Trade and Economic Development in Global Value Chains: Insights from Input-Output Analysis and Customs Transaction Level Data

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I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree.
This is a thesis in papers style, and Chapter 3 of this thesis is co-authored with my supervisor Prof. Maria Savona; I wish to acknowledge her contribution in drafting the introduction and conclusion of the Chapter. The Hirschman-Linder hypothesis has been put forward in previous work by Prof. Savona, as properly cited in the Capter 3 of this thesis; however the expansion of this conjecture to natural resource industries and the empirical testing of it is the outcome of my work for this thesis.

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Table of Contents

List of Tables

Tables in the Appendix:

Table of Figures

Figures in the Appendix:

Thesis summary

The thesis explores how the fragmentation of production and the subsequent emergence of Global Value Chains (GVCs) have changed countries' and firms' chances to benefit from international trade and attain economic development.

In the first Chapter we use inter-country input-output (ICIO) tables from the OECD and WTO to revisit the role of trade specialisation taking a value added, rather than gross export, approach that allows to identify countries' domestic contribution to trade specialisation and export performance. I explore these issues implementing the generalised method of moments (GMM) to estimate an autoregressive model. In doing this, we contribute to the literature on trade in value added, as well as on structural change and the role of manufacturing for economic growth.

We find that natural resources are not, unsurprisingly, a beneficial specialisation pattern. Specialisation in manufacturing has a different effect depending on the technology level; low-tech manufacturing seems to exert a negative effect on countries trade performance. In contrast, high-tech manufacturing and knowledge intensive business services (KIBS) do not have strong negative effects in the long run, while we detect a positive effect during the years of the crisis.

The second paper explores a related issue, focusing in particular on the relationship between domestic backward linkages and export in value added. Taking stock on the findings of the first paper, with natural resources as a detrimental specialisation pattern, we assess whether backward linkages emanating from this sector can spur export in other sectors, namely high-tech manufacturing and KIBS. We use the same data as the first Chapter and also implement a system GMM, finding that a large intermediate domestic demand from the natural resource sector has a positive effect on the export of domestic value added of both KIBS and high-tech manufacturing. These results are strong and significant both for the mining and the agriculture sectors. One of the main policy implications of these results is that countries with a large endowment in natural resources can foster domestic backward linkages to pursue export diversification.

Finally, the third Chapter studies the linkages in GVCs at the buyer-supplier level exploring how buyer supplier relationships can affect exporters capabilities in Colombia. We combine three datasets: one with information on buyer-suppliers matches, from the Colombian Customs, a second dataset with the financial statement of the exporters and a third one the complexity of the traded products computed by the Atlas of Complexity compiled by Harvard University. We then construct measures of market power and buyer-supplier dependence to study how these are related to the complexity of each relationship and the capabilities of the Colombian exporters. In line with the growing literature on trade and firm heterogeneity, we find that complex buyers tend to engage with complex suppliers, trading a larger number of products than less complex buyer-supplier pairs.

Moreover, we find that the buyer's market power and the buyer-supplier mutual dependence are associated with a higher complexity of the products traded, suggesting that large buyers in intense relationship tend to favour suppliers' efforts for product upgrading. These results lend support to the well-established literature on GVCs, confirming that power relationships are related to exporters' performance, especially in terms of sophistication. We contribute to this literature by offering a quantitative approach that relies on administrative data, rather than surveys and distinguishes different kinds of power, based on its source; within this framework we show that different kinds of power are associated with different export outcomes.

1. Introduction

One of the most salient consequences of globalisation is the fragmentation of production across countries and the emergence of global value chains (GVCs): this has led to a significant share of countries' exports consisting of imported inputs (OECD 2013a; Baldwin 2012).

It has been argued that a key factor in shaping countries' economic performance is not whether GVC integration is beneficial (or not) *per se*, but rather the way in which countries (and firms) enter GVCs (Kaplinsky 2004; Mcmillan et al. 2014; Baldwin & Lopez-Gonzalez 2015).

On the one hand, at the macro level the mode of insertion in GVCs will depend on the relationship between domestic production and export dynamics, which has become less straightforward: the divide between the two has in fact widened as countries' exports are increasingly the outcome of production activities happening in other countries (Baldwin 2011).

Therefore, it becomes necessary to reappraise this relationship and to establish whether differences in countries' productive structure are a determinant of countries' overall performance in GVCs and the sectors in which they are more likely to participate.

On the other hand, at the micro level there is now a large body of evidence emphasising the importance of power relationships within GVCs, leading to different kinds of governance and economic outcomes (Gereffi et al. 2005; Humphrey and Schmitz 2002). However, the scholarship has not so far put forward a measurable and comparable understanding of the concept of power and its relationship with firms' ability to improve their position in GVCs.

So it seems that countries' domestic features, their productive structure in particular, and the characteristics of the specific GVCs segment being entered are important factors to be studied in assessing the benefits of GVC participation. This thesis explores this overarching issue at different levels of analysis.

Value chains represent all the activities involved to bring a product or service from conception, through production to delivery to final consumers (Kaplinsky and Morris 2000). Since the late 1980s, trade liberalisation and the ICT revolution have reduced not only the costs of transport and communication, but have also made coordination of the different productive activities much easier and cheaper (Baldwin 2012). This has led to the increasing fragmentation of production across countries, making value chains global (Gereffi 1994).

Now that production is fragmented across countries, it has been argued that it is no longer necessary to develop the full set of capabilities and technology necessary to produce a particular good; these may now very well come from abroad through the import of intermediates and technology (Baldwin 2011). The main implication of this is that countries no longer specialise in a sector as a whole, but in part of its value chain (Baldwin 2012).

This has sparked some optimism with respect to the potential for new specialisation paths for countries (OECD 2013b). Developing economies can achieve these by entering GVC segments based on their factor endowments, and then upgrade to more value added intensive activities within the chain.

According to this view, GVCs would therefore provide countries with the opportunity to diversify their productive structure.

Structural change, i.e. long-term shifts in the composition of countries' economic activity and the relative importance of sectors, has been a central topic of the literature on economic development for decades (Bah 2011; Imbs and Wacziarg 2003). While it is widely recognised that changes in economies' structure are tightly linked to economic growth, we also know that these patterns have been heterogeneous across countries with different outcomes (de Vries et al. 2017; Timmer et al. 2014).

The literature around countries' specialisation trajectory has often discussed export specialisation as an expression of the underlying productive structure (Hausmann and Klinger 2006; Hausmann et al. 2007; Hidalgo et al. 2007).

The international fragmentation of production has changed this. By joining GVCs, countries can now develop an export specialisation in a given sector, without experiencing changes of the same magnitude in their domestic productive structure. This is because much of what countries export can be the outcome of imported inputs produced abroad.

In line with this, and despite many countries joining GVCs over the past decade, we observe very diverse outcomes in developing countries. This suggests that the manner in which such GVC integration takes place is crucial for countries' development (Kaplinsky 2004; McMillan et al. 2014).

The relationship between GVC participation, structural change and, ultimately, economic development is in fact not straightforward. It is likely to be related to different aspects, both at the macro-, meso- and micro-level.

In this thesis we explore in particular the three following issues:

- First, at the macro-level, do different export specialisation trajectories impact countries' trade performance, in a GVC context? To answer this question, we revisit the link between countries' domestic productive structure, trade specialisation and performance in the context of the international fragmentation of production. We find that increasing specialisation in natural resources and low-tech manufacturing has a negative impact on countries' export performance, which we discuss in relation to the on-going debate around structural change and industrialisation.
- Second, as we find that specialisation in certain sectors, such as natural resources, can be detrimental to countries' economic performance, we explore another aspect of the relationship between domestic production structure and GVC participation. Focusing on countries with a specialisation in natural resources, we look at inter-sectoral backward linkages as a platform for the emergence of exports in new sectors. Specifically we test the following new conjecture: can the intermediated domestic demand of natural resource industries spur exports from both high-tech manufacturing and knowledge intensive business services?
- Third, GVCs take place at the micro-level in the form of buyer-supplier relationships in which power asymmetries may influence the possibilities for firms to introduce new, more sophisticated products. So, is power in buyer-supplier relationships associated with export sophistication and upgrading? We contribute to the literature on power in GVCs providing new quantitative evidence at the micro level.

The remainder of this section addresses these three questions in turn, highlighting the thesis's contribution through each paper, which constitutes a Chapter each.

1.1 Trade Specialisation in Global Value Chains.

GVCs have indeed made it easier to produce and/or export new products and services, but they have also led to a growing gap between a country's exports and its actual contribution, in value added terms, to the production process (Baldwin 2011). Crucially, opening the global economy has led countries to different productive trajectories, yielding widely different outcomes (McMillan et al. 2014).

Different specialisation patterns may have different growth potentials (Amable 2000; Matsuyama 1992) due to differences in income and price elasticities of the products exported (Thirlwall 1979; Cimoli et al. 2009) as well as endogenous structural change (Fagerberg 1988; Uchida and Cook 2005).

The scholarship has particularly emphasised the positive relationship between manufacturing and economic growth (Szirmai and Verspagen 2015; Szirmai 2012; Matsuyama 2008; Rodrik 2013).

There are, however, growing concerns around this view, in the current context. First, developing countries seem to be specialising away from manufacturing towards services at increasingly low income levels (Rodrik 2015). Second, Szirmai and Verspagen (2015) cast further doubt on whether manufacturing is still working as an engine of growth, proposing evidence that the relationship between manufacturing specialisation and economic growth has weakened in the last two decades and seems to be conditional on countries' human capital supply.

Unlike manufacturing, services are not usually considered to exert positive effects on economic growth, despite the fact that structural change towards this sector at high levels of income is an empirical regularity (Bah 2011; Rodrik 2016b).

However, as the fragmentation of production has expanded, including the off-shoring of services, decoupling provision and consumption of services, a growing literature has put forward several case studies showing that the off-shoring of service activities may be a new development avenue (Gereffi and Fernandez-Stark 2010; Fernandez-Stark and Gereffi 2011; Hernandez et al. 2014).

While the debate around manufacturing and services as an engine of growth has been on-going for a long time (Di Meglio et al. 2018; Szirmai 2012), much less is known on the dynamic, rather than static, effects of changes in the production structure of countries. de Vries et al. (2017) recently emphasised how developing countries have managed to move away from an agriculture-based economic structure towards services, which led to a one-off static gain but failed to trigger a long-term positive productivity dynamic.

A value added approach is particularly relevant to understanding the implications of structural change in light of the emergence of GVCs.

First, the gross exports (or output) of a country may consist of value added imported from other countries; this makes it harder to clearly appraise countries' domestic productive structure.

Second, value added produced by a given sector may be exported indirectly in the gross export of another sector, which again would give biased perception of countries' domestic productive structure. This is likely to be particularly true for business services that are often important in increasing other sectors' performance, providing crucial inputs to the production process (Guerrieri and Meliciani 2005; Meliciani and Savona 2014).

So, a first contribution of this thesis is to revisit the link between economic performance and specialisation, contributing to the debate on premature deindustrialisation and structural change towards services in a GVC framework.

Second, we also study dynamic, rather than static and one-off, effects of changes in countries' specialisation. In doing so, we also propose a new application for input-output measures to compute specialisation indexes.

We wish therefore to study whether the acceleration in different specialisations has different impacts on countries' export growth. In order to bring this to the data and fully account for the emergence of GVCs and the subsequent fragmentation of production, we use the OECD inter-country input-output (ICIO) tables for 64 countries and 33 sectors covering the period 1995-2011.

We trace value added embodied in countries' exports back to the originating sectors, and identify countries' own contribution to their gross exports, i.e. the domestic value added. We use this measure to also compute revealed comparative advantages with Balassa indexes in value added; these reflect, we argue, countries' domestic productive structure more accurately than their gross export homologues.

We perform our analysis with an autoregressive dynamic panel, using a system GMM to deal with potential endogeneity due to the simultaneous effects between trade specialisation and export performance.

We find that countries increasing their specialisation in low-tech manufacturing and natural resources experience a decrease in the domestic value added embodied in their exports. We detect a positive effect of increases in specialisation in both high-tech manufacturing and knowledge intensive services, although only during the crisis period.

The general implication of these results is that countries' production and export structure remain a determinant of their economic performance, and countries specialising in GVCs in different sectors will fare differently.

The Chapter provides a thorough discussion of these results in relation to the debate around premature deindustrialisation, and argues that specialising in low-tech manufacturing to then move onto high-tech activities may no longer be a viable option for developing countries.

Our results on the negative effect of an acceleration of the specialisation in natural resources on countries' export performance are consistent with a very large literature regarding developing countries with such a productive structure being bound to experience stagnant or low growth. The third chapter of this thesis contributes to this literature and specifically to the view of natural resources as an enclave sector hindering the emergence of other sectors.

2.2 Revisiting the Natural Resource "Curse" in the Context of Business Services Trade: Enclave or High-Development Backward Linkages?

A common way of referring to the empirical association between natural resource abundance and disappointing economic performance is the "natural resource curse", first put forward by Corden (1982).

Around this, a fierce debate has sparked in the literature with views both in favour of this view (Auty 1986, 1987; Sachs and Warner 1997; Venables 2016; Davis and Tilton 2008) and opposing it (Lederman and Maloney 2012; Wright and Czelusta 2004; Brunnschweiler and Bulte 2008; Bloch and Owusu 2012).

One of the crucial aspects of this debate is the link between abundance in natural resources and the potential for export diversification. This is again related to the structure of the domestic economy, and specifically inter-sectoral linkages originating from natural resource industries.

The notion of a specialisation in natural resources halting the development of other sectors and, ultimately, export diversification relies on two theoretical explanations.

First, a large natural resource sector would hinder other sectors through an appreciation in the exchange rate reducing competitiveness of other tradable (manufactured) products and draw investments away from non-NR intensive sectors (Corden 1984; Harding and Venables 2016; Venables 2016).

