CS* of intermediates works in determining a higher elasticity of trade flows to a demand contraction cannot be observed with the data at hand, the identification of this *catalyst* of the collapse is the strongest and most reliable contribution of this paper. This source of heterogeneity across different products affected the responsiveness of international trade to the demand shock of 2008-09 and, crucially, it seems to be the relevant margin of intervention by firms when attempting to downsize activity and trade in the recessionary environment.

The fact that different types of products exhibited different performances during the crisis can shed light on the strategies pursued by firms to cope with these events.

3 The Effect of Liquidity Constrained Innovation on Exporting

3.1 Introduction

Innovation and exporting are activities characterized by a high degree of interdependence. Firms' decision to undertake innovative projects and invest in R&D can lead to a higher propensity to enter the export market (Roper and Love, 2002; Lachenmaier and Woessmann, 2006; Cassiman *et al.,* 2010; Damijan *et al.*, 2010; Ganotakis and Love, 2011; Becker and Egger, 2013). At the same time, exposure to trade has been found to stimulate firms' innovation efforts, through a variety of channels: access to a larger market (Trefler and Lileeva, 2010; Aw *et al,* 2011), export revenues (Bustos, 2011), higher product-market (Impulliti and Licandro, 2013) and import competition (Denicolo and Zanchettin, 2009; Liu and Rosell 2013; Fernandez and Paunov, 2013; Bloom *et. al,* 2015). In this chapter I propose a stylized theoretical framework to explore the interconnection between innovation and exporting from a novel perspective.

I develop a monopolistically competitive model with liquidity constraints to study the joint effects on selection and exporting arising from a reduction in innovative activity in an industry of producers with heterogenous efficiency. The 2008-09 financial crisis and subsequent recession exerted a negative impact on the innovative activity pursued by firms (Archibugi *et al.,* 2013; Lee *et al.,* 2015). The reduction in exteral liquidity made available by the banking sector resulted in cuts in innovation spending (Campello et al. 2010), even the abandonment of innovation projects (Paunov, 2012). In light of the well-known nexus between innovation and trade, the overall lower innovation output and the likely loss in efficiency that resulted from the financial shock could in turn have affected firms' participation in exporting. My contribution to the existing literature is to examine the role of competition effects on the relation between innovation and exporting, such that participation to exporting can be facilitated by a shock harming firms' innovation.

The key mechanism that I examine consists of the reduction in the industry-wide degree of product market competition that arises from a reduction in the average productivity and quantity produced by firms whose innovative activity is interrupted by a tightening in liquidity constraints for innovation. In an open economy where the shock to liquidity is symmetric across trading partners, access to exporting could be facilitated by the anti-competitive effects resulting from the reduced access to innovation.

This chapter provides an extension of the work of Melitz and Ottaviano (2008), adding innovation to the original model. I model R&D innovation as a costly activity that generates efficiency gains in a way which is similar to Bustos (2011), but whose outcomes differ because of the endogeneity of markups generating competitive effects which are absent in Bustos' framework. My model is also related to the work of Impullitti and Licandro (2013), which features a dynamic industry of oligopolisitic firms with endogenous markups and cost-reducing innovation, but where innovation is an ongoing decision undertaken by incumbent firms. This differs from my one-step technological upgrading choice. Impullitti and Licandro's work belongs to a class of dynamic models that study the effects of trade on competition, selection and innovation in a unified framework (Costantini and Melitz, 2007; Atkeson and Burstein, 2010; Burstein and Melitz, 2011). In these works, expected or actual changes in the trading environment are observed to generate endogenous export market selection and changes in innovation intensity, which in turn feed into each other and amplify productivity differences between exporters and innovators on one side and non-exporters and non-innovartors on the other.

The modelling structure that I present in this chapter is simpler, in that I propose a static model where innovation is a one-off decision that depends on the efficiency firms discover that they have at birth. However, my model differs from this literature in that I make innovation subject to liquidity constraints. As there is a cost associated with accessing innovation, then liquidity constraints at the firm level come into play: the capacity to overcome these constraints is endogenously determined in this model since liquidity constraints interact with productivity heterogeneity. I impose a structure whereby firms operate over two periods of time: in the first period firms make an irreversible investment to enter the domestic market, then randomly draw a productivity level from a distribution of marginal costs and, if they are profitable enough, firms produce and generate profits. In the second period, firms decide whether to innovate and upgrade their original productivity by paying a fixed cost: a fraction of this cost can be borrowed externally, but the remaining fraction needs to be financed internally through the liquidity generated in the first period. This is the simplest way possible to model a liquidity constraint. Only firms that accrue profits exceeding the fraction of the innovation cost that needs to be financed internally are able to access innovation in the second period: if this fraction is sufficiently high there is a set of firms that could profitably innovate in the absence of liquidity constraints, but are prevented from doing so. In the second period firms can also decide to export to the (symmetric) foreign partner, assuming a standard iceberg trade cost[44].

[44]Following the original Melitz and Ottaviano (2008) framework, exporting is not subject to fixed costs, but only variable costs.

Note, I make a further set of symplifying assumptions, in order to keep the model tractable and centered on the main research question. Since there is no dynamics and only two time periods over which the industry operates, for simplicity, there is no discounting in the model. Also, innovation only affects the supply side of the market, being it modelled as an efficiency gain in production, not affecting the quality of products: this differs from related works modelling innovation in the Melitz-Ottaviano framework, (e.g. Di Comite *et al.*, 2014; Antoniades, 2015) and implies that the same set of preferences applies to varieties produced by innovators and non-innovators. Finally, whereas firms can access an external capital market and borrow a fraction of the innovation fixed costs, this possibility is precluded to consumers, whose income is given by the labour supplied.

I draw from Chaney (2013) and Manova (2013) when modelling the liquidity constraint, though with a few differences relative to their frameworks. Both Chaney (2013) and Manova (2013) model liquidity constraints affecting entry into exporting, since in their models (as in Melitz 2003) to access the foreign market there is barrier represented by fixed exporting costs. There are no fixed exporting costs in my model, since the existence of a per-unit iceberg trade cost is sufficient to generate selection between firms and to induce only the more productive firms to export. Furthermore, as reported by Aw *et al.* (2011), although there are entry costs for both exporting and innovation, the costs of undertaking R&D activities are larger than the costs of exporting: this motivates my choice of featuring a fixed innovation cost which, together with the assumption that borrowing externally to innovate is difficult, generates liquidity constrained producers.

Furthermore, I structure my model over two periods of time because, in contrast to Chaney (2013) and Manova (2013) where firms pledge profits from the domestic market to enter the foreign market, firms in my framework reinvest profits into innovation in order to upgrade technology for the same market. The first period is therefore instrumental for the accumulation of internal liquidity (in heterogeneous amounts), which in turn generates constrained and unconstrained producers in the second period. Finally, Manova (2013) proposes a richer structure, modelling also a financial sector lending to producers in exchange for a collateral that can be seized in case of default. While it would enrich the model, this further structure imposed by Manova (2013) would also increase its complexity without qualitatively altering the predictions of the model. My main intention is to show how a reduction in innovative activity affects entry into exporting, and so I preferred to abstract from this additional complexity and focus on the key mechanisms under analysis.

There is a vast literature on the importance of liquidity constaints for innovation. For several reasons R&D investment can be driven below the level that would be optimal in a world of perfect financial makets. Lack of collateral value and asymmetric information problems are among the well-known reasons why firms struggle to raise external finance to sustain their innovation spending (Hall and Lerner (2010) provide a comprehensive summary of this literature). However, despite the simplicity of my modelling framework, to the best of my knowledge no work so far has introduced liquidity constraints for innovation in a heterogeneous firm model that jointly studies the decisions to export and innovate. This allows me to explore, in a novel way, how the degree of product market competition can work as a channel linking a negative shock to innovation - that I model as a tightening of the liquidity constraint - to participation in exporting.

The modelling structure and the research question are inspired by the events of the financial crisis of 2008-2009, during which innovative firms were subject to a credit rationing that worsened relative to more normal times. The theoretical predictions of this chapter are taken to the data in Chapter 4 of this thesis.

The rest of this chapter is organized as follows. In Section 3.2 I expose the model, the closed economy version in section 3.2.1. and the open economy version in section 3.2.2. In section 3.2.3 I analyse the impact of a tightening in the liquidity constraint on firms' innovation and, through the change in product market competition, on exporting. In Section 3.3 I test empirically whether the sorting of firms produced by the model into the categories of domestic producers, innovators and innovators-exporters is confirmed in the data. Section 3.4 concludes.

3.2 The Model

3.2.1 Closed Economy

The model works over two periods of time, t_1 and t_2. In t_1 firms can only produce domestically and have no access to innovation. This first period is therefore identical to the closed economy version of Melitz-Ottaviano (2008), of which I describe the key features. In the second period firms will make a decision about investing in innovation and, in the open economy version of the model, exporting part of their production abroad. This section describes the closed economy equilibrium.

The economy has L consumers, each supplying one unit of labour.

Demand

The quadratic utility function developed by Ottaviano, Tabuchi and Thisse (2002) is exploited for the demand side of the model:

$$U = \alpha \int_{i \epsilon S} q_i di - \frac{\gamma}{2} \int_{i \epsilon S} q_i^2 di - \frac{\eta}{2} \left[\int_{i \epsilon S} q_i di \right]^2 + q_o \tag{14}$$

Each consumer derives utility from a continuum of differentiated varieties, $i \epsilon S$, and a homogenous good (q_o), used as a numeraire. The demand parameters α, γ, and η are all positive constants and respectively represent the preference for any variety in the differentiated sector in terms of the numéraire q_o, the degree of product differentiation and the substitutability across varieties;

Maximising (14) with respect to the budget constraint $\int q_i(s)p_i(s)ds + q_o = y$ yields the sector demand function for each firm/variety i.

$$q_i = \frac{\alpha L}{\gamma + \eta N} - \frac{L}{\gamma} p_i + \frac{\eta N}{\eta N + \gamma} \frac{L}{\gamma} \bar{p} \tag{15}$$

where L is the number of consumers, N the number of consumed varieties and $\bar{p} = N^{-1} \int p_i$.

Inverting (15) the idiosyncratic price level p_i can be obtained:

$$p_i = \frac{\alpha \gamma}{\gamma + \eta N} - \frac{\gamma}{L} q_i + \frac{\eta N}{\eta N + \gamma} \bar{p} \tag{16}$$

Since demand is linear, there exists a choke price $p_{\max}$ at which demand for a variety i is driven to zero:

$$p_{\max} = \frac{\alpha \gamma + \eta N \bar{p}}{\eta N + \gamma} \tag{17}$$

Supply - First Period

The only factor of production is labour which is inelastically supplied at its aggregate level L, an index of the sector's size. Firms enter the industry by paying a sunk entry cost f_E and subsequently randomly draw a marginal cost c_i (inversely relate to the a productivity level) from a Pareto distribution $G(c)$. The numeraire q_o is produced at a unit cost, which pins down the wage to unity.

Firms produce the differentiated varieties using a constant returns to scale technology and face the following total costs function:

$$TC_{i,t_1} = c_i q_i, \tag{18}$$

where c_i is the randomly drawn marginal cost and q_i is the quantity produced. Firms that can cover the marginal cost survive and produce, all other firms exit immediately. Writing down the profit function $\pi_i = (p_i - c_i)q_i$, by use of equations (15), (16) and (18) and solving the profit maximisation problem yields the optimal[45] quantity $q(c)_i^*$, optimal price $p(c)_i^*$ and optimal profit $\pi(c)_i^*$ for each firm i:

$$q(c_i)_{t_1}^* = \frac{L}{2\gamma}\left(\frac{\alpha\gamma}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma}\bar{p} - c_i\right) \tag{19}$$

$$p(c_i)_{t_1}^* = \frac{1}{2}\left(\frac{\alpha\gamma}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma}\bar{p} + c_i\right) \tag{20}$$

$$\pi(c_i)_{t_1}^* = \frac{L}{4\gamma}\left(\frac{\alpha\gamma}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma}\bar{p} - c_i\right)^2 \tag{21}$$

In maximising its profit a firm takes as given the residual demand for its product, which depends on the average price level $\bar{p}$ and the number N of firms in the industry.

If the profit maximising price (20) is above the choke price (17), the firm exits. Denoting c_D as the marginal cost of a firm that makes zero profits and whose price is therefore just equal to its marginal cost[46], I can write $p(c_D) = c_D = \frac{\alpha\gamma + \eta N\bar{p}}{\eta N + \gamma} = p_{\max}$. This allows to re-write (21) as:

$$\pi(c_i)_{t_1}^* = \frac{L}{4\gamma}\left(c_D - c_i\right)^2 \tag{22}$$

Supply - Second Period: Innovation

The model as described so far is a two-period variant of Melitz-Ottaviano (2008). I now nest this framework adding a second period of time during which firms can decide to upgrade their initial productivity draw by paying a fixed cost f_I. For simplicity I do not model time discounting and do not allow for the possibility for firms to exit at the end of the first period: this implies that the decision to pay the entry cost and draw a marginal cost is made considering expected profits over the entire lifetime of the firm, i.e. two periods, as will be evident when computing the industry equilibrium[47].

This chapter proposes an approach to modelling innovation in a heterogeneous firms model which differs from previous analysis in the literature.

Recent works modelling innovation within the Melitz-Ottaviano framework assume that

[45] Optimal values of variables such as quantities, prices and the resulting profits are indexed with *.

[46] This would correspond to the pricing rule in a perfectly competitive industry; in the monopolistic competition setting under examination here only the least efficient firm is subject to this and is therefore indifferent about remaining in the industry.

[47] Allowing for exit at the end of the first period would imply that firms base their entry decision on the expected profit that are to be made in the first period only, when no competitor can innovate or export. Firms would then reassess the possibility of producing in the second period, or exiting, by evaluating the profit that can be made in an evironment that features innovators and exporters. Since adding this structure to the model does not alter qualitatively the theoretical predictions of my framework, I opted for keeping its structure simpler and impeding exit at the end of the first period.

the gain for innovating consists of a higher demand for the varieties produced (Antoniades 2015). In my work, the innovation gain is on the supply side. Aw et al., (2011) report that there are significant entry costs associated with innovation[48]; hence, depending on the initial productivity draw, some firms find it optimal to trade off a fixed cost with an innovation gain that allows firms to produce with a higher efficiency compared to that drawn at birth. Innovation is therefore modelled as an endogenous decision, based on the initial cost draw. I assume that the improved technology is produced by an outside sector and is exogenously given.

A similar supply side gain arising from innovation is modelled by Bustos (2011). However, an important difference between this work and Bustos' approach is that the latter endogenizes the decision to upgrade technology nesting the Melitz (2003) model. This implies that the model in Bustos (2011) features a constant elasticity of substitution (CES) utility function, which yields constant markups and prices, whereas in my model prices and markups are a function of the industry-wide degree of competitive pressure. From this follows that the shock to innovation that I model has a different outcome to that in Bustos' framework: I will return to this point more precisely in the section 3.2.3, which examines the comparative statics following the shock.

The assumption of firms trading off higher efficiency with a fixed innovation cost f_I is expressed with the following cost function:

$$TC_{i,t_2} = \begin{Bmatrix} TC_i = c_i q_i & i \in \ NI \\ TC_i = c_i q_i - \omega q_i + f_I & i \in \ INN \end{Bmatrix}, \tag{23}$$

where c_i is the randomly drawn marginal cost, q_i is the quantity produced and ω is the exogenous innovation gain[49], such that $0 < \omega < 1$. NI denotes non-innovators, INN denotes innovators.

The effect of innovation is stronger the larger is q_i, hence there is more to gain for firms that produce more.

Marginal costs are distributed according to a Pareto distribution G of the form: $G(c) = (c/c_m)^k$ bounded within [1, c_m]. I chose the unit of measurement of marginal costs such that the lower bound of the cost distribution is set to 1, with no loss of generality. This latter,

[48] The innovation cost f_I can be interpreted both as a fixed or as a sunk cost. The fixed (sunk) innovation cost could be paid either in the first or the second period of this model, with no difference to its implications. Once the innovation cost is paid, firms produce with constant returns to scale.

[49] This model features an additive innovation gain, whereas in Bustos (2011) the gain is proportional to the productivity of the firm. My predictions about which firms innovate change if the innovation gain is additive or proportional to firms' initial productivity. In my work, the higher productivity firms innovate if the gain ω is additive in the cost-function; whereas if the gain is proportional to productivity, lower productivity firms find it optimal to innovate.

together with the assumption that $0 < \omega < 1$, allows to avoid firms operating with negative marginal costs (that could arise if $c_i < \omega$). Hence a very efficient firm operating close to the lower bound of the cost distribution would have a small but still positive marginal cost in production.

Using again the expression for profits $\pi_i = (p_i - c_i)q_i$, by substituting in equations (15), (16) and (23) I solve the profit maximisation problem yielding the optimal quantity for each firm i that decides to innovate. Exploiting again that $c_D = \frac{\alpha\gamma+\eta N\bar{p}}{\eta N+\gamma} = p_{\max}$ gives:

$$q(c_i)^*_{INN,t_2} = \frac{L}{2\gamma}\left(c_D - c_i + \omega\right) \tag{24}$$

where $q(c_i)^*_{INN,t_2}$ defines the optimal quantity produced in period t_2 by an innovator with marginal cost c_i. By use of the inverse demand function (16) the profit maximising price for an innovator can be shown to be:

$$p(c_i)^*_{INN,t_2} = \frac{1}{2}\left(c_D + c_i - \omega\right) \tag{25}$$

Finally, from equations (24) and (25), equations for revenues, mark-ups and profits at the optimum can be written as:

$$r(c_i)^*_{INN,t_2} = \frac{L}{4\gamma}\left((c_D)^2 - c_i^2 + \omega^2\right) \tag{26}$$

$$\mu(c_i)^*_{INN,t_2} = \frac{1}{2}\left(c_D - c_i + \omega\right) \tag{27}$$

$$\pi(c_i)^*_{INN,t_2} = \frac{L}{4\gamma}\left(c_D - c_i + \omega\right)^2 - f_I \tag{28}$$

Note that equations (24)-(28) converge to those of Melitz-Ottaviano (2008) when $\omega = 0$.

Operating over the two periods, firms accrue the following profits:

$$\pi(c_i)^*_{NI} = \pi(c_i)^*_{t_1} + \pi(c_i)^*_{t_2} \tag{29}$$

if the firm does not innovate in the second period;

$$\pi(c_i)^*_{INN} = \pi(c_i)^*_{t_1} + \pi(c_i)^*_{INN,t_2} \tag{30}$$

if the firm innovates in the second period.

In this closed economy there are two cost-cutoffs to analyse. First, the exit marginal cost cutoff c_D, at which non-innovating firms are indifferent between producing or leaving the industry, since their profits are zero. This corresponds to the x-axis intercept of the profit function for non-innovators in Figure 3.1.

$$\pi(c_i)^*_{NI} = 0 \quad \rightarrow \quad \mathbf{c}_D = p_{\max} \tag{31}$$

Second, the innovation cost cutoff c_I. As evident from Figure 3.1, there is a marginal cost at which firms are indifferent between innovating or not. At this level of productivity, the innovation gain ω gives an advantage that in terms of profits corresponds exactly to the value of the fixed innovation cost f_I. This marginal cost represents the closed economy innovation cutoff c_I, in other words, the cost draw that makes innovation for the marginal firm optimal. To see this set:

$$\pi(c_i)^*_{NI} = \pi(c_i)^*_{INN} \quad \rightarrow \quad \mathbf{c}_I = c_D + \frac{\omega}{2} - f_I \frac{2\gamma}{\omega L} \tag{32}$$

In order to observe an industry with both innovators and non-innovators, the exit cut-off c_D needs to be lower than the innovation cutoff c_I. For this to be respected the following condition needs to hold:

$$f_I > \frac{L\omega^2}{4\gamma} \tag{33}$$

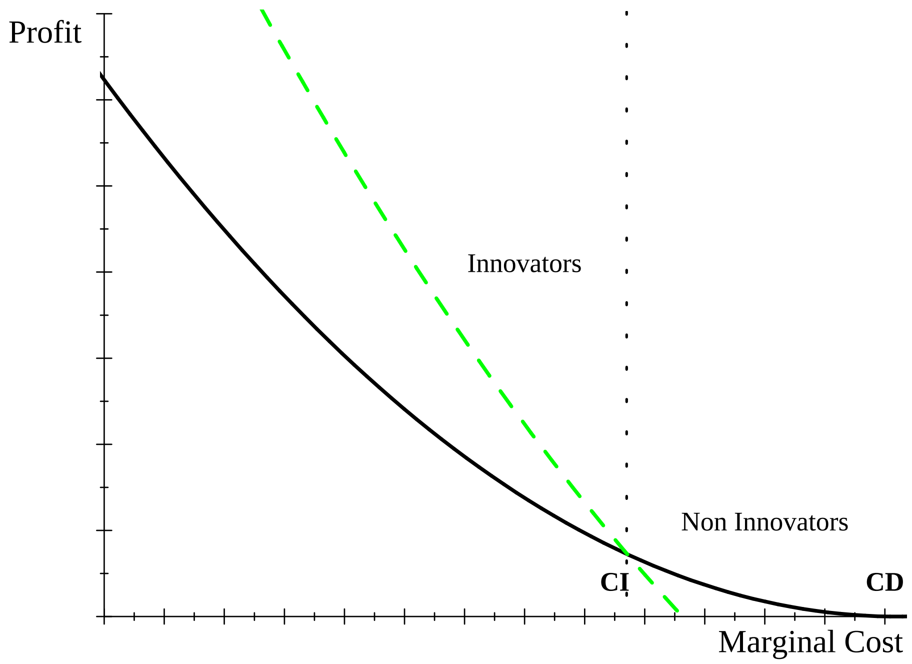
Condition (33) implies that the innovation cost f_I needs to be high enough to prevent all firms from innovating. This condition requires a larger fixed innovation cost in markets that are larger (larger L), in the presence of higher innovation gains (ω) and where varieties are less differentiated (lower γ).

This result can also be explained by drawing on the main implications of the original Melitz-Ottaviano (2008) framework: in larger markets, or where varieties are closer substitutes, competition is "tougher", i.e., c_D is lower. Given a certain innovation cost, a lower c_D reduces the range of cost draws over which innovation is not optimal. Finally, it can be envisaged from this that a larger exogenous innovation gain ω increases the degree of competition (lowers c_D). At the same time there is a direct effect of ω on the optimality conditions (24)-(28): in order to assess the impact on (24)-(28) the direct effect of a larger ω has to weighted against its indirect pro-competitive effect.

By imposing an additive innovation gain, it is found that most efficient firms are those that innovate. This is illustrated in Figure 3.1 that shows the optimal profits for non-innovators (solid line) and innovators (dashed line) against marginal cost.

Profits start at their maximum for the most efficient firms. Because the efficiency gain is additive and directly proportional to quantity, the most efficient firms that produce the largest quantity are those that choose to innovate: this applies for the cost range over which the dashed line is above the solid line, to the left of the intersection. As the initial marginal cost draw rises, the profit from innovating is progressively lower; for costs to the right of the intersection firms opt not to innovate.

Figure 3.1: Optimal Profit Functions for Innovators and Non-Innovators[50]



Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$, $\delta = 0.5$

Industry Equilibrium

The industry equilibrium had to be solved for in order to simulate Figure 3.1.

The timeline of the model is as follows. Before entering, firms evaluate the value of the entry cost f_E against the value of expected profits that can be made over their entire lifetime: since I do not allow firms to exit in period 1, firms evaluate expected profits over both time periods. In addition, a firm considers that in the second period the industry will be populated by some firms whose efficiency will increase thanks to the investment in innovation.

As long as expected profits exceed f_E, firms will continue to enter, but since entry is unrestricted, in the long run expected profits are going to be driven to zero. This is the monopolistic competition result that allows to determine the exit marginal cost threshold c_D on the cost distribution.

Upon entry, firms randomly draw a marginal cost from the cost distribution $G(c)$: firms whose marginal cost is above the exit cost cutoff c_D exit immediately, otherwise they produce remaining in the industry for two periods.

[50] The parameters were chosen in order to satisfy the various conditions in the model, other than respecting the theoretical assumptions.

I need to clarify that innovation is not subject to uncertainty in this model, except for the initial cost draw: once a marginal cost lower than the innovation threshold c_I is drawn, firms know immediately whether they will optimally innovate in the second period, or not.

Integration of firms' profits over the cost distribution $G(c)$ yields expected profits, i.e. an average profit weighted by the probability of drawing a certain marginal cost c at birth. This allows to write down the free entry condition (FEC):

$$\int_1^{c_I} \pi(c_i)^*_{INN}\, dG(c) + \int_{c_I}^{c_D} \pi(c_i)^*_{NI}\, dG(c) = f_E \tag{34}$$

Integrating (34) over two segments of the distribution $G(c)$ (between 1 and c_I for innovators, between to c_I to c_D for non innovators) and substituting in the boundaries of integration the expressions for the relevant cutoffs leads to the identification of the maximum marginal cost that allows firms to produce in the long run in the industry: the parameterized c_D. However, it needs to be clarified that the introduction of the innovation cutoff c_I makes it impossible to solve expression (34) for a generic Pareto distribution with shape parameter k, since I obtain terms to the power of k (e.g. $\left(c_D + \frac{\omega}{2} - f_I \frac{2\gamma}{\omega L}\right)^k$) whose expansion is not finite. Hence I assume a specific value for the k. This parameter is an inverse measure of the dispersion of the Pareto distribution, where higher values of k imply that more cost draws are concentrated around c_m, the upper bound[51]. Del Gatto, Mion and Ottaviano (2006) estimated that a value of 2 for this parameter characterizes the distribution of a set of industries using broad EU data. Therefore I choose[52] a value of $k = 2$. The solution of the integral for expected profits in terms of c_D leads to a complex 4th degree polynomial equation. In the Appendix to this Chapter I report the solved integral, whose solution in terms of c_D was calculated with the help of a software[53]: this latter expression is however extremely complex and too lenghty to be reported in the thesis. For this reason, I opted for obtaining a numerical solution for c_D by exploiting the parameters indicated in the figures.

The second condition that defines the equilibrium of this industry is the number of producers surviving in the long run. Since $c_D = \frac{\alpha\gamma + \eta N \bar{p}}{\eta N + \gamma}$, the entry cost cutoff c_D determines the number of firms N:

$$N = \frac{2\gamma}{\eta} \frac{\alpha - c_D}{c_D - \bar{c}} \tag{35}$$

[51] A value of 1 implies a uniform distribution of firms.

[52] I also solved the equilibrium for a higher value of k: increasing k shifts mass of the productivity distribution towards the upper bound c_m, increasing the high-cost firms in the industry. This implies a higher level of competition (lower c_D) since the industry features more firms operating with a similar level of efficiency, although this more competitive environment is populated by firms whose productivity is, on average, lower. If $k \to \infty$ the distribution becomes degenerate.

[53] Scientific Workplace.

where $\bar{c}$ represents the average cost of surviving firms.

Liquidity Constraints

A vast literature on the financing of innovation, discusses a variety of reasons why investments in innovative activities are difficult to finance with external financial resources (Bougheas *et al.,* 2003; Czarnitzki and Hottenrott, 2011). The overall riskiness of projects, the lack of collateral in physical property, together with the higher degree of informational asymmetries between firm managers and lenders, make borrowing to finance innovation difficult and internal financial resources essential. These considerations motivate my decision to introduce a further friction in the access to innovation.

I model a liquidity constraint affecting innovation decisions, based on the assumption that a fraction of the fixed innovation cost needs to be financed with internal resources, while the rest can be borrowed externally[54]. Firms must therefore rely on their own existing liquidity, generated by selling on the domestic market, in order to innovate[55].

The liquidity constraint is formalised in the following way: firms face liquidity constraints to access innovation. To cover the fraction of the fixed innovation cost that cannot be borrowed externally, firms can pledge profits obtained by selling on the domestic market in the first period; hence:

$$\pi(c_i)^*_{t_1} > \delta f_I, \tag{36}$$

where δ denotes the fraction of f_I that needs to financed internally. The remaining fraction $(1-\delta)$ can be borrowed externally from a perfectly competitive financial market[56]. Recall that this financial market is available only to producers; consumers' income is determined by the single unit of labour supplied (inelastically), whose value is pinned down to unity[57]: allowing consumers to access an external capital market would add complexity to the model, but in directions not requested by the research questions under examination in this chapter.

The existence of this liquidity constraint creates a wedge between the constrained and unconstrained profit functions of innovators, represented by the innovation profit of those firms that could have profitably innovated in the absence of the constraint, but are prevented

[54] I am aware that in my context financing for innovation should be easier than it is in reality, since there is no uncertainty embedded in the innovative process. Nonetheless, introducing liquidity constraint allows me to model the effects of a sudden reduction in external liquidity for innovation (one of the consequences of the financial crisis of 2008-09) and to explore the impact of this shock on participation in exporting.

[55] A similar assumption has been exploited by Chaney (2013) and Manova (2013), but applied to accessing foreign markets: both innovation and exporting are activities that embed higher risks compared to supplying the domestic market.

[56] This amount can be borrowed either interest free or at a positive interest rate. From the modelling point of view there is no difference, since the interest rate would just inflate the innovation cost and not change any of the qualitative implications of the model.

[57] This derives from the assumption of the cost of production of the numerarire good, set equal to one.

from doing so because they do not accrue enough profits in the first period (Figure 3.2).

Whether firms are constrained depends on the relative magnitude of the fixed innovation cost, the fraction δ that needs to be met internally, the innovation gain ω and market characteristics affecting firms' performance (i.e. market size and product differentiation). More formally, a cost cut-off corresponding to the marginal cost draw that would allow a firm to generate a profit of exactly δf_I in the first period can be derived:

$$\pi(c_i)^*_{t_1} = \delta f_I \qquad \rightarrow \qquad \tilde{c} = c_D - 2\sqrt{\delta f_I \frac{\gamma}{L}} \tag{37}$$

$\tilde{c}$ denotes therefore the cost cutoff separating constrained and unconstrained innovators.

Firms whose marginal cost is lower than $\tilde{c}$ make profits exceeding δf_I in the first period and are therefore able to invest in innovation. There exist liquidity constrained firms if:

$$c_I > \tilde{c} \tag{38}$$

For (38) to hold it can be shown that:

$$f_I < \frac{L\omega^2}{4\gamma}\left(2\delta + 2\sqrt{\delta(\delta+1)} + 1\right) \tag{39}$$

For a given innovation cost, it will be more likely that firms are going to be liquidity constrained in markets that are larger (L), in presence of a higher innovation gain (ω) or a higher fraction of the fixed cost that needs to be financed internally (δ). A higher degree of product differentiation (γ) will instead have the opposite effect due to the lower competition that a higher γ implies.

The effects of market size, the innovation gain and product differentiation work in the same way as for condition (33): higher L, higher ω and lower γ imply a higher degree of competition, i.e. a lower c_D, which compresses the range of the cost distribution over which firms produce without investing in innovation. However, the larger is δ, the larger the share of firms that could have innovated in a frictionless financial market but are impeded from investing in innovation.