This view was first put forward based on the experience of the Netherlands after the discovery of a large endowment in natural gas that negatively impacted exports in other sectors, which is why this mechanism is often referred to as the Dutch disease.

Second, and more broadly, natural resource industries are often considered enclave sectors, with little to no inter-sectoral linkages with the rest of the economy (Heeks 1998; Matsuyama 1992; Vogel 1994). The importance of such linkages stems from Hirschman's (1958) seminal contribution on the importance of inter-sectoral linkages to provide input (forward) to and require output (backward) from other sectors.

In this view, the growth in a large sector, well connected with the rest of the economy through backward and forward linkages, would also lift other sectors, through an unbalanced development strategy.

More recently, and relatedly with this literature, Hausmann and Klinger (2006) and Hidalgo et al. (2007) have adopted a different approach to look at linkages between sectors. Instead of input-output flows, they use the probability of two products being exported by the same countries to proxy for similarity in capabilities requirements and create a product space. They find that not all products are equally connected to each other; they also conclude that natural resource sectors tend to produce low-complexity products that are unlikely to lead to the emergence of other industries.

Based on this approach, Hausmann et al. (2008) argue that forward linkages stemming from the natural resource sector would not be a suitable avenue for fostering export diversification towards downstream manufacturing activities in resource abundant countries.

Most of the literature has indeed focused on forward linkages from natural resource industries to the manufacturing sector, debating around the viability of resource based industrialisation as a development strategy for countries abundant in natural resources (Auty 1987; Roemer 1979; Massol and Banal-Estañol 2014; Morris et al. 2012).

The third chapter of this thesis contributes to this debate by exploring a different strategy, i.e. whether countries with a large endowment in natural resources could exploit backward linkages to foster the export of the knowledge intensive business services or high-tech manufacturing that provide domestic inputs for the extraction of natural resources.

Moreover we wish to test whether this potential effect is stronger for countries with a specialisation in natural resources. This is because, first, such countries would benefit from a way of exploiting their specialisation to foster exports in other sectors and specialise away from natural resource industries. Second, countries with a specialisation in natural resources are also more likely to have a large domestic intermediate demand stemming from this industry and thus be able to exploit this mechanism to a greater extent than other countries.

To test this set of hypotheses we implement an autoregressive panel analysis with the ICIO data from the OECD. Consistent with Chapter 2, our measures are computed in value added terms: this is to take into account the emergent GVCs and the issues discussed in the previous section, i.e. export specialisation based on value added (rather than gross exports) is more likely to represent the underlying domestic structure, and services often tend to be exported embodied in other manufactured products.

We find that backward linkages from the natural resource sector can indeed foster exports in knowledge intensive business services. We also test our main conjecture for the export of high-tech manufacturing, finding that in this case the positive effect of backward linkages from natural resource industries vanishes when we control for the productivity of this sector.

This suggests that relying on the sheer strength of backward linkages from natural resource industries may be a more promising strategy towards fostering exports in knowledge intensive business services rather than high-tech manufacturing.

Our findings contribute to revisiting the natural resource curse and, within this debate, we challenge the view that natural resource sectors are enclaves lacking input-output linkages with the rest of the economy and hindering economic diversification. In fact, we find the opposite to be true for knowledge intensive business services and this effect to be stronger in countries with a specialisation in natural resource sectors.

In line with the Chapter 2, this second contribution of the thesis also suggests that the productive structure and specialisation trajectories are a determinant not only of the extent to which countries will benefit from participation to GVCs, but also which GVC they will be most likely to join in the first place.

3.3 Power and Export Sophistication in Buyer-Supplier Relationships: Insights from Colombian Customs Data

Chapters 2 and 3 in this thesis look at both GVC participation and structural change as aggregate phenomena; these are, however, the results of changes and firm-to-firm interactions at the micro level.

There is a well-established literature on GVCs exploring such interactions, mainly through case studies at the firm or industry level (Gereffi and Fernandez-Stark 2011; Hernandez et al. 2014; Frederick et al. 2015).

In parallel, the literature on structural change has been enriched with new evidence looking at products at a more disaggregated level, rather than broad macro-sectors, proposing the notion of sophistication as key to identifying profitable trajectories for structural change and export upgrading (Hidalgo and Hausmann 2009; Cristelli et al. 2014; Zhu and Fu 2013; Poncet and Starosta de Waldemar 2013).

Chapter 4 blends these two streams of literature to explore the association between buyer-supplier international trade relations and supplier's export sophistication, putting forward a quantitative approach based on large samples from transaction level data.

One of the main insights of the literature on GVCs is that while the fragmentation of production has made it easier for suppliers in developing countries to have access to global markets and foreign, more productive, buyers, this is no guarantee that suppliers will easily increase the sophistication of their exports.

In particular, this literature has emphasised that GVCs are ruled by lead firms that establish different kinds of governance and power relationships, determining who does what, and thus supplier's possibilities of upgrading along the value chain (Kaplinsky 2013; Gereffi 1994; Gereffi et al. 2005).

The concept of export upgrading is particularly important because recent contributions in the literature have better qualified the widely accepted positive relationship between exports and growth, by introducing the *quality* of exports as a determinant of firms' (and countries') economic performance (Iacovone and Javorcik 2009, 2010; Hidalgo et al. 2007; Poncet and Starosta de Waldemar 2013; Lall et al. 2006).

Based on this, the idea of export sophistication has become central to capturing the 'quality' of the exports, and an increasing body of evidence supports the idea that increases in export sophistication go hand in hand with improvements in economic performance (Minondo 2010; Hidalgo et al. 2007; Lall et al. 2006; Zhu and Fu 2013).

While adopting a mainly qualitative approach, the literature on GVCs has gathered a large body of evidence on the importance of power asymmetries as a determinant of supplier's upgrading possibilities over the past two decades (Humphrey and Schmitz 2002; Giuliani et al. 2005; Gereffi et al. 2005; Gereffi and Fernandez-Stark 2011).

The importance of buyer-supplier relationships has also been emphasised by literature relying on micro-level transaction data. This literature has contended that mutual knowledge between buyers and suppliers is key to a relationship's survival and profitability, especially in the context of low contract enforceability (Macchiavello and Morjaria 2015, 2016; Macchiavello and Miquel-Florensa 2017). This latter stream of literature has, however, put little evidence forward concerning the linkage between power asymmetries in trade relationships and suppliers' upgrading.

We attempt to fill this gap by constructing measures of power in trade relationships: we distinguish in particular between two kinds of power, based on its source: (i) relational power based on dyadic features of the relationship, such as the dependence of one party on the other, and (ii) market power, i.e. the position that each of the trading parties occupies in the market, which we capture with market shares.

We then explore the association of these different kinds of power to supplier's sophistication, the likelihood of introducing a new product and that of increasing the supplier's sophistication.

To test these hypotheses we use transaction data from the Colombian customs. After extensive cleaning, we obtain buyer-supplier pairs in each year and quantify both the power in each pair and the sophistication of the products in which they trade.

We find that suppliers that depend heavily on purchases from their buyers are more likely to have low sophistication levels of exports and are less likely to upgrade to more sophisticated products. A large market size of the buyer is positively associated with higher levels of sophistication of trade.

Suppliers with large market shares are more likely to start trading in new products, while the dependence of the buyer vis-à-vis the supplier is positively associated with increases in the sophistication of the products traded within the pair.

We also explore how these associations change across destination countries and find that while a large market share of a buyer is, on average, associated with high export sophistication, buyers dominating the market in the US tend to import low sophistication products and make it harder for suppliers to upgrade.

The main implication of these findings is that power in trade relationships seems to be related to suppliers' upgrading prospects. We contribute to the growing literature on buyer-supplier relationships, and we also offer new quantitative evidence in favour of the mainly qualitative literature on GVCs.

We also expand the literature on GVCs, qualifying the concept of power and its relationship with supplier's upgrading in a more nuanced way.

More specifically, we find that different kinds of power, i.e. whether they stem from buyer-supplier mutual dependence or the wider market structure, are correlated in different ways to both sophistication and upgrading.

These results are relevant both to firms that should take power asymmetries into account when attempting to enter foreign markets, as well as to policy makers in the design of policies to foster domestic suppliers' engagement with global markets.

This is a first contribution based on micro-level evidence, paving the way for future research on inter-firms' relationship in trade, exploring more potential factors shaping power between trading partners, such as ownership relationships, size, productivity and technological capabilities of the buyer. To the best of our knowledge these are issues that have so far remained unexplored that would yet provide very useful insights for trade theory as well as to both private firms and policy makers.

2.Trade Specialisation and Performance in Global Value Chains

Abstract

This Chatper investigates whether trade specialisation explains economies' trade performance within a Global Value Chain (GVC) context. We consider trade specialisation in natural resources, high and low tech manufacturing and business services, before and after the financial crisis. The aimed contribution of this Chapter is to shed light on the effects of trade specialisation as measured in domestic value added embodied in exports rather than gross exports. We add to the literature on GVCs by: (i) studying the role of the domestic productive structure in countries' trade specialisation and performance, (ii) accounting for the rate of changes in trade specialisation as affecting GVC performance. We employ Balassa indexes based on value added flows in a GMM dynamic panel framework.

We find that trade specialisation in low-tech manufacturing and natural resources have a negative impact on value added exported by countries. High-tech manufacturing and knowledge intensive services exhibit a positive effect during the crisis period. We discuss these findings in relation to the recent debates on the role of manufacturing and premature de-industrialisation in developing countries.

2.1 Introduction

Countries' economic development and its relationship with the productive structure has been the subject of a long and established literature, spanning several decades, looking at the role of specific sectors, such as agriculture, manufacturing ad services (Kaldor 1968; Matsuyama 2008; Szirmai and Verspagen 2015), the linkages across sectors (Guerrieri and Meliciani 2005; Hirschman 1958; Evangelista et al. 2015; Meliciani and Savona 2014; Lopez-Gonzalez et al. 2015), and the importance of trade structure for economic performance (Balassa 1978; Hausmann et al. 2007; Lederman and Maloney 2012; Lee 2011).

In the past decades, globalisation has brought about a much higher degree of interdependence and interconnectedness across countries, also in trade flows. A consequence of this, and arguably one of the most relevant changes in recent years concerning the nature of trade, is that intermediate goods account for an increasing share of trade flows (OECD 2013a). This is because production is scattered across countries, and global value chains (GVCs) represent a large proportion of trade (Gereffi 1994; Gereffi et al. 2005; Baldwin and Robert-Nicoud 2014). This Chapter studies countries' export performance in light of this significant change.

Foreign imported inputs constitute an increasing share of gross exports, which in turn are less representative of countries' domestic production structure (Koopman et al. 2014). As Baldwin (2011, p.33) puts it, while previously *"exporting engines was a sign of victory now it is a sign that the nation is located in a particular segment of an international value chain"*. Moreover, this phenomenon has turned foreign countries not only into export destinations, but also into co-producers; this changes the way in which we think about countries' trade specialisation and its impact on export performance.

In light of the growing importance of GVCs, this Chapter investigates the role of trade specialisation as a determinant of countries' export performance. In particular, we argue it is increasingly important to distinguish countries' domestic value added contribution from what other countries provide, rather than relying on gross exports. In sum, rather than "what you export matters", as posited by Hausmann et al. (2007), it is what a country produces (and then exports) that matters.

In addition, we characterise changes in trade specialisation, not only in terms of direction, i.e. in which sectors a country specialises, but also in terms of the rate of change, i.e. the speed at which such changes occur.

More specifically, we focus on the relationship between countries' acceleration in specialisation and the growth of export shares. This is quite a novel approach, and complements earlier studies on countries' trade and structural change, which focus on static effects.

We also include services (and in particular knowledge intensive business services - KIBS) in the analysis of output and export specialisation; as opposed to manufacturing, services have been comparatively overlooked in the literature on both trade and structural change, despite some exceptions (Anderson et al. 2015; Wolfmayr 2012; Varela and Hollweg 2016; Di Meglio et al. 2018). However, services represent an increasing share of trade and countries' productive structures (Anderson et al. 2015). Being less tradable than manufactured goods, it is even more important to assess their contribution to countries' trade with a value added approach.

We build on Kowalski et al. (2015) and operationalise our questions by estimating the effect of the rate of change in countries' trade (in value added) specialisation on the growth of countries' share in domestic value added exported. We find that trade specialisation in low-tech and natural resources has a negative or not significant impact, while we detect a positive and significant effect of increases in specialisation in KIBS and high-tech manufacturing, although only after the financial crisis. These results suggest that countries increasing their specialisation towards low-tech manufacturing are likely to experience a decrease in the growth of export shares in value added terms. Relating this more in general to the debate on manufacturing as an engine of growth (Rodrik 2016b; Szirmai and Verspagen 2015; Szirmai 2012) this hints towards a differential impact of specialisation in high- versus low-tech manufacturing.

Our results are also relevant to the literature on the role of countries' trade specialisation and their performance (Hausmann et al. 2007; Hidalgo et al. 2007), which has so far overlooked the emergence of GVCs (Koopman et al. 2014). We provide a richer understanding of trade specialisation, not only through our value added approach, but also looking at the speed of changes in specialisation, which the literature has shown to have important effects on countries' long-term growth dynamics (de Vries et al. 2017; Timmer and de Vries 2009; Timmer et al. 2014).

The remainder of the Chapter is organised as follows: Section 2 reviews the relevant literature; Section 3 presents our value added based measures and some relevant descriptive evidence; Section 4 illustrates how they are computed and the overall empirical strategy as well as the data used; Section 5 presents the results and discusses the Chapter's findings; Section 6 concludes.

2.2 Trade specialisation and performance in the context of GVCs

2.2.1 Trade specialisation and the domestic productive structure

There is a long standing literature looking at exports as a driver of economic growth (Balassa 1978; Marin 1992). The export sector has been regarded as more productive (Feder 1982) for reasons ranging from access to a larger market, economies of scale and scope, technological spillovers, and incentives for exporters to increase productivity (Bustos 2015; Rivera Batiz and Romer 1991). Moreover, access to international market has historically played an important role in the development of several developing countries, particularly in East Asia (Lee et al. 2011; Kim and Lee 1987; Kim 1980; Hobday 2015; World Bank 1993).

Economic theory has mainly stressed the role of factor endowment in shaping countries' comparative advantage and specialisation in trade. According to this view, countries should specialise in sectors in which they have a comparative advantage, regardless of the sector's specific characteristics.

In contrast with this sector-neutral approach, some economists have also argued that countries' specialisation and its changes reflect their technological capabilities, endogenous technical change and thus their competitiveness (Fagerberg 1988; Uchida and Cook 2005). In this stream of research, income and price elasticities vary across specialisation trajectories, determining demand and productivity growth dynamics (Thirlwall 1979). So, trade specialisation and trade performance influence each other and, at times, countries go down specialisation patterns with low growth potential (Amable 2000) as shown, for instance, by Matsuyama (1992) for the agriculture sector.

A more recent literature has looked at countries' trade specialisation, and revealed comparative advantage (RCA) in particular, to infer countries' underlying domestic capabilities. Hidalgo et al. (2007) and Hausmann and Klinger (2007) have argued that countries' export specialisation reflects their domestic capabilities as well as their development perspectives. As a result, Hausmann et al. (2007) show that export specialisation is a determinant of future economic growth and that therefore "what you export matters".

Interestingly, Hausmann and co-authors link countries' export specialisation with their underlying domestic economic structure and ultimately study how this evolves and affects long-term growth. However, they do not account for the increasing fragmentation of production across countries that accompanies the emergence of global value chains (GVCs) and the limitations of using gross export data to infer on the domestic economic structure and capabilities (Baldwin 2012).

The relationship between domestic productive structure and GVCs is not merely a methodological issue but represents a significant change in countries' specialisation opportunities. In fact, while globalisation has opened up new specialisation avenues for countries (Baldwin 2011), this has yielded rather diverse outcomes as developing countries have taken different specialisation patterns at different speeds, also depending on their pre-existing productive structure (McMillan et al. 2014).

2.2.2 Direction and pace of change in countries' trade specialisation and economic structure

Within the literature on structural change, manufacturing has traditionally been considered as the engine of growth; Szirmai (2012) provides a thorough discussion of the different arguments in favour of this hypothesis. The first Kaldor's Law (1968), postulates that manufacturing share and economic growth are positively correlated, and Verdoorn's Law posits a positive relationship between the manufacturing sector's size and its productivity. Furthermore, manufacturing has been argued to have many linkages with other sectors, for which it provides either inputs or demand for output (Hirschman 1958), as well as opportunities for technology and knowledge spillovers. Rodrik (2013) finds that while the convergence between developing and advanced economies predicted by neoclassic growth models is conditional on a set of other factors, such as education and institutions, productivity in the manufacturing sector shows unconditional convergence, i.e. irrespective of countries' characteristics.

Recent evidence seems to question whether manufacturing is still playing its traditional role of a growth engine. In another contribution, Rodrik (2015a) argues that rapid industrialisation for developing countries is going to be more difficult in the future due to the strong Chinese competition in low-tech labour-intensive manufacturing sectors and the fragmentation of production.

Szirmai and Verspagen (2015) also find that an increasing amount of human capital is now needed in order for manufacturing to trigger its engine of growth effect. This evidence suggests that specialisation in high- and low-tech manufacturing may yield different outcomes in terms of countries' economic performance.

Services have traditionally not been considered to exert the same virtuous properties on economic growth. However, structural change towards services is an empirical regularity associated with economic growth (Bah 2011), both in high and low income countries. Rodrik (2015b) finds that structural change towards services and away from manufacturing is happening in developing countries at much lower income levels than in the past; for this reason, he raises concerns for its implication for low-income countries' growth perspectives.

In contrast with this view on the contribution of services to economic development, recent studies on the emergence of GVCs in services have provided evidence on the opportunities of offshoring service activities from developed towards developing countries (Gereffi and Fernandez-Stark 2010; Hernandez et al. 2014). However, most of the studies in this strand of work take a qualitative approach, while little quantitative evidence has been offered so far to the debate around GVCs and the role of services in developing countries.

While the body of literature on the direction of structural change is vast, still little is known on the dynamic effects of the pace at which countries specialise on their growth rate. It has been argued that the speed at which structural change takes place is key to countries' successful development (Haraguchi 2014; Matsuyama 1992). McMillan et al. (2014) stress the importance of the dynamic effects of structural change, distinguishing between structural change that is growth enhancing or growth reducing. In particular they argue that developing countries with significant productivity differences between sectors may have a lot to gain – or to lose – by simply reallocating the labour force from low to high productivity growth sectors.

For instance, when we compare Asian and Latin American countries, we see that while in the former structural change has favoured sectors with higher productivity dynamics, this has not happened in the latter (Timmer et al. 2014). More specifically, Asian economies have moved towards manufacturing sectors that had a faster technological dynamic and thus higher productivity growth rates. In contrast, Latin America and Africa have specialised in services that did have higher productivity *levels* than agriculture, but much lower productivity growth *rates* than other manufacturing sectors. The result has been a static, one-off, productivity boost rather than a dynamic one (de Vries et al. 2017; Timmer and de Vries 2009; Timmer et al. 2014).

The qualitative literature on GVCs has also emphasised the importance of speed when countries specialise in sectors with high value added content, in order to reap the benefits of the first-mover. Furthermore it is important that countries maintain their ability to specialise quickly so they can sustain a rent, deriving from constantly moving towards new high-value added sectors (Kaplinsky 2004).

For this reason, it is particularly interesting to look at rates of change, rather than levels, in both export performance and specialisation.

2.2.3 Research question and Chapter's contribution

This Chapter sets out to study the relationship between trade specialisation and performance in the context of GVCs. We aim to take into account that the emergence of GVCs has made the relationship between export specialisation and the underlying domestic productive structure less straightforward, with the former being less and less representative of the latter. This requires a novel understanding of trade flows: they are no longer the outcome of exchanges of finished goods produced within countries' borders, but rather a process of production fragmented across borders in which countries are both destination and co-producers.

In addition, and in line with a growing literature, we argue that changes in countries' specialisation will have an impact on the dynamic of their export performance, i.e. the rate at which it will improve (or worsen), and that the speed at which countries change their specialisation will also be a determinant of their performance. This is something that the scholarship has already acknowledged (McMillan et al. 2014; Kaplinsky 2004), although the evidence on this remains scarce, compared to the vast body of studies looking at the relationship between levels of trade specialisation and levels of export performance.

Following on from this, this Chapter aims to answer the following research question: do changes in countries' trade specialisation affect their export performance, within a GVC context?

We bring this hypothesis to the data by computing measures of trade specialisation and of trade performance. In order to account for the emergence of GVCs and to explore the relationship between exports and domestic specialisation, we build on the growing literature on trade in value added, which we review in detail in the next section.

2.3 Measuring trade in a GVC context: descriptive evidence

In order to account for the emergence of GVCs and the gaping divide between trade in value added and gross exports, a recent and growing stream of research has developed a set of measures capturing countries' participation in GVCs. De Backer and Miroudot (2013) and, more recently, Johnson (2018) provide a quite complete review of the measures of both backward participation, i.e. the value added a country imports from other countries that is subsequently exported, and forward participation, i.e. the value added a country exports and is subsequently exported by third countries.

In line with the export-led growth models, the underlying assumption of this strand of literature is that GVC participation is desirable and that it should lead to economic growth. Without making such an assumption, Banga (2014) argues that linking into GVCs is not necessarily enough to trigger export-led growth. As an alternative measure of countries' GVC performance, she proposes to use the difference between backward and forward participation and found very unequal benefits being drawn from GVC participation across countries. Based on these results, she argues for policies favouring forward, rather than backward, participation.

Kowalski et al. (2015) show, however, that backward and forward participation may be complementary and propose an alternative measure of countries' trade performance in GVCs. They look at domestic value added embodied in countries' exports (DVA, henceforth), which corresponds to the share of exports that is used to remunerate domestic labour and capital. This measure captures the parts of countries' domestic productive structure that can compete in the international market and ultimately contributes to their export.

In order to measure countries' performance in GVCs, we thus follow Kowalski et al. (2015) and opt for DVA as our main variable of interest, which we use to compute both our outcome and explanatory variables. This variable is particularly interesting for us for two main reasons.

First, while DVA can be intuitively understood as the value added homologue of gross exports, it is worth stressing that this measure accounts for the fact that within each country value added exported by one sector may be generated by different sectors. This measure thus allows reallocating value added to the sector that originated it rather than the one that exported it. This is particularly relevant when looking at countries' export specialisation in relation to domestic structure, and *a fortiori* for business services that are often embodied in manufacturing goods and exported.

Second, the growth of a country's share in total DVA flows (which we will refer to as DVA share henceforth) is loosely related to countries' competitiveness. This is because an increasing growth rate in DVA share is arguably a manifestation of countries' increasing competitiveness in the export markets (Kowalski et al. 2015a).

The literature has yet to reach a consensus on a single approach to measuring DVA. Koopman et al. (2014) suggest using a vector of gross exports including both final and intermediate foreign demand. Johnson (2018) points out that in Koopman et al.'s (2014) approach, foreign intermediate demand is treated inconsistently because it is included in both the gross export vector and in the global Leontief Inverse, which leads to a double counting of a sort.

In an attempt to tackle all these issues, our measure of DVA includes the value added exported by a country either as final foreign demand or intermediate foreign demand, the latter being the value added demanded by other countries' production processes. However, we also exclude the value added generated by a country, exported to meet foreign intermediate demand and then re-imported to satisfy the country's own final demand[1].

We use the Inter-Country Input-Output (ICIO) tables compiled by the OECD, and compute countries' DVA shares and value added RCA in four sector groups: knowledge intensive business services (KIBS), natural resource (NR), low-tech and high-tech manufacturing (LTMF and HTMF respectively).

In Section 2.4 we explain in more detail how these measures are computed. However, we first present some descriptive evidence of how different our value added measures are compared with their gross export homologues, especially when looking at countries' trade specialisation. This evidence suggests that when countries export value added of a sector indirectly, i.e. embodied in exports of other sectors, a gross export approach is likely to underestimate trade specialisation.

We compare countries' RCA when computed in gross exports and DVA, and we show that using value added has a relevant impact on our trade specialisation measure. To be sure, the pattern of GVC participation may vary across sectors. KIBS are often non-tradable; as a consequence their contribution to a country's export is likely to be indirect, e.g. KIBS value added provided domestically contributing to the gross export of manufacturing. For this reason gross export figure may underestimate KIBS importance for countries' export and therefore the countries' trade specialisation.

Manufacturing on the other hand usually consists of tradable products, whose production is likely to be fragmented across countries. For this reason gross export figures may be overestimated, due to the large share of imported inputs that are included in gross export.

Figure 2.1 below shows how the average RCA in KIBS over the years changes across countries when using measures based on gross exports or DVA. We take KIBS as a particular example since, as we have already pointed out, this sector is more likely to be exported indirectly through manufactured exports. However, the same pattern can

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[1] We provide a more formalised explanation of how this measure is computed in the Appendix.

be found looking at the other three macro-sectors in our analysis[2]. Regardless of the mechanisms at play, it is important to note that using a value added approach, as opposed to a gross export one, will yield different specialisation patterns for most countries.

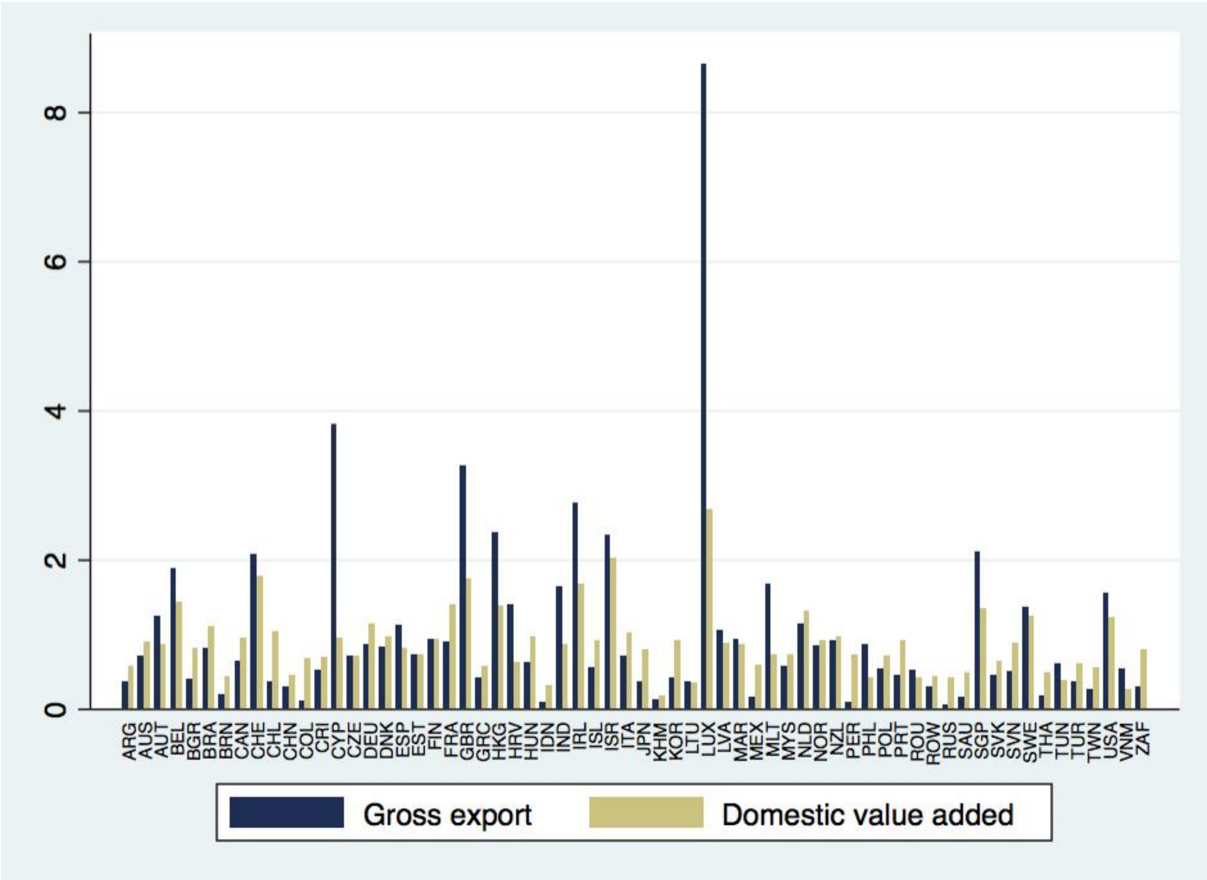

Figure 2.1: Country Average RCA in KIBS across years in gross exports and domestic value added

Note: Figure 1.1 compares countries' average RCA in KIBS across years in our sample, using gross exports and domestic value added in exports.