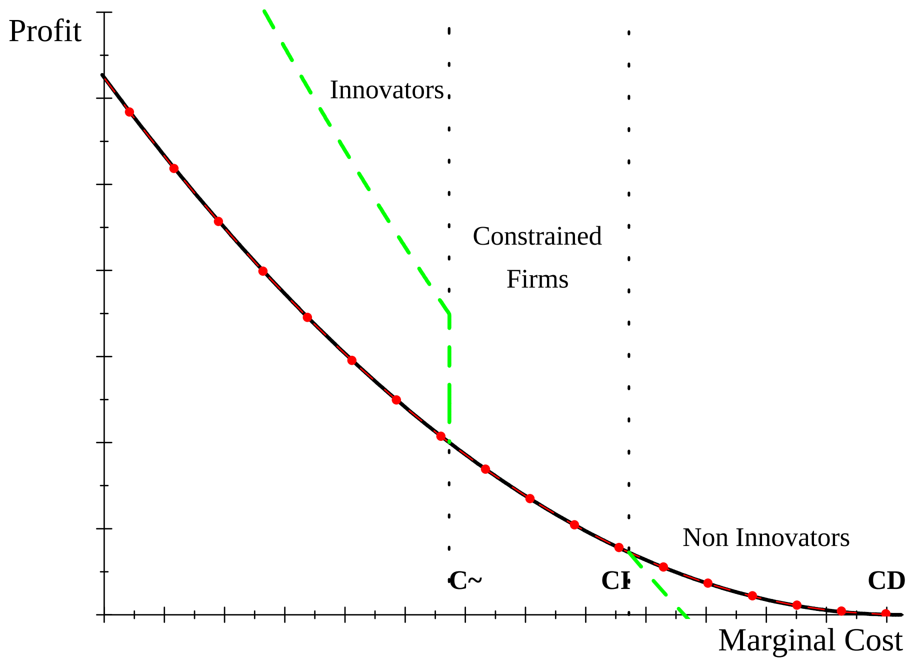
Imposing a liquidity constraint implies a revision of the closed economy Free Entry Condition. If the constraint is binding, i.e. $c_I > \tilde{c}$, there is a group of firms whose marginal cost lies between $\tilde{c}$ and c_I: these firms could have profitably innovated in the absence of the financial frictions, but are forced to produce with the efficiency they were assigned at birth because they do not generate sufficient liquidity internally. The FEC (34) becomes:

$$\int_{1}^{\tilde{c}} \pi(c_i)^{*}_{INN}\ dG(c) + \int_{\tilde{c}}^{c_D} \pi(c_i)^{*}_{NI}\ dG(c) = f_E \tag{40}$$

Solving (40) allows me to pin down the new exit cutoff c_D and $\tilde{c}$, the cutoff separating innovators from non-innovators. In the latter group there are both liquidity constrained firms and producers whose efficiency would have not been high enough to innovate even if financial markets were perfect. Figure 3.2 illustrates this equilibrium.

Moving from high to low marginal costs along the x-axis, Figure 3.2 shows how as marginal costs decrease, firms pass from being Non Innovators to Innovators. Between the dotted vertical lines, representing c_I and $\tilde{c}$, respectively, producers are efficient enough to invest in innovation, but fall short of internal liquidity. The constraint creates a wedge represented by a profit loss for "missed-innovators" and shows how financial markets imperfections can be detrimental to innovation, preventing firms to access it even if they would be productive enough to sustain the cost associated with the technology upgrade.

Figure 3.2: Optimal Profit Functions for Innovators and Non-Innovators under liquidity constraints.



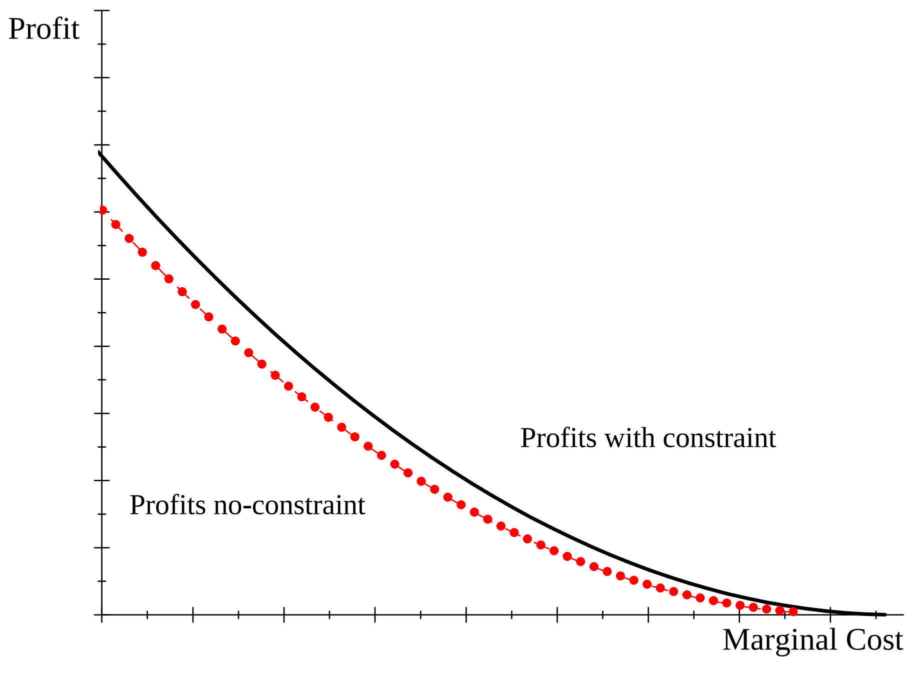
Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$, $\delta = 0.5$

A further implication of the introduction of the liquidity constraint is how it affects the degree of competition in the market. In figure 3.2 I overlay, on the black solid profit function for non-innovators, the profit function for non-innovatos derived in Figure 3.1, i.e. of a market with no liquidity constraints for innovators. This is shown with the the dotted line lying above the black solid line.

Figure 3.3 shows more in detail this result[58]: the introduction of the liquidity constraint reduces the overall degree of competitive pressure in the market.

In Figure 3.3 we can observe that, without constraint, firms make a lower profit at any given marginal cost level. Furthermore, the x-axis intercept of the unconstrained profit function lies to the left relative to the intercept in the market with constraint: this directly represents the difference in c_D between the two cases. Taken together, Figures 3.2 and 3.3 show that imperfections in financial markets result in a reduced range of the cost distribution over which firms can access innovation and a corresponding lower degree of competition. Relatively less efficient firms (those whose productivity is in between the two x-axis intercepts of the two profit functions) manage to survive in a market that is characterized by larger, markups prices and higher average marginal costs.

Figure 3.3: Optimal Profit Functions for Innovators with and without liquidity constraints



Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$, $\delta = 0.5$

3.2.2 Open Economy

In the second period (t_2) over which this model works, besides innovating firms can also decide to access a foreign market.

[58] Of course the profit function for innovators is also affected by the introduction of the constraint, but since the cutoff summarising the competitive envirnoment c_D is represented by the x-axis intercept of the profit function for non-innovators, I decided to only show the latter one.

I assume that markets are segmented. I assume, furthermore, a two country world where, for simplicity, the domestic (d) and foreign (f) market share the same preferences: this implies that the two markets share the same demand function (15).

In this framework, the innovation decision is taken jointly to the export decision, and firms paying the fixed innovation cost f_I to adopt the more efficient technology are able to use that same technology for the production of export goods.

Export costs are modelled as variable per unit trade cost τ, such that in order for x units to arrive at destination, τx units have to be shipped, with $\tau > 1$ (standard iceberg costs formulation).

Initially the conditions for optimal quantity, price and profit are derived for any pair of countries; later I will impose the assumption that the countries are identical to facilitate the derivation of the long run free entry condition in the open economy.

Ranking of Cutoffs

The possibility to export gives rise to four categories of firms: *domestic producers non-innovators*, *domestic producers innovators*, *exporters non-innovators* and *exporters innovators.* Although in the real world all four categories do co-exist, this model can only have three categories in equilibrium: the payment of a cost for engaging in innovation and the variable cost associated with exporting, sorts the firms either along ranking A:

(A): *Domestic Producer* → *Domestic Producer Innovator* → *Exporter Innovator*

or along this ranking B:

(B): *Domestic Producer* → *Exporter Non-Innovator* → *Exporter Innovator*

Put differently, in a market of profit maximising firms that work at their optimum, a firm will sort itself into either innovation or exporting, whichever becomes affordable first. Since both innovation and exporting are costly activities, the selection will depend on productivity. The least productive firms keep their drawn efficiency and produce only for the domestic market; in the middle range of the productivity distribution firms find it optimal to either innovate or export, depending on the relative magnitude of the costs to access these activites. Only the most efficient firms that generate sufficient profits can also access the relatively more expensive operation, sorting themselves into both innovation and exporting. It is impossible for two firms with the same productivity to decide differently about innovation and exporting, so either ranking A or ranking B prevails.

From a modelling point of view, which of the two rankings prevails depends on assumptions about the relative magnitude of the variable exporting cost τ, the fixed innovation cost f_I , market size L and the degree of product differentiation γ. These assumumptions need to be guided by the data in this case. The empirical test of the ranking, in section 3.3 of this Chapter, supports ranking A. In Chapter 4, the regressions testing the average difference in firms' markup across groups of producers reveal that Exporters-Innovators charge the highest markups, followed by firms that only export without innovating; innovators that never export rank third and charge markups that are are marginally higher (although not significantly so) than domestic producers that do not innovate. Since markups (27) are a positive function of firms' productivity (lower marginal costs - higher markup), the ranking of markups in Chapter 4 also supports ranking A.

Both the ranking and the markups test therefore suggest that the marginal innovation decision is happening at a lower productivity level than the exporting decision: this implies the cost cutoff ranking that I assume for the rest of this work:

$$c_D > c_I > c_X \ , \tag{41}$$

where c_X is the cost cut-off separating domestic producers from exporters[59]. This implies that no firm decides to export without having decided to innovate as well, because if relatively less efficient firms can innovate but cannot export, all exporters will have already sorted themselves into innovation.

It needs to be added that if condition (39) holds, there are going to be liquidity constrained firms that could profitably innovate but are prevented from doing so because they do not generate enough liquidity internally. This means that the liquidity cutoff $\tilde{c}$, while being lower than the innovation cutoff c_I, has to be higher than the exporting cutoff c_X, so to allow for the existence of *Domestic Producers Innovators*: if $\tilde{c}$ were lower than both c_I and c_X, there would be only two categories of firms in equilibrium: *Domestic Producers* and *Exporters-Innovators*, with some of the latter being liquidity constrained. Hence the ordering in (41) needs to be amended in this way:

$$c_D > c_I > \tilde{c} > c_X \tag{42}$$

Open Economy Optimality Conditions

The presence of a per-unit iceberg export cost induces selection into exporting. This is

[59]The determination of this cutoff is going to be exposed in the section below.

represented by the fact that the unit cost for a firm with cost draw c is c for the domestic market and τc for the export market. Alternatively, the entry cost-cutoff in the foreign market for an exporter c_D^x, can be written as:

$$c_D^x = \frac{c_F}{\tau} \ , \tag{43}$$

where c_F denotes the entry cost cutoff for the domestic producers in the foreign market. From (43) it is evident that, being $\tau > 1$, it is harder for an exporter to survive in the foreign market, compared to a domestic producer. In what follows I express the optimal quantity, price and profits for an exporter in terms of the cost cutoff faced by domestic producers in the foreign markert, c_F.

Recall that in this framework, given the cutoff ordering assumption (42), the marginal exporter is an innovator. This implies that, once a firm sustained the investment to upgrade its efficiency, it will use the upgraded technology to produce for the foreign market. Futhermore, no firm will ever export and not also produce for its domestic market[60]: this implies that each firm's profit can be separated into portions earned from domestic sales and export sales, by accounting for the innovation overhead production cost in domestic profit, if the marginal exporter is an innovator[61]. Writing down the profit function $\pi_i = (p_i - c_i)q_i$, by use of equations (15), (16) and (18) and considering the surcharge represented by the iceberg cost, the optimal quantity $q(c_i)^{*f}_{X,INN,t_2}$, optimal price $p(c_i)^{*f}_{X,INN,t_2}$ and optimal profit $\pi(c_i)^{*f}_{X,INN,t_2}$ obtained by an exporter in the foreign country[62] can be written as:

$$q(c_i)^{*f}_{X,INN,t_2} = \frac{L^f}{2\gamma}\left(c_F - c_i\tau + \omega\right) \tag{44}$$

$$p(c_i)^{*f}_{X,INN,t_2} = \frac{1}{2}\left(c_F + c_i\tau - \omega\right) \tag{45}$$

$$\pi(c_i)^{*f}_{X,INN,t_2} = \frac{L^f}{4\gamma}(c_F - c_i\tau + \omega)^2 \tag{46}$$

Finally, the total profit accrued by an exporter selling on both the domestic and foreign market in the second period is going to be:

$$\pi(c_i)^{*}_{X,INN,t_2} = \pi(c_i)^{*d}_{INN,t_2} + \pi(c_i)^{*f}_{X,INN,t_2} = \frac{L}{4\gamma}(c_D - c_i + \omega)^2 + \frac{L^f}{4\gamma}(c_F - c_i\tau + \omega)^2 - f_I \tag{47}$$

[60] A firm would strictly earn higher profits by also producing for its domestic market. As will be evident below, the variable profit on the domestic market $\frac{L}{4\gamma}(c_D - c_i + \omega)$ is always positive and the fixed innovation cost f_I has already been incurred.

[61] Concerning this, my modelling structure is similar to Melitz (2003).

[62] The superscript f denotes the foreign country.

Operating over the two periods over which this model works, the total profit accrued by an exporter over its lifetime is:

$$\pi(c_i)^*_{X,INN} = \pi(c_i)^*_{t_1} + \pi(c_i)^*_{X,INN,t_2} \tag{48}$$

For simplicity, I now assume further that the home and the foreign country are identical: so $c_D = c_F$ and $L = L^f$. This does not alter the predictions of the model, but facilitates getting simpler and more interpretable solutions, mostly for the Free Entry Condition.

I explained the cost cutoff rankings in terms of the threshold separating domestic producers from exporters, $c_{X.}$ This cutoff is identified setting:

$$\pi(c_i)^*_{INN} = \pi(c_i)^*_{X,INN} \quad \rightarrow \quad c_X = \frac{1}{\tau}(c_D + \omega) \tag{49}$$

The expression for the export cutoff (49) shows immediately that $c_X < c_D$ if innovation is absent ($\omega = 0$).

Assuming ranking (42) best describes the sorting of firms into innovation and exporting, it needs to be shown that:

$$c_X < \tilde{c} \tag{50}$$

This holds if:

$$f_I < \frac{L}{4\gamma\delta\tau^2}\left[c_D(1-\tau) + \omega\right]^2 \tag{51}$$

It follows from condition (51) that given a certain innovation cost f_I, the higher the share of it that has to be financed off profits accrued in the first period (δ), the more likely for exporters to be liquidity constrained as well, as far as their innovation choice is concerned. A higher δ thus makes it more likely for condition (51) to be violated, which in turn implies an equilibrium where firms sort themselves into innovation at a productivity level which is higher compared to that required to access exporting, contradicting ranking (42).

Higher variable trade costs (τ) have the opposite effect. A higher barrier to access the foreign market makes it of course more difficult to enter exporting, making it more likely for condition (51) to be satisfied, given f_I. The effect of a higher τ can be explored by differentiating the right hand side of (51) with respect to τ:

$$\frac{\partial}{\partial\tau}\left(\frac{L}{4\gamma\delta\tau^2}\left[c_D(1-\tau) + \omega\right]^2\right) = -\frac{L\left(c_D + \varphi\right)}{2\tau^3\gamma\delta}\left(c_D - \tau c_D + \omega\right) \tag{52}$$

The assumptions that $\tau > 1$ and $0 < \omega < 1$, provided $c_D(\tau - 1) > \omega$, ensure that the expression in (52) is positive, which confirms the effect of iceberg transport costs on (51).

Concerning the remaining parameters, a higher L, a higher ω and a lower γ, make it easier for condition (51) to be satisfied. The larger the innovation gain, the lower the productivity level at which firms optimally invest in innovation; whereas in larger markets (L) and in markets where varieties are less differentiated (lower γ) competition is "tougher", making it harder for any firm to access exporting.

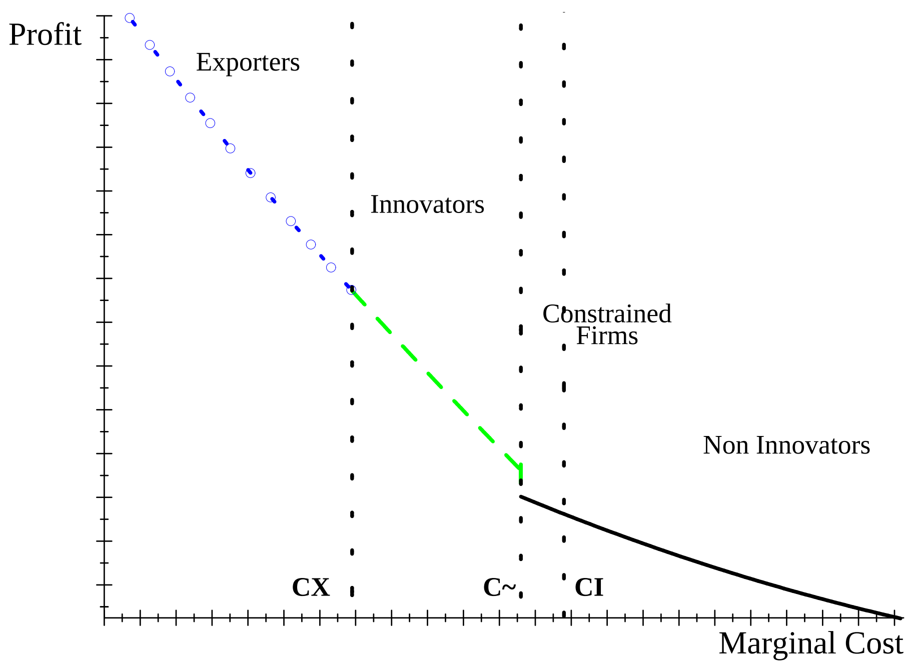
Finally, whatever affects c_D indirectly, reinforces condition (51) if c_D increases, i.e. competition becomes less "tough": inspecting the expressions definining $\tilde{c}$ (37) and c_X (49) reveals that an increase in c_D induces both cutoffs to increase, but the effect is stronger on $\tilde{c}$:

$$\frac{\partial \tilde{c}}{\partial c_D} = 1 \quad > \quad \frac{\partial c_X}{\partial c_D} = \frac{1}{\tau} \tag{53}$$

Therefore, as competition changes, the movement in $\tilde{c}$ is more than proportionate compared to c_X, with the cutoffs moving closer together as competition increases, and further apart when competition decreases.

Summing up, provided the conditions necessary for $c_D > c_I > \tilde{c} > c_X$ to hold ((33), (39) and (51)) are all satisfied, then in the second period firms sort themselves into the three categories of *Domestic Producers*, *Domestic Producers Innovators* and *Exporters Innovators*.

Figure 3.4: Optimal Profit Functions in Open Economy.



Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$, $\delta = 0.2, t = 1.14$

Figure 3.4 shows how producers sort themselves in the open economy equilibrium, with the three dotted vertical lines representing respectively, from left to right, c_X, $\tilde{c}$ and c_I. As in Figure 3.2 and 3.3, the x-axis intercept of the profit function for non-innovator represents c_D.

Industry Equilibrium in the Open Economy with Liquidity Constrained Innovation

To close the model it is necessary to derive the open economy free entry condition, the equilibrium condition in an economy where firms can both innovate and export.

If entry is unrestricted in both countries, firms choose a production location before entry and pay the sunk entry cost: in the first period firms discover their productivity, decide whether to produce or exit immediately, and accrue profits by selling on the domestic market. In the second period firms make decisions about innovation and exporting: both activities are costly, hence only the most efficient producers engage in these activities, along the productivity path described above. For innovation there is the further limitation, consisting of having to finance a fixed cost for which borrowing is constrained: only firms that accrued enough profits in the first period are able to access innovation. As there are no entry barriers, firms enter while there are positive expected profits to be made: in the long run this will drive expected profits to zero and pin down the maximum marginal cost that allows firms to operate in the market (c_D), which summarizes the toughness of the competitive environment.

Exploiting the fact that firms operate and obtain profits over two periods (t_1 and t_2), and that $c_D > c_I > \tilde{c} > c_X > 1$, but that, *de facto*, there are no firms innovating in the cost range $c_I \sim \tilde{c}$, expected profits can be written as:

$$\int_1^{c_X} \pi(c_i)^*_{X,INN}\ dG(c) + \int_{c_X}^{\tilde{c}} \pi(c_i)^*_{INN}\ dG(c) + \int_{\tilde{c}}^{c_D} \pi(c_i)^*_{NI}\ dG(c) = f_E \tag{54}$$

Equating (54) to the sunk cost f_E and solving for c_D pins down the long run competitive equilibrium on which all the conditions derived in this section depend on. Similarly to the closed economy equilibrium, I report the solution to (54) in the Appendix to this Chapter, although the full analytical solution in terms of the exit cutoff c_D could not be reported in this thesis because of its complexity. In the following sections I will therefore exploit numerical solutions to the open economy exit cost-cutoff c_D.

The second equilibrium condition is the number of surviving firms. In an open economy the number of sellers in one country is comprised of domestic producers and exporters from the foreign country. Melitz-Ottaviano (2008) show that the distribution of costs c of domestic producers matches the distribution of delivered costs τc of foreign producers, over the support given by the Pareto distribution with c_D as its upper bound. Because of this, also in the open economy the number of producers derives from the fact that the exit cutoff c_D corresponds to the cost draw that gives zero profits, since $c_D = p_{\max}$ and which summarizes the toughness of the competitive environment.

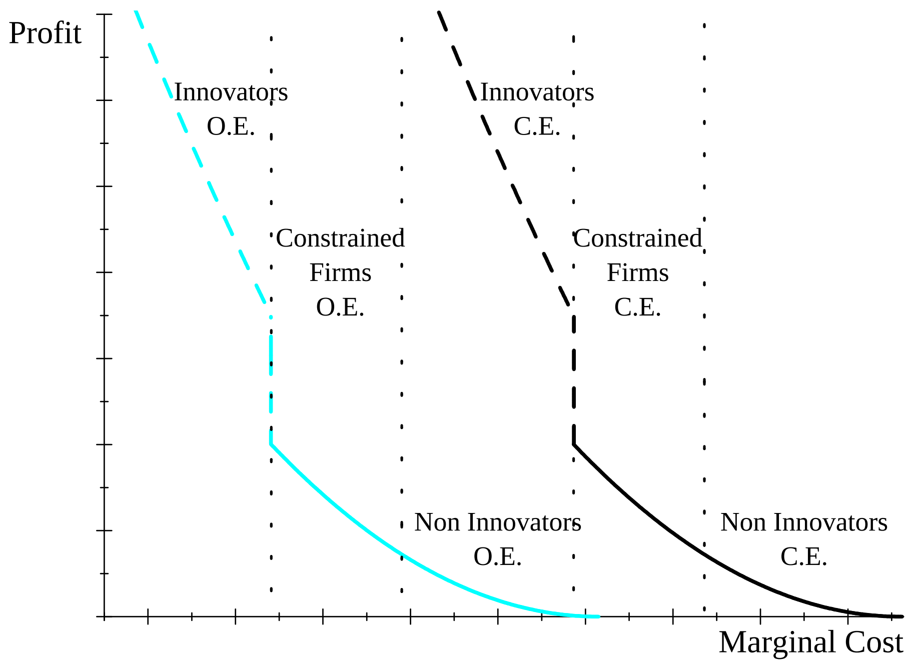
Impact of International Trade

Before analysing the impact of a financial shock on an economy populated by innovators and exporters, I briefly analyse the impact of international trade. This can be done by comparing the simulated equilibria in the closed and the open economy.

Exposure to international trade produces the well known re-destribution effects originally described by Melitz (2003), whereby market shares are reallocated from the least to the most productive firms, while simultaneously the least productive ones exit.

This is evident in Figure 3.5, that simulates the profit functions of firms in the various categories and constrasts the Closed Economy (C.E., darker line) and Open Economy (O.E., lighter line) optimal conditions (of which I only show the outer contour).

Figure 3.5: Impact of international trade on Innovators and Non-Innovators



Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$, $\delta = 0.5, t = 1.14$

Moving from autarky to a simple two-country world with identical economies increases the overall degree of competitive pressure, shown by the lower x-axis intercept for the O.E. contour: all the firms whose marginal cost falls between the two x-axis intercepts are forced to leave the market because of the "tougher" competitive environment: this corresponds to the so-called *selection-effect* of international trade The same applies to the symmetric foreign economy. Figure 3.5 focuses on the effects of trade at the bottom of the productivity distribution[63]. In addition to the market shares reallocation due to the exit of the least productive firms, it is evident that at any given marginal cost, the profit of the producers shown in Figure 3.5 is lower in the open economy: these are firms whose market shares are lower as a consequence of import competition, that is therefore responsible for a further reallocation of market shares to firms that now export to the foreign market. There is indeed a corresponding gain for the most productive firms at the top of the productivity distribution (not shown), that expand their sales and profits in the open economy: this corresponds to the so-called *pro-competitive effect* of international trade.

These redistribution effects imply that the economy, overall, is populated by firms that are on average larger, more productive and make more profits[64]; however, due to the *pro-competitive effect* of trade, these firms charge lower prices and markups.

Overall, not suprisingly, the effects of the impact of trade in this model are identical to those of a trade liberalization between symmetrical countries in Melitz-Ottaviano (2008).

3.2.3 A Shock to the Liquidity Constraint

Having described the open economy equilibrium of an industry with heterogeneous firms where the presence of liquidity constraints prevents a set of firms from accessing innovation, I now explore how this equilibrium changes in the event of a shock that causes the liquidity constraint to become more binding.

An important point of analysis of this model lies in the identification of the effects of a financial crisis, which can be seen as a shock to the possibility to access innovation: in the crisis of 2008-2009, the tightening of the money market prompted banks to reduce the amount of liquidity available to firms (Campello *et al.,* 2010), and more so for the riskier activities undertaken by innovative firms. In the model this corresponds to an increase in the share of the innovation cost that needs to be financed internally (δ), drawing on the profits made in period t_1, before deciding to upgrade technology.

To study how a tightening of liquidity constraints affects this industry, the cutoffs determining selection into exporting (c_X), innovation ($\tilde{c}$ and c_I) and domestic production (c_D) need to be differentiated with respect to δ:

$$\frac{\partial \tilde{c}}{\partial \delta} = \frac{\partial c_D}{\partial \delta} \frac{\partial \tilde{c}}{\partial c_D} - \left(\frac{\gamma f_I}{L\delta} \right)^{\frac{1}{2}} \tag{55}$$

[63] Given the parameter chosen for the simulation, I cannot show the effects on the entire cost distribution.
[64] This follows directly from the results of the original Melitz and Ottaviano (2008) work.

$$\frac{\partial c_X}{\partial \delta} = \frac{\partial c_D}{\partial \delta}\frac{\partial c_X}{\partial c_D} \tag{56}$$

$$\frac{\partial c_I}{\partial \delta} = \frac{\partial c_D}{\partial \delta}\frac{\partial c_I}{\partial c_D} \tag{57}$$

As reflected in (55), a change in δ has a direct effect on the liquidity constraint cutoff $\tilde{c}$, together with an indirect effect arising from the change in the overall degree of competition, represented by the entry threshold $c_{D,}$ which in turn affects $\tilde{c}$. The exporting and the innovation cutoffs c_X and c_I are instead affected only indirectly, through the change in c_D. In order to analyse the overall impact of a shock to δ on this economy, also the direct effect of δ on c_D has therefore to be evaluated.

Due to the elaborated form of the free entry conditions (40) and (54) in this model, both in the closed and in the open economy, the solution of the entry threshold c_D is extremely complex. By parameterizing the cost distribution $G(c)$ assuming a Pareto distribution of the form $G(c) = (c/c_m)^2$ bounded within $[1, c_m]$, an analytical solution was found; however, because of its length and complexity it is not reported here. For the closed economy equilibrium condition (40) I obtained a full analytical solution; whereas for the even more complicated open economy equilibrium I fixed some of the parameters in order to get a solution for c_D: I did, however, obtain a solution of c_D in terms of δ, so as to be able to perform an analysis of the shock.

As a consequence of the difficulties in obtaining a manageable analytical solution for c_D, it follows that direct differentiation of c_D with respect to δ proves too complex for this to be reported here: similarly to the solutions to the free entry conditions, the derivative $\partial c_D/\partial \delta$ can be calculated but is too lengthy to be included in this chapter.

For these reasons, to analyse the impact of a change in the liquidity constraint δ, I performed a numerical simulation exercise.

After obtaining the solutions to (40) and (54), I simulated the values of the derivatives of interest within the range of values that δ can take in this model, to infer the direction of movements of the cutoffs and the reallocation of producers across the various categories as a consequence of this.

Shock to the Entry Cutoff $\mathbf{c}_D$

The impact of a change in the liquidity constraint on innovation and exporting works through a change in the degree of competition in the market, c_D. Table 3.1 shows the results of the numerical simulation. The choice of the parameters was guided by the theoretical assumptions about the various elements of the model, other than making sure these values satisfy jointly the conditions for which the model yields an industry populated by *Domestic Producers, Innovators* and *Exporters-Innovators.*

The first result shown in Table 3.1 is the range of values that δ can take in order to satisfy condition (39), which is necessary for the liquidity constraint to be binding. With an assumed fixed cost of 400, together with the values of the remaining parameters, δ needs to exceed a value of approximately 18% for the market to have firms that are liquidity constrained. The maximum value that δ can take is 1; larger values are mathematically possible in this model but not economically meaningful[65]. This range of values for δ is where I confine the evaluation of the free entry conditions.

Moving the constraint from its minimum to its maximum, results in an increase in c_D, both in the closed and in the open economy, i.e. lowers the overall degree of competition. This implication is going to be crucial for the main result of this paper[66]. The least efficient firms that could not profitably have survived before the shock, now obtain some market shares and produce. This also implies that exit rates are lower (the pre-entry probability of survival is higher), average prices $\bar{p}$ and markups are higher, but that average productivity $1/\bar{c}$ in the economy falls.

Table 3.1: Simulation of the impact of a change in δ on the entry cutoff c_D

δ values for condition (39) to hold:	if $f_I = 400 \rightarrow 0.181 < \delta < 1$	
Solution to FEC: c_D	$\delta = 0.181$	$\delta = 1$
Closed Economy	10.321	10.324
Open Economy	9.625	9.636
$\partial \mathbf{c}_D / \partial \boldsymbol{\delta}$	$\delta = 0.181$	$\delta = 1$
Closed Economy	5.38×10^{-6}	5.34×10^{-3}
Open Economy	1.57×10^{-2}	1.15×10^{-2}

Note: Other parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $t = 1.14$

The numerical solutions of c_D show also the impact of international trade on competition: regarless the value of δ, moving from autarky to costly trade (since τ is still assumed to larger than 1) increases the degree of competition, i.e. lowers c_D, confirming the main result of Melitz-Ottaviano (2008) in my framework.

Differentiating the solution to the free entry condition with respect to δ re-states that an increase in the share of liquidity that firms need to provide internally in order to access

[65] If δ were larger than 1, it would mean that firms needed to accrue more than 100% of the innovation cost f_I in the first period in order to be able to access innovation in the second period. $\delta = 1$, harsh but not impossible, implies that it is impossible to borrow to finance an investment in innovation.

[66] Figure 3.3 already presented this result graphically, while Table 3.1 makes it now more explicit.

innovation results in competition being less "tough": at both the minimum and the maximum value that δ can take, the slope c_D with respect to δ is positive. This results holds both in the closed and in the open economy. Figure 3.6 and Figure 3.7, in the Appendix, confirm this result once again, showing the the slope of the free entry condition with respect to δ is positive througout the range of δ values that satisfy condition (39) in the model.

To understand fully what is driving the effect of a tighter liquidity constraint on competition I turn now to the derivation of the effects of δ on the other cutoffs separating the three categories of producers.