Source: Author's own calculation using ICIO tables.

In Figure 2.1, we can see that using DVA does not simply reduce the RCA. For countries such as Chile, France, Germany, Italy or Japan, the gross export RCA underestimates their trade specialisation in KIBS. In contrast, countries such as Luxembourg, the UK, Cyprus, Ireland, India and Singapore, see their RCA increase significantly when measured in gross exports.

2 Figures A1-A3 in the Appendix report the same comparison between gross exports and domestic value added for the other three sector groups, NR, LTM and HTM, respectively.

It is important to stress that using gross exports does not move all RCAs in the same direction, which makes the bias of using of gross exports particularly relevant when studying trade specialisation. The distribution of the two variables differs substantially, which means that estimates based on gross exports may lead to incorrect conclusions: RCAs based on gross exports capture values exported by services but possibly originating from other sectors (and countries), while they leave out value added originating from domestic services but exported by other sectors. This arguably explains the difference between DVA and gross export-based RCAs: sectors that are less tradable, such as services, may be traded through other sectors' exports, which would only be captured by DVA-based RCA.

In support of this conjecture we see in Figure 2.1 that gross export RCA inflates the KIBS specialisation of countries that are direct exporters of services (such as the UK, Luxembourg, Singapore, and India), while it underestimates the service specialisation of countries that are direct exporters of other sectors but that also have significant domestic provision of services (such as Australia, France, Germany, and Japan).

In conclusion, we argue that value added based measures better capture the link between trade specialisation and the underlying domestic economic structure. It does this by focusing on the parts of the domestic productive structure that contribute to countries' export performance, either directly or indirectly.

Within this value added based approach we are particularly interested in looking at how the evolution of countries export structure in relation to trade performance has changed over time. We find some significant heterogeneity of these measures of specialisation when we distinguish between high-income and developing countries in our sample[3]. In Figure 2.2 we see that developing countries tend to have much starker specialisations, especially in natural resources and low-tech manufacturing, although this seems to decrease over time. We note an increase over time of the specialisation in high-tech manufacturing; however, this remains smaller than high-income countries. Developing countries seem to have been specialising away from KIBS, showing a slightly decreasing trend.

[3] We use the WB threshold of US$ 12,236 of GDP per capita. Table A1.2 reports number of years in which each country is above this threshold and therefore considered as high-income.

It is worth bearing in mind that this does not contradict the evidence Rodrik (2015b) puts forward concerning countries' premature deindustrialisation and shift towards services; Rodrik refers to low-productivity services, such as retail or non-tradable services, that are not KIBS.

High-income countries have more homogeneous specialisations, with the RCA KIBS being consistently above 1. On average, natural resources also exhibit a high RCA among high-income countries, which is most likely explained by the presence of few resource rich countries in our sample, such as Saudi Arabia, Brunei and Norway. We can also see a decreasing trend in the specialisation in low-tech manufacturing among high-income countries.

Both this, and the strong specialisation in KIBS of high-income countries are consistent with the established view that, as income in countries increases, their specialisation tends to move away from manufacturing towards services (Bah 2011). The different specialisation between developing and high-income economies can also be explained by the fragmentation of productive activities, in particular the offshoring of manufacturing towards developing countries with lower wages, while higher value added activities have been retained in high income economies; Baldwin and Lopez-Gonzalez (2015) refer to these as head-quarter economies.

The fact that high-income countries tend to have more homogeneous specialisation across sectors, and be more specialised in high-tech and knowledge intensive industries, is also to be expected. This is because more advanced and sophisticated economies will have a larger set of capabilities and therefore be able to produce a larger set of goods and services in a competitive way (Hausmann and Hidalgo 2011; Hidalgo and Hausmann 2009; Felipe et al. 2012).

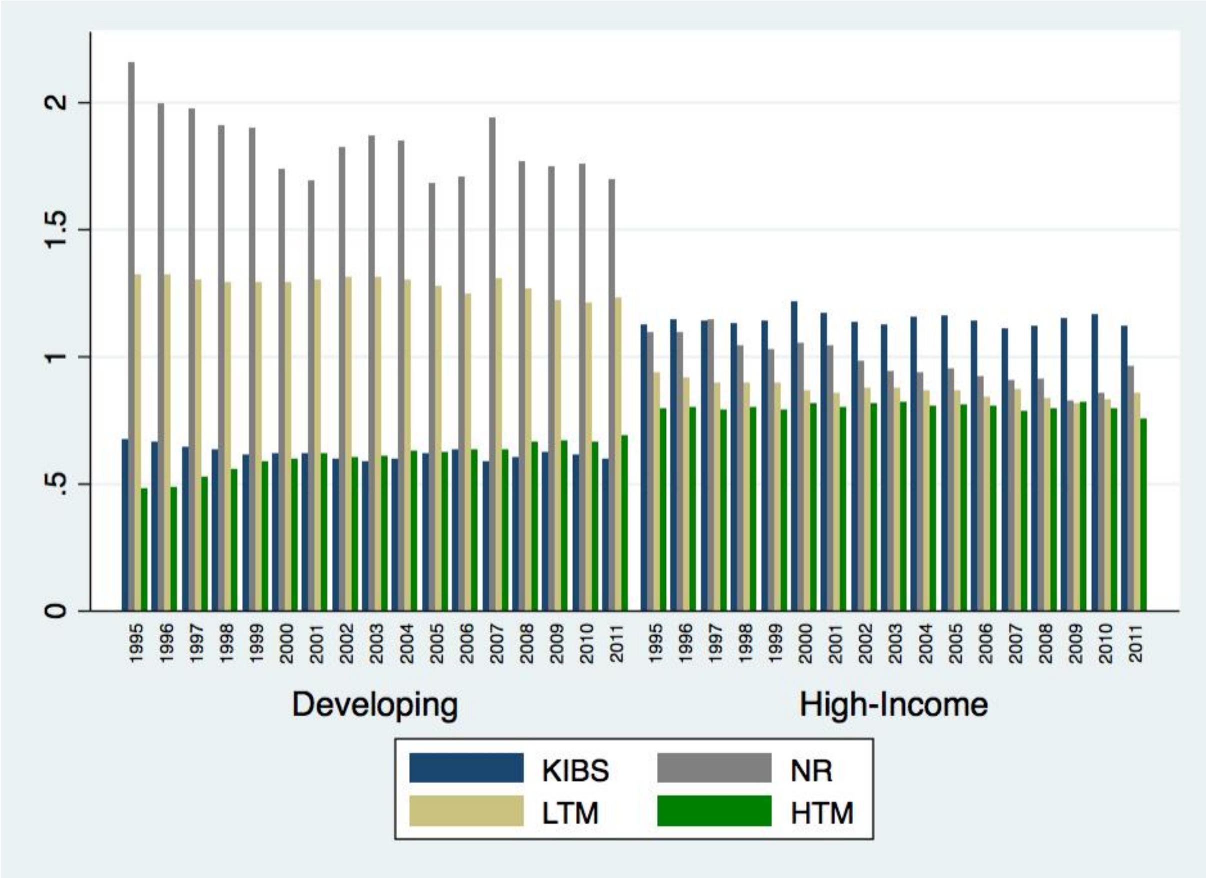

Figure 2.2: Average RCA over the years, comparing high-income and developing countries

Note: Figure 2.2 shows the average domestic value added based RCA computed across all countries for each year, dividing the sample between high-income and developing countries.

Source: Author's own calculation using ICIO tables.

Overall it seems that, over time, countries have specialised away from low-tech manufacturing (especially high-income ones) and natural resources (especially developing ones), with the largest changes taking place in these two sectors and in developing countries.

As this Chapter's aim is to study the effect of changes in trade specialisation on trade performance with a value added approach, we now turn to how domestic value added in exports has evolved over time, looking again at high-income and developing countries separately. Figure 2.3 reports the yearly average changes in domestic value added exported. We can clearly observe the impact of the financial crisis in 2007 and 2009. It is also interesting to see that, in its aftermath, developing countries' exports in value added have been growing at a higher rate than high-income countries. The crisis years thus seem to be significantly different from the rest of our panel, which is why our analysis will also explore these separately.

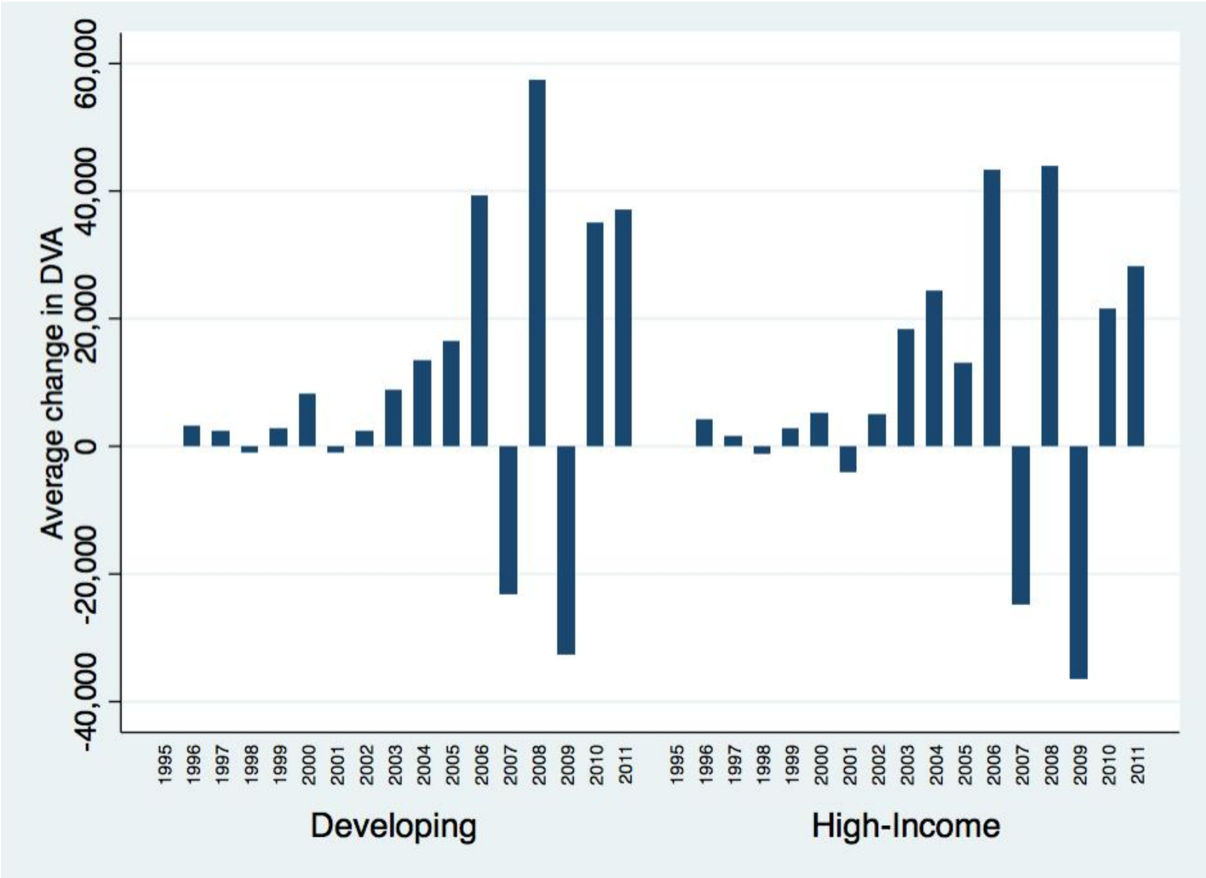

Figure 2.3: Average change in DVA across countries and over time, comparing high-income and developing countries, thousands of US dollars.

Note: Figure 2.3 shows the average change in DVA in thousands of USD, across countries for every year in our sample, dividing between developing and high-income countries.

Source: Author's own calculation using ICIO tables.

In conclusion, we find some considerable changes in the specialisation pattern across developing and high-income countries. Specialisation in natural resources and low-tech manufacturing seem to have changed the most, with a decreasing trend, over the years. In contrast, specialisation in KIBS and high-tech manufacturing has been more stable over the years, despite a decreasing trend among developing countries.

These sectors appear to have been a more difficult specialisation trajectory for countries to undertake. Based on this preliminary evidence and the existing literature reviewed, we would expect a negative impact of the specialisation in natural resources and low-tech manufacturing on countries' growth in DVA shares.

We also know that the relationship between export specialisation and economic performance is likely to be affected by reverse causality (Amable 2000) and serial correlation. In the next section we discuss how our econometric strategy deals with these, as well as how we compute the DVA and the RCA with ICIO data.

2.4 Methodology and empirical strategy

In the previous section we reviewed the growing literature on measurement of GVC participation and DVA in particular, arguing that such an approach would allow the capturing of countries' domestic contribution to exports in a more accurate way.

As has been emphasised, the notion of speed of structural transformation is particularly interesting from a theoretical point of view, as countries' ability to *rapidly* shift trade specialisation may be an advantage in itself. Secondly, looking at changes is conceptually closer to structural change and allows the capture of the dynamic effects related to growth rates rather than levels (Timmer et al. 2014). In order to investigate this dynamic aspect of changes in countries' trade specialisation, in our econometric approach we look at growth rates, i.e. changes in the log of the variables.

We compute the DVA-based measures using the OECD ICIO tables. Data are available for 64 countries (including a compound for the rest of the World), 33 sectors (including natural resources, manufacturing and services), for the years 1995 to 2011

We compute our measure of countries' DVA in gross exports as follows:

$$DVA_i = V'(I - A)^{-1}E$$

Where *V'* is a diagonalised vector, yielding a *ij* x *ij* diagonal matrix where all elements of the diagonal are populated with the value added output shares for each country *i* and sector *j*.

$(I\text{-}A)^{-1}$ is an inter-country Leontief inverse matrix capturing the inter-industry linkages. This matrix captures the relationship between all sectors from all countries.

E is a *ij x 1* column vector including sector's export in each country, i.e. the value added generated by country *i* and exported either through foreign final demand or foreign intermediate demand, netting out, however, the value added that is then reimported to meet country *i's own final demand*. We obtain DVA_{ij}, which is an *ij x 1* column vector containing each country *i*'s and sector *j*'s domestic value added in exports. We then aggregate across all sectors and obtain our variable *DVA*.

We then take each country *i*'s share in worldwide flows of DVA, and divide it by the share the country represents of the world population as follows:

$$DVASH = \frac{\frac{DVA_i}{\sum_i DVA_i}}{\frac{population_i}{\sum_i population_i}}$$

This ratio captures the extent to which a country accounts for total DVA flows, normalised by population, considering that larger countries account for a larger share of total DVA flows.

Our main explanatory variables are computed as the Balassa index (Balassa 1965), but we use domestic value added flows rather than gross exports as follows:

$$RCA_{ij} = \frac{\frac{DVA_{ij}}{DVA_i}}{\frac{\sum_i DVA_{ij}}{\sum_i DVA_i}}$$

We use the share that our sector of interest *j* represents in the domestic value added embodied in the exports of country *i* and weight this with the share that domestic value added from sector *j* represents in world wide value added flows. We compute this RCA index for four groups of industries: KIBS, NR, LTMF and HTMF[4].

So, the general form of the estimated equation in our econometric analysis is the following:

$$\begin{aligned} dvash_t = \beta_0 + \beta_1 dvash_{t-1} &+ \beta_2 tfp_t + \beta_3 kibs_{rca_t} + \beta_4 nr\_rca_t \\ &+ \beta_5 ltmf\_rca_t + \beta_6 htmf\_rca_t + \beta_7 secenrol_t + \beta_8 internetaccess_t \\ &+ \alpha_i + \alpha_t + \varepsilon_t \end{aligned}$$

[4] A detailed breakdown of how these sectors are aggregated is provided in the Appendix in Table A1

Where $dvash_t$ is the growth rate of *DVASH* at time *t*, and all variables are expressed in changes; α_t and α_i are year and country fixed effects (FE) respectively; $\_rca_t$ are the growth rates of the RCA of the four groups of industries discussed above.

Both human capital and technological capabilities play a significant role in countries' trade specialisation and competitiveness (Guerrieri and Meliciani 2005). For this reason we control for both of them, using gross enrolment in secondary education (*secenrol)* and Internet users per 1,000 inhabitants (*internetaccess*), both taken from the World Bank's World Development Indicators.

Finally, we also acknowledge that having such aggregated data may not capture the inter-country differences in productivity and development, which are likely to be related to both our outcome and explanatory variables. For instance, being specialised in KIBS in Singapore is probably not the same as in Peru. More productive countries are also more likely to participate to trade and to have a specific specialisation. In order to deal with this issue we also control for countries' total factor productivity (*tfp*) using the Penn World Tables.

We perform our analysis using the system generalised methods of moments (GMM) developed by Blundell and Bond (1998), which deals more efficiently with models with high persistence like ours than the first-differences GMM developed by Arellano and Bond (1991). We estimate the two-step robust version of system GMM with the Windmeijer correction to deal with heteroscedasticity and finite sample (Windmeijer 2005).

Using GMM allows us to deal with the potential reverse causality that could affect ordinary least squares (OLS) estimators, by using lags of the observed variables as instruments. In fact, while trade specialisation may indeed impact countries DVA, it is also possible that countries that export more value added tend to specialise in some sectors in particular. Using lags to instrument within our sample allows us to deal with the simultaneity of the relationship between countries' trade specialisation and their trade performance within GVCs.

Finally, we opt for an autoregressive model as exports in panel data often present serial correlation. This means that the outcome variable and its lag are correlated by construction through the FE, and that OLS estimators would be biased and inconsistent. The system GMM, by instrumenting with past lags, deals with this issue too.

2.5 Econometric results and discussion

The ICIO data cover a rather long span of time including the financial crisis (2007 onwards), which we have seen shows a significantly different pattern from previous years.

Table 2.1 reports the results of our main model results for all years available in our data, as well as for the crisis years only. As expected, natural resources exert a negative and significant effect on the growth of export shares during all the years in our sample. This is largely consistent with an established view of natural resources as a sector with low productivity dynamic (Matsuyama 1992).

Table 2.1: GMM results on the effect of increases in trade specialisation on growth of export shares, in value added terms

VARIABLES	(1) All years	(2) Crisis years
dvash	-0.0606	-0.282***
	(0.0455)	(0.0488)
tfp	**0.715*** **	**1.046*** **
	(0.196)	(0.238)
kbs_rca	-0.00295	**0.118***
	(0.0392)	(0.0631)
nr_rca	**-0.170*** **	-0.00891
	(0.0560)	(0.0540)
ltm_rca	**-0.183** **	**-0.153** **
	(0.0761)	(0.0741)
htm_rca	0.0104	0.0250
	(0.0561)	(0.0692)
secenrol	-0.00136	0.000180
	(0.00130)	(0.00149)
Internet access	0.00178	0.00151
	(0.00158)	(0.00254)
Constant	0.0870**	0.0118
	(0.0379)	(0.0162)
Observations	780	278
Number of groups	59	59
AR(2)	0.852	0.398
Hansen test overidentification	0.477	0.135
Difference-in-Hansen	0.606	0.473

System GMM estimates on the effect of increases in specialisation for each of the four sector groups on countries' share in domestic value added in exports. The four sector groups are: knowledge intensive business services (KIBS), natural resources (NR), low- and high-tech manufacturing (LTM and HTM, respectively). Education is gross enrolment in secondary education; Internet access is Internet users per thousand inhabitants. Crisis years are 2007-2011.

Standard errors in parentheses, all variables in changes, _rca and _shr in natural logs.
For the AR and Hansen tests the p values are reported.
*** p<0.01, ** p<0.05, * p<0.1

Source: author's own calculation using ICIO tables.

Low-tech manufacturing also has a negative impact on our outcome variable, both when looking at the crisis years or at all the years. This was also expected and has significant implications for developing countries in particular for at least two reasons. First, these countries seem to be more specialised in low-tech manufacturing and are moving away from this sector at a slower pace than high-income countries (see Figure 2.3); second, while manufacturing has traditionally been regarded as the engine of growth, and low-tech manufacturing as a stepping-stone for structural change and industrial upgrading, we have seen while reviewing the literature that some doubt has been cast over this notion (Rodrik 2016a; Szirmai and Verspagen 2015).

Moreover, we do not detect any significant impact of high-tech manufacturing on the growth of export shares. However, this is not completely unexpected, both based on the descriptive evidence showing specialisation in this sector to be rather stable over the time span considered (see Figure 2.2 and 2.3), and the evidence for a similar year period offered by Szirmai and Verspagen (2015). They examine structural change between 1950 and 2005, and, in the last decade, find a slowing down of manufacturing's beneficial effect on growth and an increased dependence on human capital for manufacturing to be exerting its traditional role of engine of growth.

Concerning KIBS, we do not detect any significant effect, except a weakly significant and positive coefficient for the crisis years. These results do not allow, however, considering as unwarranted Rodrik's (2015b) concerns with respect to developing countries' structural change towards services and its consequences on economic development.

One of the main limitations of the ICIO data is the high level of aggregation of sectors, while a wide range of countries are included. As seen while discussing the descriptive evidence, our specialisation measures exhibit significant heterogeneity across countries based on the development level of the country. We try to account for this by including total factor productivity as a control, which has a consistently positive and significant effect, as expected.

We wish to explore more in depth whether specialisation in any of our four macro-sectors has different impacts on countries depending on their income level. We achieve this by interacting our specialisation variables with a dummy variable, *dvpd*, taking value 1 if the country is high-income and 0 otherwise.

Table 2.2: GMM results on the effect of increases in trade specialisation on growth of export shares, in value added terms, controlling for income level

VARIABLES	(1) All years	(2) Crisis years
dvash	-0.0522	-0.274***
	(0.182)	(0.0723)
dvpd	**-0.0618***	-0.0727
	(0.0366)	(0.0445)
tfp	1.152	**0.953*** **
	(0.801)	(0.354)
kbs_rca	-0.277	**0.214*** **
	(0.253)	(0.0560)
kibs_rca*dvpd	-0.249	-0.0396
	(0.368)	(0.155)
nr_rca	-0.303	-0.0179
	(0.295)	(0.109)
nr_rca*dvpd	-0.233	0.0183
	(0.179)	(0.0771)
ltm_rca	**-0.980*** **	-0.0815
	(0.363)	(0.117)
ltm_rca*dvpd	0.279	-0.0158
	(0.211)	(0.118)
htm_rca	-0.00881	**0.218** **
	(0.200)	(0.0976)
htm_rca*dvpd	-0.151	-0.0775
	(0.154)	(0.0682)
secenrol	0.000506	-0.00243
	(0.00912)	(0.00170)
internetaccess	-0.00300	0.00240
	(0.00351)	(0.00267)
Constant	0.0619	0.0352
	(0.0924)	(0.0505)
Observations	780	278
Number of groups	59	59
AR(2)	0.557	0.113
Hansen test overidentification	0.371	0.139
Difference-in-Hansen	0.278	0.735

System GMM estimates on the effect of increases in specialisation for each of the four sector groups on countries' share in domestic value added in exports. The four sector groups are: knowledge intensive business services (KIBS), natural resources (NR), low- and high-tech manufacturing (LTM and HTM, respectively). Education is gross enrolment in secondary education; Internet access is Internet users per thousand inhabitants; dvpd is a dummy variable taking value 1 if the country has a GDP per capita above US$ 12,236. Crisis years are 2007-2011.

Standard errors in parentheses, all variables in changes, _rca and _shr in natural logs. For the AR and Hansen tests the p values are reported.

*** p<0.01, ** p<0.05, *p<0.1

Source: Author's own calculation using ICIO tables.

When controlling for income levels we find some interesting results, although it is worth noting that the interacted terms are not statistically significant, hence specialisation patterns do not seem to affect high-income countries in a different way from low-income countries.

Low-tech manufacturing still exerts a negative effect, which is consistent with what we found in our previous specification. Natural resources, while maintaining a negative sign, do not seem to have any significant impact on export share growth, once we control for countries levels of income. This suggests that the negative impact of increasing specialisation in this sector on countries' DVA share depends on income rather than the natural resource sector *per se*. Interestingly, we also find high-tech manufacturing and KIBS to exert positive effects, although only during the crisis years, i.e. from 2007 onwards; this suggests that when global demand contracts, this is likely to affect less high-tech manufacturing and KIBS. Concerning the latter, this result is consistent with our findings in Table 2.1.

While we find no evidence concerning the long-term effect of increasing specialisation in technology and knowledge intensive sectors on countries' export shares, these results suggest that in periods of crisis, such industries may prove to be a beneficial specialisation trajectory.

2.6 Discussion and concluding remarks

This Chapter has looked at the effect of the acceleration in the pace of trade specialisation on countries' trade performance. We also explore which sectors provide a beneficial specialisation path.

This Chapter shows that the emergence of GVCs has increased the divide between domestic productive structure and countries' trade specialisation, as an increasing share of gross exports stems from imported input produced abroad. In order for trade specialisation to be representative of countries' domestic contribution, it is therefore crucial to take a value added approach.

We take such an approach to compute both our specialisation measures and the export shares of each country. This methodological novelty reflects a different theoretical understanding of trade flows that are not the outcome of countries independent production but rather of cross-country interdependencies. This is the result of the fragmentation of production and emergence of GVCs that make gross exports an unreliable measure of countries' domestic production structure. As a consequence, researchers seeking to infer capabilities from countries' export structure should be wary of using gross exports; this is because they would be capturing part of the value added that has been provided by other countries.

This is also very relevant for policy makers designing export-oriented policies that need to ensure that changes in gross export specialisation also drive changes in countries' domestic productive structure.

In addition to this novel view on trade specialisation, which can now be linked to domestic economic structure, we also look at the dynamics of specialisation trajectory and its outcome in terms of export shares.

We find evidence that is, broadly speaking, in line with the large literature on manufacturing, in particular the most recent contributions highlighting a potential change in the role of this sector for economic growth. While taking a methodologically different approach, our results support the findings of Szirmai and Verspagen (2015) who look at structural change between 1950 and 2005 and find that "since 1990, manufacturing is becoming a somewhat more difficult route to growth than before" (Szirmai and Verspagen 2015, p.58).

Our results also suggest that countries increasing their specialisation towards low-tech manufacturing are unlikely to see their trade performance improve at a faster rate. This can be because competing in low-tech manufacturing has become harder as China rose to be the world's main manufacturer, exploiting its large endowment in low cost labour.