Shock to the Liquidity Constraint Cutoff $\tilde{\mathbf{c}}$

A tightening in the liquidity constraint (higher δ) corresponds to a reduction in the liquidity constraint cutoff $\tilde{c}$ for relatively less efficient producers. However, as discussed in section 3.2.3, $\tilde{c}$ is subject to both a direct and an indirect change as a consequence of an increase in δ. Evaluating the derivative of $\tilde{c}$ with respect to δ, it is easy to see that the direct effect is negative:

$$\frac{\partial \tilde{c}}{\partial \delta} = -\left(\frac{\gamma f_I}{L\delta}\right)^{\frac{1}{2}} \tag{58}$$

The direct effect (58) makes $\tilde{c}$ in Figure 3.4 move leftward, implying a higher productivity threshold to access innovation. On the other hand, the indirect effect of δ on $\tilde{c}$ is positive: this works through the impact of δ on the entry cost cutoff c_D, which has been shown in the previous section to be positive. The resulting impact of δ on $\tilde{c}$ is therefore a combined outcome of the direct and the indirect effects, that partially offset each other. To show which effect dominates, I proceed again by simulating the effect of a tightening in the liquidity constraint on the value of the $\tilde{c}$ cutoff, over the range of values that δ can take in this model.

Table 3.2: Simulation of the impact of a change in δ on the liquidity constraint cutoff $\tilde{c}$

δ values for condition (39) to hold:	if f_I= 400 $\rightarrow$ $0.181 < \delta < 1$	
Value of $\tilde{c}$	$\delta = 0.181$	$\delta = 1$
Closed Economy	9. 872	9. 267
Open Economy	9. 153	8. 578
$\boldsymbol{\partial \tilde{c}/\partial \delta}$	$\delta = 0.181$	$\delta = 1$
Closed Economy	−1. 247	−0.523
Open Economy	−1. 231	−0.518

Note: Other parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, c_m= 40, f_E= 900, $t = 1.14$

Table 3.2 shows that the value of $\tilde{c}$ in both the closed and the open economy is, first of all, lower than the exit threshold c_D (in Table 3.1), as expected for values of δ that range between 0.181 and 1 (i.e. ensuring condition (39) holds). Additionally, the effect of trade is again visible through the reduction in the value of $\tilde{c}$ when comparing the closed to the open economy scenario.

Importantly, increasing the value of δ reduces $\tilde{c}$: this means that the direct effect of the increase in δ dominates the indirect effect working through the reduction in competition (increase in c_D). As expected, if the liquidity constraint becomes more binding, innovative activity is reduced, despite the fact that the overall degree of competition decreases.

This effect works similarly to an increase in import competition in the original Melitz-Ottaviano (2008) model: product market competition is affected by the reduction in the quantity produced by a range of producers – those that are no longer able to access innovation - and higher industry wide average prices $\bar{p}$. Given that market size is fixed, market shares are going to be redistributed from these firms to the less efficient ones. As a result of the shock, average productivity in the industry falls and the reduction in competitive pressure allows firms to charge higher prices and markups. Notice, however, that those firms whose efficiency is high enough for them not to be subject to the tighter post-shock constraint obtain some of the market share lost by the firms hit by the shock: firms at the top of the productivity distribution make higher profits and charge higher markups compared to the pre-shock equilibrium.

In Table 3.2, differentiation of $\tilde{c}$ with respect to δ is more than a mere restatement of the result that increasing δ reduces $\tilde{c}$ as a consequence of the direct effect of δ dominating the indirect effect of lower competition. It is to be seen from (58) that the negative direct effect decreases as δ increases. This is why it is key to show that even when δ reaches its maximum value, the slope of $\tilde{c}$ with respect to δ is still negative, although lower in absolute terms. Figures 3.8 and 3.9 in Appendix show that the effect of δ on $\tilde{c}$ is negative throughout all values that δ can take, provided condition (39) holds.

To conclude the analysis of a tightening in liquidity constraints on innovation, the unconstrained innovation cutoff c_I would move in the opposite direction to $\tilde{c}$, i.e. unconstrained innovation would become more accessible to relatively less efficient producers. This is explained by the fact that the effect on c_I works entirely through the change in the entry threshold c_D. However, the positive impact on c_I remains entirely hypothetical, because it derives from a more binding liquidity constraint to access innovation, which reduces competition precisely because it reduces access to innovation in the first place.

Shock to Exporting

The analysis of the impact of a change in δ on the exporting cutoff is relevant and at the same time straightforward. Regardless of whether the exporting cutoff c_X lies to the left (for which condition (51) needs to hold) or to the right of $\tilde{c}$ in Figure 3.4, an increase in δ would unambiguously affect c_X positively. Tighter liquidity constraints for innovation affect the exporting decision only indirectly, through the change in competition represented by the movement of the entry cost cutoff c_D: section 3.3.1 showed that the entry threshold increases, allowing relatively less efficient firms to survive in the market. A similar effect occurs at a higher range of the productivity distribution: the efficiency threshold separating exporters and non-exporters becomes more accessible. As a consequence, some relatively less efficient non-exporters manage to overcome the entry barrier represented by the exporting costs and sell in the foreign market.

Table 3.3 repeats for c_X the simulation performed for c_D and $\tilde{c}$, showing how the value of the exporting cutoff increases with the value of δ. Similarly, the slope of c_X with respect to δ is positive throughout the values of δ that ensure the liquidity constraint is binding.

As mentioned above, the relative positions of $\tilde{c}$ and c_X are irrelevant for the result concerning participation to exporting: regardless of whether the marginal exporter is an innovator (as assumed in this work) or a non-innovator, the anti-competitive effect that arises from a reduction in innovative activity has positive repurcussions on firms that are close (but below) to the exporting threshold. These latter firms are able to overcome the variable costs associated with exporting if the shock to innovation is symmetric across trading partners. Firms will also obtain higher markups by selling in an industry whose degree of competitive pressure is reduced.

Table 3.3: Simulation of the impact of a change in δ on the exporting cutoff c_X.

Value of c_X	$\delta = 0.181$	$\delta = 1$
Open Economy	9.057	9.067
$\boldsymbol{\partial c_X / \partial \delta}$	$\delta = 0.181$	$\delta = 1$
Open Economy	1.38×10^{-2}	1.01×10^{-2}

Note: Other parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $t = 1.14$

Main Results of Simulation

In this section I summarise the results of the simulation exercise, into the main proposition of the model, which is tested empirically Chapter 4 of this thesis.

Provided conditions (39) and (51) hold, this model describes an industry where, in equilibrium, domestic producers, innovators and exporters-innovators coexist. In order to model the impact of a sudden reduction in external liquidity for innovation, which was one of the effects of the financial crisis of 2008-2010 (Lee et al., 2015), I simulated the effects of a tightening in the liquidity constraint which innovative firms are subject to. Making liquidity tighter has three main effects in the model:

First, innovation becomes more selective, since the range of the productivity distribution over which firms can access innovation is reduced in favour of the most efficient producers. This is a consequence of the increase in the fraction of the innovation costs that needs to be financed out of internal liquidity and is shown by a reduction in the liquidity constraint cutoff $\tilde{c}$ that moves to the left with respect to its pre-shock position (Figure 3.4B below).

Second, the reduction in innovative activity lowers the industry wide degree of competitive pressure. Firms that could have innovated in the absence of the shock are now forced to produce with the efficiency they were assigned at birth and therefore produce a lower quantity of their varieties. This results in a reduction in the average productivity in the industry ($1/\bar{c}$), together with an increase in average prices $\bar{p}$ and markups μ, thanks to the lower price elasticity of demand arising from the shock. This anti-competitive effect is peculiar to the this model that nests the Melitz-Ottaviano (2008) framework. The competition effects, in fact, arises as a consequence of the linear demand specification: Melitz-Ottaviano (2008) show that this latter leads to a price elasticity of demand σ_i which is a function of the entry cost cutoff c_D:

$$\sigma_i = \left[\frac{\partial q_i}{\partial p_i}\frac{p_i}{q_i}\right] = \left[\left(\frac{c_D}{p_i} - 1\right)\right]^{-1} \tag{59}$$

The higher c_D induces therefore a lower σ_i: this is what allows all surviving producers to charge higher markups.

Third, entry into exporting is made more accessible relative to the pre-shock environment. This is a direct consequence of the reduction in competitive pressure which lowers σ_i and allows firms to charge higher markups. Exporting is subject to costs that make it a selective activity, but if the shock to innovation is symmetric across trading partners (implying that the effects to c_D in both countries are proportional - symmetrical in my case of identical countries) some firms that were above the pre-shock export entry cutoff c_X find themselves below the post-shock c_X and will start selling abroad.

This is the key result emerging from the analysis carried out in this chapter: there is an interlinkage between innovation and international trade, working through the change in competition. Positive innovation outcomes have been positively associated by the literature with the propensity to export (Cassiman et al., 2010; Becker and Egger, 2013), but my framework suggest that also another type of relation might exist: entry into exporting could be facilitated also by a negative shock to innovation which is symmetric between trading partners, thanks to the reduction in the toughness of comepetition both in the domestic and in the foreign market. From an empirical point of view this anti-competitive shock results in higher markups, extra resources that firms potentially use to sustain the costs associated with exporting.

Importantly, the model of Bustos (2011), which is the closest to mine in the literature[67], does not yield the same prediction from a shock to innovation. As her model is based on the Melitz (2003) framework, which implies constant markups, there cannot be any competitive effects arising from a shock to innovative activity, i.e., no movement in c_D and c_X.

Proposition 1 summarises these three results, of which figure 3.4B shows a graphical simulation.

Proposition 1 *Provided conditions (33) and (39) hold, in an industry populated by domestic producers, liquidity constrained innovators and innovators-exporters, a tightening of liquidity constraints for innovation (36) makes access to innovation more selective. This reduces the degree of competitive pressure which, in turn, results in a lower entry threshold into the export market and higher average markups and prices charged by all surviving producers.*

Figure 3.4B shows the simultanenous effect on the two main cutoffs[68] and the three categories of producers resulting from an increase in δ. The exporting cutoff c_X moves righwards, with respect to its pre-shock positions allowing relatively less efficient domestic producers (innovators) to enter exporting. The liquidity constraint cutoff $\tilde{c}$ moves instead leftwards, increasing the efficiency thereshold that is needed to access innovation: this results in a larger range of the productivity distribution over which firms are liquidity constrained.

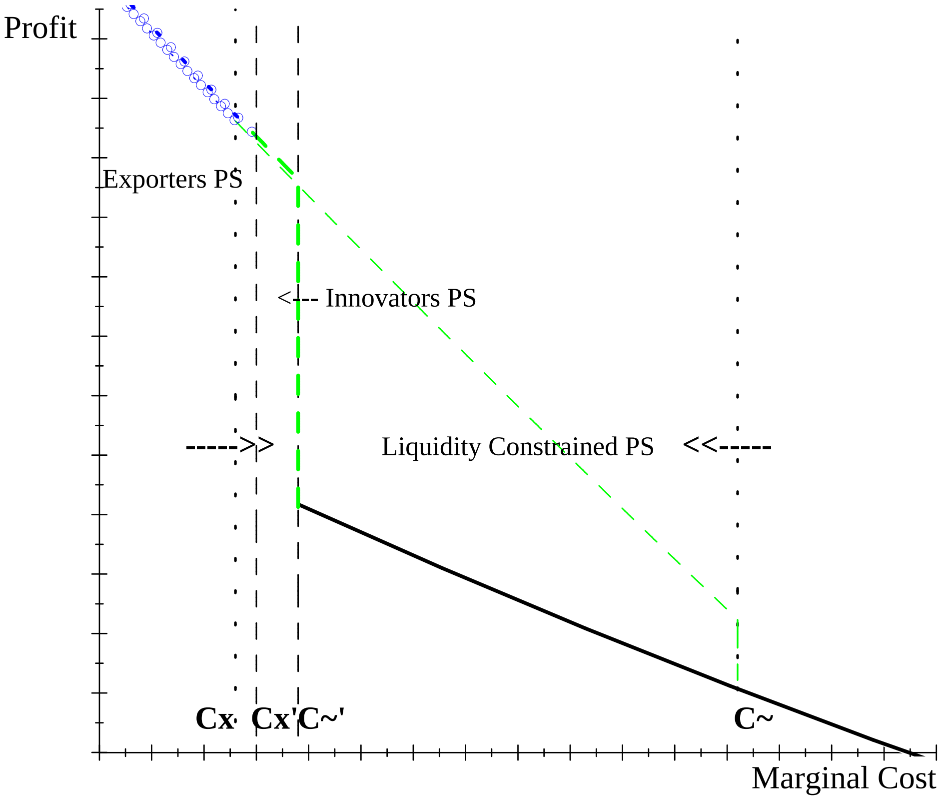
It is also evident that the reduction in innovative activity lowers profits for the constrained firms, whereas profits appear higher for firms that manage to access innovation and exporting after the shock[69]: this corresponds to the reallocation of market shares. Note, it was not possible to show graphically the effect of δ on c_D in Figure 3.4B (it is on the far right of the simulated graph), because the scale of the picture needed to be reduced to allow it to show the other cutoff movements.

[67]Bustos (2011) also features supply side gains from costly innovation in a monopolistic competition heterogenous firms trade model.

[68]The pre-shock cutoffs are represented by the dotted vertical lines, the post-shock cutoffs by the dashed vertical lines. Notation wise, I label the post-shock liquidity constraint and exporting cutoffs with, respectively, $\tilde{c}'$ and c'_X

[69]The higher profit for post-shock innovators is barely visible in Figure 3.4B, because of the scale and the parameters exploited in the simulation.

Figure 3.4B: Impact of tighter liquidity constraint for innovators.



Parameter values: $L = 1000, \gamma = 0.7, \omega = 0.7, c_m = 40, f_E = 900, f_I = 400,$

$$\delta_1 = 0.2, \delta_2 = 0.28, t = 1.14$$

Figure 3.4B pushes forward an additional result of this work: the effect of the tightening in liquidity affects mostly firms in the middle range of the productivity distribution, both for innovation and exporting. In Chapter 4 of this thesis, dedicated to an empirical examination of the main predictions of the model, I expressely separate the effect of the shock across quartiles of the firm size and productivity distribution.

An important note is due here: the qualitative impact of a shock to δ on the various cutoffs is robust to the assumption made above about the cutoff ranking (42). The choice of the ordering, $c_D > c_I > \tilde{c} > c_X$, implies that the marginal innovator is less productive than the marginal exporter, and is guided by empirical results of section 3.3 below and Chapter 4, where I exploit Slovenian firm level data. In case a different assumption were made, such that the marginal innovator were more productive than the marginal exporter[70], the model would have produced the same qualitative implications from a change in δ: innovation becomes harder to access and, through the reduction in the industry wide level of competition, the exporting cost threshold c_X becomes more accessible. I show in the Appendix how the expressions for the cutoffs and the free entry condition would change.

[70]Bustos (2011) made this assumption in her paper, where she uses Argentinian firm level data.

However, different rankings might yield different quantitative implications due to initial relative position of the cutoffs and the direction of their movement. In the scenario assumed in this paper, with $c_D > c_I > \tilde{c} > c_X$, following an increase in δ the liquidity cutoff and the exporting cutoff move towards each other, and depending on the size of the shock they might end up in a different relative position, i.e. $c_D > c_I > c_X > \tilde{c}$. This still implies that innovation and exporting become, respectively, less and more accessible, but in this scenario there would be no longer domestic innovators, because the constraint is binding up to a point where only exporters are able to overcome it. The economy would finally be composed of domestic producers, exporters non innovators, and exporters innovators.

3.3 Test of cutoff ranking - condition (41)

Before concluding this chapter, I provide an empirical test the sorting pattern of firms into exporting and innovation assumed in the model.

For this task I exploit firms' characteristics within 2-digit NACE industries pre- and post- shock: this allows me to infer the direction of movement of the cutoffs separating the categories of firms, as induced by the shock. The shortage of external liquidity causes the innovation cutoff to move up the productivity distribution making access to innovation harder and lower competitive pressure arises from the reduction in innovative activity. This, in turn, indirectly facilatates entry into exporting: this happens at the bottom of the exporting distribution.

Data

I exploit the Slovenian Community Innovation Surveys (CIS) carried out biannually by the Statistical Office of the Republic of Slovenia (SORS) matched with the firm balance sheet data collected by the Agency of the Republic of Slovenia for Public Legal Records and Related Services (AJPES) and custom level data collected by the Custom Authorities. These are the same data used for the analyses in Chapter 2 and 4, for which an overview is provided in the Introduction to this thesis.

The dimension of the final sample was dictated by the CIS surveys, which cover about 2,200 firms in each survey. I defined a firm as an exporter in a certain year if the firm was seen as exporting in at least one month over the year; while I defined a firm as an innovator when the firm replied positively to at least one of the questions asking whether, over the years covered by the survey, the firm introduced a new product or service, a new process, an organisational innovation or a marketing innovation.

3.3.1 The ranking

In the model I assumed that the decision to enter exporting happens at a productivity level which is higher than that at which firms decide to innovate, in other words, that the marginal innovator is less productive than the marginal exporter, and that underlying productivity differences across firms produce a sorting of firms into these three groups: the low productivity firms only serve the domestic market without innovating, the middle group innovates without exporting, and the most productive firms decide to both export and to upgrade their technology by investing in innovation.

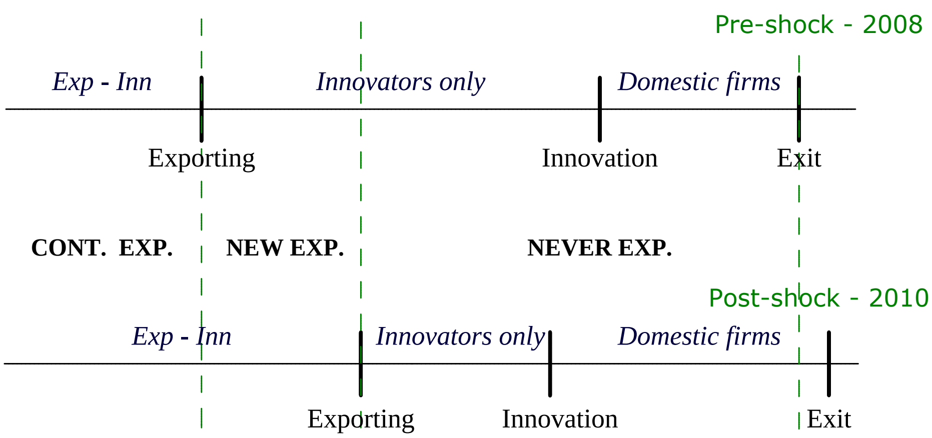
To test this ranking assumption I follow the approach of Bustos (2011) and examine the ex-ante/ex-post characteristics of firms in the three categories.

In order to have a balanced panel of firms for the test and because of the timing of the financial crisis and the time span covered by the surveys, I restricted the sample, in this phase of the analysis, to the 2008 and the 2010 surveys. The financial storm hit the European banking sector in October 2008, while the following recession bit hardest in 2009. Additionally, the surveys contain information on the innovative behaviour of firms during the preceding three years[71]. For these reasons I considered the 2008 survey as covering the pre-shock period and the 2010 survey for the post-shock period.

To make the reading lighter, in this Section I will refer to the liquidity constraint cutoff $\tilde{c}$ as the innovation cutoff, given that the position and movement of unconstrained innovation cutoff c_I are irrelevant of the liquidity constraint is binding.

Figure 3.10 illustrates the pre- and post-shock cutoff positions. The shock makes the innovation cutoff move leftwards, making access to innovation harder; the exporting cutoff moves rightwards due to the reduced degree of comepetition spurring entry into exporting.

Figure 3.10: Cutoff ranking before and after a liquidity tightening.



[71] For example, the 2008 survey asks firms whether they introduced new products or services over the last three years (2006-2008) and reports figures for innovation expenditure for the survey year.

A convenient approach is to divide firms into three mutually exclusive categories of exporters (never exporters[72], new exporters[73] and continuing exporters[74]) and measure their innovation intensity within 2-digit NACE industries. I expect that in 2008 and 2010 new exporters and continuing exporters are more technologically intensive than never exporters. Analysing the change from 2008 to 2010, new and continuing exporters should report a change in innovation intensity which is larger with respect to never exporters, since firms that are affected by the shock to innovation should fall in the never exporter category. Between new- and continuing exporters there should instead be no differential change in innovation intensity between 2008 and 2010[75]. To check these propositions, I ran specification (60):

$$\ln(Inn.\_Int.)_{ij} = \beta_0 + \beta_1 New\_Exp_{ij} + \beta_2 Cont\_Exp_{ij} + \beta_3 Stop\_Exp_{ij} + \gamma_j + \varepsilon_{ij} \ , \quad (60)$$

where $Inn.\_Int$ denotes the ratio of innovation expenditure over the number of employees, $New\_Exp.$, $Cont.Exp.$ and $Stop\_Exp.$ denote three binary variables taking value 1 if the firm belongs to those categories, γ_j denotes a set of 2-digit industry fixed effects; i and j index firms and sectors, respectively.

Table 3.4: Ranking test

	(1) 2008	(2) 2010	(3) Change	(4) 2008	(5) 2010	(6) Change
	Base cat. Never Exporters			Base cat. Continuing Exporters		
Continuing exporters	0.957***	0.869***	0.648***			
	(5.66)	(5.64)	(4.32)			
New exporters	0.132	0.115	0.0092	-0.824***	-0.754***	-0.638**
	(0.62)	(1.03)	(0.08)	(-4.15)	(-4.67)	(-3.43)
Never exporters				-0.957***	-0.869***	-0.648***
				(5.66)	(5.64)	(4.32)
N	1308	1308	994	1308	1308	994

Note: t statistic in parentheses; standard errors clustered at the sector level;
* p < 0.10, ** p < 0.05, *** p < 0.01.

Table 3.4 confirms the ranking assumption before the shock (columns 1 and 4), even though the result that new exporters are more innovation intensive than never exporter is not statistically significant. After the shock (in 2010), as expected, never exporters and new exporters are less technologically intensive than continuing exporters (column 5). Lastly,

[72] Firms that do not export in both 2008 and 2010: 395 firms.

[73] Firms that export in 2010 but were not exporting in 2008: 70 firms.

[74] Firms that export in both 2008 and 2010: 763 firms

[75] Notice that only the direction of the movement of the cutoffs can be predicted, the magnitude of the movement cannot be anticipated. This is an important observation because with this ranking of firms the shock would cause the cutoffs to move towards each other: the cutoffs could end up maintaining their relative positions, or else changing them with the innovation cutoff overtaking the exporting cutoff. This would cause different conclusions because new exporters could end up being not more innovation intensive and not upgrading their technology faster than never exporter after the shock.

columns (3) and (6) show that never exporters and new exporters were hit harder by the shock compared to continuing exporters and slowed down their innovation intensity with respect to top category: this goes in direction of a shock to innovation affecting mainly firms in the middle range of the productivity distribution. Note that new exporters were expected to upgrade their technology faster than never exporters: this might not show in the data because, since the cutoffs move towards each-other, the exporting cutoff could have moved rightwards substantially, overtaking the innovation cutoff. In this case the group of new exporters would be made up of some pre-shock non-innovator, hence presenting on average a change in innovation intensity which is not different compared to never exporters. This might also explain why I find new exporters slowing down their innovation intensity relative to continuing exporters, rather than showing no change: among the new exporters there might be firms that stopped innovating rather than continuing to innovate, hence causing the result above.

Note that this cutoff ranking is the opposite of Bustos (2011), who assumes that the marginal exporter is less productive than the marginal innovator. To reassure that Bustos' ranking does not hold for Slovenian firms, I inspect what the shock to liquidity for innovation would cause in case I reversed my ranking assumption. The innovation and exporting cutoffs would still move in the direction predicted by the model (rightwards and leftwards, respectively), but starting from opposite relative positions. While most of the predictions for continuing-, new- and never-exporters would be the same as in Table 3.4, the prediction that continuing exporters upgrade their technology faster than never exporters would be reversed. If Bustos' ranking held in the Slovenian case, the firms hit by the shock to innovation would be in the continuing exporter category, and not in the never exporter category[76]: this would show as a negative coefficient for continuing exporters in column (3), or a positive one for never exporters in column (6). Since this is strongly rejected by the data, I consider the results in Table 3.4 as evidence in favour of the ranking assumption (41) of my model.

A second and simpler test can be performed by focusing on a cross section of data (2008) and dividing firms into four categories: firms that neither export nor innovate (526 firms), firms that only innovate without exporting (384 firms), firms that only export without innovating (498 firms) and firms engaging in both activities (890 firms). Since the ranking is based on productivity of firms at birth I regressed two productivity measures on these mutually exclusive categories of firms to check whether the ordering assumed above is consistent with firms' average productivity across the four categories. The difference between firms only

[76] Never exporters would not innovate either before or after the shock.

innovating without exporting and firms only exporting without innovating (excluded category in Table 3.5) is key, because this is indicative of which activity firms engage in first as we move from a lower to a higher range in the productivity distribution.

Table 3.5: Ranking test - Second Strategy

	(1) TFP[77]	(2) Value added
No_Inn-No_Exp	0.00546	-0.235***
	(0.07)	(-5.60)
Only Inn	-0.0624	-0.139*
	(-0.53)	(-2.48)
Both Inn_Exp	0.0269	0.0743*
	(0.65)	(2.52)
N	2272	2244

Note: t statistic in parentheses; standard errors clustered at the sector level;* p < 0.10, ** p < 0.05, *** p < 0.01.

The coefficient on the "only innovation" dummy is negative for both measures, but significant only for the value added equation. This is indicative of the innovation decision happening at a productivity level which is lower than that at which firms start exporting, thus providing further support to the ranking choice.

3.4 Conclusion

I this chapter I developed a monopolistically competitive heterogeneous firm model with endogenous markups and liquidity constraints for innovation, to study the effects of a reduction in innovative activity on participation in exporting. The main contributions consist of introducing liquidity constraints into a heterogenous firms trade model with endogenous markups that studies jointly the decisions to export and to innovate; in addition to showing that a negative shock to innovation, which is symmetric across trading partners, can have an indirect positive effect on the propensity to export through the decrease in product-market competition.

The model is based on the work of Melitz and Ottaviano (2008) and adds efficiency-enhancing innovation on the supply side of the model: this is an activity that firms can access by sustaining a fixed cost. Liquidity constaints for innovation are modelled assuming that firms can borrow externally only a fraction of the fixed innovation cost, while they must pledge internal liquidity for the remaining fraction. This liquidity constraint interacts with efficiency heterogeneity: producers will in fact be able to overcome the constraint depending on their productivity at birth. If the fraction of the fixed innovation cost that needs to be

[77] TFP is computed as the residual of a log-linearized three factor Cobb-Douglas production function with capital, labour and material inputs

bourne out of internal funds is high enough, the equilibrium will feature a set of firms that would be able to innovate in a world of perfect financial markets, but are prevented from doing so. A first set of results shows that liquidity constraints produce *anti-competitive* effects: in an industry with liquidity constraints inducing a sub-optimal level of innovation firms are, on average, less productive, charge higher prices and higher markups relative to an industry with no liquidity constraints.

Exposure to international trade in a two-country world with symmetrical economies produces the same qualitative results as the original Melitz-Ottaviano (2008) model. Both the so-called *selection effect* and the *competitive effect* of trade are present. Integrating the domestic with the foreign economy through costly trade increases the "toughness" of competition, inducing the least efficient firms to exit (*selection* effect) and resulting in a market featuring higher average productivity, lower prices and lower markups (*pro-competitive* effect). Market shares will be redistributed from the less efficient firms (exiters and surviving domestic producers) to the more efficient firms (exporters).

The model then attempts to show the effects of a feature of the financial crisis of 2008-09: a tightening in liquidity constraints for innovative firms. It is shown that, if liquidity becomes tighter, the anti-competitive effects arising from innovation being below its optimal level are reinforced. Access to innovation becomes more selective, restricting the range of the productivity distribution over which firms will be able to enhance their efficiency. In turn, the reduction in the industry wide degree of competition results in more accessible threshold to enter the domestic and the export market. This latter is a consequence of the shock to innovation being symmetric across the trading partners. The model also predicts that the negative impact on innovation and the positive impact on exporting affect firms in the middle range of the productivity distribution.

The theoretical predictions arising from a tightening in external liquidity for innovation are taken the the data and tested in the Chapter 4 of this thesis.

4 From Innovation to Exporting in Times of Crisis: Evidence from Slovenia

4.1 Introduction

The crisis of 2008 was a financial shock of historic proportions with severe impacts on real decisions made by firms. Access to external finance became significantly more difficult due to credit rationing (Ivashina and Scharfstein, 2010), a higher cost of borrowing (Campello *et al.,* 2011) and difficulties in initiating a new credit line (Campello *et al.*, 2010). The inability of firms to borrow externally led to reductions in employment, the postponement and cancellation of investment projects and various reductions in spending, with the biggest cuts being reported on technology expenditure[78]. The survey of Campello *et al.* (2010) shows how this latter phenomenon affected both private and public firms across various size classes, especially in Europe and the US[79].

The main aim of this chapter is to study the impact of the 2008 crisis from a particular angle. I examine the effect of the reduction in external finance during the 2008 crisis on firms' innovation activity, and estimate how this shock indirectly affected firms' export participation. I therefore contribute to the literature on the nexus between international trade and innovation, exploring in a novel way how innovation can impact export participation. Furthermore, I also add more broadly to the literature on the financing of innovation, and the effects of 2008 financial crisis on innovation in particular.

The empirical analysis is theoretically motivated and guided by the heterogeneous firms' trade model, based on the work of Melitz and Ottaviano (2008), which constitutes the third chapter of this thesis. In the model, a symmetric[80] reduction in external liquidity available for innovation reduces the number of firms undertaking this activity, resulting in a reduction in average productivity as well as a fall in the industry-wide degree of product market competition. This latter effect induces relatively easier access in the export market[81].

In this chapter I take the propositions of the model to the data. I use Slovenian firm level data matched with innovation surveys and custom level trade data and find that in sectors characterized by higher (external) liquidity needs for innovation, firms experienced a larger fall in the probability of innovating and a larger increase in the probability of exporting, relative

[78] Relative to capital expenditures, marketing expenditures, dividend payments and salaries for employees.

[79] Relative to Asian firms.

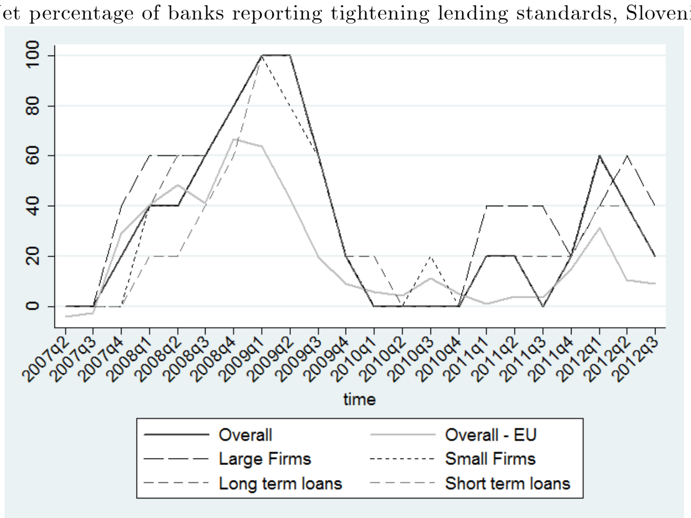
[80] An asymmetric shock to innovation has not been explored theoretically. This would possibly have different implications for exporting relative to a symmetric shock, due to the degree of competitive pressure changing differently across the two countries. I leave the examination of these effects to additional work that can be undertaken in the future.

[81] In the theoretical model this is represented by a lower productivity threshold to access exporting.

to sectors characterized by lower (external) liquidity needs for innovation. Additionally, firms' markups are found to have increased by more in sectors where the reduction in the probability of innovating was larger.