Another, speculative, explanation could be that before the emergence of GVCs, specialisation in low-tech manufacturing would also foster domestic linkages with the high-tech sectors, whereas now these linkages are across borders, as these two activities no longer need to take place in the same country or region.

Concerning high-tech manufacturing, we find rather weak evidence that this could be a beneficial specialisation pattern, since we only detect positive effects when looking at the crisis period and accounting for income differences across countries.

High-tech manufacturing is usually considered a sector with fast productivity growth, although in the last decade its effects on growth seem to be fading (Rodrik 2016a; Szirmai and Verspagen 2015; Szirmai 2012). From a development standpoint, high-tech manufacturing may prove to be a difficult industry in which to specialise, as can be seen in Figure 1.3, because it is likely to have higher barriers to entry. In addition, one could wonder how big a share of labour this sector will be able to absorb, especially in developing countries. This may explain why we find no significant results for high-tech manufacturing when we do not take into account income differences across countries.

Finally, a novel aspect of this research is the inclusion of services, that tend to be often exported indirectly, i.e. embodied in manufacturing exports, and for which our value added approach is particularly suited.

Services have traditionally been considered less dynamic by the literature on structural change and economic development (Baumol 1967; Rodrik 2013; Timmer et al. 2014), although an emerging stream of research has been looking at the off-shoring of services towards developing countries, as a consequence of the emergence of service GVCs, in a rather optimistic way (Gary Gereffi and Fernandez-Stark 2010).

Our results offer no strong evidence in support of the idea that increased specialisation in KIBS may be beneficial to countries' export performance in the long run. We find, as for high-tech manufacturing, a positive effect only during the crisis years. Overall, this evidence seem to justify Rodrik's concern about what he refers to as premature de-industrialisation of developing countries (Rodrik 2016a, 2015b). From a policy perspective, it also warrants caution when considering the increasing off-shoring of services (Fernandez-Stark and Gereffi, 2011) as a new developmental avenue for low and middle income countries. Our results suggest in fact that while increasing specialisation KIBS could offer a short-term increase in the domestic value added in gross export, this may have no significant effect in the long-run.

Our results are somewhat weakened by the high level of aggregation and relatively short time span covered by our data. Related to this, another shortcoming of the data is also the relative low number of observations, which may question the reliability of the GMM. This methodology is designed for instances with a small number of years but a large number of observations for each cross-section; to mitigate this we have tried several combination of instruments, choosing the most robust ones and also relying on the Hansen and Arellano tests for overidentification and serial correlation, respectively. Taking stock on this however, future research should look at more disaggregated sectors over longer time periods.

Exploring trade in value added at a more granular level is crucial because trade is involving more and more intermediates, and production is increasingly being fragmented across countries in terms of tasks rather than products (Grossman and Rossi-Hansberg 2006; Lanz et al. 2011): working with aggregated manufacturing and services categories may hide substantial differences. An additional advantage of focusing on tasks across sectors is that this allows exploring the relationship between the fragmentation of production and employment related issues such as skills requirement and wages. Unfortunately there is still a lack of reliable data to explore these issues at a high level of disaggregation both in high-income and especially in developing countries.

Moreover, the increasing fragmentation of production across countries, and the blur of the divide between manufacturing and services, brings up the issue of domestic inter-sectoral linkages. This in turn raises the question of the relationship between domestic economic structure and GVC participation and performance, which should also be explored by future work.

3. Revisiting the Natural Resource "Curse" in the context of trade in value added: Enclave or high-development backward linkages?

Abstract

The Chapter puts forward and empirically tests the conjecture that specialisation in Natural Resource Industries (NRI) might not necessarily be a "curse" for (developing) countries, to the extent that it provides opportunities for export diversification in backward linked sectors à la Hirschman. We first revisit the evolution of the debate around the NRI "curse", including those views that are sceptical of diversification based on beneficiation from NRI. We then empirically test whether NRI might represent a sufficient "domestic representative demand" à la Linder for backward linked sectors such as Knowledge Intensive Business Services (KIBS) or high tech manufacturing that might provide new opportunities for export diversification based on virtuous pathways of domestic structural change. We find empirical support for this conjecture and discuss our results as a contribution to revisiting the NRI curse debate.

3.1 Introduction

Countries rich in or dependent on Natural Resources (NR)[5] might be "blessed" or "cursed", depending on a large number of factors. The literature has copiously analysed these, as effectively summarised in some of the most recent reviews (Badeeb et al. 2017; Havranek et al. 2016; Van Der Ploeg and Poelhekke 2017).

The term "Natural Resource Curse" was first coined by Auty (Auty 1993, 1987) and is now commonly referenced. This is since the publication of a widely cited work by Sachs and Warner (Sachs and Warner 1995, 1997). In a nutshell, the "curse" thesis argues that countries rich in or dependent on NR experience low and/or stagnant growth performance, with detrimental consequences for their development (Venables 2016; Harding and Venables 2016).

[5] NR is commonly intended to be non-renewable extractive industries such as oil and gas. The renewables, such as forestry, water, land that produce raw material and commodities, usually fall into the primary activities. Here we look at both types of sectors, as detailed below. The literature on the NR "curse" instead tends to associate NR primarily with extractive industries. Broadly, and based on Venables (2016), countries rich in NR have at least 20% of their export or fiscal revenues coming from NR. For countries dependent on NR, this share is at least 50%.

The theoretical explanations and empirical grounding of the NR curse include a classical argument of factors crowding-out, i.e. production inputs that are moved away from non-resources activities, as well as trade related issues such as the worsening of the balance of payment and terms of trade due to the contraction of the non-resources tradable sectors (the well-known Dutch disease, more below) (Corden 1982; Corden 1984) and the volatility of commodity[6] prices, which makes resource rents uncertain. Moreover natural resource rich countries will miss the learning-by-doing opportunity, stemming from the maintenance of a core non-resource (manufacturing mainly) sector (Torvik 2001). Finally, the scholarship has also noted a negative association of NR dependence with quality of institutions (Mehlum et al. 2006).

It is also worth noting tha a high heterogeneity in the type of natural resources (i.e. coal rather than oil or diamonds), levels of initial investments, quality of institutions and the public management of rents (Havranek et al. 2016) make the presence of a “curse” largely heterogeneous across countries. The literature has identified cases of growth-adverse NR dependence (e.g. RDC, Angola, and many African countries) that are counter-balanced by cases of a growth-enhancing one (e.g. Botswana, Norway, Chile, Australia) (Venables 2016). Overall, the latest two decades of scholarship has shown large country heterogeneity on the presence of an NR “curse”, so that a negative relationship between NR endowment (abundance or dependence) and growth has not proven to be conclusive (James 2015; Badeeb et al. 2017).

One of the arguments contributing to the NR curse debate - of particular interest here - is the link between NR abundance/dependence, domestic structural change, and the trade patterns of NR industries (NRI from now on) versus non-resource industries. For instance, trade scholars have developed the Dutch disease argument by looking at the link between NR and non-resource sector *exports,* with a particular interest in developing countries (Torvik 2001; Harding and Venables 2016). It has been argued that, because NR exports might be detrimental to non-resource tradables, it is difficult

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[6] The term “commodity” generally refers to homogenous goods whose market cannot be easily fragmented. This is often, although not exclusively, the case for the production of both renewable and non-renewable natural resource sectors. Henceforth, we refer to both of these when we use the term commodity.

to achieve diversification through industrial policies and “move away” from NR (Harding and Venables 2016; Venables 2016).

The issue of diversification in NR rich countries, traditionally envisaged as away from NRI, towards an (export-driven) manufacturing sector, calls for adequate attention to the role of the structure of the domestic economy. The importance of the structure of sectoral (backward and forward) linkages, alongside the levels of exports in NR and non-resources industries, has started to become more widely recognised (Baldwin and Venables, 2015; Cust and Poelhekke, 2015).

The case for making good use of backward and forward linkages within development policies is not new, and dates back to the seminal work by development economists such as Hirschman and Rostow (Hirschman, 1958; Rostow, 1960).[7] Hirschman took a remarkably original stand with respect to the mainstream growth theory based on factor endowments. The role of linkages in Hirschman’s work serves the purpose of creating new sectors by way of scalable intermediate demand, and therefore represents a useful device to identify strategies of industrial policy that favour diversification of the sectoral composition of economies.

When it comes to the issue of diversifying away from NR, the linkages framework, and specifically the argument of *beneficiation* (that is the development of downstream, forward-linked manufacturing industries that process raw materials and NR) has been criticised despite a substantial paucity of recent specific contributions. Hausmann et al. (2008), for instance, argue that policies aimed at beneficiation are misguided, as diversification should be based on similarity of factor and technological capabilities intensity rather than vertical linkages, most especially when NR is concerned. The argument, within the product space framework (Hidalgo et al. 2007; Hausmann et al. 2007), seems to have been crafted only with respect to beneficiation (i.e. forward-linked industries), rather than to backward-linked ones, that are those that could be demanded by NRI as intermediate inputs.

[7] According to Hirschman (1958), there are different types of externalities, depending on whether activities are related to one another by backward or forward inducement mechanisms, i.e. whether certain sectors, by demanding inputs, induce the growth of supplier industries (input-provision or backward linkage effect) or, rather, by supplying output induce the growth of client industries (output provision or forward linkage effect).

This Chapter aims to revisit the role of Hirschman linkages, particularly of NR backward-linked business services, to identify whether new patterns of export diversification in NR rich countries can emerge, depending on the revealed comparative advantage in NR of countries, and by distinguishing between extractive industries and agriculture. We aim therefore to contribute to the NR curse debate by offering a novel perspective and empirical evidence that might ground a whole new set of reflections on how to craft industrial, trade and development policies for NR-rich emerging countries.

We claim that for NR-rich countries, many of which are emerging economies, a specialisation in NRI might not necessarily be a "curse", to the extent that it provides opportunities for export diversification in backward-linked sectors à la Hirschman. Such opportunities might be based on virtuous pathways of domestic structural change that do not necessarily involve "moving away" from NRI, but use them as a platform to sectoral (and technological) upgrade towards directions that have not often been considered, let alone as virtuous ones, such as backward-linked business services.

A previous work (López-Gonzalez et al. 2015) put forward a Hirschman-Linder conjecture on the determinants of participation in business services (BS) Global Value Chains (GVCs) and found empirical support for it. We have argued that participation in BS GVCs, particularly in emerging countries, depends on the specific domestic structure of backward-linked industries to BS, particularly manufacturing industries. A critical mass of domestic intermediate demand for BS is found to be as important, and in the case of emerging countries even more important, as the foreign demand of (BS) intermediates. There is, therefore, a specific role of backward-linkages and the scale of the intermediate demand for BS that explains the potential for export diversification.

By drawing on this empirically grounded conjecture and extending the argument, here we ask whether NRI might represent a sufficient 'domestic representative demand' à la Linder for backward-linked sectors such as Knowledge Intensive Business Services (KIBS)[8]. Should this be the case, there would be an opportunity to spur export

[8] We also test our conjecture by looking at high-tech manufacturing.

diversification in sectors such as KIBS. This would create a whole new narrative around NR and trade and development policy “when backward and forward linkage matter” (Baldwin and Venables 2015), albeit with a set of sectors so far overlooked.

We empirically test our conjecture within a general method of moments (GMM) dynamic framework, to ascertain whether the domestic intermediate demand arising from the NR sector, distinguishing between extractive industries and agriculture[9], has a positive impact on the export performance of other sectors, in particular KIBS. We use data from the OECD inter-country input output tables (ICIO) to capture domestic intermediate demand as well as value added in exports.

We find empirical support for the Hirschman-Linder conjecture in the case of NRI. We find that countries, particularly those with a revealed comparative advantage in NRI, and particularly agriculture, benefit from a sufficient ‘representative domestic demand’ for KIBS coming from NRI, which favours trade in KIBS value added. Our main results also hold when looking at domestic intermediate demand for high tech manufacturing sectors, though we find stronger support for such an effect to exist between the mining, rather than agriculture, and manufacturing sector.

These results seem to corroborate the idea that vertical linkages matter in the first place and that the presence of backward linkages to NRI, particularly when a country has a revealed comparative advantage in agriculture, might be a way of rethinking export diversification strategies that exploit NRI, rather than bypassing them. More in general, the NR curse might therefore be reversed, with adequate efforts.

The Chapter is organised as follows. We first revisit the evolution of the NR curse debate that is relevant to the purpose of this Chapter (Section 3.2). We then describe the empirical strategy and the data (Section 3.3) and present some initial descriptive evidence in support of our main conjecture (Section 3.4). This is followed by a discussion of the econometric results in order to contribute to the NR curse debate from the perspective of structural change and export diversification (Section 3.5). We conclude by drawing implications from the perspective of industrial, trade and development policies (Section 3.6).

[9] In the Appendix we provide a detailed disaggregation of the sectors included in the empirical analysis.

3.2 Background

In what follows we offer a review of the debate on the NR curse and related topics. As a general background, we first review the seminal NR curse contributions; we then review a second stream of scholarship that has focused on the specialisation in Natural Resource Industries (NRI) and its consequences for export diversification, to which this Chapter aims to contribute.

3.2.1 The evolution of the NR curse debate

An abundance of NR and specialisation in NRI have been alternatively regarded as a “blessing” or a “curse” for economic development. At first, NR was considered as an opportunity for countries to develop, following a path similar to that of the USA and Australia (Rostow 1960).

Among the first scholars to question the dominant view of their time, Singer (1950) and Prebisch (1959), considered NR as an “inferior” specialisation strategy, notably with respect to manufacturing, because of the difference in income-demand elasticity and the deteriorating terms of trade in natural resources. Demand for exports from natural resource industries is, in fact, less elastic than for manufactured goods. This means that as world income grows, demand for commodities from NR will grow less than that for manufactured products. As a consequence, countries exporting NR-based commodities and importing manufactured products will face price to import increases at a faster rate than the price of exports.