The financial literature has explored the impact of financial shocks and the reduction in banking activity on the real economy. Banking crises hinder real activity (Kroszner *et al.*, 2007; Dell'Ariccia *et al.*, 2008) through the reduction in the provision of credit and liquidity to firms during time of distress. In the 2008 crisis, CFOs of financially constrained firms reported having experienced credit rationing, higher costs of borrowing and to have bypassed attractive investment opportunities due to difficulties in raising external finance. Credit conditions led constrained firms to cut investment and to burn through their liquid assets (mostly cash reserves) to buffer against the credit supply shock (Campello *et al.*, 2010). Lending standards tightened dramatically over the two years between 2008 and 2009: in Slovenia, the spike in the net percentage of banks reporting tightening terms and conditions was higher than the EU average, as illustrated in Figure 4.1.

Figure 4.1: Net percentage of banks reporting tightening lending standards, Slovenia 2007-2012.



A reduction in bank finance can be particularly harmful for those firms that generally face higher than average difficulties in raising external finance, the innovative firms. It is well known that innovative projects, inherently riskier and often backed by intangible assets rather than physical property, tend to be financed primarily by internal financial resources (Hall and Lerner 2010). External financing constraints are in fact responsible for the procyclicality of R&D spending (Ouyang 2011), which tends to fall in periods of contraction because of the inability of firms to obtain funding by banks when internal liquidity is short[82].

[82] The opportunity cost of R&D is lower in downturns and this should make R&D investment countercyclical (Davis and Haltiwanger 1990, Aghion and Saint-Paul 1998). Nonetheless, in the data innovation and R&D are found to be procyclical. Liquidity constraints reconcile this finding with the opportunity cost hypothesis Aghion *et al.* (2008).

Importantly, Ayyagari *et al.* (2007) find that the externally financed proportion of a firm's innovation expenditure is positively associated with firms' innovation. Conditional on the availability of internal financial resources, therefore, innovation in firms that depend more heavily on external financing to sustain their innovation spending, might be more vulnerable to a credit crunch: one of the further aims of this work is to test this proposition in the context of the Great Recession.

Early research on external finance and innovation points against the role of banks in financing innovation[83], in favour of equity finance (Brown *et al.,* 2009). Although there is evidence consistent with the importance of public equity markets to finance innovation (Acharya and Xu, 2013)[84], there is a growing consensus that bank finance is an important source of capital, even for innovative firms. During the Great Depression of 1930s, the drop in availability of external bank finance impacted the rate of innovation (Nanda and Nicholas, 2014); while more recently, it is shown that banks finance and monitor innovative projects. Patents are often used as collateral for loans and the credit received seems to directly finance research (Chava *et al.* 2013; Mann 2015); external bank finance is an important source of start-up capital (Robb and Robinson, 2014) and, finally, the US banking deregulation over the 1980s had a measurable positive impact on innovation, especially in small private firms that depend more on bank finance for capital than publicly-traded firms (Chava *et al.,* 2013; Cornaggia *et al.,* 2013). Exploring how the exogenous reduction in banking finance during the crisis of 2008 impacted firms' innovation activity appears, therefore, to be of the utmost interest.

There is already some evidence on the effects of the 2008 crisis on innovation. The largest cuts by firms as a consequence of the inability to borrow were on innovation spending (Campello *et al.*, 2010); firms without public financial support reduced their innovation spending by more, up to abandoning innovation projects altogether[85] (Paunov, 2012); and from a survey of EU firms (OECD, 2012) it emerges that obtaining external finance for innovation was the most pressing problem for 20% of firms. Importantly, Lee *et al.* (2015) specifically study access to finance for innovative SMEs in the crisis, detecting that the more severe absolute credit rationing that innovative firm experience in general worsened significantly in the crisis. This chapter adds to this literature, exploring how the probability of successful innovation by Slovenian firms was affected by the financial crisis, depending on the relative dependence of a sector on external liquidity for innovation, a measure of vulnerability

[83] Hall and Lerner (2010) extensively discuss this literature.

[84] They find that publicly-traded firms in industries that are more dependent on external finance generate more patents of higher quality and novelty relative to privately held firms.

[85] 25% of the sample of Latin American firms surveyed.

to be hit by a sudden and exogenous reduction in external banking finance.

The contribution of my work extends then to the indirect impact that the negative shock to innovation had on firms' participation to exporting, through the change in product market competition.

Innovation has been associated both positively and negatively with competition, with causality running from innovation to competition, and *vice-versa*. In the theoretical model presented in the third chapter of this thesis, innovation is positively linked to competition: the reduction in innovative activity reduces average productivity and at the same time relaxes competitive pressure, allowing firms to increase markups. On the other hand, higher levels of innovation could raise entry barriers (Sutton 2006), reducing competition. Besides testing the sign of this relationship, the empirical analysis in this chapter considers that causality might run also in the opposite direction[86].

If the shock to innovation reduces competitive pressure and allows firms to charge higher markups, some relatively less efficient domestic producers may now manage to overcome the costs associated with exporting. This is a novel angle from which the innovation-trade nexus is being explored, which adds to the growing literature exploring the interlinkages between trade and innovation. The impact of international trade on innovation has been studied under various aspects: trade liberalization positively affects firm innovation through tougher competition (Teshima 2010; Impullitti and Licandro, 2013), higher revenues for exporters (Bustos, 2011) and access to a larger market (Trefler and Lileeva, 2010). Innovation can also be stimulated by higher import competition (Denicolo and Zanchettin, 2009), which in turn is observed to lead to quality upgrading (Fernandez and Paunov, 2013), more patenting, investment in IT and higher TFP (Bloom *et al.,* 2015). The reverse effect on the other hand, i.e. the effect of product and process innovation on trade, is less well explored. The long-standing debate about what confers a competitive advantage to exporters and importers, is far from being settled. Firm productivity is typically modelled as a random draw, exogenous to the firm; however, once one accounts for innovation, firm characteristics and export participation become endogenized, potentially allowing firms to overcome the barriers associated with participation to the export market. In favour of this argument are Cassiman *et al.,* (2010), Ganotakis and Love (2011) and Becker and Egger (2013), all finding that product innovation

[86] Higher competition might increase profit margins for firms closer to the technological frontier and induce more innovation, aimed at "escaping competition" (Blundell *et al.*, 1998). On the other hand, in sectors where innovations are made by laggard firms with low profits, competition could reduce incentives to innovate: this is the Schumpeterian approach, which predicts a negative relation between the two variables. Aghion *et al.,* (2005) reconcile the two approaches detecting an inverted-U shape relation: as competition increases, innovation first increases then decreases, because at low levels of competition the "escape competition" effect is likely to dominate the Schumpeterian effect, with the opposite being true at higher levels of competition.

is a key factor in raising firm's propensity to export. My chapter speaks to this literature from a new perspective: entry into exporting could be facilitated also by a negative shock to innovation which is symmetric between trading partners, thanks to the reduction in the toughness of comepetition both in the domestic and in the foreign market. From an empirical point of view this anti-competitive shock results in higher markups, extra resources that can be used to sustain the costs associated with the exporting.

The remaining parts of this chapter are organized as follows. Section 4.2 introduces the data used in the empirical analysis. Section 4.3 describes the main measures and Section 4.4 explains the estimation strategy. Section 4.5 briefly provides some descriptive statistics concerning the sample of Slovenian firms under consideration in this work. Section 4.6 presents the results. Section 4.7 exposes some futher results and robustness checks and Section 4.8 concludes.

4.2 Data

Four firm level data sources are used in the analysis: the Community Innovation Surveys (CIS) carried out biannually by the Statistical Office of the Republic of Slovenia (*SURS*), the firm balance sheet data collected by the Agency of the Republic of Slovenia for Public Legal Records and Related Services (*AJPES*), the custom trade data recorded by the Slovenian Customs Administration (*CARS*) and the firm balance-sheet information available in *Compustat*[87]. *Compustat* is a firm level data source which can be accessed on the Wharton Research Databases Services (WRDS) data portal, containing detailed balance sheet and income statement data on about 24,000 listed North American companies. *Compustat* is a widely exploited dataset in the literature, most prominently by Rajan and Zingales (1998), among many others.

The Slovenian data can be matched by use of unique firm identifiers, while the match with the US data was performed at the 4-digit sector level, by matching the European NACE rev.2 4-digit classification of activities with the US NAICS 2007 6-digit classification[88]. All four data sources span from 2000 to 2012.

All monetary variables are deflated by use of the available price indexes: for the Slovenian

[87] A more detailed explanation of the three Slovenian dataset was provided in the introduction to the thesis.

[88] This match was performed by use of the concordance table produced by Eurostat and some personal elaboration needed because the match between EU and US sectors is not univocal one-to-one. With the intention of preserving the structure of the NACE classification I matched more than one NACE sector to the same NAICS sector when this correspondence was found. In cases where more than one NAICS sector was seen to correspond to the same NACE sector, I decided to match the NAICS sector with the largest amount of sales. In any case, this adjusment was necessary only for handful of 6-digit NAICS sectors. Furtheremore, being the analysis in this paper carried out a the 2-digit industry level, this correction has no impact on the results.

data I used the 2-digit PPI series produced by SORS for the 28 manufacturing sectors and the CPI for the remaining 47 sectors. The US data are deflated by using the PPI series produced by the U.S. Bureau of Labour Statistics.

The dimension of the final sample was dictated by the samples surveyed in the CIS: these data are collected through a combination of a stratified sample for firms between 10-49 employees and a census survey for bigger firms, covering about 2,200 firms in each survey. The final sample used in the estimation includes 6154 firms over seven surveys[89]. However, due to the nature of the sampling strategy, the panel dimension is jeopardised: only 3,593 firms appear in more than one survey. Out of these, 2,373 firms innovated at least once and 2,654 exported at least once. I define a firm as an exporter in a certain year if the firm was seen as exporting in at least one month over the year; while I define a firm as an innovator when the firm replied positively to at least one of the questions in the CIS asking whether, over the years covered by the survey, the firm introduced a new product or service, a new process, an organisational innovation or a marketing innovation.

4.3 Empirical Methodology

The aim of the empirical analysis is to exploit the context of the 2008-2009 financial crisis to examine how a negative shock to the innovative activity performed by firms can indirectly affect participation to exporting, through a change in product market competition, which I measure by estimating the markups charged by producers.

The arguably exogenous 2008-2009 financial shock was transmitted to the real activity of firms through a severe reduction in the availability in external banking finance. The perspective of my analysis necessitates therefore isolating the impact of the credit crunch on innovation, in order to then be able to assess whether this particular aspect of the financial crisis had an indirect impact on firms' markups and participation to exporting.

Before proceeding to the exposition of the estimation strategy, I present the main variables exploited in the analysis.

4.3.1 Shock to innovation

Examining and identifying correctly the specific effect of the crisis on the financing of innovation, requires an exogenous and observable source of variation across firms in their access to external finance, to be exploited in estimation.

Unfortunately, in standard firm balance sheet data there is neither direct information on

[89] CIS3, Statistical Report on Innovation Activity 2002, CIS4, CIS2006, CIS2008, CIS2010, CIS2012.

the working capital that firms use to finance operations of different kinds, nor it is possible to observe directly the amount of credit specific for innovation. Furthermore, direct measures of overall credit provided by the banking sector are only approximable by the stock of short term liabilities in a given year. Finally, even if a proxy for credit obtained by firms were constructed from balance sheet data, this would be simultaneously determined with the innovative status of the firm, causing estimates of the effect of the credit crunch on innovation to be inconsistent. Firms that intend to innovate are more likely to hit a financing constraint than firms that do not even try (Hajivassiliou and Savignac, 2007) and this gives rise to a reverse causality issue.

The endogenous link between innovation and financial constraints is well documented in the literature and has been recently dealt with either by use of credit indexes (Czarnitzki and Hottenrott, 2011), particular survey designs to identify constrained firms (Hottenrott and Peters, 2012), or by use of instrumental variables (Gorodnichenko and Schnitzer, 2013). A more indirect approach consists of exploiting sectoral variation in external financial dependence, in a difference-in-difference setting. The most widely used measure of dependence on external finance is the ratio introduced by Rajan and Zingales (1998). Given that the Rajan-Zingales measure is arguably an exogenous and stable characteristic of different sectors, mostly justified on technological grounds, it has been widely applied to various contexts in order to overcome the simultaneous determination of credit and financial variables on one side, and the type of activity performed by firms on the other, e.g. production (Kroszner *et al.,* 2007), exporting (Iacovone and Zavacka, 2009) and, more recently, also innovation (Acharya and Xu, 2013).

I had two options for identifying the shock in my context, i.e. the effect of the reduction in banking finance on innovation. I could either attempt to instrument the credit crunch of 2008-09, by exploiting Slovenian firms' balance sheet variables (e.g. overdues, collateral); or else I could identify the effect of the crisis indirectly, by relying on an exogenous sectoral source of cross-sectional variation in a before-after crisis (difference-in difference) setting.

I avoided the direct instrumentation of the shock in my context, because I could only approach the instrumentation of credit constraints in general, and not of constraints specific to innovation. I therefore base my identification strategy on the differential impact of the crisis across sectors differing along the dimension of their need of external finance, making this sectoral dependence specific to innovation. The Rajan-Zingales ratio, in fact, proxying the structural dependence on external finance, is not well suited to my context because it is not specific to innovation and is meant to capture the long-run requirement of external funds as a source of physical capital, rather than the short run vulnerability to a financial shock. For these two reasons I propose an alternative measure, inspired by the work of Raddatz (2006), meant to capture the sectors' external liquidity need for innovation expenditure: the ratio of innovation expenditure over revenue.

I follow the approach of Raddatz (2006) and compute a measure of *external liquidity needs* for innovation using data of US firms taken from Compustat[90]. This strategy borrows from Rajan and Zingales (1998) the assumption that sectors differ structurally from each other – in terms of their liquidity needs – due to technological factors, and that these differences persist across countries and time. The innovation expenditure over revenue ratio is computed at the firm level and then averaged over all years available in the data, up to the crisis, in order to obtain a time constant measure. The mean[91] ratio of each sector is then taken as a measure of *external liquidity needs* for innovation expenditure.

This variable is a standard ratio used in the innovation literature to measure innovation intensity, however it can be reinterpreted as the fraction of innovation expenditure that can be financed with ongoing revenue. Firstly, it is useful to isolate the shock imparted by the crisis directly on the financing of innovation, being the measure specific to innovation expenditure. Furthermore the denominator, revenue, is the first source of liquidity for innovative firms: innovation is financed mainly with internal funds, because of the higher information asymmetry and riskiness embedded in this activity compared to more standard production processes. A higher innovation expenditure over revenue ratio shows that a smaller fraction of innovation expenditure can be financed by ongoing revenue, therefore proxying the degree of dependence on external finance to sustain innovative activity, i.e. a higher ratio indicating a higher dependence. In other words, a higher ratio can signal the vulnerability of being hit by a reduction in external liquidity provided by the banking sector. Due to the sudden nature of the 2008 crisis, the need of external liquidity of an industry for its innovation expenditure is a better determinant of the vulnerability to such a short-run financial shock, compared to the original Rajan-Zingales measure.

For all these reasons, the ratio of innovation expenditure over revenue (to which I henceforth refer to as *liquidity needs,* LN) suits this particular analysis well. It is doubtless that in the financial crisis and subsequent recession firms suffered also from a shock to their internal

[90] Data of all US firms available in Compustat were used, over all years from 2000 to 2007. The original sample for this variable included 6380 firms (and 31,538 firm-year observations), but I dropped 0.9% of them to eliminate some very large outliers. The final Compustat sample includes therefore 6362 firms (31,323 firm-year observations).

[91] If the median is exploited, instead of the mean, results are extremely similar. See Tables 4.13 and 4.14 in Appendix.

liquidity, but, after controlling for the use of internal financial resources[92], the structural LN ratio constitutes an exogenous source of variation proxying the degree of exposure to a sudden reduction in the provision of external banking finance[93].

Lastly, the identifier of the crisis years needs a brief explanation. The financial crisis hit in the last quarter of 2008 with most of the impact on the European banking sector at the beginning of October 2008, while the following recession bit hardest in 2009. Firms' sales and profits in Slovenia increased in 2008 from 2007, but fell hard in 2009 and 2010, starting to recover only in 2011. Considering this timing, since each biannual CIS survey contains information on the innovative behaviour of firms during the preceding years, I considered the 2010 survey as the one covering the crisis years.

The shock to innovation is therefore identified in a difference-in-difference setting, where the LN ratio is interacted with a binary variable taking value 1 for years covered by the 2010 CIS survey.

4.3.2 Shock to competition and exporting

The second aim of this work is to examine whether participation in exporting was facilitated by the impact of the crisis on innovation.

The theoretical *Proposition 1* in chapter 2 argues that a reduction in external liquidity for innovation makes access to innovation more selective, thereby reducing the degree of competitive pressure which, in turn, results in a lower entry threshold into the export market. As a consequence, in this empirical framework, I expect innovation to have been harmed by more in sectors characterised by higher LN for innovation, relative to sectors characterized by lower LN. In addition, I expect entry into exporting to have been facilitated by more in sectors where innovation was harmed by more, because the channel linking innovation and exporting, competition, was affected by more. From an empirical point of view, I expect firms' markups to have increased by more in sectors where innovative activity was reduced by more by the lack of external banking finance, such that firms found it relatively easier to overcome the cost associated with exporting. I identify the shock on exporting using the same difference-in-difference setting exploited to identify the shock to innovation, but I expect the coefficient on the LN ratio in the crisis years to take a sign which is opposite with respect to

[92] Proxied by the change in cash stocks and the level of cash flow.

[93] It is difficult to interpret the LN ratio differently in my context. Sectors characterized by higher liquidity needs (or sectors with higher *innovation intensity*, in the economics of innovation terminology) are found in the data to be the more technologically advanced sectors, with the pharmaceutical industry topping the LN measure and the retail and transport sectors found at the bottom. I would indeed expect the highly innovative industries to be more exposed to a sudden reduction in external liquidity and to therefore report a larger loss in innovative output, relative to sectors whose innovativeness is lower. I will provide a further assessment of the interpretation of the LN measure after exposing the estimation results.

that for innovation.

The positive effect on entry into exporting, stemming from the negative impact on innovation, should be mediated by a reduction in competitive pressure, which lead firms to increase markups. I therefore also estimate the effect of the shock on markups, again using the difference-in difference approach through which I test how the crisis affected innovation and exporting. Afterwards, I show that the relatively positive impact of the crisis on exporting vanishes, or is at least dampened, when conditioning on firms' market power.

To estimate markups I implement the recent methodology of De Loecker and Warzynski (2012), henceforth DLW. The advantage of the DLW method is that it allows me to obtain time-varying firm specific markups, without the need to specify how producers compete in the product market.

The DLW procedure relies on the mild assumption that firms are cost-minimizing and combines output elasticities of variable inputs to their revenue shares in order to estimate price-cost ratios. Let the a production function take the form:

$$Q_{it} = Q_{it}\left(K_{it,}L_{it}\right)\Omega_{it} \ , \tag{61}$$

where Q denotes value added produced, K denotes physical capital, L denotes labour, $\Omega_{it} = \exp(\omega_{it})$ where ω_{it} denotes a Hicks-neutral productivity term. The Lagrangian associated with the cost minimization is:

$$\Lambda_{it} = Q_{it}\left(K_{it,}L_{it},\lambda_{it}\right) = P_{it}^{L} * L_{it} + r_{it} * K_{it} + \lambda_{it}\left(Q_{it} - Q_{it}\left(K_{it,}L_{it},\omega_{it}\right)\right), \tag{62}$$

where λ_{it} is the marginal cost of production, as $\partial\Lambda/\partial Q_{it} = \lambda_{it}$. Treating labour as a variable input, its first order condition is:

$$\frac{\partial\Lambda}{\partial L_{it}} = P_{it}^{L} - \lambda_{it}\frac{\partial Q_{it}}{\partial L_{it}} = 0 \tag{63}$$

Multiplying through by L_{it}/Q_{it} and defining the markup μ_{it} as the price-marginal cost fraction $\mu_{it} = P_{it}/\lambda_{it}$, the first order condition can be rearranged such that:

$$\mu_{it} = \frac{\theta_{it}^{L}}{\alpha_{it}^{L}}, \tag{64}$$

where θ_{it}^{L} denotes the output elasticity of labour and α_{it}^{L} denotes the share of the expenditure on labour in total sales, $\alpha_{it}^{L} = \frac{P_{it}^{L}L_{it}}{P_{it}Q_{it}}$. The basic insight of the DLW procedure is that the output elasticity of a variable factor of production is equal to its expenditure share in total revenue only when price equals marginal cost of production. Under any form of imperfect competition, a markup will drive a wedge between the input's revenue share and its output elasticity.

The share of labour costs in sales α_{it}^{L} is easily observable in the data. The output elasticity of labour θ_{it}^{L} is instead derived from the estimation of a trans-log production function, based on the Ackerberg, Caves, and Frazer (2006) approach, henceforth (ACF). More details about the estimation procedure[94] are provided in subsection 4.4.

4.4 Estimation strategy

The methodology exploited in this work is intended to test *Proposition 1* of the theoretical framework that constitutes the second chapter of this thesis. A reduction in external financing of innovation reduces innovative activity and, through the reduction in competitive pressure arising from the shock to innovation, allows an easier entry into exporting. There is therefore a threefold task to be accomplished. First, to assess the impact of the reduction in external finance during the 2008 crisis on innovation. Second, to estimate the effect of this particular shock on firms' markups and on exporting. Third, since the shock under examination should affect exporting only through the change in competition, to show that conditioning on firms' markup dampens the effect on exporting. Finally, the theoretical model predicts that the shock should affect firms in the middle range of the productivity distribution: I therefore repeat the estimations unpacking the impact of the crisis on innovation and exporting over quartiles of the firms' productivity distribution.

4.4.1 Innovation

To assess the impact of the reduction in external finance on innovation specification (65) is estimated:

$$\begin{aligned} Inn_{it} &= \beta_0 + \beta_1 Inn_{it-1,} + \beta_2 LN_j + \beta_3 Crisis_t + \boldsymbol{\beta}_4 LN_j * Crisis_t \\ &\quad + \sum_n \beta_n IF_{it} + \sum_r \beta_r X_{it-1} + \delta_i + \rho_{jt} + \varsigma_t + \varepsilon_{it} \end{aligned} \tag{65}$$

The dependent variable is a binary indicator taking value 1 if the firm reports to have introduced a new product, process, marketing or organizational innovation over the time

[94] Since both DLW and I apply the procedure to estimate markups with Slovenian firm level data, I decided to follow their approach in the specification of the production function and the cost-minimization problem and to therefore use labour as the variable input in production. However, the DLW procedure can be applied to any input that one considers variable (e.g. materials or electricity, in a gross-output rather than a value-added setting). Importantly, one needs also to condition on the use of dynamic inputs that can be subject to adjustment costs (in my setting capital), as implied by the cost-minimization.

span covered by the CIS survey. LN_j denotes the *external liquidity needs* variable, which is the sectoral time invariant ratio of innovation expenditure over revenue calculated for each 2-digit NACE sector j. $Crisis$ is a dummy taking value 1 in 2010 and value 0 in 2000, 2002, 2004, 2006, 2008 and 2012. IF_{it} denotes cash-flow and the change in cash-stock, variables controlling for the use of internal financial resources. The change in cash-stock is an especially important control: due to the high costs of adjusting R&D spending, firms aggressively buffer innovation from transitory volatility in internally generated cash flow and lack of external finance (Brown *et al.,* 2012). To correctly identify the effect of the reduction in external banking finance on innovation it is therefore imperative to control for the change in the reserves of liquidity that firms use to shield innovation from shocks of the kind under examination. X_{it-1} denotes a vector of other firm level controls[95]. δ_i, ς_t and ρ_{jt} denote, respectively, a full set of firm fixed effects, time dummies and 2-digit industry-time trends. Finally, to account for the persitence of innovation, I estimate specification (65) in a dynamic panel setting, adding the first lag of the dependent variable to the empirical model.

The focus is on $\boldsymbol{\beta}_4$, which is expected to take a negative sign: in sectors characterized by higher external liquidity needs for innovation expenditure, the sudden reduction in external liquidity provided by the banking sector should have reduced the probability of innovating by more, relative to sectors characterized by lower external liquidity needs for innovation expenditure.

4.4.2 Exporting

To assess how this particular financial shock affected firms' participation to exporting I estimate specification (66):

$$\begin{aligned} Exp_{it} &= \beta_0 + \beta_1 Exp_{it-1,} + \beta_2 LN_j + \beta_3 Crisis_t + \boldsymbol{\beta}_4 LN_j * Crisis_t \\ &+ \sum_n \beta_n IF_{it} + \sum_r \beta_r X_{it-1} + \delta_i + \rho_{jt} + \varsigma_t + \varepsilon_{it} \end{aligned} \tag{66}$$

The dependent variable is a binary indicator taking the value 1 if the firm exported at least once during a year. As explained in section 3.2.2, for exporting I exploit the same difference-in-difference strategy as in specification (65). The rationale is that, since I expect the financial shock to have harmed innovation more in sectors with higher LN, it is precisely in those sectors that entry into exporting should have been facilitated by more. I expect

[95] The controls are employment, capital intensity, and a binary indicator taking value 1 if the firm is in receipt of public funding for innovation. These variables are lagged by one year in estimation to reduce reverse causality concerns.

therefore $\boldsymbol{\beta}_4$ to take a positive sign in the regressions where the probability of exporting is on the left hand side.

4.4.3 Markups

The theoretical model in Chapter 3 predicts that a negative shock to the financing on innovation results in lower competitive pressure and higher firms' markups. This is the channel leading to a relatively easier possibility to access the export market. To assess how markups were affected by the shock to innovation, I exploit again the difference-in-difference strategy of specification (65). Since the financial crisis is expected to have harmed innovation by more in sectors characterized by higher LN, markups are expected to have increased by more in those sectors. To test this rationale I estimate specification (67):

$$\begin{aligned} \mu_{it} \quad &= \quad \beta_0 + \beta_1 LN_j + \beta_2 Crisis_t + \boldsymbol{\beta}_3 LN_j * Crisis_t \\ &\quad + \beta_4 Kint_{it-1} + \beta_5 Empl_{it-1} + \delta_i + \rho_{jt} + \varsigma_t + \varepsilon_{it} \end{aligned} \tag{67}$$

The dependent variable is the value of firms' markup estimated by exploiting the DLW procedure: this corresponds to the ratio of the output elasticity of labour over the revenue share of labour costs (64). While the revenue share α_{it}^L is observable in the data, I need to estimate the output elasticity of labour θ_{it}^L.

The production function that I take to the data, and that I estimate separately for each 2-digit NACE industry, is a log-transformation of (61). I adopt a value-added translog production function of this form:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{lk} lk_{it} + \omega_{it} + \epsilon_{it}, \tag{68}$$

where the lower cases represent the natural logarithms of the variables. Value-added is defined as output net of material inputs, capital is proxied with the value of fixed assets, labor with the number of employees. Value added, capital and material inputs are expressed in constant Euros. I estimate a translog production function rather than a Cobb-Douglas specification, because the latter would restrict the input elasticities to be constant across firms in the same sector, implying that all the within-industry variance of markups is explained by the variance of revenue shares across firms. The translog, on the other side, allows me to have firm and time specific markups, because inputs' elasticities depend also on the level of the inputs used by each firm: in this case the variation of markups depends on both the heterogeneity of output elasticities and the variability of revenue shares. From (68), the output elasticity of labour I need to compute markups is given by:

$$\theta_{it}^{L} = \hat{\beta}_l + 2\hat{\beta}_{ll} l_{it} + \hat{\beta}_{lk} k_{it} \quad (69)$$

In order to obtain consistent estimates of $\hat{\beta}_l, \hat{\beta}_{ll}$ and $\hat{\beta}_{lk}$, I need to control for unobserved productivity shocks potentially correlated with inputs' choices. To deal with this well-known simultaneity problem I rely on a material input demand function (70) to proxy for productivity (Levinsohn and Petrin, 2003). The material demand proxy that I exploit includes a vector $\mathbf{z}_{it}$ of additional state variables that can potentially affect the optimal input demand.

$$m_{it} = m_t\left(k_{it,}\omega_{it}, \mathbf{z}_{it}\right) \quad (70)$$

This means that I allow the input coefficients to vary by exporters and innovators, since the $\mathbf{z}_{it}$ vector includes the exporting and the innovation status, other than time and 4-digit NACE fixed effects. The advantage of accounting for the variables in $\mathbf{z}_{it}$ in the estimation routine, is that I do not have to take a stand on the exact underlying model of competition in each industry. The inverse function $h_t(.)$ of (70), $\omega_{it} = h_t(k_{it,}m_{it}, \mathbf{z}_{it})$ is then used as the productivity proxy in estimation.

For the estimation of the production function (68) I follow the two-stage ACF approach. In the first stage I run:

$$y_{it} = \phi_t(k_{it}, l_{it}, m_{it}, \mathbf{z}_{it}) + \epsilon_{it}, \quad (71)$$

where I obtain an estimate of $\hat{\phi}_{it}$, expected output[96].

Given my choice of using a translog function, $\hat{\phi}_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{lk} lk + h_t(k_{it,}m_{it}, \mathbf{z}_{it})$. The firm specific proxy for productivity $h_t(.)$ enters as a third order polynomial, including full interactions with the state variables in $\mathbf{z}_{it}$.

In the second stage I retrieve the production function coefficients needed to compute the output elasticity (69). The identification of these coefficients relies on the law of motion of

[96] Ideally I would need a measure of physical output on the left hand side of (68), rather than deflated revenue, becasue the latter might reflect price differences across firms within an industry. However, unobserved price variation that is uncorrelated with input choices (and therefore picked up in ϵ_{it}) is explicitly eliminated when computing markups, since the empirical counterpart of $\alpha_{it}^{L} = \frac{P_{it}^{L} L_{it}}{P_{it} Q_{it}}$ used to calculate (64) is $\hat{\alpha}_{it}^{L} = \frac{P_{it}^{L} L_{it}}{\exp(\hat{\phi}_{it})}$.This correction allows me to eliminate any variation in α_{it}^{L} not related to variables impacting input demand $(k_{it}, l_{it}, m_{it}, \mathbf{z}_{it})$, including input prices and other market characteristics. Additionally the use of the productivity proxy $h_t(.)$ controls for price variation correlated with variation in productivity. Finally, DLW show that when relying on revenue data, only the level of markups is potentially affected, but not how markups change over time. This is reassuring for my analysis, since I focus on changes in markups, rather than their level.

productivity, given by (72):

$$\omega_{it} = \gamma_t \left(\omega_{it-1}, Exp_{t-1,} Inn_{t-1}\right) + \xi_{it} \tag{72}$$

In (72) I allow for the potential of past exporting and innovation to affect firms' productivity. De Loecker (2007, 2013) showed that there are important gains from learning by exporting and accounting for the possibility of this happening appears crucial in my context.

ω_{it} can be computed after the first stage, using $\omega_{it} = \hat{\phi}_{it} - \beta_l l_{it} + \beta_k k_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{lk} lk$. By regressing ω_{it} on its lag, one can recover ξ_{it}, the innovation in productivity unforseen by the firm and that is uncorrelated with inputs' choice: endogenising past exporting and innovation in (72) allows me to obtain an innovation in productivity ξ_{it} uncorrelated with firms' past innovation or exporting behaviour.

By following ACF and DLW, I use the GMM approach and exploit the following moment conditions to identify $\beta_l, \beta_k, \beta_{ll}, \beta_{kk}$ and β_{lk}:

$$\begin{aligned} E(\xi_{it} l_{it-1}) &= 0 \\ E(\xi_{it} k_{it}) &= 0 \\ E(\xi_{it} l_{it-1}^2) &= 0 \\ E(\xi_{it} k_{it}^2) &= 0 \\ E(\xi_{it} l_{l-1} k) &= 0 \end{aligned} \tag{73}$$

The moments in (73) imply that capital is assumed to be decided a period ahead and is therefore uncorrelated with innovations in productivity; labour is instead expected to react to current productivity shocks and needs to be instrumented by its first lag.

Note that the markups constructed by use of (64) are estimates, since they depend on the estimated production function coefficients. Using estimated coefficients introduces a source of uncertainty in the markup estimates. I account for the measurement error in this variable when I estimate (some of) the reduced form regressions exploiting specification (67) and when condition for markups in specification (66), by bootstrapping over the entire procedure. I execute the following steps in sequence: 1) estimate the production function, 2) recover the input coefficients, 3) calculate markups, and 4) project markups on the shock imparted by the reduction in external liquidity for innovation. I then repeat this procedure 100 times, using bootstrapped (with replacement) samples that keep the sample size equal to the original sample size. This allows me to compute the bootstrapped standard error on some of the coefficients[97] in the Results section.

4.5 Descriptive Statistics

Before presenting the results of the analysis, I briefly report some descriptive statistic about the measures exploited in estimation. The main regressor, the LN ratio of innovation expenditure over revenue is calculated for each 2-digit NACE sector by using data of all US firms available in Compustat, over all years from 2000 to 2007. Once merged on the Slovenian data, this ratio varies over 76 industries ranging from a minimum of zero (Nace sector 49 - Land transport) to a max of 4.62 (Nace sector 21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations).

Table 4.1: Descriptive Statistics- chapter 3

	Obs	Mean	Std.	Min	Max
Liquidity Needs (firm level)	31,323	0.99	5.51	0	100
Liquidity Needs (sectoral level)	76	0.45	0.85	0	4.62
Markup I (no z_{it}, no endogenous exp. and inn.)	10,158	1.12	1.17	-29.3	36.1
Markup II (z_{it}, no endogenous exp. and inn.)	10,127	1.26	1.27	-25.3	17.5
Markup III (z_{it}, endogenous exp. and inn.)	10,127	1.27	1.34	-25.5	15.6
Employees	12,895	122.3	356.47	0	8899
Capital Intensity	12,775	616.8	1825.6	0	56798
Cash Stock	12,748	0.040	0.081	0	4.66
Cash Flow	12,799	0.054	0.084	0	0.98

Source: SORS and author's calculations.

I report statistics about three different markup variables, computed with the DLW methodology: in Markup **I** I include neither additional state variables in the productivity proxy (70) nor the impact of past exporting and innovation in the law of motion of producitivity; in Markup **II** I add the exporting and the innovation status in the material demand function and, finally, in Markup **III** I account for both the the impact of the state variables in (70) and the endogeneity of exporting and innovation. The mean values are highly comparable with those in DLW.

The remaining controls are standard variables representing the number of employees, capital intensity (fixed tangible assets per employee), cash stock from balance sheet data and cash flow (sum of income before extraordinary items, innovation expenditure and depreciation). Cash-stock and cash-flow are scaled by beginning of period's value of total assets.

[97] This procedure is computationally very intensive and becasue of real time constraints when carrying out the data analysis at the Statistical Office in Ljubljana, I had to limit the bootstrap procedure to a few selected regressions and to not more than 100 repetitions.

4.5.1 Markups, Export and Innovation Status

Given that I estimated firm specific markups, I can simply relate them to a firm's export or innovation status in a regression framework, to explore whether there are systematic differences across groups of producers. I create four mutually exclusive categories of producers, depending on firms' exporting and innovation status[98] and then estimate the percentage difference in markups between them. This is the specification[99] taken to the data:

$$\ln \mu_{it} = \delta_0 + \delta_1 ExpInn_{it} + \delta_2 OnlyExp_{it} + \delta_3 OnlyInn_{it} + \sum_r \sigma_r \mathbf{f}_{it} + \nu_{it}, \tag{74}$$

where μ_{it} is the firm specific markup estimated with the DLW procedure, corresponding to Markup **III** in Table 4.1. $ExpInn_{it}$ is a dummy denoting firms that are both exporting and innovating over a year, $OnlyExp_{it}$ denotes firms that export but do not innovate, $OnlyInn_{it}$ denotes firms that innovate but do not export. I control for labour and capital intensity to capture differences in size and factor use and add a full set of industry-time interactions. These latter controls are collected in the vector $\mathbf{f}_{it}$. The δ coefficients cannot be considered causal, but are intended to test whether, on average, markups differ across the four categories of producers.

Table 4.2: Markups, Export and Innovation Status

	(1)	(2)	(3)	(4)
				Boot. SE
Exp. Inn.	0.050***	0.049***	0.012*	0.050***
	(0.009)	(0.011)	(0.007)	(0.012)
Only Exp.	0.038***	0.036***		0.038***
	(0.008)	(0.011)		(0.013)
Only Inn.	0.001		-0.036***	0.001
	(0.011)		(0.011)	(0.011)
No Exp. No Inn.		-0.001	-0.038***	
		(0.010)	(0.008)	
Cons.	0.960***	0.961***	0.994***	0.960***
	(0.010)	(0.001)	(0.011)	(0.011)
N	11637	11637	11637	11637

Note: Robust standard error in parenthesis, * p<0.10, ** p<0.05, *** p<0.01

Specification (74) tests directly an implication of the theroretical model of Chapter 3, based on Melitz and Ottaviano (2008). In the model markups are a positive function of the distance between a firm's marginal cost from the the industry exit cost-cutoff, i.e., the higher a firm's productivity (the lower its marginal cost), the higher its markup. From this follows

[98] The four categories are: neither innovator nor exporter, only innovator, only exporter, innovator-exporter.

[99] This is the same specification by which De Loecker and Warzinsky (2012) test for the mean difference in makups between exporters and non-exporters.

that firms performing both exporting and innovation should charge the highest markups and firms producing only for the domestic market without innovating should charge the lowest markups. Between these extremes, the productivity ranking assumption was that the marginal innovator is less productive than the marginal exporter: this implies that firms performing only innovation without exporting should charge a markup which is lower compared to firms that only export, without innovating. This result would confirm the assumption about the ranking of producers made in Chapter 2.

The results in Table 4.2 confirm the theoretical model's prediction about firms' markups. Firms that both export and innovate report the highest price-cost margins. In the middle range of the producitivity distribution, exporters that do not innovate are found to charge, on average, higher markups than innovators that do not export. This suggests that firms select into exporting at a productivity level which is higher compared to the level at which firms start innovating, confirming the producitivity ranking assumption. Finally, firms that neither export nor innovate are found to charge the lowest markups, although the difference with the group of only innovators is small and not statistically significant.

4.6 Results

In this section I present the estimates of the impact of the 2008-09 financial crisis on firms innovation, markups and participation to exporting.

4.6.1 Impact on Innovation

Table 4.3 reports the results from estimating specification (65). The dynamic-panel setting applied to the data at hand, with a short time dimension (at most 7 surveys) relative to number of cross-sectional units, requires me to instrument the lagged dependent variable Inn_{it-1} to circumvent the correlation of this regressor with the residual of the model (Nickell bias). For this purpose I apply the Arellano-Bond methodology in a GMM setting, exploiting further lags of the dependent variable to instrument Inn_{it-1}.

A GMM procedure applied to a dynamic-panel offers a variety of estimation options to the researcher. In order to justify the choice about the estimator made in this work, in Table 4.3 I compare results from a pooled-OLS model (POLS), a fixed-effects *within* estimator (FE) and a system-GMM estimator (Blundell and Bond, 1998). In the last two columns (7 and 8) I report the system-GMM result where the forward-orthogonal transformation (instead of first-differencing) suggested by Areallano and Bover (1995) is performed on the data[100].

[100] This is particularly useful when the panel under examination is unbalanced.

For all the GMM estimators I perform the Windmeijer correction to obtain robust standard errors in small samples.

The coefficient on the lagged dependent variable is indicative of the correct specification of the GMM models. Both the POLS and the FE estimators are biased, but they can be taken as, respectively, an upper and a lower bound estimate of the lagged dependent variable. Bond and Windmeijer (2001) suggest, in fact, that the GMM estimate should lie in between the POLS and the FE ones. This "rule-of-thumb" applies neatly in my context: the INN_{t-1} coefficient takes values of opposite sign in the POLS and FE model, while the Syst-GMM model, in columns (5)-(8) is well behaved[101] and, especially in the specifications where I control for cash-flow and the change in cash stocks, I obtain a lagged dependent variable coefficient lying between the POLS and the FE, even though close to the upper bound. This implies that for the main results in this work I am going to consider the system GMM as the preferred estimator[102]. The option of exploiting a difference-GMM estimator (Arellano and Bond, 1991), in place of the system-GMM, has also been considered, but after careful inspection of the initial results a choice in favour of the system-GMM has been made instead[103].

The system GMM jointly estimates specification (65) in differences and in levels, using lagged levels as instruments for the regression in differences and lagged differences as instruments for the regressions in levels[104]. I rely on lagged levels dated from $t-3$ to $t-6$ for the regression in differences and lagged differences dated $t-2$ for the regression in levels. The reason for taking as instruments lags starting at $t-3$ (and not $t-2$) is that the Arellano-Bond test for serial autocorrelation rejects the null of no first-order serial correlation in the residuals, given a p-value $< 5\%$ for the Arellano-Bond test of second-order serial correlation in the differences of estimated residuals (AR(2)). This implies that the $t-2$ lag is correlated

[101] This is visible from the lagged dependent variable coefficient and the p-values for the Hansen-J test statistic, whose range indicate that the instruments are valid and not affected by a weak instrumentation issue.

[102] In the GMM regressions, besides the lagged dependent variabel INN_{t-1}, I treat as endogenous the cash-flow variables and the change in cash stock. These regressors are instrumented with lags dated from t-3 onwards.

[103] Several reasons lead me to prefer the system-GMM over the difference-GMM. Bond and Windmeijer (2001) suggest that the difference-GMM estimates can be downward biased becasue of weak instrumentation, and that inspection of the Hansen-J test results can be indicative of this issue. In my context, I obtained p-values for the Hansen-J test close to unity, a signal of weakness of the difference-GMM, which cannot therefore be regarded as reliable for my results. Furthermore the lagged dependent variable coefficient for the difference-GMM is below the FE estimate: again this is a signal of a downward bias due to weak instrumentation, and a system GMM estimator is to be preferred instead. Finally, and importantly, it is to be clarified that the main coefficient of interest (the LN*Crisis interaction) is not affected by the choice between difference- or system-GMM, with the main result of this work being upheld regarless the choice about the estimator.

[104] Estimating the model in both differences and levels addresses the weak instrument problem arising from using lagged-levels of persistent explanatory variables as instruments for the regression in differences (Blundell and Bond, 1998). However, a strong assumption of this approach is that changes in the instrumental variables are uncorrelated with the fixed effects.

with the residual and is invalid as an instrument. To assess instrument validity I report the Hansen J-test of the null that the over-identifying restrictions are valid: here I always fail to reject the null, confirming the validity of the instrumentation procedure.

The main result standing out in Table 4.3 is the negative impact of the financial crisis on the probability of innovating, for firms in sectors characterised by higher liquidity needs for innovation, relative to firms in sectors characterized by lower liquidity needs. The reduction in the availability of external banking finance during the 2008-09 crisis hurt innovation by more in sectors that are structurally more exposed to the risk of being hit by this kind of shock. The negative coefficient on the LN*Crisis interaction is also surprisingly stable across the various estimators and, importantly, robust to controlling for the use of internal financial resources.

Table 4.3: Impact of Financial Crisis on Innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	POLS		Within-FE		GMM			
					Syst-GMM			
					First-Diff		Orth. trans.	
INN_{t-1}	0.392***	0.385***	-0.096***	-0.109***	0.435***	0.284**	0.414***	0.273**
	(0.024)	(0.023)	(0.021)	(0.021)	(0.156)	(0.116)	(0.158)	(0.112)
LN*Crisis	**-0.058****	**-0.057****	**-0.047*****	**-0.042****	**-0.048****	**-0.048****	**-0.059*****	**-0.060*****
	(0.017)	**(0.024)**	**(0.014)**	**(0.017)**	**(0.021)**	**(0.021)**	**(0.019)**	**(0.020)**
Cash-Flow		0.017***		0.014***		0.008		0.008
		(0.004)		(0.004)		(0.009)		(0.008)
Cash-$Flow_{t-1}$		0.036		0.098*		0.476'		0.551*
		(0.042)		(0.057)		(0.311)		(0.288)
$\triangle$Cash-Stock		-0.00006'		-0.00002		-0.00042***		-0.00043***
		(0.00004)		(0.00004)		(0.00015)		(0.0001)
Firm FE	no	no	yes	yes	yes	yes	yes	yes
Ind. Trends.	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes
N	7290	7211	7290	7211	7290	7211	7290	7211
Hansen-J test (p)					0.261	0.519	0.271	0.569
AR(2) test (p)					0.019	0.0245	0.024	0.026
AR(3) test (p)					0.940	0.990	0.906	0.963
N GMM Instr.					95	127	95	127

Note: Robust S.E. clustered at sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01

Concerning these latter variables, the change in cash-stock takes the expected negative sign - a reduction in reserves of cash is positively related to innovation (Brown *et al.,* 2012) - and is statistically significant; the cash flow variable instead appears positive and significant (as expected) only on its first lag, failing to show any effect when observed contemporaneously with innovation. Importantly, controlling for the use of internal financial resources leaves the negative impact of the financial crisis virtually unchanged. In terms of economic significance, finally, the crisis effect is also sizeable: based on the estimate in column (6), the crisis reduced the the probability of innovating by 2.7 percentage points (-0.048 * 0.562) for firms in an industry at the 80th percentile (0.576) of the LN distribution, compared firms in an industry at the 20th percentile (0.014). When the orthogonal transformation is performed on the data (column 10), this impact rises to 3.4 percentage points (-0.060 * 0.562).

4.6.2 Impact on Exporting

Table 4.4 reports the results from estimating specification (66).

Table 4.4: Impact of Financial Crisis on Exporting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	POLS		Within-FE		GMM			
					Syst-GMM			
					First-Diff		Orth. trans.	
EXP_{t-1}	0.654***	0.653***	-0.018	-0.026	0.491**	0.612***	0.480**	0.492**
	(0.024)	(0.023)	(0.024)	(0.025)	(0.24)	(0.131)	(0.242)	(0.228)
LN*Crisis	**0.065*** **	**0.064*** **	**0.035*** **	**0.038*** **	**0.062*** **	**0.062*** **	**0.060*** **	**0.060*** **
	(0.011)	**(0.011)**	**(0.012)**	**(0.014)**	**(0.016)**	**(0.016)**	**(0.015)**	**(0.015)**
Cash-Flow		0.001		0.012		-0.005		0.001
		(0.001)		(0.016)		(0.006)		(0.001)
$Cash\text{-}Flow_{t-1}$		-0.021		-0.065**		-0.092		-0.045
		(0.058)		(0.030)		(0.190)		(0.059)
ΔCash-Stock		-0.00029***		-0.00001		-0.00017*		-0.000025*
		(0.00001)		(0.00001)		(0.0001)		(0.000014)
Firm FE	no	no	yes	yes	yes	yes	yes	yes
Ind. Trends.	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes
N	7290	7211	7290	7211	7290	7211	7290	7211
Hansen-J test (p)					0.408	0.492	0.438	0.469
AR(2) test (p)					0.031	0.008	0.035	0.020
AR(3) test (p)					0.269	0.210	0.281	0.124
N GMM Instr.					96	128	96	128

Note: Robust S.E. clustered at sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01

One of the main contributions of this chapter is to explore whether the negative shock to innovation imparted by the financial crisis had an indirect effect on firms' participation to exporting. This hypothesis is tested by exploiting the same diff-in-diff setting of specification (65), following the rationale that the crisis should have increased the probability of exporting precisely in those sectors where the probability of innovating was reduced, in relatively terms. The channel is the change in product market competition, that I test by estimating firms' markups.

The results in Table 4.4 confirm the choice about the system-GMM estimator made above. The coefficient on INN_{t-1} shows a high degree of persistence for exporting and, similarly to innovation, the estimates of the difference GMM model lie below the within-FE estimator, supporting the choice of exploiting the system GMM estimator in this application. I apply the same lag structure used for the innovation regressions to the regressions for exporting, given the results of the AR(2) test for error autocorrelation.

The coefficient on the LN*crisis interaction strongly confirms the hypothesized indirect impact of the shock to innovation on exporting, across sectors showing different external liquidity needs for innovation expenditure. In sectors characterized by higher LN, the shock increased the probability of exporting, relative to sectors characterized by lower LN. This indirectly shows that the crisis had a differential impact across sectors and that where the probability of innovating was reduced, the probability of exporting was increased, in relative terms. Similarly to Table 4.3, the estimated coefficient varies only a little across the various estimators, conferring a good degree of robustness to this finding. The variables proxying the use of internal financial resources fail to show a statistically singificant impact on the probability of exporting, except for the change in cash-stock. However, it is noticeable that these latter controls do not affect size and significance of the main effect under examination.

Finally, in terms of economic magnitude, based on the estimate in column (6) the crisis increased the probability of exporting by 3.5 percentage points (0.062 * 0.562) for firms in an industry at the 80th percentile (0.576) of the LN distribution, compared firms in an industry at the 20th percentile.

4.6.3 Impact on Markups

The relatively higher probability of exporting, estimated for firms in sectors characterized by higher LN for innovation as a consequence of the financial crisis, should be due to the impact of the negative shock to innovation on firms' markups. The increase in price-cost margins, arising from the reduction in innovative activity, facilitates entry into exporting for some domestic-producers that otherwise wouldn't have been able to overcome the entry barrier.

Table 4.5 reports the results from estimating specification (67). In columns (1)-(3) and (7) the dependent variable is firms' markup in levels (where Markup I, Markup II and Markup III correspond to the three specifications for markups explained in Table 4.1), whereas in columns (4)-(6) and (8) the natural log of the markup is exploited.

In sectors characterized by higher LN for innovation, I estimate an increase in firms' markups in the crisis, relative to sectors characterized by lower LN for innovation. Focusing on the specifications exploiting Markup III, I estimate an average increase of 1.3% (0.023 * 0.526) in price-cost margins for firms in an industry at the 80th percentile of the LN distribution, compared to firms in an industry at the 20th percentile (alternatively, I estimate an increase of 2.3 percentage points (0.044*0.526), with the level of markups on the LHS). Boostrapping standard errors, to attempt a correction of the measurement error introduced during the estimation of the LHS variable, leaves this result unchanged.

Table 4.5: Impact of Financial Crisis on Markups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Within-FE							
Dep. Var.	Markup I	Markup II	Markup III	ln(Markup I)	ln(Markup II)	ln(Markup III)	Markup III	ln(Markup III)
							Bootstrapped SE	
LN*Crisis	**0.066****	**0.085***	**0.044***	**0.010+**	**0.019***	**0.023****	**0.044'**	**0.023***
	(0.025)	**(0.047)**	**(0.025)**	**(0.007)**	**(0.011)**	**(0.010)**	**(0.027)**	**(0.012)**
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends.	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes
N	7010	7009	7009	6964	6929	6933	7009	6033

Note: Robust S.E. clustered at the sector level in parenthesis, + $p<0.20$, ' $p<0.15$, * $p<0.10$, ** $p<0.05$, *** $p<0.01$

The result in Table 4.5 represents an additional novel contribution of this work, since to the best of my knowledge, no work so far has estimated the effect of the 2008-09 financial crisis on firms markups. It appears therefore that in sectors where innovative activity was relatively more affected by the reduction in external banking finance, there was an overall decrease in the degree of product-market competition that allowed producers to increase their markups.

4.6.4 Disentangling the reduction in financing and the competition effects

According to the theoretical framework guiding the empirical analysis in this chapter, a reduction in competitive pressure (shown by an increase in markups) should benefit both innovators and exporters: easier competition allowing a larger margin between prices and costs facilitates the investment in innovation and entry into exporting. Especially those firms whose productivity is close to the pre-shock cost-cutoffs separating innovators/non-innovators and exporters/non-exporters could have now gathered the resources allowing them to access innovation or, for the most producitive firms, exporting. The prediction of the theoretical model, however, is that the reduction in external finance for innovation results in less innovative activity, because the negative impact of the reduction in extenal finance dominates the positive impact of the reduction in competition. For exporters on the other hand, becasue there is no direct consequence from the reduction in the financing of innovation, the only effect at work is the increase in markups, which should result in an unmbiguously positive impact on the probability of exporting.

Table 4.6: Disentangling the reduction in financing and the competition effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Innovation					Exporting				
					Boot. SE					Boot. SE
INN_{t-1}	0.260*	0.229*	0.579***	0.444***	0.229*					
	(0.148)	(0.118)	(0.110)	(0.089)	(0.129)					
EXP_{t-1}						0.569***	0.529***	0.420**	0.329'	0.529***
						(0.219)	(0.198)	(0.210)	(0.210)	(0.239)
LN*Crisis	**-0.051*** **	**-0.052*** **	**-0.053*** **	**-0.054*** **	**-0.052***	**0.039+**	**0.038+**	**-0.019**	**0.005**	**0.038+**
	(0.020)	**(0.021)**	**(0.023)**	**(0.023)**	**(0.027)**	**(0.027)**	**(0.027)**	**(0.043)**	**(0.034)**	**(0.029)**
Markup III	0.036+	0.036+			0.036+	0.393**	0.369**			0.369**
	(0.028)	(0.028)			(0.024)	(0.155)	(0.144)			(0.164)
Ln(Markup III)			0.306'	0.264+				3.465*	2.589*	
			(0.210)	(0.192)				(1.880)	(1.385)	
Cash-Flow		0.007		0.009	0.007		-0.001		-0.044**	-0.001
		(0.007)		(0.007)	(0.009)		(0.001)		(0.018)	(0.004)
Cash-$Flow_{t-1}$		-0.078		0.021	-0.078		-0.116		0.064	-0.116
		(0.065)		(0.029)	(0.075)		(0.265)		(0.068)	(0.297)
ΔCash-Stock		-0.00107'		-0.00107**	-0.00107+		0.00001		0.00001	0.00001
		(0.00065)		(0.00054)	(0.00080)		(0.00001)		(0.00002)	(0.0001)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	7009	6984	6933	6908	6984	7009	6984	6966	6941	6984
Hansen-J test (p)	0.662	0.719	0.732	0.764		0.601	0.632	0.619	0.687	
AR(2) test (p)	0.101	0.120	0.0019	0.0048		0.0144	0.0153	0.0634	0.110	
AR(3) test (p)	0.741	0.725	0.626	0.645		0.436	0.283	0.121	0.526	
N GMM Instr.	92	124	91	123	124	94	126	93	125	126

Note: Robust S.E. clustered at the sector level in parenthesis, + $p<0.20$, ' $p<0.15$, * $p<0.10$, ** $p<0.05$, *** $p<0.01$

In Table 4.6 I attempt to disentangle the effect of the change in competition from that of the reduction in external banking finance. In Table 4.3 and 4.4 in fact, the coefficient on the LN*Crisis variable, negative for innovation and positive for exporting, includes both the impacts of the reduction in financing for innovation and the reduction in competition. Controlling explicitly for markups in specification (65) and (66) allows me to unpack and separate these effects. Given that a relatively higher markup is beneficial for both innovators and exporters, this exercise should show that the negative coefficient on LN*Crisis for innovation increases in size and remains significant, whereas the positive coefficient on exporting should vanish or, at least, be somewhat attenuated. The markup should instead enter with a positive coefficient in both cases. The results in Table 4.6 are largely supportive of the theoretical predictions.

In columns (1)-(5), controlling for firms' markups generates a slightly stronger negative impact of the crisis on innovation, for firms in sectors characterized by higher LN relative to sectors characterized by lower LN. The increase in size of the LN*Crisis interaction is admittedly very modest, but in line with the expectation that the change in firms' markups partially offsets the negative shock imparted by the reduction in financing for innovation. The Markup III variable takes a positive coefficient, both when used in levels and in logs, although it's statistical significance is only very marginal (10% < p value <15-20%).

In columns (6)-(10) I test the proposition that the relatively better exporing perfomance for firms in sectors characterized by higher LN should have been mediated by the increase in firms' markups. Table 4.6 shows indeed that separating out the effect of the markup on exporting, reduces both size and significance of the LN*Crisis variable, as expected. This supports the rationale that the relatively easier access to the export market, detected in sectors relatively more affected by the shock to innovation, was channelled by a reduction in the degree of product market competition. This finding is confirmed both when controlling for the level of markups, or for the natural log of this variable[105].

Finally, a word of caution is needed concerning the possible endogeneity of the markup variable exploited in table 4.6 (and tables 4.7, 4.8, 4.9, 4.10 below). Exporters charge higher markups compared to domestic firms (as evident from Table 4.2), with this raising the concern that Markup III could be simultaneously determined with the dependent variable[106]. In table 4.6 I do not to treat Markup III as an endogenous regressor (i.e. I did not instrument Markup III with its past values), both in the innovation and in the exporting regressions. On one hand, I try to mitigate some of the reverse causality concerns when calculating the Markup

[105] As mentioned in section 4.3.1, interpreting the effect estimated on the LN ratio differently from what done in this work is difficult. Innovators in sectors characterized by higher LN were more exposed to the sudden reduction in external liquidity that characterized the 2008-10 crisis, as shown in Table 4.3. The indirect effect of this shock on exporting, estimated in Table 4.4, has been argued to have worked through a reduction in the degree of product market competition, as the theoretical proposition of Chapter 3 states. Alternative channels linking a negative shock to innovation, arising from a liquidity tightening, to a relatively better export performance, are hard to rationalize. A possibility could be that, being exporting a source of revenues that firms can reinvest in innovation (as argued by Bustos, 2011), innovators that were hit relatively harder by the financial shock could have made an effort to gather extra-liquidity from exporting. Therefore, in higher LN sectors the shock to innovation could have lead to a relatively higher probability to export, becasue of firms attempt to exploit the export market to compensate for the lack of liquidity received by the banking sector. However, the 2008-09 years were not a favourable period for exporting, as the Trade Collapse shows. Therefore, besides the fact of having a strong theoretical reason to push forward the competition channel as a link between innovation and exporting, I doubt that the alternative explanation provided here could have been at work in the 2008-09 crisis.

[106] Possibly the same concern could apply in the regressions for innovators, although these firms were not found to charge higher markups compared to domestic producers in Table 4.2.

III variable: in its construction, I directly allow for exporters and innovators to produce under a different technology by including a firm's export and innovation status as an input in the production function[107], other than allowing the law of motion of productivity (72) to depend on the past exporting and innovation status of a firm, thereby taking into account the potential learning-by-exporing or productivity enhancing effects of innovation that could determine firms' markups[108]. On the other hand, however, it is arguable that a simulataneity bias might still arise when exploiting the contemporaneous Markup III variable, expecially when the probability of exporting is on the left hand side.

For this reason I also report the results from estimating the specifications in Table 4.6 where I instrument Markup III with lags dated $t-3$ onward[109]. These results are presented in Table 4.6B in the Appendix and show that the main finding of this section is upheld. The effect of the financial crisis on innovation is well defined by the coefficient on the LN*Crisis interaction, although the instrumentation of the markup causes the coefficient of this control to shink in size and to lose statistical significance. Noticeably, relative to Table 4.6, in Table 4.6B the variables proxying for the use of internal financial resources are more in line with the expected effect: the lagged cash flow presents a large and positive coefficient, while the change in cash stock is negative and strongly significant. For exporting, the important result is that I again find that controlling for markups attenuates the impact of the LN ratio, with this latter coefficients shrinking in size and losing significance. Unfortunately, similarly to the regressions for innovation, the instrumentation of Markup III results in a loss of size and significance of this variable, especially when used in level. A possible explanation for the loss in significance of the markup lies in the fact that there is measurement error in this variable: when I attempt the instrumentation with its past values, the measurement error prevents this variable from maintaining its effect[110]. This certainly is a caveat arising in my context and is a shortcoming arising from the attempt to address the simultaneous determination of a firms' export status and its market power.

[107] This controls for the impact of being an innovator and/or and exporter in determining the optimal input demand and therefore, indirectly, for the type of competition faced by firms in an industry (De Loecker and Warzynski, 2012)

[108] De Loecker and Warzinsky (2012) show that when endogeneising the export status, particularly in the law of motion of productivity, reduces the estimated difference between markups charged by exporters and non-exporters.

[109] Considering my procedure to estimate Markup III, together with the fact that firm fixed effects are present in all regressions, lagged markups should present an acceptable degree of exogeneity from the export status.

[110] Unfortunately this is a shortcoming of the DLW procedure for the estimation of markups. Notice, for instance, from table 4.1, that even though Markup III is positive on average, it varies from negative to positive values. The negative values are due to the estimated output elasticities of labour for some of the firms, which turn out negative: this is true for only a minority of producers, but it is a signal that the estimation procedure by which markups are obtained introduces some noise in the variable, which is then picked up in the GMM instrumentation procedure.

4.7 Further Results and Robustness Checks

The results in section 4.6 largely, although indirectly, corroborate the theoretical predictions of the model in Chapter 3: a reduction in the availability of external liquidity for innovation results in a relatively lower probability of innovation but, through the reduction in product market competition, in a relatively easier access to exporting. In this section I provide further tests to support the findings of this work.

4.7.1 Additional Controls

Tables 4.7 and 4.8 show the results from adding a set of selected controls to specification (65) and (66), that allow me to test a few additional hypotheses.

In the introduction I reported a rich literature studying the nexus between innovation and exporting, with works exploring both directions of causality: from exporting to innovation (e.g. Bustos, 2011; Trefler and Lileeva, 2010) and from innovation to exporting (e.g. Becker and Egger, 2013). In light of this literature, not conditioning for the past exporting or innovation status of a firm could raise concerns of omitted variable bias, in case some of the regressors were correlated with these activities.

Furthermore, adding a lagged exporting and innovation dummy to, respectively, the innovation and exporting regressions, can shed further light on their reciprocal determination. Finally, in the dynamic-panel GMM setting I can instrument EXP_{t-1} and INN_{t-1} with the second (and further) lags of these regressors, avoiding the Nickell bias.

From the inspection of Table 4.7 it is evident that past exporting is strongly correlated with current innovation; similarly, past innovation is positively associated with current exporting (Table 4.8). In columns (2) of the these tables I also control for contemporaneous innovation and exporting and again a positive association is detected, although significantly so only for the exporting regressions.

In column (3) of Table 4.7 I test the hypothesis that past investment in R&D could affect the probability of innovation. R&D is an activity subject to high adjustment costs, that firms try to avoid by buffering against liquidity shortages. Additionally, investment in innovation might take a few years to materialize. This leads to the hypothesis that high levels of R&D spending in the past might determine a higher probability to innovate, despite the sudden financial shock experienced by firms in 2008.

Table 4.7: Further hypothesis - Impact on Innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Innovation				
	Without Markup					Adding Markup			
INN_{t-1}	0.364***	0.387***	0.218*	0.356***	0.298***	0.206**	0.367***	0.248***	0.255***
	(0.142)	(0.139)	(0.124)	(0.119)	(0.102)	(0.093)	(0.088)	(0.095)	(0.075)
LN*Crisis	**-0.042****	**-0.060*****	**-0.047***	**-0.042****	**-0.033***	**-0.046****	**-0.047*****	**-0.029+**	**-0.034'**
	(0.020)	**(0.022)**	**(0.024)**	**(0.019)**	**(0.019)**	**(0.017)**	**(0.022)**	**(0.020)**	**(0.020)**
$\mathbf{EXP}_{t-1}$	0.387*			0.243*	0.171'	0.304***	0.209**	0.231*	0.177*
	(0.204)			(0.129)	(0.119)	(0.128)	(0.098)	(0.134)	(0.092)
$\mathbf{EXP}_{t}$		0.231							
		(0.187)							
$\mathbf{R\&D}_{t-2}$			0.323***		0.319***			0.381**	0.367***
			(0.123)		(0.113)			(0.111)	(0.105)
Markup III						0.031		0.031	
						(0.028)		(0.028)	
Ln(Markup III)							0.355'		0.346*
							(0.217)		(0.217)
Cash-Flow			-0.001	0.002	0.002	0.003*	0.003*	0.002**	0.002*
			(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Cash-Flow_{t-1}			-0.034**	-0.029**	-0.025+	0.006	-0.003	-0.013+	-0.020**
			(0.065)	(0.014)	(0.018)	(0.023)	(0.014)	(0.009)	(0.009)
△Cash-Stock			-0.00050**	-0.00092**	-0.00081**	-0.00096***	-0.00092***	-0.00100***	-0.00093***
			(0.00024)	(0.00046)	(0.00035)	(0.00034)	(0.00031)	(0.000190)	(0.00018)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	7290	7290	3701	6933	3701	7009	6908	3600	3576
Hansen-J test (p)	0.302	0.697	0.403	0.551	0.541	0.592	0.597	0.524	0.552
AR(2) test (p)	0.023	0.016	0.073	0.009	0.024	0.0144	0.003	0.043	0.051
AR(3) test (p)	0.849	0.999	0.245	0.888	0.314	0.436	0.615	0.568	0.527
N GMM Instr.	108	113	117	140	130	137	136	128	128

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01

This rationale is strongly confirmed in Table 4.7: $R\&D_{t-2}$, which being the CIS surveys biannual (as is my time dimension) refers to expenditure in R&D performed four to six years before the financial crisis, is very strongly and positively associated with a higher probability of innovation during the 2008-2010 period. Taking two lags for this regressors causes a marked reduction in sample size, but nonetheless the coefficient on $R\&D_{t-2}$ is identified very precisely.