The presence of NRI was deemed beneficial only conditionally on the development of a substantial manufacturing sector (Prebisch 1959), within a balanced development strategy à la Nurkse (1952). The argument was based on the evidence that productivity increases in the NRI would make large parts of the workforce redundant, which, in the absence of a manufacturing sector absorbing this labour, would lead to unemployment, particularly in developing countries (Prebisch 1959).

The scepticism around economic development ensuing from a large NR endowment and specialisation in NRI became a dominant view in the 1980s, when the Dutch Disease thesis was first coined (Corden 1982; Auty 1993). In a nutshell, based on the experience of the Netherlands after the discovery and export of natural gas in the

1960s and 1970s, the Dutch disease implies that the use of production factors in the extraction of NR – assuming full employment – diverts resources from other tradable, (typically manufacturing sectors) and non-tradable sectors (typically services sectors) for which demand (and/or import) increases. The consequence is a worsening of the balance of payments and the terms of trade in the NR rich country. In addition, a contraction of manufacturing exports might affect “learning by doing” and dynamic efficiency at the macro level (Torvik 2002, 2001).

Apart from the particular argument behind the Dutch Disease, the scholarship has identified a range of negative effects that a large export-oriented natural resource sector would have on the rest of the economy, hindering its overall performance. Because of the exports from the NRI, the country’s currency would appreciate making other tradable sectors less competitive (Harding and Venables 2016). Specialisation in NRI would also draw investment and other resources away from other sectors (Sachs and Warner 1997; Matsuyama 1992). By concentrating all the revenues in one sector, the country would become exposed to price volatility of the exported natural resource.

Indeed, over the last decade some scholars have challenged the existence of the NR curse, by reverting to historical examples (Wright and Czelusta 2004). For instance, some scholars have argued that the resource curse would not be inevitable if “high-quality” institutions were in place, capable of investing and distributing resource revenues in a virtuous way (Brunnschweiler 2008; Boschini et al. 2013; Venables 2016).

Scholars have also raised a range of issues questioning the empirical soundness of the evidence brought in support of the resource curse (see for instance, Stijns 2000; Lederman and Maloney 2006; Brunnschweiler and Bulte 2008). In particular, it has been argued that the empirical evidence in support of the curse thesis, as in the seminal Sachs and Warner (1995), is based on cross-sectional data, which are not fit to capture the evolution over time of both institutions and technology (Robinson et al. 2006; Van Der Ploeg and Poelhekke 2017; James 2015). Also, natural resource *abundance* is often confused with natural resource *dependence* (Brunnschweiler and Bulte 2008); when this is disentangled from natural resource rents, the latter can actually have a positive impact on economic growth (Ding and Field 2005).

Crucially to our purpose here, another reason why the NR sector has been perceived as detrimental for economic development is that it has often been regarded as an enclave (Heeks 1998), extracting resources from the country, with few linkages with the rest of the domestic economy and most of the profits being shipped away (Weisskoff and Wolff 1977).

Being an enclave also affects the opportunities in natural resource dependent countries for export diversification (Lederman and Maloney 2006). In this respect, contributions have focused on the chances of diversifying "away" from NRI (Harding and Venables 2016; Baldwin and Venables 2015). Baldwin and Venables (2015), for instance, to model the effects of trade policies aimed at increasing industrialisation in developing – albeit not specifically NR rich – countries. These policies, they argue, should take into account the interactions between backward and forward linkages between "part" and "final" goods; they conclude that, because linkages create a multiplier effect, targeted trade and industrial policies that make sense of the domestic structure of linkages would increase the industrial base and its export performance. The theoretical framework and ensuing argument might well be applied to NR rich countries, although the authors do not go that far.

3.2.2 Export diversification, NRI and "high development linkages"

There seems to be a consensus on the importance for countries with a specialisation in NRI to spur the emergence of other sectors in their export portfolio, reducing their dependence on NRI. While such changes may be driven by a variety of factors, it is worth noting that changes in countries' export specialisation are tightly linked to the underlying domestic structure (Hausmann and Klinger 2006; Hausmann et al. 2007), including an increasing number of complex products and services (Hidalgo and Hausmann 2009; Hidalgo 2009; Felipe et al. 2012). Consistent with this view, export diversification has often been a stated policy goal of many commodity dependent countries (Massol and Banal-Estañol 2014).

However, it has been argued that export diversification may be hard to achieve, particularly for countries abundant in NR; this is because NRI is an enclave lacking significant linkages with the rest of the economy (Heeks 1998; Hirschman 1958). The view of NRI as an enclave posits that NR sectors, and extractive industries in particular, are dominated by large foreign companies, employing a foreign skilled workforce, importing intermediate goods and services, shipping profits back to where they are headquartered, and mainly selling on the international market. For these reasons, NRI has often been regarded as ill-suited to foster the emergence of new sectors through backward or forward linkages (Bloch and Owusu 2012; Heeks 1998).

However, recent qualitative contributions have cast some doubt on the enclave hypothesis about NRI (Bloch and Owusu 2012; Adewuyi and Ademola Oyejide 2012; Marin and Stubrin 2015; Marin et al. 2009; Walker 2001), putting forward a range of examples such as the gold mining sector in Ghana (Bloch and Owusu, 2012) and positive experience of specialist services and equipment for mining in South Africa (Kaplan, 2012). This idea is partly based on important changes the natural resource sector has undergone in recent years. The sector has seen an increase in outsourcing of non-core activities towards local suppliers, which would foster domestic backward linkages (Barnett and Bell 2011; Aragón and Rud 2013).

The debate in the literature around the enclave hypothesis for NRI has also largely hinged upon the role of forward and, to a lesser extent, backward linkages.

Taking a different approach, Hidalgo et al. (2007) and Hausmann and Klinger (2006) have looked at how some products favour the emergence of others in countries' export structure, finding again that NRI is unlikely to lead to the emergence of new industries. Rather than input-output linkages, Hausmann and co-authors look at capabilities requirements, which they infer as using goods' joint probability of being exported by the same country as a measure of proximity (Hidalgo et al. 2007; Hidalgo & Hausmann 2009). The core intuition of this approach is that if a pair of products has a high probability of being exported by the same countries, they must require a similar set of capabilities to be produced.

Using this measure of proximity, Hausmann et al. build a 'product space' where some products are more or less connected to others (Hausmann et al. 2007; Hidalgo et al. 2007).

While the product space approach does not rely on backward or forward linkages, it yields similar conclusions to the traditional enclave view: within the product space, NRI is shown to be among the least connected goods, making it thus particularly hard to diversify starting from a specialisation in such industries.

Consequently, policies encouraging export diversification through beneficiation, i.e. fostering forward linkages and trying to move from NRI to more downstream manufacturing processing activities, are considered ill advised for two reasons. First, NRI is a poorly connected sector to begin with and, second, export diversification is not driven by input-output linkages but, rather, by similarity in capability requirements. In fact, Hausmann et al. (2008) argue that rather than moving vertically, industrial policies should focus on goods that lie closer in the product space to what they currently export. In doing so, they join a quite long-standing view in the economic debate that looked with criticism at resource based industrialisation policies (Auty 1986).

3.2.3 The Hirschman-Linder hypothesis and NRI: research questions

In this Chapter we explore the role of backward linkages. We refer in particular to the Hirschman-Linder hypothesis that we have developed in previous work (Lopez-Gonzalez et al. 2015).

This conjecture blends the concept of backward linkages à la Hirschman, with the idea of "domestic representative" demand à la Linder (Burenstam Linder 1961). According to this, countries would be able to export a certain good if they attained a benchmark level of domestic demand; this would make domestic producers competitive enough to operate in the international market.

Linder (1961) puts forward this thesis concerning *final* manufactured products. In Lopez-Gonzalez et al. (2015) we have explored whether *intermediate* domestic demand could be a determinant of countries' GVC participation in KIBS, finding support for this hypothesis concerning domestic backward linkages between the manufacturing sector and KIBS.

Here we explore whether the Hirschman-Linder hypothesis could apply to backward linkages emerging from NRI demand, particularly to KIBS. In particular, we pose the following questions:

- What is the NRI's relationship with KIBS domestic *backward* linked sectors, and can this intermediate demand generated by NRI drive the emergence of other sectors in export?
- Does this conjecture apply to high-tech manufacturing too?
- Does specialisation in NRI affect the potential effect of NRI intermediate demand on the export of KIBS and high-tech manufacturing?

3.3 Data and Empirical Strategy

We aim to test our main conjecture, that domestic intermediate demand from the NR sector to KIBS and high-tech manufacturing sectors can be a "representative demand" à la Linder, favouring the emergence of other sectors and ultimately fostering export diversification. Relatedly, we would also expect countries with a specialisation in NRI to be more apt to use such sector as a platform to spur exports in other sectors.

It also seems important to distinguish between extractive NRI and renewable ones; the latter are natural resources from soil, such as the agriculture sector. They are, in contrast with extractive activities such as mining, usually considered to be less prone to NR curse effects (Venables 2016), However, they also yield commodities that may risk making the producing country highly dependent on them, exposed to price volatility and, crucially to our analysis, less likely to diversify due to the lack of inter-sectoral linkages (Vogel 1994; Matsuyama 2008; Hirschman 1958).

For these reasons we include them in our analysis. However, bearing in mind the differences between these two sectors, we present our results separately, looking at the relationship between intermediate domestic demand from these sectors and KIBS. So, our NRI are the two following sectors:

- agriculture, hunting and fishing (AGR);
- mining and quarrying (MIN).

In the remainder of the thesis when we refer to both AGR and MIN, we will use the general term NRI. When our analysis's results only apply to either sector, we will use the name of the relevant sector.

In Appendix A3, Table A3 reports the full list of the sectors used in our analysis and how they are aggregated into KIBS and high-tech manufacturing, following the OECD classification.

3.3.1 Data

In order to test this Chapter's main hypothesis on the effect of NRI intermediate demand on export in other sectors, we use the inter-country input-output (ICIO) tables compiled by the OECD, covering 33 sectors in 64 countries for the years 1995-2011. ICIO tables allow observing inter-sectoral linkages, tracing value added flows from the originating to the destination sector, both domestically and across borders[10]. Moreover, a value added approach allows capturing each sector's domestic value added contribution to countries' exports, reallocating value added exported to the sectors from which it has originated (Koopman et al. 2010).

This way we can assess the extent to which the increase of exports from a given sector is driven by domestic productive activity in that sector, as opposed to value added contributions coming from other sectors, either domestic or abroad (i.e. imports).

With 33 sectors, the data are quite aggregate and each sector category includes a wide range of different activities. This means that very diverse activities are included in each sector. We try to mitigate this shortcoming by looking at exports to focus on the share of production that is tradable and meets high enough quality standards to be competitive on the international market (Hidalgo et al. 2007). This choice is also consistent with the literature on the Dutch disease (Corden 1984; Torvik 2001), which focuses on the effect of large NRI on exports from other sectors.

In order to maximise the number of observations on which we can rely, we carry out our econometric analysis at the geo-sector level, i.e. looking at each of the two KIBS

[10] While a range of inter-country input-output databases are available, we chose the ICIO from the OECD because it ensures the largest coverage of countries, while still being based on statistical information from countries, without using imputation methods (Kowalski et al. 2015b).

sectors, ITS and BZS, in each country. We have thus a panel of 64 countries, i.e. 128 country-sector combinations, which we refer to as geo-sectors henceforth, over the 1995-2011 period[11]. In the next subsection we detail how we use the ICIO tables to compute the outcome and main explanatory variables.

3.3.2 Variables

Our literature review has emphasised the importance for countries with large NRI to diversify their export portfolio, which means putting in place policies to spur the exports of other sectors. Our main conjecture is that domestic intermediate demand stemming from NRI could achieve just this; this would imply for policy makers that fostering backward inter-sector linkages could be an effective policy tool to achieve export diversification. We operationalise this conjecture by estimating domestic value added in exports of sectors different from NRI as a result of NRI backward linkages. For simplicity, our discussion here refers to KIBS, although the same variables have been computed for high-tech manufacturing.

Our main outcome variable is domestic value added in exports per capita from the KIBS sector, which we compute as follows: let *VAE* be a c*i x 1 column vector with each country *c* and sector *i* domestic value added embodied in gross export:

$$VAE = V'(I - A)^{-1}E$$

Where V' is a ci x ci diagonal matrix populated with each geo-sector value added share in output, i.e. value added produced by a given geo-sector divided by its total output. $(I\text{-}A)^{-1}$ is the traditional Leontief inverse capturing all inter-sectoral relationships for all sectors and countries. Finally, E is a ci x 1 column vector with each geo-sector export. The elements of *VAE* include all value added that is originated by country *i* but consumed abroad, either through foreign final demand or foreign intermediate demand. We exclude from this measure the value added exported as foreign intermediate demand but then re-imported through country *i*'s own final demand.

[11] The ICIO data provide a balanced panel. However, the World Development Indicators have some missing values, which makes the final panel we are working with unbalanced and forces us to drop some countries from our analysis altogether, such as Brazil, Brunei, Vietnam and the rest of the World compound.

From this *VAE* vector we select the elements corresponding to each country's KIBS sectors. We therefore obtain our vector of observations, which we divide by each country's population obtaining *dva_kbs_cap*, i.e. value added in exports per capita in KIBS sector[12].

It is worth pointing out that our outcome variable includes the KIBS value added that is exported indirectly through NRI exports. This is also included in our explanatory variable that captures the domestic demand of NR for KIBS. In order to avoid this pitfall, we exclude from our outcome variable the portion of KIBS value added that is exported through NRI. In this way we avoid any mechanical, i.e. by construction, linkage between our two variables of interest.