It is to be noticed that conditioning on past R&D spending does not affect the coefficient on LN*Crisis; only when taking into account jointly the effect of past exporting and past R&D expenditure on innovation (column 5), is the size of the main coefficient somewhat reduced. Finally, the probability of exporting, in Table 4.8, is not found to be associated with past R&D spending, but the main positive effect imparted by the financial crisis on sectors with higher LN is robust to adding this control.

Table 4.8: Further hypothesis - Impact on Exporting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Exporting				
	No Markup					Adding Markup			
EXP$_{t-1}$	0.543***	0.580***	0.551***	0.531***	0.583***	0514**	0.258	0.764***	0.476’
	(0.170)	(0.167)	(0.190)	(0.165)	(0.145)	(0.201)	(0.257)	(0.191)	(0.249)
LN*Crisis	**0.066****	**0.072*****	**0.061*****	**0.065*****	**0.069*****	**0.038+**	**0.013**	**0.094****	**0.091****
	(0.014)	**(0.017)**	**(0.021)**	**(0.019)**	**(0.022)**	**(0.017)**	**(0.032)**	**(0.043)**	**(0.042)**
INN$_{t-1}$	0.202**			0.206**	0.170***	0.121*	0.434***	0.197	0.187’
	(0.204)			(0.088)	(0.119)	(0.064)	(0.164)	(0.191)	(0.123)
INN$_{t}$		0.180**							
		(0.077)							
R&D$_{t-2}$			0.027		-0.073			1.146	0.296
			(0.060)		(0.113)			(1.293)	(1.392)
Markup III						0.365***		-0.027**	
						(0.145)		(0.013)	
Ln(Markup III)							2.624**		0.889+
							(1.323)		(0.620)
Cash-Flow			0.001	-0.001	-0.001	-0.0001	-0.034**	-0.001	-0.001
			(0.001)	(0.002)	(0.001)	(0.002)	(0.014)	(0.003)	(0.005)
Cash-Flow$_{t-1}$			-0.071	-0.160**	-0.161**	-0.136**	-0.224**	-0.084	-0.183
			(0.064)	(0.014)	(0.076)	(0.062)	(0.109)	(0.144)	(0.145)
$\triangle$Cash-Stock			0.000004	-0.000001+	0.00001	0.00001	0.000001	0.00001	-0.00004*
			(0.000018)	(0.000001)	(0.00001)	(0.00002)	(0.00002)	(0.00002)	(0.00002)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	7290	7290	3701	7211	3701	6984	6941	3600	3576
Hansen-J test (p)	0.553	0.562	0.498	0.531	0.445	0.743	0.797	0.864	0.811
AR(2) test (p)	0.009	0.016	0.117	0.008	0.114	0.016	0.066	0.113	0.130
AR(3) test (p)	0.249	0.190	0.280	0.209	0.256	0.293	0.689	0.286	0.773
N GMM Instr.	110	116	118	137	127	134	133	133	133

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ’ p<0.15, * p<0.10, ** p<0.05, *** p<0.01

In columns (6)-(9) of both Tables 4.7 and 4.8 I attempt again to disentangle the effect of the reduction in external banking finance from the increase in firms’ markups in determining the likelihood of introducing a new product or process and entering into exporting. For innovation, controlling for firms’ markups does not affect the results about the impact of past exporting and past R&D spending reported in columns (1)-(5), other than leaving the main coefficient on the LN*Crisis interaction substantially unaffected. Similar results are found when intrumenting Markup III with its past values, as shown in columns (1)-(4) of Table 4.7B in Appendix. For exporting (in Table 4.8), on the other hand, conditioning on firms' markups yields the expected outcome, but only in column (6) and (7): here firms' price-cost margins appear as a significantly large determinant of the probability of exporting, and to also absorb most of the impact of the LN*Crisis variable.

Where the estimation is carried out on a smaller sample (columns 8 and 9) due to controlling for R&D spending two periods (4 to 6 years) ahead of the shock, the coefficient of the Markup variable is smaller and, in one case, even enters with the wrong sign. This result suggests a potential caveat to the earlier conclusions, becasue the result that the shock to innovation affected entry into exporting only through the change in firms' markups is not entirely upheld. However, considering that the sample size drops by about 50%, and that the lagged R&D variable that causes the change is not strictly relevant to the probability of exporting (recall that I already control for the past innovation status), I relegate the missed results in columns (8) and (9) to a relatively minor concern. Finally, columns (5)-(8) in Table 4.7B in Appendix show that when addressing the endogeneity of markups by instrumenting it with its lags, leads to conclusions that differ only marginally from what reported here, with the caveat of the loss in significance of the Markup III variable.

4.7.2 Effects by Quartile of the Firm Size and Productivity Distributions

The results about the impact of the financial crisis of 2008 on innovation, markups and exporting presented in Section 4.6 and 4.7 concern the overall effect of the shock on the entire distribution of firms in my sample. However, the theoretical model of Chapter 3 is more specific about which firms are affected by the shock and predicts a negative impact on innovation and a positive impact on exporting in the middle range of firms' productivity distribution, with the extremes of the distribution not being affected. More precisely, the prediction is that the reduction in external liquidity for innovation induces the interruption of innovation efforts for firms that were above the innovation thereshold before the crisis but below it afterwards; on the other side, entry into exporting is induced for firms that were below the exporting threshold before the crisis but above it afterwards.

In order to test this prediction I ranked firms according to their size and their productivity and estimated the impact of the financial shock on each quartile of the firm distributions.

This approach is very similar to Bustos (2011), so, to facilitate a comparison with her results I first use the proxy for initial productivity exploited in her work[111], to which I to refer to as the Bustos' size distribution. In addition to Bustos' measure, I also rank firms according to their productivity computed with the ACF procedure, including my amendments to the material demand proxy (70) and the law of motion of productivity (72) explained in section 4.4.3. As a robustness check, I also present results exploiting the Levinsohn and Petrin (2003) (LP) productivity estimator.

I need to clarify that Bustos' measure is a proxy for relative size, i.e. size of a firm relative to its industry average and that when exploiting the ACF and LP productivity estimates, I present results for both the relative and absolute ranking of firms. In other words, to construct the quartiles, I exploit both the value of a firm's productivity relative to its 2-digit industry average (relative productivity), and the absolute value of a firm's productivity with respect to all other firms in the estimation sample (absolute productivity). The more suitable measure in my application is the relative productivity of a firm with respect to its industry average, but given that many sectors are populated by only a very small number of firms, some of the results appear more robust when exploiting the ranking that depends on the absolute productivity[112].

To unpack the shock over quartiles, I estimate the following equation:

$$
\begin{aligned}
Inn_{it} \quad = \quad & \beta_0 + \beta_1 Inn_{it-1}, + \sum_{d=1}^{4} \beta_{d1} \left(LN_j * Q_i^d \right) + \sum_{d=1}^{4} \beta_{d2} \left(Crisis_t * Q_i^d \right) \\
& + \sum_{d=1}^{4} \boldsymbol{\beta}_{d3} \left(LN_j * Crisis_t * Q_i^d \right) + \sum_{d=1}^{4} \boldsymbol{\beta}_{d4} Q_i^d + \sum_{n} \beta_n IF_{it} \\
& + \sum_{r} \beta_r X_{it-1} + \delta_i + \rho_{jt} + \varsigma_t + \varepsilon_{it},
\end{aligned} \tag{75}
$$

where d indexes each of the four quartiles of the size or the productivity distribution, and Q_i^d denotes a dummy taking value 1 when firm i belongs to quartile d. I assigned firms to the quartiles according to their relative or absolute productivity in 2008 (before the shock).

Similarly to the method followed in section 4.6.4, I tried to disentangle the effect of the change in competition from that of the reduction in availability of external banking finance.

[111] This is the firm size in terms of (log) employment relative to the two-digit industry average.

[112] It needs to be specified also that the choice of ranking firms depending on their relative or absolute productivity only affects the assignment of firms to a particular quartile of the productivity distribution. The estimation of productivity iself, both with the ACF and the LP procedure, has been carried out separately by 2-digit NACE industries.

This was done by running specification (76):

$$\begin{aligned} Inn_{it} &= \beta_0 + \beta_1 Inn_{it-1,} + \sum_{d=1}^{4} \beta_{d1} \left(LN_j * Q_i^d \right) + \sum_{d=1}^{4} \beta_{d2} \left(Crisis_t * Q_i^d \right) \\ &+ \sum_{d=1}^{4} \boldsymbol{\beta}_{d3} \left(LN_j * Crisis_t * Q_i^d \right) + \sum_{d=1}^{4} \boldsymbol{\beta}_{d4} Q_i^d + \sum_{d=1}^{4} \beta_{d5} \left(MarkupIII_{it} * Q_i^d \right) \\ &+ \sum_n \beta_n IF_{it} + \sum_r \beta_r X_{it-1} + \delta_i + \rho_{jt} + \varsigma_t + \varepsilon_{it} \end{aligned} \quad (76)$$

To estimate the shock on exporting, I ran the same specifications as in (75) and (76), replacing the left hand side variable and the first regressor with the dummy identifying the export- and lagged export- status.

Estimation results are presented in Table 4.9 for innovation and Table 4.10 for exporting[113]. Columns (1)-(5) report the results from estimating specification (75) on Bustos' size distribution, the ACF and LP productivity distribution where firms are ranked depending on their relative productivity (ACF-r and LP-r) and the ACF and LP distributions where firms are ranked depending on their absolute productivity (ACF-a and LP-a).

The coefficients on the LN*Crisis interactions clearly point in direction of a stronger negative impact on innovation for firms in the middle range of the size and productivity distributions: this finding is consistent across all specifications and the two types of ranking exploited. It is the coefficient on the second or third quintile resulting to be the largest and the most significant one, confiming also this prediction of the theoretical model.

Interestingly this results holds regardless of whether firms are ranked depending on their relative or their absolute productivity. For the ACF distribution, the relative productivity ranking shows neatly that the impact of the financial crisis was on the third quintile of the distribution, whereas when ranking firms depending on their absolute productivity the shock seems to affect both firms in the second and in the fourth quartile, but with a larger coefficient for the less productive firms. For the LP productivity distribution, it is the relative ranking that appears to produce the less clear-cut results: in column (3) the crisis produces an effect which is spread over the first and second quartile (although stronger on the second), while in column (5) the negative coefficient on the second quartile is clearly much larger and significant compared to the remaining ones.

[113] Here I report only one regression for each distribution and type of ranking. I opted for showing the more complete specification where all the variables controlling for the use of internal financial resources are included. Adding also past exporting (innovation) to the innovation (exporting) regressions and past values of investment in R&D leaves all results unchanged.

Table 4.9: Effects by Quartile of the Firm Size and Productivity Distribution - Innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Innovation									
	Bustos	ACF-r	LP-r	ACF-a	LP-a	Bustos	ACF-r	LP-r	ACF-a	LP-a
INN_{t-1}	0.223*	0.349***	0.381**	0.353***	0.377***	0.219**	0.345***	0.350***	0.350***	0.342***
	(0.123)	(0.121)	(0.119)	(0.120)	(0.123)	(0.099)	(0.102)	(0.098)	(0.102)	(0.101)
LN*Crisis* 1st Q	-0.019	-0.018	-0.051**	-0.013	-0.038'	-0.031	-0.018	-0.051**	-0.020'	-0.026
	(0.044)	(0.030)	(0.022)	(0.019)	(0.026)	(0.042)	(0.030)	(0.023)	(0.020)	(0.030)
LN*Crisis* 2nd Q	**-0.143*** **	-0.023	**-0.078** **	**-0.127***	**-0.187***	**-0.156*** **	-0.020	**-0.075***	**-0.122***	**-0.206** **
	(0.037)	(0.026)	**(0.039)**	**(0.065)**	**(0.105)**	**(0.039)**	(0.026)	**(0.043)**	**(0.072)**	**(0.098)**
LN*Crisis* 3rd Q	-0.035	**-0.139*** **	0.008	-0.014	0.057	-0.035	**-0.140*** **	0.009	-0.010	0.033
	(0.039)	**(0.035)**	(0.032)	(0.010)	(0.082)	(0.039)	**(0.037)**	(0.030)	(0.020)	(0.087)
LN*Crisis* 4th Q	-0.034'	-0.079'	-0.064+	-0.103**	-0.077	-0.029	-0.075+	-0.062+	-0.102**	-0.088
	(0.023)	(0.051)	(0.047)	(0.041)	(0.082)	(0.024)	(0.054)	(0.048)	(0.047)	(0.082)
Ln(Mar. III)* 1st Q						0.098	0.174**	0.157'	0.160*	0.214*
						(0.089)	(0.074)	(0.104)	(0.088)	(0.125)
Ln(Mar. III)* 2nd Q						0.142*	0.108	0.213**	0.157'	0.157'
						(0.076)	(0.106)	(0.086)	(0.106)	(0.099)
Ln(Mar. III)* 3rd Q						0.163*	0.081	0.074	0.113	0.115
						(0.084)	(0.101)	(0.130)	(0.150)	(0.103)
Ln(Mar. III)* 4th Q						-0.037	0.110***	0.104***	0.047*	0.125***
						(0.035)	(0.041)	(0.036)	(0.027)	(0.048)
IF controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	7211	7211	7211	7211	7211	6906	6906	6906	6906	6906
Hansen-J test (p)	0.618	0.746	0.580	0.691	0.604	0.771	0.797	0.864	0.673	0.756
AR(2) test (p)	0.096	0.013	0.009	0.011	0.011	0.054	0.007	0.007	0.055	0.008
AR(3) test (p)	0.926	0.997	0.908	0.964	0.944	0.799	0.727	0.656	0.760	0.672
N GMM Instr.	136	135	135	132	135	135	134	134	131	134

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01

In columns (6)-(10) I condition also on firms markups, to observe whether separating the role of the change in competition from that of the reduction in external financing yields different results. The coefficients on the markups interactions are all positive, except in one case, and mostly also statistically significant. It cannot be said that firms' markups neatly show their effect on innovation for firms in the second and third quartile of the distributions, however, for three out of the five distributions controlling for the price-cost margin makes the coefficient on the LN*Crisis increase, as expected, although only very marginally. The coefficients in columns (6)-(10) in Table 4.9 can be compared with those in columns (1)-(5)

in Table 4.9B in Appendix, where I instrument the markup variables with their lags. The main finding of this section is confirmed also when addressing the potential simultaneity bias between innovation and price-cost margins, since the coefficients on the LN*Crisis variable show neatly the impact of the financial crisis on innovation, whereas the markups show a positive and (often) significant association with the innovation status. Overall, it can be concluded that the impact of the financial crisis on innovation appears very well defined and concentrated on firms in the middle range of the size and productivity distributions.

Table 4.10: Effects by Quartile of the Firm Size and Productivity Distribution - Exporting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Exporting									
	Bustos	ACF-r	LP-r	ACF-a	LP-a	Bustos	ACF-r	LP-r	ACF-a	LP-a
EXP_{t-1}	0.526**	0.558***	0.547**	0.536***	0.592***	0.546**	0.704***	0.702***	0.620***	0.760***
	(0.221)	(0.201)	(0.212)	(0.215)	(0.170)	(0.191)	(0.189)	(0.164)	(0.213)	(0.181)
LN*Crisis* 1st Q	0.059*	0.018	0.055***	0.010*	0.074*	0.044+	-0.007	0.063*	-0.014	0.077
	(0.030)	(0.030)	(0.013)	(0.006)	(0.044)	(0.034)	(0.030)	(0.037)	(0.024)	(0.061)
LN*Crisis* 2nd Q	0.028	0.085***	**0.101***	0.027	**0.168***	0.003	0.090'	**0.087**	-0.104+	**0.070**
	(0.029)	(0.018)	**(0.052)**	(0.035)	**(0.087)**	(0.033)	(0.026)	**(0.092)**	(0.076)	**(0.116)**
LN*Crisis* 3rd Q	**0.111*****	**0.121*****	0.046*	**0.097*****	0.046	**0.107+**	**0.104**	-0.024	**0.074+**	-0.053
	(0.026)	**(0.037)**	(0.024)	**(0.011)**	(0.050)	**(0.081)**	**(0.083)**	(0.030)	**(0.057)**	(0.087)
LN*Crisis* 4th Q	0.054**	0.085***	0.082**	**0.098*****	0.028+	0.036	0.085'	0.092+	**0.082***	-0.012
	(0.021)	(0.031)	(0.037)	**(0.031)**	(0.082)	(0.030)	(0.055)	(0.071)	**(0.049)**	(0.038)
Ln(Mar. III)* 1st Q						0.022	-0.002	0.038	0.038	0.090+
						(0.042)	(0.073)	(0.051)	(0.035)	(0.069)
Ln(Mar. III)* 2nd Q						0.176*	-0.018	0.630	0.199***	0.119'
						(0.090)	(0.098)	(0.932)	(0.065)	(0.076)
Ln(Mar. III)* 3rd Q						1.118+	0.049	0.107	0.103*	0.118'
						(0.852)	(0.095)	(0.110)	(0.053)	(0.075)
Ln(Mar. III)* 4th Q						0.084	-0.025	0.071	1.225	0.972
						(0.088)	(0.698)	(0.073)	(1.110)	(0.921)
IF controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	7211	7211	7211	7211	7211	6941	6941	6941	6941	6941
Hansen-J test (p)	0.276	0.259	0.385	0.261	0.479	0.521	0.495	0.497	0.346	0.479
AR(2) test (p)	0.013	0.006	0.008	0.009	0.006	0.008	0.002	0.001	0.015	0.005
AR(3) test (p)	0.199	0.177	0.181	0.166	0.218	0.356	0.208	0.249	0.175	0.218
N GMM Instr.	138	134	134	138	137	137	133	133	137	136

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01

Table 4.10 reports the results from estimating specifications (75) and (76) for exporting.

Looking at columns (1)-(5), what emerges is that the financial shock impacted the probability of exporting mostly for firms in the third quintile of the firm size and productivity distributions. For the ACF distributions, the effect of the crisis appears strong also for firms in the fourth quartile, especially when ranking firms depending on their absolute productivity (in column (4) the coefficients on the third and fourth quartile are almost identical, although more precisely estimated on the third). For the LP distributions the most affected firms appear to be in the second quartile: this shows very neatly in column (5).

For exporting, columns (6)-(10) acquire more importance than for innovation, because the positive coefficients estimated in columns (1)-(5) should be due to the effect of the crisis through firms' markups: controlling for the latter, no direct impact should emerge on the LN*Crisis interactions. Overall, across the various distributions, it is noticeable how conditioning on markups makes the statistical significance of the coefficients on all LN*Crisis variables almost vanish: this applies to all quartiles, including those where the effect of the crisis was estimated to be less strong.

The size of the coefficients is also reduced, as expected, but in some cases not by a large amount. The markup variables show a positive association with the probability of exporting, but significantly so only for the Bustos, the ACF-a and LP-a distributions: it is in fact evident how these are the regressions where the size and significance of the LN*Crisis coefficients are reduced by most.

On the whole Table 4.10 and 4.9B confirm the prediction that the shock hit mostly firms in the middle range of the productivity distribution. Importantly, the finding that the reduction in external finance for innovation positively affected exporting through a reduction in competitive pressure is fairly robust when estimating these effects on each quartile of the firm productivity distribution.

Similarly to what done for the innovation regressions, also for exporting the coefficients in columns (6)-(10) can be compared with their counterparts in Table 4.9B in Appendix: instrumenting the Markup III variables produces results that are very similar, if not stronger, to what discussed here. After controlling for firms' market power, the direct effect of the shock to innovation on exporting is significantly reduced, across the various distributions. The markup variables, instead, take a positive coefficient in most of the specifications and quartiles, as expected[114].

[114] Notice that when I disaggregate the effect of the shock on quartiles of the firms' size and productivity distribution, I do not encounter the shortcoming from the instrumentation of markups that I reported above when estimating the effect of the crisis on the entire distribution of producers.

4.7.3 A Placebo Test

This section presents the results from running a simple falsification test. In order to confirm that the impacts on innovation, exporting and markups detected in this work are peculiar to the crisis of the period 2008-2010, I ran specifications (65), (66) and (67) by changing the timing of the crisis. Table 4.11 and 4.12 show the estimation results.

Table 4.11: Placebo Tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Crisis 2010	**Crisis 2012**	**Crisis 2008**	**Crisis 2006**	**Crisis 2004**	**Crisis 2002**	**Crisis 2000**
				Innovation			
INN_{t-1}	0.284**	0.276**	0.300**	0.281**	0.278**	0.281**	0.279**
	(0.116)	(0.119)	(0.137)	(0.117)	(0.118)	(0.118)	(0.118)
LN*Crisis	**-0.048****	0.103***	0.024	0.038	0.034	0.0079	0.027
	(0.021)	(0.027)	(0.042)	(0.049)	(0.045)	(0.056)	(0.020)
IF Controls	yes	yes	yes	yes	yes	yes	yes
N	7211	7211	7211	7211	7211	7211	7211
Hansen-J test (p)	0.519	0.623	0.598	0.644	0.627	0.639	0.611
AR(2) test (p)	0.025	0.027	0.023	0.028	0.028	0.028	0.0279
AR(3) test (p)	0.990	0.993	0.871	0.998	0.999	0.995	0.998
N GMM Instr.	127	127	127	127	127	127	127
				Exporting			
EXP_{t-1}	0.612***	0.613***	0.610***	0.603***	0.605***	0.608***	0.614***
	(0.132)	(0.131)	(0.131)	(0.132)	(0.131)	(0.131)	(0.130)
LN*Crisis	**0.062*****	-0.088***	-0.151***	-0.042	0.057*	-0.067***	0.014
	(0.016)	(0.018)	(0.039)	(0.035)	(0.030)	(0.026)	(0.012)
IF Controls	yes	yes	yes	yes	yes	yes	yes
N	7211	7211	7211	7211	7211	7211	7211
Hansen-J test (p)	0.492	0.490	0.493	0.487	0.498	0.502	0.491
AR(2) test (p)	0.008	0.009	0.009	0.009	0.010	0.010	0.008
AR(3) test (p)	0.210	0.207	0.220	0.219	0.210	0.213	0.217
N GMM Instr.	128	128	128	128	128	128	128
				Markup			
LN*Crisis	**0.023****	-0.039’	-0.039***	-0.061	-0.008	0.077	-0.027
	(0.010)	(0.025)	(0.013)	(0.051)	(0.014)	(0.062)	(0.024)
N	6933	6933	6933	6933	6933	6933	6933
Firm FE	yes	yes	yes	yes	yes	yes	yes
Ind. Trends	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ’ p<0.15, * p<0.10, ** p<0.05, *** p<0.01

In Table 4.11 I report only the coefficient on the LN*Crisis interaction, which is the main regressor of interest, and the coefficient on the lagged dependent variable that reassures about the correct specification of the various models. Column (1) in Table 4.11 reports the same regression coefficient as shown in column (6) in Table 4.3, 4.4 and 4.5, for innovation, exporting and markups, respectively. This is the main model estimated with system-GMM and where all controls are added, including the variables proxying for the use of internal financial resources (IF controls). The coefficient in column (1) can be taken as a benchmark and compared to the other columns where exactly the same specification is estimated, with the difference that the crisis dummy takes value 1 each time in a different year. All regressions in Table 4.11 include the common set of controls specified at the bottom of the table, i.e. firm FE, 2-digit industry time trends, time dummies and lagged firm level controls[115].

Starting from the panel for innovation, it is evident that the relatively lower probability of innovation estimated for firms in sectors characterized by higher LN relative to firms in sectors characterized by lower LN is strictly peculiar to the financial crisis of 2008-10. This specific effect is identified only over these years and can, therefore, be ascribed to the reduction in external liquidity for innovation caused by the credit crunch that characterized the crisis. The coefficient for 2012 takes exactly the opposite sign and is strongly significant, hinting at a rebound in the probability of innovation in higher LN sectors estimated for the after-crisis period. Before the financial crisis instead, there appears to be no effect at all.

Repeating this exercise for exporting shows similar results, although with less precision. In 2008-10 I find a higher probability to export in sectors characterized by higher LN, relative to lower LN sectors. Both before and after the crisis, in 2008 and 2012, the effect appears to be the opposite: interestingly these coefficients of opposite sign are matched by the corresponding coefficients for markups and innovation, which also take the opposite sign compared to column 1 (at least in 2012). It therefore is tempting to infer that around the crisis years the relation between innovation, exporting and markups that I describe in this work could have applied in both directions.

For exporting, 2004 shows a coefficient which is similar to that in 2010, but I do not have enough elements to explain what could have driven this result.

Inspecting the panel for the markups regressions in Table 4.11, besides the two years surrounding the financial crisis during which firms' price-cost margin are estimated to have fallen more in sectors characterized by higher LN, no other year shows a significant effect.

Table 4.12 shows a placebo test which is similar in spirit to that of Table 4.11. I attempt to detect whether in off-crisis years there are effects on innovation, exporting and markups similar to those detected during the crisis. For Table 4.12 I ran a specification similar to (65), (66) and (67), where the sectoral LN ratio is interacted not with the crisis dummy, but

[115] These latter ones differ slighly across the regression for innovation (capital intensity, employment, dummy identifying firms in receipt of public funding for innovation), exporting (capital intensity and employment) and markups (capital stock and employment).

with all the other dummies identifying each time period in the data. This produces a setting where every year can be considered a "shock", with respect to 2008-10 (which acts like an excluded base category). In other words, Table 4.12 can be seen as a negative of the main result in Tables 4.3, 4.4 and 4.5.

Table 4.12: Placebo test- 2

	(1)	(2)	(3)
	Innovation	**Exporting**	**Markup**
INN_{t-1}	0.295***		
	(0.097)		
EXP_{t-1}		0.681***	
		(0.126)	
LN * Crisis 2012	0.072***	0.020	-0.015*
	(0.026)	(0.124)	(0.008)
LN * Crisis 2008	0.009	-0.127	-0.056***
	(0.028)	(0.116)	(0.015)
LN * Crisis 2006	0.100'	-0.232	-0.086*
	(0.066)	(0.229)	(0.045)
LN * Crisis 2004	0.125'	-0.244	-0.038***
	(0.083)	(0.315)	(0.013)
LN * Crisis 2002	0.107	-0.402	-0.006
	(0.088)	(0.448)	(0.034)
LN * Crisis 2000	0.094	-0.026	-0.013
	(0.066)	(0.295)	(0.071)
IF controls	yes	yes	yes
Firm FE	yes	yes	yes
Ind. Trends	yes	yes	yes
Time FE	yes	yes	yes
Firm controls	yes	yes	yes
N	7211	7211	6933
Hansen-J test (p)	0.273	0.143	
AR(2) test (p)	0.028	0.009	
AR(3) test (p)	0.995	0.220	
N GMM Instr.	129	130	

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01

From column (1) it is evident that in every time period, with respect to 2008-10, firms in sectors characterized by higher LN saw a higher probability of innovating, relative to lower LN sectors. The effect is almost null for the period immediately before the crisis (LN* 2008 crisis), but rather large in years further away from the crisis, or immediately afterwards. For exporting, in column (2), in all the off-crisis time periods there is a large and negative coefficient (albeit not significant), except for 2012. This suggests firms in higher LN sectors could have experienced a lower probability of exporting, relative to the period covered by the crisis. Finally, in the third column I estimate a lower markup for firms in higher LN sectors relative to lower LN sectors in every period, with respect to the 2008-10 crisis.

Taken together, the results of Table 4.12 indeed appear as a negative image of the main results presented in section 4.5, which, interpreted along with the estimates in Table 4.11, confirm that the impacts on innovation, exporting and firms' markup under study in this work can safely be considered an exclusive consequence of the financial crisis of 2008-10.

4.8 Conclusion

This chapter addresses the impact of the 2008-10 financial crisis on firms' innovation, exporting and markups by analysing matched firm level balance-sheet and innovation survey data for Slovenia.

This chapter is dedicated to testing empirically the main propositions of the theoretical framework that constitutes the third chapter of this thesis. The main contribution consists of the observation of the nexus between international trade and innovation from a new angle. Product and process innovation have been found by the litearature to be associated with a higher propensity to export. My works explores a particular setting, in which participation in exporting could be facilited also by a negative shock that impedes firms' innovation. A reduction in external liquidity for innovation can, in fact, lead firms to drop projects or slow down innovative activity, resulting in an overall lower innovation output. This can in turn affect positively firms' participation in the export market, if the shock to innovation reduces the degree of competitive pressure and allows firms to charge higher markups that can be exploited to sustain the costs associated with exporting.

The empirical analysis makes use of the financial crisis of 2008-10 as a setting to test these hypotheses and largely confirms them. In a difference in difference estimation procedure inspired by the methodology of Rajan and Zingales (1998) and Raddaz (2006), I find that in sectors characterized by higher external liquidity needs for innovation expenditure firms reported a lower probability of innovation in the crisis, relative to sectors characterized by lower external liquidity needs. It is precisely in these sectors (the higher liquidity needs ones) that I estimate an increase in firms' markups and in the probability of exporting, in relative terms.

To confirm the proposition that the positive impact on exporting arising from the financial shock is mediated by the increase in firms' price-cost margin, I disentangle the impact of the innovation shock from that of markups. I estimate time varying firm specific markups by applying the recent methodology of De Loecker and Warzinsky (2012) and show that conditioning on this variable in the main regressions reduces both size and significance of the effect of the reduction in external liquidity for innovation on exporting.

An important set of results arises from estimating the impact of the reduction in finance for innovation over quartiles of the firms size and productivity distributions. I find that the shock hit mostly firms in the middle range of the distributions, both for innovation and exporting, thereby confirming another prediction of the theoretical model.

In conclusion, besides adding to the literatures on the financing of innovation and on the effect of the 2008-10 crisis, this work sheds further light on the long-studied interdependence between firm level innovation and exporting, suggesting that markups can act as a channel in transmitting a shock to the former to the latter of these two activity performed by firms.

5 Conclusion

The research in this thesis is dedicated to the study of the repercussions of the financial crisis of 2008-09 on various dymensions of firms' activities.

I directed the focus of my analysis on the behaviour of those firms that constitute the most productive fringe among the producers within an economy, traders and innovators. The motivation is that the events of 2008-09 constituted a shock of historic proportions for importers and exporters worldwide and for firms engaged in innovative activities. The nature of the crisis, a financial crisis of unprecedented depth since the Great Depression of 1930s, spurred me to gather a deeper understanding of the strategies pursued by firms to cope with the challenges raised by the imperfections of financial markets.

The three main parts in which this thesis is divided, concentrate the attention on peculiar aspects that characterized the response of firms to the crisis and aim to contribute the the growing literatures triggered by this event.

In the Chapter 2 I explore the product dimension of the Trade Collapse exploiting Slovenian custom and firm balance data, adding to the literature studying the dramatic and sudden reduction in international trade (-30% between September 2008 and January 2009), particularly severe for exchanges among OECD economies. The main contribution of this chapter consists of the identification of a new source of heterogeneity in the response of trade flows to the shock. The share of imported intermediates in firms'costs was identified as a *catalyst* of the trade collapse, because imports of higher cost-share (CS) inputs fell more than proportionately compared to imports of lower cost-share inputs in the downturn, and rebounded by more in the recovery. This larger responsiveness, in both sub-periods of the event, suggests a deeper trough of the collapse for transactions involving higher CS inputs. I advance a theoretical mechanism to explain this result: trade of higher CS products could have been more sensitive to the demand collapse because of larger inventory adjustments. In an inventory management model where firms minimize the cost of holding inventory, I show how storage costs lead firms to order a lower quantity of higher CS items (and to re-order them more frequently) and to then operate larger adjustments when demand is disrupted, relative to lower CS products.

In this chapter I also examine the role of Intra-Firm trade during the crisis. On average, shipment between affiliated firms (IF trade) did not perform differently relative to shipments between unaffiliated firms (AL trade). Despite this, IF trade could have acted as an accelerating factor for transactions involving higher *CS* products. The lower degree of uncertainty and the more rapid communication characterizing business relations between parties related by ownership rights, could lead to a more effective management of inventory stocks both in good and in bad times: the size of the inventory buffer is likely to be smaller, but the reaction in case the stock needs to be downsized could be larger, in proportional terms (with this responsiveness being even bigger for high CS products). This hypothesis could explain the larger adjustment measured in both the downturn and the recovery for imports of higher CS products when involving related parties, relative to AL trade. The reaction of IF trade differed from AL trade also with respect to trade margins: the share of intensive margin relative to extensive margin adjustments was seen to be larger for IF trade, possibly due to the ease of adjustment of offshoring (IF) relative to outsourcing (AL) agreements.

Chapter 3 and 4 are dedicated to the exploration of the impacts of the 2008-09 financial crisis on firms' innovation activity and its indirect effects on participation in exporting. The main aim of these chapters is to explore the interconnection between innovation and exporting from a novel perspective: a negative shock to innovation, which is symmetric across trading partners, can induce anti-competitve effects and, through these, facilitate entry into exporting. This is a new angle from which the nexus between trade and innovation is observed, which adds to a literature that so far concentrated on the positive relation between these two activities. To address this reserach question and to guide the empirical work of Chapter 4, in Chapter 3 I develop a monopolistically competitive heterogeneous firm model with endogenous markups and liquidity constraints for innovation. The model allows me to isolate the relation running from a reduction in innovative activity, as a consequence of a tightening in external liquidity for innovation, to a relatively easier participation in exporting, working through a reduction in the industry-wide degree of competitive pressure. Chapter 4 then exploits the financial crisis of 2008-09 as a setting to test the propositions of the theoretical model.

In addition to the novelty of the reserach question which adds to the literatures on the innovation-trade nexus and the impacts of the 2008 financial crisis, Chapter 3 makes also a theoretical contribution, consisting of the introduction of liquidity constraints into a heterogenous firms trade model with endogenous markups that studies jointly the decisions to export and to innovate. The model is based on Melitz and Ottaviano (2008) and adds costly efficiency-enhancing innovation on the supply side of the original framework. Liquidity constaints for innovation are modelled assuming that firms can borrow externally only a fraction of the innovation cost, while they must pledge internal liquidity for the remaining fraction: if the latter fraction is high enough, the equilibrium will feature a set of firms that would be able to innovate in a world of perfect financial markets, but are prevented from doing so. A first result is that liquidity constraints produce *anti-competitive* effects: in an industry where potential innovators are liquidity constrained firms are, on average, less productive, charge higher prices and higher markups relative to an industry with no liquidity constraints. Integrating the domestic with the foreign economy through costly trade increases the "toughness" of competition, as in the original Melitz-Ottaviano (2008) model: the least efficient firms exit (*selection* effect) and the surviving producers feature higher average productivity, lower prices and lower markups (*pro-competitive* effect).

The model then shows that a tightening in liquidity constraints for innovative firms reinforces the anti-competitive effects arising from innovation being below its optimal level. Access to innovation becomes more selective, but, in turn, the reduction in the industry wide degree of competition results in a more accessible threshold to enter the domestic and the export market. This latter is also a consequence of the shock to innovation being symmetric across the trading partners. The model also predicts that the negative impact on innovation and the positive impact on exporting affect firms in the middle range of the productivity distribution.

These theoretical predictions are taken to the data and tested in the Chapter 4 of this thesis, by analysing matched firm level balance-sheet and innovation survey data for Slovenia. In this chapter I find evidence in support of the proposition that participation in exporting could be facilited by a negative shock that impedes firms' innovation. In a diff-in-diff estimation strategy inspired by the methodology of Rajan and Zingales (1998) and Raddaz (2006), I find that in sectors characterized by higher external liquidity needs for innovation expenditure firms reported a lower probability of innovation in the crisis, relative to sectors characterized by lower external liquidity needs. It is precisely in these sectors (the higher liquidity needs ones) that I estimate an increase in firms' markups, confirming the anti-competitive effects of the shock to innovation, and in the probability of exporting, in relative terms.

I estimate time varying firm specific markups by applying the recent methodology of De Loecker and Warzinsky (2012) and furthermore show that conditioning on this variable attenuates the effect of the reduction in external liquidity for innovation on exporting, thereby providing support to the rationale that the relatively better export perfomance induced by the innovation shock was mediated by the reduction in product market competition.

Lastly, I show that the shock hit mostly firms in the middle range of the firms' size and producitivity distributions, both for innovation and exporting, thereby confirming another prediction of the theoretical model.

In conclusion, my thesis shows that there might subtantial perverse effects arising from imperfections in financial markets. Events like the crisis of 2008-2009, suddently hitting delicate and inherently risky activities such as international trade and investment in innovation, can result in losses in competition and average productivity (Chapters 3 and 4) or severely disrupt operations of firms, inducing them to resort to specific strategies to cope with shock (e.g. adjusting imports of higher CS inputs by more than imports of lower CS inputs, possibly becasue of differential inventory adjustments - Chapter 2). I have also attemped to shed light on the long-studied interdependence between firm level innovation and exporting, showing how markups can act as a channel in transmitting a shock to the former to the latter of these two activity performed by firms.

The research in these areas is far from complete, but even by narrowing down the focus of the study on the peculiar issues that I considered in this thesis, there is considerable space (and scope) for further work to be undertaken.

Concerning Chapter 2, a deeper sectoral characterization of the unequal trade adjustment across products that I estimate, appears an obvious extension of my findings, also in light of the differential involvement in global value chains across firms. Unfortunately, lack of inventory data at the product level impedes a direct test of the inventory adjustment hypothesis that I raise in Chapter 2, but the result that product cost-share appears as the relevant margin of intervention by firms when attempting to downsize activity and trade in a recessionary environment calls for a deeper investigation on the causes of this behaviour.

In Chapter 3 I propose a simple model to explore how a shock to innovation can indirectly stimulate entry into exporting, and cast the analysis in a two-country world with symmetrical economies experiencing the same shock. An immediate extension of this approach would be to explore the effect of an asymmetric shock to liquidity for innovation, examining how the loss of innovative output in one country affects international trade between the two economies. Additionally, also relaxing the symmetric countries assumption could potentially lead to different results, depending on which economy experiences the shock to innovation. It is to be considered, however, that even in the simpler framework that I propose in Chapter 3, numerical simulation was necessary to derive the equilibrium condition: increasing the complexity of the model further, might lead to an even less tractable structure.

With respect to the empirical application of the model's prediction, the crisis of 2008-09 lent itself as a "laboratory" for the analysis I perfomed in Chapter 4, and it does not appear easy to imagine an alternative setting in which to explore the outcomes of a sudden, exogenous shock to innovation. A change in fiscal regimes applying to innovators, or, possibly, a sudden event affecting the industry's labour market skill pool, could work as external sources of variation to be explored in a setting where innovation and exporting are studied jointly. In particular this latter scenario attracts my interests for future research: the inteplay between international trade and innovation could be altered by an exogenous shock affecting the labour market firms operate in, and eventually shed light on the challenges represented by an imperfect overalap of goods and labour market integrations.

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6 Appendix

6.1 Appendix to Chapter 2

6.1.1 A simple model of inventory management

Drawing on the seminal contribution of Arrow et al. (1951) and the extensive work of Hadley and Whitin (1963) I present a simple framework to demonstrate Hypothesis 1, namely that trade of higher cost-share inputs responds to a fall in demand more than trade of lower cost-share inputs. I exploit the simplest version possible of the so called "lot size-reorder point" model, or (S, s) model, abstracting from uncertainty in the demand pattern for simplicity of exposition.

The aim of the (S, s) model is to derive the optimal quantity S^* of inventory to order and the optimal reorder point r at which to place the order, given a rate of demand δ and a procurement lead time τ. The reorder point defines the safety stock s, which consists of the amount of inventory on hand when the procurement arrives. Here it is assumed that δ and τ are constant over time and deterministic: this makes clear that the same quantity is ordered each time an order is placed, and that the safety stock always has the same value[116]. The optimal values $S^*$and r^*minimise the average annual cost function, which includes the cost of the units purchased, the cost of placing an order, the cost of sourcing and handling inventories and the cost of carrying inventories.

Ordering costs are represented by a fixed cost A, independent of the order size; whereas the cost of the units purchased is represented by a constant marginal cost c. Sourcing and handling costs can instead be conceived to be rising in the quantity purchased[117], and in the simplest formulation, to be rising in a linear way, i.e. ωS^2, such that at the margin this corresponds to $2\omega S$. With a constant rate of demand δ the quantity ordered S is going to be depleted in time $T = S/\delta$: this is the length of a cycle. The inverse of this ratio represents the average number of cycles, i.e. δ/S. Hence ordering and purchasing costs are $(A + cS + \omega S^2)\delta/S = A\delta/S + c\delta + \omega S\delta$. Furthermore, since the unit cost c is assumed to be independent of the quantity ordered, the reordering rule need not to include the variable cost term $c\delta$: the expression for ordering and purchasing costs becomes $A\left(\delta/S\right) + \omega\delta S$.

Carrying cost are modelled as a constant instantaneous rate $0 < I < 1$, proportional to the value of the goods stored and to the length of time the goods remain in inventory. Per cycle, inventory carrying costs therefore are: $Ic\int_0^T \left(S + s - \delta t\right) dt = Ic\left[\left(S + s\right)T - \frac{\delta T^2}{2}\right] = IcT\left[(S/2) + s\right]$. Multiplying this by the average number of cycles gives $Ic\left[(S/2) + s\right]$. Lastly, in this simplified version of the (S, s) model with deterministic demand and procurement time, a firm can minimise its carrying cost by having $s = 0$, so that the system just runs out when a new procurement arrives.

The average variable cost is then:

$$C = A\frac{\delta}{S} + \omega\delta S + Ic\left[\frac{S}{2}\right] \tag{77}$$

[116]The assumption of determinisic and constant demand also rules out the risk for the firm to stock out. This assumption might not appear realistic, but, as mentioned, adding demand uncertainty into the model introduces a layer of complexity which is unnecessary for the purposes of this section.

[117]This marginal cost that I refer to as "sourcing and handling cost" can in reality proxy a variety of factors that make the cost of holding inventories rise with the quantity stored. An example could be rising transportation costs, if the distance from suppliers increases when sourcing additional items from alternative locations that are further away. Alternatively, there can be rising labour costs, related to the operations of receiving, inspecting and handling a larger quantity of items. Also storage costs could be convex in the quantity stored (Chazai et al. 2008). Finally and more generally, this rising cost could capture a higher degree of complexity in coordinating the management of an increasing quantity of items stored.

Minimisation of (77) allows to obtain the optimal quantity to order, S^*:

$$S^* = \sqrt{\frac{2\delta A}{Ic + 2\omega\delta}} \tag{78}$$

Equation (78) is a popular expression in the literature, under the name of lot-size formula, or economic order formula, or Wilson formula.

The optimal reorder point r is derived following again Hadley and Whitin (1963). If m is the largest integer less than or equal to τ/T, then, an order is placed when the on-hand inventory reaches

$$r^* = \delta(\tau - mT) = \delta\tau - mS^*, \tag{79}$$

such that the on-hand inventory is zero at the time the order arrives.

When an optimal policy is used, the average amount of inventory in the system will be:

$$\bar{S}^* = \frac{S^*}{2} = \sqrt{\frac{A\delta}{2\left(cI + 2\delta\omega\right)}} \tag{80}$$

It follows directly from equation (80) that the average inventory increases with the square root of the sales rate δ, and not proportionately with it. Similarly, the average inventory varies inversely as the square root of the marginal cost c, so that the average inventory for high cost products should be lower than for low cost products.

To verify Hypothesis 1 I compute the proportional rate of change of the value of the items in inventory with respect to a change in demand (which is the theoretical counterpart of the mid-point growth rate exploited in estimation), $\frac{\partial(\bar{S}^*c)/\partial\delta}{\bar{S}^*c}$, and show how this changes with respect to the cost-share.

Notice, however, that the cost-share does not appear directly in (80): the cost-share measures the value of the imported item in total costs, whereas (80) relates the average quantity stored with the unit-cost. A higher unit-cost determines a smaller quantity to be ordered, but it can be shown that a higher unit-cost always corresponds to a higher value of the stock, hence to a higher cost-share. Intuitively, this is because the negative effect of the unit-cost on the quantity is less than proportional. Consider two inputs h and l, where h denotes a high unit-cost intermediate and l denotes a low unit-cost intermediate, such that $c_h > c_l$. Although $\bar{S}_h^* < \bar{S}_l^*$,the higher cost input corresponds to a higher value, such that $\bar{S}_h^* c_h > \bar{S}_l^* c_l$, which in turn implies a higher cost-share $\bar{S}_h^* c_h / \left(\bar{S}_h^* c_h + \bar{S}_l^* c_l\right) > \bar{S}_l^* c_l / \left(\bar{S}_h^* c_h + \bar{S}_l^* c_l\right)$. To see this consider that:

$$\frac{\partial\left(\bar{S}^*c\right)}{\partial c} = \frac{\left(cI + 4\delta\omega\right)\left(A\delta\right)^{1/2}}{2^{1/2}\left(cI + 2\delta\omega\right)^{3/2}} > 0, \tag{81}$$

which implies $\bar{S}_h^* c_h > \bar{S}_l^* c_l$, since $c_h > c_l$. Alternatively, consider that the elasticity of S with respect to c is less than unity: $\varepsilon_{S,c} = -\frac{1}{2\left(1+\frac{2dw}{cI}\right)}$.

Finally, to demonstrate hypothesis 1, observe that $\frac{\partial(\bar{S}^*c)/\partial\delta}{\bar{S}^*c}$ is increasing in the unit cost c and hence in the cost share, since:

$$\frac{\partial\left(\bar{S}^*c\right)/\partial\delta}{\bar{S}^*c} = \frac{1}{2\delta(1 + \frac{2\delta\omega}{cI})} \quad \text{and} \quad \frac{\partial}{\partial c}\left(\frac{1}{2\delta(1 + \frac{2\delta\omega}{cI})}\right) = \frac{\omega I}{\left(cI + 2\delta\omega\right)^2} > 0. \tag{82}$$

Hypothesis 1 is indeed confirmed by this simple version of the (S, s) model, since inventory adjustments can be shown to lead to changes in import flows. A larger responsiveness of higher cost-share intermediates accelerates the reaction of imports during a crisis, conferring to the cost-share a role of catalyst of the collapse.

6.1.2 Margin decomposition

I decompose mid-point growth rates, rather than standard growth rates, to correct for attrition bias. Because of the way this variable is computed, each elementary monthly growth rate (g_{ickt}), which is the monthly year on year growth rate of the shipment of each CN-8 digit product k, performed by a firm i, to a certain destination c, in month t, will take a value between -2 and +2. This allows to classify elementary growth rates into four types: increased ($0 < g_{ickt} < +2$) and decreased ($-2 < g_{ickt} < 0$) flows, corresponding to the variation in the value of the shipment of the same product by the same firm to the same destination with respect to the same month of the previous year; and created ($g_{ickt} = +2$) and destroyed ($g_{ickt} = -2$) transactions. These latter ones can correspond to new or destroyed shipments of a product to an already served destination by the same firm (product margin), to an added or dropped destination by a continuing firm (destination margin) or to a firm entering or exiting the export market (firm margin). This method allows to precisely measure the contribution of each margin to the total variation of trade, as the sum of the margins provides a correct approximation of the observed aggregate growth rate (Bricongne et al. 2012). It should be noticed that such a fine level of disaggregation and frequency of observation inflates the contribution of the extensive margin compared to when more aggregate data are used. The intensive margin is in fact only due to continued shipments of the same product to the same destination by a continuing firm, year after year.

To perform the decomposition, each single flow is weighted by its share in total Slovenian shipments during the same period:

$$s_{ickt} = \frac{x_{ickt} + x_{ick(t-12)}}{\sum_c \sum_i \sum_k x_{ickt} + \sum_c \sum_i \sum_k x_{ick(t-12)}} \tag{83}$$

The year on year growth rate of the total value of Slovenian exports is then obtained by summing each flow g_{ickt} weighted by s_{ickt} across all exporters, products and destinations.

$$G_t = \sum_c \sum_i \sum_k g_{ickt} * s_{ickt} \tag{84}$$

This aggregation can be made by subsets of the total growth rate, and this is how the decomposition is performed. Once it is identified whether, say, a destroyed flow is due to firm, destination or product exit, simply adding up the corresponding weighted growth rates yields a certain margin. In this way for each month I identified the intensive margin and the three extensive margins, separating these then further for intra-firm and arm's length transactions. The net margins are given by the sum of the positive and negative contributions.

6.1.3 Drawback of the related party trade proxy.

The strength of this exercise rests also on the identification of intra-firm trade, which however suffers from some imperfection in its measurement: my strategy is to label shipments as intra-firm when originating from firms belonging to a group and directed to a country where there is a firm belonging to the same business group. This causes some arm's length transaction to be labelled as intra-firm: it happens when, for shipments to a certain destination, a firm belonging to a group ships goods to firms outside the group, opting for a mixed strategy of arm's length and intra-firm in that destination. This would somewhat inflate the related party trade proxy, causing the estimates to be biased towards zero: unfortunately the lack of data about intra-firm trade does not allow to fix this issue in my context.

As a partial validation of this related-party trade variable I can compare the share of intra-firm trade I measure to figures emerging from other works. In 1999 l' "Enquete sur les exchange intra-group", a French survey of firms representing 61% of French exports, estimated that 32% of transactions (not volumes) were among related parties: in Slovenia I measure this to be about 38%. As a further cross country reference, I estimate about 49% of the value of exports in 2007 to be intra firm: this value is extremely close to Altomonte et al.'s estimate of 48% for French exports (obtained using my same related party trade proxy) and, importantly, it is close to the 46.8% measured for US exports (Census Bureau data). Lastly, the most direct validation is possible when considering bilateral trade between Slovenia and the US: Lanz and Miroudot (2011), according to the Related Party database by US Census Bureau, measure 51.3% of imports from Slovenia to be intra-firm, while with my approximation I obtain a figure of about 52.6%.

Given these relatively reassuring similarities between the share of intra-firm trade estimated with the related party trade proxy used in this paper and the quoted figures exploiting the actual measurement by US custom authorities, I feel rather confident is relying on my approximation.

6.1.4 Orbis data for 2011 only

The full ownership data, including links up the 10th level of subsidiarity, was extracted from ORBIS as for 2011: for the crisis years, 2008 and 2009, it was only possible to obtain the status of the ownership network for the 1st level of subsidiarity. Furthermore, the coverage of firms in ORBIS for Slovenia increased substantially from 2008 to 2011: a large number of firms and groups – especially of smaller size – were absent in 2008, and were added over time. This imposed a choice between two "pictures" of the status of ownership links to use in this work: the 2011 data export allows to obtain a great deal more description about firms' affiliation (10 levels of subsidiarity instead of 1) with over 10 times the number of firms about which ownership information is available.

Importantly, this large difference in the number of firms is also due to the increase in coverage. However, this richness of ownership data and the increase in coverage come at the cost of assuming that the 2011 picture is accurate enough to represent the situation in 2008-09. The 2008-09 data extract offers in fact a more up-to-date image of ownership links: despite this, the significantly lower representation of smaller groups and the absence of information about links beyond the 1st level made me opt for the 2011 extract.

6.1.5 Geographical disaggregation of Slovenian trade.

In terms of the geographical disaggregation of Slovenian trade, this country finds itself in between of some of bigger EU countries on one side (Germany, Italy and Austria) and the block of former Yugoslavian and eastern-European economies on the other one. This geographical divide is mirrored by the composition of the trade flows departing from Slovenia. The majority of transactions are with countries of the former Yugoslavian republic (over 40% of the exports are directed to Croatia, Bosnia and Serbia), but taking into account the value of shipments completely overturns this ranking, with the three biggest Euro-zone economies (Germany, Italy and France) absorbing about 40% of the value of Slovenian exports. Table 2.16 provides an overview of the 10 top served destinations.

Table 2.16: Geographical decomposition of Slovenian exports

Destination	Shipments %	Destination	Shipments %	Destination	Shipments %
		Number of Shipments, in %.			
All Flows		Intra-Firm		Arm's Length	
Croatia	19.29	Croatia	6.2	Croatia	13.09
Bosnia	12.41	Bosnia	3.85	Serbia	10.00
Serbia	10.00	Germany	2.41	Bosnia	8.55
Germany	6.49	Austria	1.79	Germany	4.09
Austria	5.11	Italy	1.25	Italy	3.35
Italy	4.60	Macedonia	0.96	Austria	3.32
Macedonia	3.60	Czeck Republic	0.68	Macedonia	2.63
Montenegro	2.94	France	0.59	Montenegro	2.43
Hungary	2.06	Hungary	0.59	Kosovo	1.89
Kosovo	1.89	Poland	0.56	Hungary	1.47
		Value of shipments: shares in %.			
All Flows		Intra-Firm		Arm's Length	
Germany	19.81	Germany	10.24	Germany	9.57
Italy	11.2	France	7.14	Italy	6.01
France	8.68	Italy	5.19	Austria	4.66
Croatia	8.25	Croatia	4.27	Croatia	3.97
Austria	7	Russia	2.9	Serbia	3.36
Russia	3.72	Austria	2.34	Bosnia	1.99
Serbia	3.36	Poland	1.99	France	1.54
Bosnia	3.35	Great Britain	1.43	Hungary	1.34
Poland	2.99	Bosnia	1.36	Great Britain	1
Great Britain	2.44	Czeck Republic	1.31	Poland	1

6.1.6 A firm level cost-share measure

The results presented in Tables 2.4, 2.5 and 2.6 explore the unequal trade adjustment of products accounting for a diffent share of firms' costs (or firms' sales), where the CS measure is specific for each CN-8 product in each NACE (4-digit) sector.

In order to explore the CS heterogeneity further, an attempt has also been made to compute the CS measure at an even finer level of disaggregation, making the CS ratio product-firm specific. The CS variables (6) and (7) therefore become:

$$CS_{ki}^{\text{costs-firm}} = \frac{1}{Y} \sum_{y=2000}^{2007} \left(\frac{\sum_{t=1}^{12} im_{kic,t}}{C_{iy}} \right), \quad CS_{ki}^{\text{sales-firm}} = \frac{1}{Y} \sum_{y=2000}^{2007} \left(\frac{\sum_{t=1}^{12} im_{kic,t}}{S_{iy}} \right) \tag{85}$$

Table 2.14 shows the results from estimating specification (8) and (9) exploting the firm level CS measures.

Table 2.14: The Cost-Share as a Catalyst of the Collapse - Firm level measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rates				Standard Growth Rates (Log-change)			
PANEL A: $CS^{\text{costs-firm}}$								
CS	-0.026*	-0.043***	**-0.040***	-0.055***	-0.024	-0.046***	**-0.046'**	-0.070***
	(0.015)	(0.013)	**(0.022)**	(0.017)	(0.019)	(0.012)	**(0.030)**	(0.020)
Int		0.046***		0.053***		0.019***		0.023***
		(0.005)		(0.011)		(0.007)		(0.008)
Int*CS		-0.026'		0.025		-0.031		0.041
		(0.015)		(0.031)		(0.021)		(0.039)
CS*Rec			**0.033'**	0.031			**0.055**	-0.120***
			(0.021)	(0.026)			**(0.039)**	(0.036)
Int*Rec				-0.019***				-0.010
				(0.007)				(0.009)
Int*CS*Rec				-0.001				-0.088*
				(0.039)				(0.049)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	4711097	4711097	4711097	4711097	1680951	1680951	1680951	1680951
PANEL B: $CS^{\text{sales-firm}}$								
CS	-0.012'	-0.011	**-0.018'**	-0.010'	-0.072**	-0.050	**-0.091****	-0.056
	(0.008)	(0.009)	**(0.011)**	(0.071)	(0.028)	(0.040)	**(0.040)**	(0.047)
Int		0.046***		0.053***		0.019***		0.025***
		(0.005)		(0.011)		(0.006)		(0.008)
Int*CS		-0.001		-0.021**		-0.040		-0.069
		(0.003)		(0.010)		(0.049)		(0.067)
CS*Rec			**0.015****	-0.003			**0.011****	0.072
			(0.007)	(0.021)			**(0.004)**	(0.070)
Int*Rec				-0.019***				-0.013
				(0.007)				(0.090)
Int*CS*Rec				0.034				0.071
				(0.034)				(0.090)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	4707816	4707816	4707816	4707816	1784484	1784484	1784484	1784484

Note: Standard errors clustered at the firm level in parentheses; ' $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The results support the main finding of this work: even when the CS is computed at the firm-product level it appears that imports of products accounting for a larger CS underwent a larger fall in the downturn and a larger rebound in the recovery. This is shown for both the $CS^{\text{sales-firm}}$ and the $CS^{\text{costs-firm}}$ measures in columns (3) and (7). A noticeable difference compared to the results exploiting the product-industry CS measures (Table 1.4 and 1.5), is that in Table 14 the accelerating impact of the CS appears to be driven by non-intermediate goods rather than intermediates.

This however does not exlcude that also for intermediates a higher CS (measured at the firm level) implied an accelerated reaction during the trade collapse. Table 2.15 shows the results from reestimating the specifications in Table 2.14 on the subsample of intermediates. The sign pattern in columns (2) and (4) is consistent with the hypothesis that higher CS intermediates underwent a larger adjustment, even though results are statistically significant at the conventional levels only for the CS measure in terms of firms' sales (Panel B)[118].

Table 2.15: The CS as a Catalyst - Firm level measures- Intermediates

	(1)	(2)	(3)	(4)
	Mid-Point Growth Rates		Standard Growth Rates	
PANEL A: $CS^{\text{costs-firm}}$				
CS	-0.017	**-0.033**	-0.013	**-0.025**
	(0.014)	**(0.026)**	(0.018)	**(0.034)**
CS*Rec		**0.037**		**0.025**
		(0.029)		**(0.035)**
FEs	yes	yes	yes	yes
N	2478335	2478335	888694	888694
PANEL B: $CS^{\text{sales-firm}}$				
CS	-0.012'	**-0.033***	-0.079***	**-0.120****
	(0.008)	**(0.017)**	(0.026)	**(0.048)**
CS*Rec		**0.033***		**0.132****
		(0.017)		**(0.054)**
FEs	yes	yes	yes	yes
N	2477753	2477753	888607	888607

Note: Standard errors clustered at the firm level in parentheses;
' $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

[118] For the sake of brevity I omitted the tables showing the results for the quantity and the unit values of imports. These results are in line with what found in the other sections of this paper, and namely that quantity adjustments show very similar coefficients to value adjusments, and with unit-values being mostly insignificant.

6.1.7 Additional Tables the Chapter 2

Table 2.6B: The Cost-Share as a Catalyst - CS^{sales}.Only 06-07 for CS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rates				Standard Growth Rates (Log-change)			
PANEL A: Imports - values								
CS	-0.004	-0.003	-0.011	-0.006	-0.023*	-0.018	-0.045*	-0.030
	(0.005)	(0.004)	(0.073)	(0.006)	(0.013)	(0.014)	(0.026)	(0.022)
Int		0.033***		0.043***		0.009**		0.014**
		(0.005)		(0.006)		(0.004)		(0.006)
Int*CS		-0.004		**-0.022**		-0.014		**-0.046**
		(0.011)		**(0.019)**		(0.025)		**(0.041)**
CS*Rec			0.012	0.004			0.049	0.025
			(0.008)	(0.007)			(0.034)	(0.021)
Int*Rec				-0.025***				-0.013
				(0.007)				(0.009)
Int*CS*Rec				**0.040***				**0.072**
				(0.023)				**(0.048)**
PANEL B: Imports - quantity								
CS	-0.005	-0.004	-0.009	-0.006	-0.019*	-0.013	-0.039*	-0.022
	(0.005)	(0.005)	(0.007)	(0.006)	(0.010)	(0.010)	(0.020)	(0.018)
Int.		0.031***		0.039***		0.001		0.004
		(0.005)		(0.006)		(0.005)		(0.006)
Int*CS		-0.001		**-0.014**		-0.017		**-0.049**
		(0.011)		**(0.018)**		(0.021)		**(0.042)**
CS*Rec			0.008	-0.003			0.043	0.025
			(0.008)	(0.037)			(0.026)	(0.021)
Int*Rec				-0.024***				-0.013
				(0.007)				(0.009)
Int*CS*Rec				**0.032**				**0.072**
				(0.022)				**(0.048)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5269440	5269440	5269440	5269440	1739618	1739618	1739618	1739618

Note: Standard errors clustered at the firm level in parentheses;
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.7B: Firm affiliation and cost-share - CS^{sales}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
PANEL A: Imports - values								
IF	-0.012	-0.007	0.008	0.010	-0.013	-0.007	-0.007	-0.016
	(0.022)	(0.024)	(0.029)	(0.030)	(0.010)	(0.012)	(0.013)	(0.016)
CS	-0.008***	-0.008***	-0.008***	-0.008***	-0.004**	-0.003*	-0.004	-0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)
IF*CS	0.007	0.008	**-0.056**	-0.014	-0.058	-0.051	**-0.207****	-0.075
	(0.006)	(0.017)	**(0.072)**	(0.060)	(0.052)	(0.054)	**(0.103)**	(0.073)
Int		0.029***		0.035***		0.008**		0.009
		(0.004)		(0.005)		(0.004)		(0.006)
Int*IF		-0.011		-0.007		-0.013		0.015
		(0.018)		(0.024)		(0.010)		(0.015)
Int*CS		-0.015		**-0.064****		-0.081**		**-0.160*****
		(0.015)		**(0.025)**		(0.019)		**(0.043)**
Int*CS*IF		0.012		-0.072		0.057		-0.206
		(0.059)		(0.079)		(0.086)		(0.161)
IF*Rec			-0.048	-0.042			-0.016	0.025
			(0.033)	(0.036)			(0.021)	(0.024)
CS*Rec			0.001	0.000			-0.001	-0.004
			(0.002)	(0.002)			(0.008)	(0.008)
IF*CS*Rec			**0.076**	0.025			**0.443****	0.088
			(0.070)	(0.053)			**(0.172)**	(0.115)
Int*Rec				-0.015*				-0.001
				(0.008)				(0.010)
Int*IF*Rec				-0.011				-0.069***
				(0.025)				(0.022)
Int*CS*Rec				**0.096*****				**0.265*****
				(0.045)				**(0.070)**
Int*CS*IF*Rec				0.206**				0.511**
				(0.101)				(0.250)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5388408	5388408	5388408	5388408	1753520	1753520	1753520	1753520

Note: Standard errors clustered at the firm level in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.8B: Intra-firm versus arm's length trade. Quantity and Unit-Values.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
PANEL A: Import Quantities								
IF	-0.003	-0.005	0.018	0.024	-0.000	0.008	0.001	-0.003
	(0.022)	(0.0234)	(0.029)	(0.030)	(0.011)	(0.013)	(0.013)	(0.017)
Int		0.020***		0.017***		0.001		-0.004
		(0.004)		(0.005)		(0.005)		(0.007)
IF*Int		-0.018		-0.013		-0.017		0.007
		(0.018)		(0.023)		(0.012)		(0.015)
IF*Rec			-0.053	-0.048			-0.004	0.030
			(0.034)	(0.035)			(0.021)	(0.024)
Int* Rec				0.005				0.010
				(0.008)				(0.011)
IF*Int*Rec				-0.011				-0.062***
				(0.022)				(0.022)
PANEL B: Imports - Unit Values								
IF	-0.008	-0.003	0.011	0.016	-0.014**	-0.017*	-0.013	-0.017*
	(0.021)	(0.022)	(0.028)	(0.029)	(0.006)	(0.009)	(0.008)	(0.010)
Int		0.026***		0.027***		0.007**		0.009*
		(0.004)		(0.005)		(0.003)		(0.005)
IF*Int		-0.012		-0.011		0.006		0.006
		(0.015)		(0.022)		(0.008)		(0.009)
IF*Rec			-0.049	-0.047			-0.000	0.000
			(0.033)	(0.035)			(0.012)	(0.013)
Int*Rec				-0.001				-0.003
				(0.008)				(0.006)
IF*Int*Rec				-0.004				-0.001
				(0.025)				(0.014)
FEs.	yes	yes	yes	yes	yes	yes	yes	yes
N	5672551	5672551	5672551	5672551	1784484	1784484	1784484	1784484

Note: Standard errors clustered at the firm level; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.10B: Frequency of shipments - Inventory adjustment. Firm affiliation and CS^{sales}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
IF	0.024	0.006	0.011	0.011	-0.001	0.004	0.001	0.002
	(0.058)	(0.008)	(0.007)	(0.010)	(0.005)	(0.006)	(0.001)	(0.007)
CS	-0.003***	-0.003***	-0.003***	-0.003***	-0.001***	-0.001***	-0.003***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
IF*CS	-0.003	0.003	**-0.045**	0.003	-0.056*	-0.029	**-0.087**	**-0.049**
	(0.015)	(0.011)	**(0.035)**	(0.025)	(0.032)	(0.022)	**(0.058)**	**(0.039)**
Int		0.023***		0.031***		0.009*		0.008**
		(0.003)		(0.003)		(0.002)		(0.003)
Int*IF		0.003		-0.001		-0.004		-0.003
		(0.009)		(0.011)		(0.005)		(0.006)
Int*CS		0.002		**-0.050***		-0.049		**-0.057***
		(0.015)		**(0.026)**		(0.030)		**(0.031)**
Int*CS*IF		-0.054		-0.103		-0.051		-0.102***
		(0.037)		(0.065)		(0.047)		(0.049)
IF*Rec			-0.022	-0.026			-0.005	-0.004
			(0.016)	(0.020)			(0.088)	(0.011)
CS*Rec			0.001	-0.000			0.004**	-0.004***
			(0.001)	(0.000)			(0.001)	(0.001)
IF*CS*Rec			**0.049**	-0.001			**0.066**	0.046
			(0.031)	(0.026)			**(0.058)**	(0.047)
Int*Rec				-0.021***				-0.004
				(0.006)				(0.005)
Int*IF*Rec				0.009				-0.001
				(0.015)				(0.009)
Int*CS*Rec				**0.111*** **				**0.016**
				(0.042)				**(0.012)**
Int*CS*IF*Rec				**0.103**				0.085*
				(0.087)				(0.046)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5309737	5309737	5309737	5309737	837032	837032	837032	837032

Note: Standard errors clustered at the firm level in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

6.2 Appendix to Chapter 3

6.2.1 Solutions to the Free Entry Conditions

Here I provide the solutions to the integration of the expressions for expected profits for the closed and the open economy.

Free Entry Condition in the Closed Economy - (34)

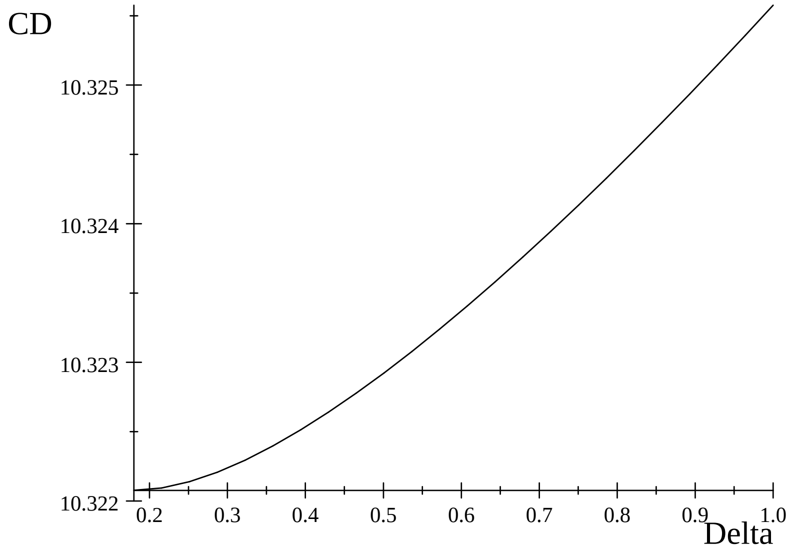
$$\frac{L}{2\gamma c_m^2}\left(\frac{\varphi^2}{2}\left(c_D-2\sqrt{\delta f_I\frac{\gamma}{L}}\right)^2+c_D\omega\left(c_D-2\sqrt{\delta f_I\frac{\gamma}{L}}\right)^2-\frac{2}{3}\omega\left(c_D-2\sqrt{\delta f_I\frac{\gamma}{L}}\right)^3\right)$$
$$-\frac{L}{2\gamma c_m^2}\left(\frac{c_D^2}{2}+\frac{1}{4}+\frac{\omega^2}{2}-\frac{2}{3}c_D+c_D\omega-\frac{2}{3}\omega\right)-\frac{L}{2\gamma c_m^2}\left(\frac{c_D^2}{2}+\frac{1}{4}-\frac{2}{3}c_D\right)$$
$$-f_I\frac{1}{c_m^2}\left(c_D-2\sqrt{\delta f_I\frac{\gamma}{L}}\right)^2+f_I\frac{1}{c_m^2}+\frac{L}{\gamma c_m^2}\frac{1}{12}c_D^4=f_E$$

Free Entry Condition in the Open Economy - (54)

$$\frac{L}{2\gamma c_m^2}\left(\begin{array}{c}\frac{c_D^2}{2}\left(\frac{1}{t}\left(c_D+\omega\right)\right)^2+\frac{t}{4}\left(\frac{1}{t}\left(c_D+\omega\right)\right)^4+\frac{\omega^2}{2}\left(\frac{1}{t}\left(c_D+\omega\right)\right)^2\\-\frac{2}{3}c_Dt\left(\frac{1}{t}\left(c_D+\omega\right)\right)^3+c_D\omega t\left(\frac{1}{t}\left(c_D+\omega\right)\right)^2-\frac{2}{3}t\omega\left(\frac{1}{t}\left(c_D+\omega\right)\right)^3\end{array}\right)$$
$$-\frac{L}{2\gamma c_m^2}\left(\frac{c_D^2}{2}+\frac{1}{4}+\frac{\omega^2}{2}-\frac{2}{3}c_D+c_D\omega-\frac{2}{3}\omega\right)$$
$$-\frac{L}{2\gamma c_m^2}\left(\frac{c_D^2}{2}+\frac{t}{4}+\frac{\omega^2}{2}-\frac{2}{3}c_Dt+c_Dt\omega-\frac{2}{3}t\omega\right)-\frac{L}{2\gamma c_m^2}\left(\frac{c_D^2}{2}+\frac{1}{4}-\frac{2}{3}c_D\right)+f_I\frac{1}{c_m^2}$$
$$+\frac{L}{2\gamma c_m^2}\left(\frac{\omega^2}{2}\left(c_D-2\sqrt{\delta f_I\frac{\gamma}{L}}\right)^2+c_D\omega\left(c_D-2\sqrt{\delta f_I\frac{\gamma}{L}}\right)^2-\frac{2}{3}\omega\left(c_D-2\sqrt{\delta f_I\frac{\gamma}{L}}\right)^3\right)$$
$$-f_I\frac{1}{c_m^2}\left(c_D-2\sqrt{\delta f_I\frac{\gamma}{L}}\right)^2+\frac{L}{\gamma c_m^2}\frac{1}{12}c_D^4=f_E$$

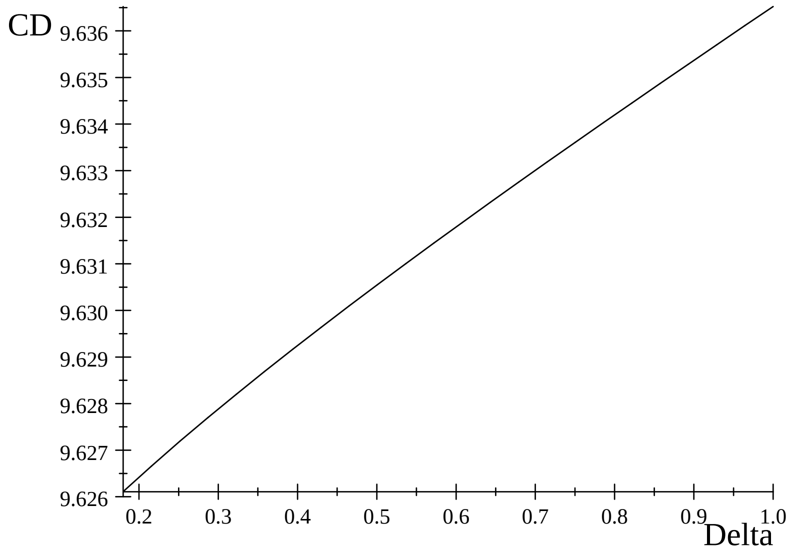
The solutions to (34) and (54) presented here need then to be solved for c_D. This last step was peformed with the help of Scientific Workplace: unfortunately the solutions are too lenghty for me to be able to include them in this thesis. Numerical simulations were therefore performed to obtain the results exposed in Chapter 3.

Figure 3.6: Closed economy FEC as a function of delta.



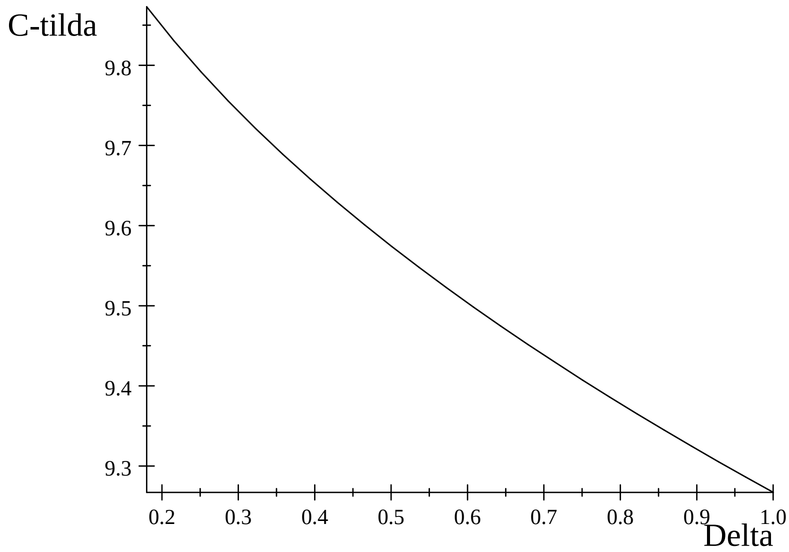
Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$.

Figure 3.7: Open Economy FEC as a function of delta.



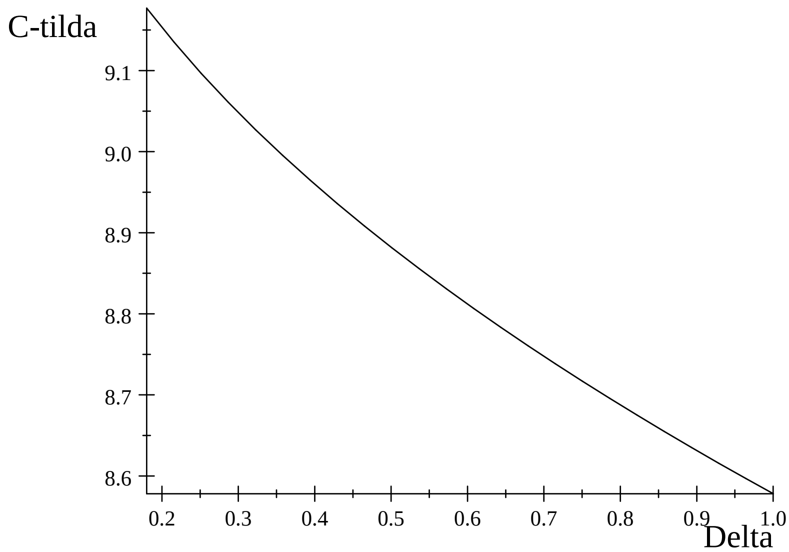
Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$, $t = 1.14$.

Figure 3.8: Closed economy $\tilde{c}$ as a function of delta.



Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$.

Figure 3.9: Open Economy $\tilde{c}$ as a function of delta.



Parameter values: $L = 1000$, $\gamma = 0.7$, $\omega = 0.7$, $c_m = 40$, $f_E = 900$, $f_I = 400$, $t = 1.14$.

6.2.2 Reverse ranking

As mentioned in section 2.3.4 of Part II, the model in this chapter can accommodate both the ranking of producers that I assumed and the reverse ranking assumed by Bustos (2011). In other words, it makes no qualitative difference for the main predictions of my framework, whether selection into innovation happens at a lower productivity level relative to the decision to enter exporting, or viceversa.

However, some of the conditions derived in chapter 2 would change. If the innovation decision concerns firms that have already selected themselves into exporting at a lower productivity level, the industry would be populated by domestic producers, exporters non-innovators and innovators-exporters. This implies that conditions (42), stating that $c_D > c_I > c_X > \tilde{c}$ would have to be re-written as:

$$c_D > c_X > c_I > \tilde{c} \tag{86}$$

Condition (86) implies that the open economy version of my model would have to change to accommodate the fact that now there are going to be two types of exporters: non-innovators and innovators. Optimal profits would become:

$$\pi(c_i)^*_{X,NI} = \frac{L}{4\gamma}(c_D - c_i)^2 + \frac{L^f}{4\gamma}(c_F - c_i\tau)^2 \tag{87}$$

$$\pi(c_i)^*_{X,INN} = \frac{L}{4\gamma}(c_D - c_i + \omega)^2 + \frac{L^f}{4\gamma}(c_F - c_i\tau + \omega)^2 - f_I \tag{88}$$

(87) is identical to the expression for exporter's profit in the original Melitz-Ottaviano (2008) model, whereas profits for innovators-exporters remain unchanged with respect to those derived in Section 3.

Reversing the cutoff ranking also implies that there will no innovator among domestic producers, or else, that all innovators are also exporters. All this requires deriving new expressions for the exporting and the innovation cutoffs:

$$\pi(c_i)^*_{D,NI} = \pi(c_i)^*_{X,NI} \quad \rightarrow \quad c_X^{rev} = \frac{1}{\tau}(c_D) \tag{89}$$

$$\pi(c_i)^*_{X,NI} = \pi(c_i)^*_{X,INN} \quad \rightarrow \quad c_I^{rev} = \frac{1}{1+\tau}\left(2c_D + \omega - \frac{2\gamma f_I}{L\omega}\right) \tag{90}$$

The exporting cutoff c_X^{rev} becomes identical to the Melitz-Ottaviano threshold to access exporting, since now innovation is only selective at the top of the productivity distribution.

The liquidity constraint cutoff $\tilde{c}$ remains the same an in Section 3, since this depends on the profit functions relative to the 1st period over which the model works (which remain unchanged).

$$\tilde{c}^{rev} = c_D - 2\sqrt{\delta f_I \frac{\gamma}{L}} \tag{91}$$

After having derived the cutoffs for the case where the marginal exporter is less productive than the marginal innovator, I need to re-state the conditions that ensure that the reverse cutoff ranking (86) holds.

Exporting is going to be selective as long as $\tau > 1$, hence this is enough for $c_D > c_X$.

For the threshold to access exporting to be higher than the thereshold to access innovation (and assuming the liquidity constraint is binding, i.e. $c_I > \tilde{c}$), the following condition needs to hold:

$$c_X^{rev} > \tilde{c}^{rev} \quad iff \quad f_I > \frac{L}{4\gamma\delta\tau^2}\left[c_D(1-\tau)\right]^2 \tag{92}$$

Condition (92) is similar to (51) in chapter 2, but of course the inequality is reversed.

Finally, for the liquidity constraint to be binding and the industry to have some fimrs that successfully export but did not generate enough liquidity in the first period for them to be able to also access innovation, the following condition needs to hold:

$$f_I < \frac{L\varphi}{2\gamma}\left(c_D(1-\tau) + \omega\delta\left(1 + \frac{1}{\delta} + 2\tau + \tau^2 + (1+\tau)\frac{\omega^2}{\delta}\sqrt{\frac{\delta}{\omega^4}\left(\frac{2c_D\,(1-\tau)}{\omega} + 2 + \delta(1+\tau^2+2\tau)\right)}\right)\right) \tag{93}$$

With the expressions for the exporting and the liquidity constraint at hand, and assuming conditions (92) and (93) are both satisfied, expected profits can be written as:

$$\int_1^{\tilde{c}} \pi(c_i)^*_{X,INN,t_2} + \pi(c_i)^*_{D,NI,t_1} dG(c) + \int_{\tilde{c}}^{c_X} \pi(c_i)^*_{X,NI,t_2} + \pi(c_i)^*_{D,NI,t_1} dG(c)$$
$$+ \int_{c_X}^{c_D} \pi(c_i)^*_{NI,t_2} + \pi(c_i)^*_{NI,t_1} dG(c) \tag{94}$$

Setting (94) equal to sunk entry cost f_E defines the Free Entry Condition in the open economy with the reverse cutoff ranking. This can finally be solved for the entry threshold c_D, which summarises the toughness of the competitive environment and all the other conditions that derive from that.

6.3 Appendix to Chapter 4

Table 4.6B: Disentangling the reduction in financing and the competition effects - Instrumenting Markup

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Innovation					Exporting				
					Boot. SE					Boot. SE
INN_{t-1}	0.430***	0.310***	0.383**	0.284***	0.310*					
	(0.165)	(0.114)	(0.151)	(0.107)	(0.177)					
EXP_{t-1}						0.248	0.283	0.374**	0.570**	0.283
						(0.236)	(0.234)	(0.174)	(0.236)	(0.239)
LN*Crisis	**-0.059*** **	**-0.058*** **	**-0.062*** **	**-0.061*** **	**-0.058** **	**0.038+**	**0.037+**	**0.031**	**0.029**	**0.037**
	(0.019)	**(0.020)**	**(0.018)**	**(0.019)**	**(0.027)**	**(0.028)**	**(0.029)**	**(0.029)**	**(0.034)**	**(0.030)**
Markup III	0.028	0.027			0.027	0.021	0.021			0.021
	(0.025)	(0.029)			(0.031)	(0.018)	(0.019)			(0.020)
Ln(Markup III)			0.096	0.065				0.228	0.367	
			(0.081)	(0.055)				(0.288)	(0.313)	
Cash-Flow		0.007		0.007	0.007		0.002		0.018	0.002
		(0.008)		(0.009)	(0.009)		(0.002)		(0.028)	(0.004)
Cash-$Flow_{t-1}$		0.447*		0.454*	0.447'		-0.165**		-0.559	-0.165'
		(0.244)		(0.241)	(0.305)		(0.075)		(0.456)	(0.107)
$\triangle$Cash-Stock		-0.00042**		-0.00045**	-0.00042**		-0.00002		0.00001	-0.00002
		(0.00017)		(0.00017)	(0.00019)		(0.00002)		(0.00002)	(0.00002)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	7009	6984	6933	6908	6984	7010	6985	6967	6942	6984
Hansen-J test (p)	0.542	0.855	0.613	0.853		0.711	0.832	0.822	0.931	
AR(2) test (p)	0.027	0.023	0.032	0.031		0.295	0.182	0.018	0.110	
AR(3) test (p)	0.697	0.747	0.691	0.733		0.633	0.429	0.918	0.526	
N GMM Instr.	100	132	99	131	132	102	134	101	133	134

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01

Table 4.7B: Further hypothesis - Impact on Innovation and Exporting - Instrumenting Markup

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Innovation Adding Instrumented Markup				**Exporting** Adding Instrumented Markup			
INN$_{t-1}$	0.311***	0.330***	0.187**	0.165**	0.010	0.176	0.031'	0.215*
	(0.083)	(0.073)	(0.091)	(0.083)	(0.022)	(0.271)	(0.019)	(0.130)
LN*Crisis	**-0.037***	**-0.044****	**-0.027**	**-0.028+**	**0.038+**	**0.052***	**0.043**	**0.079***
	(0.022)	**(0.022)**	**(0.027)**	**(0.019)**	**(0.028)**	**(0.030)**	**(0.038)**	**(0.036)**
EXP$_{t-1}$	0.289***	0.301**	0.257*	0.259**	0.278	0.498**	0.592***	0.581***
	(0.132)	(0.125)	(0.133)	(0.132)	(0.235)	(0.237)	(0.203)	(0.179)
R&D$_{t-2}$			0.279***	0.287**			0.877	0.079
			(0.138)	(0.136)			(1.090)	(0.822)
Markup III	0.015		0.013		0.012		0.038	
	(0.020)		(0.018)		(0.010)		(0.031)	
Ln(Markup III)		0.061		0.137'		0.169		0.091
		(0.065)		(0.087)		(0.161)		(0.101)
Cash-Flow	0.011+	0.012'	0.016**	0.002	0.002	-0.013	-0.001	-0.000
	(0.008)	(0.008)	(0.007)	(0.002)	(0.002)	(0.015)	(0.002)	(0.004)
Cash-Flow$_{t-1}$	0.415'	0.556**	0.503*	-0.025+	-0.171**	-0.089	-0.107	-0.090
	(0.256)	(0.023)	(0.258)	(0.018)	(0.074)	(0.083)	(0.135)	(0.113)
△Cash-Stock	-0.00044***	-0.00047***	-0.00054***	-0.00081**	-0.00016	-0.00001	-0.00002	0.000001
	(0.00014)	(0.00015)	(0.00014)	(0.00035)	(0.00002)	(0.000016)	(0.000018)	(0.00002)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes
N	6984	6908	3600	3563	6985	6974	3600	3596
Hansen-J test (p)	0.492	0.457	0.776	0.756	0.413	0.497	0.522	0.537
AR(2) test (p)	0.006	0.004	0.042	0.005	0.191	0.036	0.145	0.120
AR(3) test (p)	0.681	0.667	0.501	0.474	0.425	0.254	0.292	0.289
N GMM Instr.	145	144	136	136	143	142	137	137

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01

Table 4.9B: Effects by Quartile of the Distribution - Innovation and Exporting - Intrumented Markup

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Innovation					**Exporting**				
	Bustos	ACF-r	LP-r	ACF-a	LP-a	Bustos	ACF-r	LP-r	ACF-a	LP-a
INN_{t-1}	0.161**	0.282***	0.285**	0.352***	0.377***					
	(0.079)	(0.094)	(0.074)	(0.101)	(0.123)					
EXP_{t-1}						0.237**	0.549***	0.447**	0.541***	0.442***
						(0.115)	(0.135)	(0.184)	(0.162)	(0.101)
LN*Crisis* 1st Q	-0.039	-0.014	-0.052***	-0.021’	-0.035’	0.056	0.000	0.051+	-0.003’	0.026
	(0.044)	(0.033)	(0.014)	(0.013)	(0.022)	(0.054)	(0.018)	(0.035)	(0.019)	(0.030)
LN*Crisis* 2nd Q	**-0.164*** **	-0.023	**-0.104** **	**-0.124***	**-0.199***	0.005	0.087’	**0.055**	0.005	**0.078**
	(0.038)	(0.030)	**(0.043)**	**(0.070)**	**(0.112)**	(0.037)	(0.057)	**(0.073)**	(0.039)	**(0.098)**
LN*Crisis* 3rd Q	-0.036	**-0.135*** **	-0.002	-0.009	0.042	**0.105***	**0.075**	0.014	**0.055**	0.039
	(0.035)	**(0.031)**	(0.040)	(0.020)	(0.061)	**(0.063)**	**(0.072)**	(0.026)	**(0.059)**	(0.057)
LN*Crisis* 4th Q	-0.031+	-0.081’	-0.087’	-0.099**	-0.069	0.039+	0.089’	0.081	0.094	-0.028
	(0.023)	(0.053)	(0.057)	(0.048)	(0.081)	(0.029)	(0.061)	(0.077)	(0.075)	(0.024)
Ln(Mar. III)* 1st Q	-0.039	0.131	0.248***	0.046*	0.174’	-0.182*	-0.142*	-0.143+	-0.014	0.071’
	(0.037)	(0.112)	(0.092)	(0.027)	(0.120)	(0.094)	(0.082)	(0.101)	(0.091)	(0.051)
Ln(Mar. III)* 2nd Q	0.116	0.067	0.320	0.161*	0.152*	0.043	0.194	0.197	0.465**	0.110’
	(0.092)	(0.342)	(0.304)	(0.093)	(0.087)	(0.352)	(0.377)	(0.245)	(0.189)	(0.069)
Ln(Mar. III)* 3rd Q	0.153**	0.133	0.039	0.135+	0.095	0.882*	-0.108	-0.036	-0.442	0.090’
	(0.065)	(0.482)	(0.447)	(0.103)	(0.100)	(0.463)	(0.260)	(0.425)	(0.490)	(0.064)
Ln(Mar. III)* 4th Q	0.168**	0.052	0.410’	0.073	0.125***	0.088	0.211	0.185	0.254	0.121
	(0.080)	(0.244)	(0.265)	(0.120)	(0.042)	(0.279)	(0.193)	(0.296)	(0.282)	(0.112)
IF controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Ind. Trends	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	6906	6908	6933	6908	6933	6941	6908	6966	6908	6966
Hansen-J test (p)	0.818	0.855	0.769	0.782	0.704	0.521	0.513	0.476	0.673	0.756
AR(2) test (p)	0.109	0.023	0.021	0.005	0.019	0.195	0.020	0.002	0.055	0.008
AR(3) test (p)	0.819	0.740	0.673	0.751	0.199	0.330	0.196	0.646	0.760	0.672
N GMM Instr.	171	166	171	163	171	169	168	168	169	168

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ’ p<0.15, * p<0.10, ** p<0.05, *** p<0.01

Table 4.13: Main results by exploiting the **median** LN - Innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Innovation				
	OLS	FE	GMM-SYS	OLS	FE	GMM-SYS	GMM-SYS	GMM-SYS	GMM-SYS
					Adding Markup			Instrumenting Markup	
INN_{t-1}	0.386***	-0.109***	0.245**	0.383***	0.310*	0.251***	0.258**	0.276***	0.281**
	(0.023)	(0.021)	(0.114)	(0.023)	(0.177)	(0.0952)	(0.113)	(0.104)	(0.115)
LN*Crisis	**-0.078***	**-0.049+**	**-0.107'**	**-0.073***	**-0.058****	**-0.075'**	**-0.083****	**-0.102****	**-0.091'**
	(0.042)	**(0.036)**	**(0.069)**	**(0.040)**	**(0.027)**	**(0.051)**	**(0.039)**	**(0.049)**	**(0.05)**
Markup III							0.036+		0.026+
							(0.026)		(0.018)
Ln(Markup III)				0.018	0.131	0.424**		0.044	
				(0.020)	(0.111)	(0.216)		(0.154)	
Cash-Flow	0.017***	0.014***	0.008	0.017***	0.014***	0.007	0.006	0.004	0.007
	(0.004)	(0.004)	(0.008)	(0.005)	(0.037)	(0.007)	(0.007)	(0.008)	(0.008)
Cash-$Flow_{t-1}$	0.040	0.099*	0.547*	0.079*	0.102*	-0.002	-0.227	0.306+	0.433*
	(0.041)	(0.057)	(0.282)	(0.044)	(0.059)	(0.320)	(0.422)	(0.221)	(0.240)
△Cash-Stock	-0.00006'	-0.00002	-0.00044***	-0.00	-0.00042**	-0.00091*	-0.00079*	-0.00094**	-0.00043**
	(0.00004)	(0.00004)	(0.00016)	(0.00017)	(0.00019)	(0.00047)	(0.00042)	(0.00042)	(0.00017)
Firm FE	no	yes	yes	no	yes	yes	yes	yes	yes
Ind. Trends.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	7211	7211	7211	6941	6908	6941	6984	6908	6984
Hansen-J test (p)			0.413			0.351	0.396	0.484	0.435
AR(2) test (p)			0.038			0.047	0.075	0.052	0.034
AR(3) test (p)			0.987			0.738	0.709	0.690	0.731
N GMM Instr.			127			123	124	136	137

Note: Robust S.E. clustered at the sector level in parenthesis, + $p<0.20$, ' $p<0.15$, * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Table 4.14: Main results by exploiting the **median** LN - Exporting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Exporting				
	OLS	FE	GMM-SYS	OLS	FE	GMM-SYS	GMM-SYS	GMM-SYS	GMM-SYS
					Adding Markup			Instrumenting Markup	
EXP_{t-1}	0.651***	-0.027	0.491**	0.648***	-0.027	0.423***	0.622**	0.590***	0.274
	(0.024)	(0.025)	(0.224)	(0.023)	(0.025)	(0.250)	(0.182)	(0.224)	(0.233)
LN*Crisis	**0.117*** **	**0.049***	**0.115*** **	**0.119*** **	**0.036**	**0.018**	**0.101**	**-0.045**	**0.044**
	(0.031)	**(0.027)**	**(0.035)**	**(0.025)**	**(0.029)**	**(0.091)**	**(0.088)**	**(0.123)**	**(0.091)**
Markup III							0.386**		0.032
							(0.153)		(0.025)
Ln(Markup III)				0.014	0.032	2.053+		0.397+	
				(0.015)	(0.058)	(1.571)		(0.302)	
Cash-Flow	0.001	0.001	0.000	0.001	0.001	-0.024*	-0.001	-0.001	0.003
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.013)	(0.002)	(0.020)	(0.002)
Cash-Flow_{t-1}	-0.020	-0.067**	-0.043	-0.019	-0.069**	0.0316	-0.126**	0.215	-0.172**
	(0.001)	(0.002)	(0.001)	(0.064)	(0.029)	(0.063)	(0.059)	(0.260)	(0.240)
$\triangle$Cash-Stock	-0.00001***	-0.00001	-0.00001+	-0.00001***	-0.00001	0.00001	-0.00001	-0.00001	-0.00001
	(0.00000)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Firm FE	no	yes	yes	no	yes	yes	yes	yes	yes
Ind. Trends.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	7211	7211	7211	6941	6908	6941	6984	6974	6985
Hansen-J test (p)			0.213			0.251	0.257	0.242	0.187
AR(2) test (p)			0.015			0.018	0.014	0.014	0.022
AR(3) test (p)			0.181			0.501	0.322	0.630	0.441
N GMM Instr.			128			124	125	132	133

Note: Robust S.E. clustered at the sector level in parenthesis, + p<0.20, ' p<0.15, * p<0.10, ** p<0.05, *** p<0.01