Our main explanatory variable, domestic intermediate demand for KIBS from the NR sector, is computed in a similar way, but we take the ci x ci matrix X_DVA where each entry is populated with each geo-sector value added contribution to each sector's output:

$$X\_DVA = V'(I - A)_d^{-1}F$$

This matrix is computed very much in the same way as *VAE* but we substitute the *ci* x 1 E vector with the *ci* x *ci* matrix F populated with zeros off the diagonal and with each geo-sector final demand on the diagonal. We also use $(I\text{-}A)_d^{-1}$, which is the usual Leontief Inverse, although we extract from it a block-diagonal matrix where the dimensions of the block are the number of sectors, 33 in this case. This matrix will thus only capture the inter-sectoral linkages within the same country.

From the resulting *ci* x *ci* matrix we isolate those entries belonging to KIBS rows and to NR columns that correspond to how much each KIBS geo-sector contributes in value added terms to each of the two NR sectors' output. We then aggregate across NR sectors and divide by each country's population and obtain *dd_kbs_nr_cap*.

12 This variable is computed in the same way as the DVA variable used in Chapter 2 to compute both RCAs and DVA shares.

Finally, both human capital and information and communication technologies (ICT) infrastructure have played a significant role in the expansion of the service sector and its linkages with the rest of the economy (Guerrieri and Meliciani 2005).

For this reason we rely on the World Bank World Development Indicators and use gross enrolment in secondary education to capture human capital and Internet users per thousand inhabitants as a proxy of technological infrastructure, particularly related to ICT.

3.3.3 Econometric strategy

To test our main conjecture of the Hirschman-Linder hypothesis applied to NR, the general form of our estimated equation is the following:

$$dva\_kbs\_cap_{it} = \alpha_0 + \beta_1 dva\_kbs\_cap_{it-1} + \beta_2 dd\_kbs\_nr\_cap_{it} + \beta_3 dd\_kbs\_nr\_cap_{it} * nr\_rca_{ct} + \beta_4 schooling_{ct} + \beta_5 internetaccess_{ct} + \alpha_i + \alpha_t + \varepsilon_{it}$$

In our econometric equation presented above, $dva\_kbs\_cap_{it}$ is the KIBS value added embodied in each geo-sector's i gross exports per capita in each year t, $dd\_kbs\_nr\_cap_{it}$ is the per capita domestic intermediate demand provided by the NR sector to each geo-sector: both these variables are in log.

$schooling_{ct}$ captures human capital through years of schooling in each country c and year t, while $internetaccess_{ct}$ is Internet users per thousand inhabitants and captures countries' technological infrastructure. We also control for geo-sector and year fixed effects (FE) α_i and α_t respectively.

While our main hypothesis concerns the positive effect of intermediate domestic demand stemming from NRI on the domestic value added exported by both KIBS and high-tech manufacturing for all countries, we expect that the specialisation in NR sectors of a country may influence the relationship between our outcome and explanatory variables. An additional hypothesis we wish to test is, in fact, whether countries with a specialisation in NRI experience a stronger relationship between backward linkages stemming from NRI and the DVA they export from KIBS and high-tech manufacturing.

To test this, we interact our main explanatory variable with a dummy variable *nr_rca* taking value 1 if the country has a revealed comparative advantage (also measured in value added) in the natural resource sector[13]. This will allow us to explore whether a specialisation in natural resources affects the relationship between exports of value added in KIBS and the intermediate domestic demand generated by the natural resource sector.

Using the revealed comparative advantage to assess countries' specialisation in NRI is a data-driven approach. This has the advantage that our definition of specialisation does not rely on any *ex-ante* and arbitrary definition of how much NRI should represent of a country's GDP or exports.

Two more issues need to be dealt with. First, export of KIBS is likely to be affected by serial correlation, as current levels of exports are often correlated with past ones. Second, the relationship between exports of KIBS and the domestic intermediate demand coming from NR is likely to go both ways; while we want to test whether increases in the intermediate domestic demand generate increases in the export of KIBS, it is also possible that the causation's direction may go the other way, through a simultaneous effect.

In order to deal with both these issues, we opt for an autoregressive model, including the lag of the outcome variable on the right-hand side of the equation, $dva\_kbs\_cap_{it-1}$, and use a system GMM, which allows instrumenting our endogenous variables with its own past lags.

We also cluster the standard errors by country and perform the robust version of the system GMM with Windmeijer's (2005) correction for finite sample.

All of the variables we have computed with the ICIO tables are per capita measures of DVA flows across sectors (for the explanatory variables), and from one sector to the rest of the world (for the outcome variable). This is to account for countries' differences in size, assuming that population is a good proxy for countries' size.

[13] Since we test our results separately for AGR and MIN, we use a dummy variable that takes value 1 for countries with an RCA in the relevant sector, either AGR or MIN. These RCAs are computed in the same way as discussed in Chapter 2.

However, this may not necessarily apply to NRI in particular, whose size can be driven by the endowment of natural resources that need not be tightly related to the population of a country. We present in the Appendix a robustness check of our results, accounting for countries' size using Leontieff Inverse coefficients[14]. This captures NRI intensity in inputs from KIBS and high-tech manufacturing, which is independent of countries' size and on countries' population.

Before discussing our econometric results in the next section, we present here some descriptive evidence concerning the relationship between intermediate NR-KIBS domestic demand and KIBS domestic value added in exports.

3.4 Descriptive evidence

In this section we present some preliminary evidence supporting our main conjecture that larger domestic intermediate demand from NRI has a positive effect on DVA export of KIBS.

Figure 3.1 plots the natural logs of DVA from the KIBS sector and the logs of intermediate demand emanating from the NR sector for KIBS. The dots in blue and green correspond to countries with and without an RCA in NRI, respectively. The same applies for the fitted lines in light blue and dark green, while the fitted line in red is plotted without distinguishing between countries with or without an RCA.

[14] See Tables A8 and A9 in the Appendix

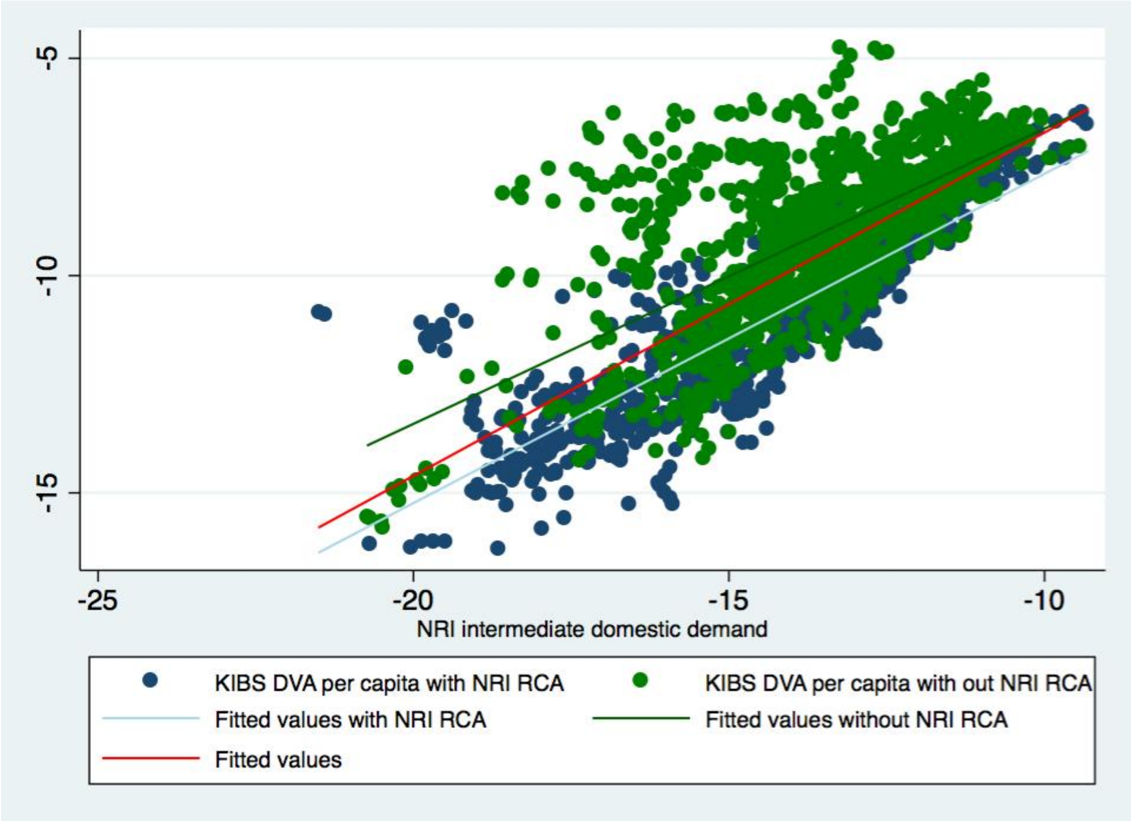

Figure 3.1: Natural logs of domestic intermediate demand per capita from NRI and natural logs of KIBS domestic value added in export per capita.

Source: authors' own calculation with ICIO tables.
Note: figure 3.1 plots the natural log of intermediate domestic demand per capita from NRI against the natural log of KIBS DVA per capita. These are all negative because the original data from the ICIO tables are measured in millions of USD, which yields values below 1 when divided by the population to obtain per capita measures.

We find a strong and positive relationship between our two variables. We also see that the countries without an RCA in NRI tend to have higher levels of KIBS DVA, although the fitted line has a slightly lower slope; this suggests that the relationship may be less strong. Countries without an RCA in NRI have in fact higher variability of KIBS DVA for similar levels of intermediate demand for KIBS from NRI.

As we mentioned, our econometric analysis will look at AGR and MIN separately, so we now offer some descriptive evidence on the relationship between these two sectors' intermediate demand and DVA in KIBS.

The positive association detected in Figure 3.1 is borne even more strongly when we look at the AGR sector alone, in Figure 3.2: the colour legend in this figure is the same for Figure 3.1. We see again that the countries without an RCA in AGR tend to cluster in the upper-right corner of the graph, which means that they usually have higher levels of both intermediate domestic demand from AGR and KIBS DVA. However, the slope of the fitted line is smaller when compared to the subsample of countries with an RCA in AGR, which suggests that the relationship between intermediate demand from AGR and the export of KIBS DVA may be stronger for countries with an RCA in AGR.

This also brings support to the idea that the relative size of the NR sector may be a factor influencing the relationship between the intermediate domestic demand originating from this sector and the DVA exported by KIBS.

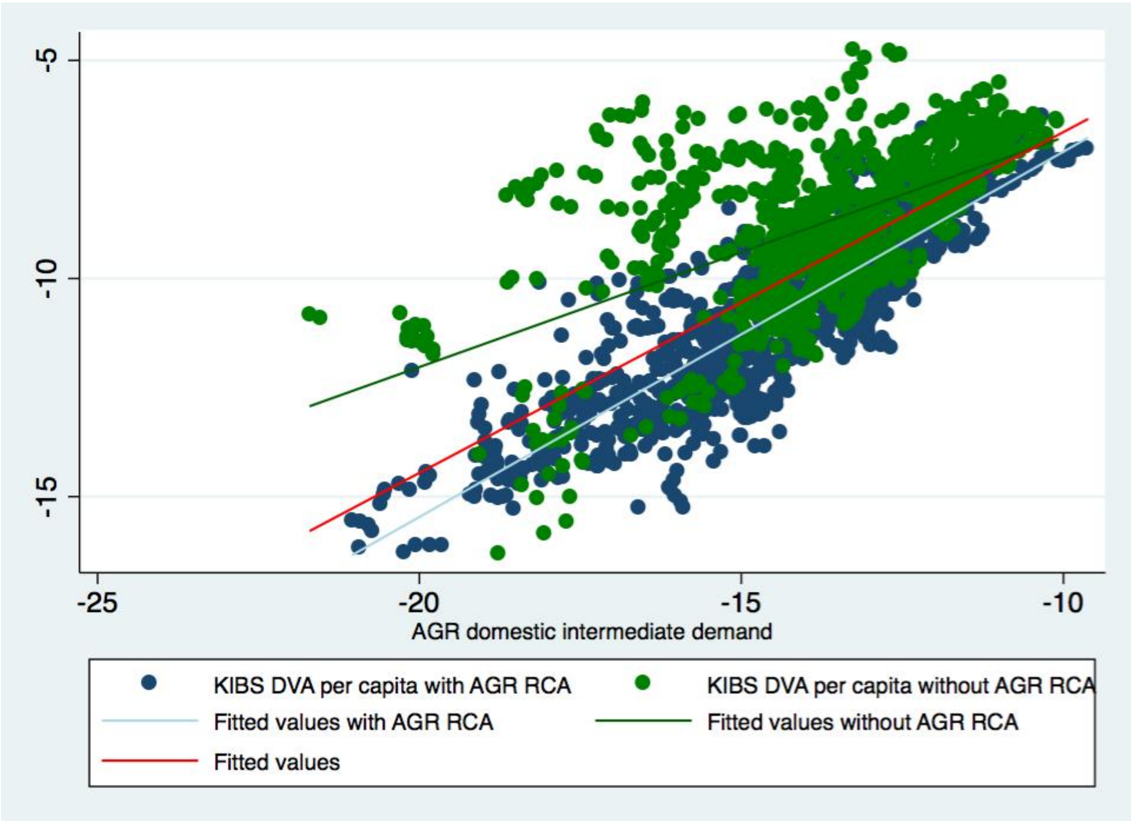

Figure 3.2: Natural logs of domestic intermediate demand per capita from AGR and natural logs of KIBS domestic value added in exports per capita.

Source: authors' own calculation with ICIO tables.
Note: figure 3.2 plots the natural log of intermediate domestic demand per capita from AGR against the natural log of KIBS DVA per capita. These are all negative because the original data from the ICIO tables are measured in millions of USD, which yields values below 1 when divided by the population to obtain per capita measures.

When we turn to the MIN sector in Figure 3.3, we find once again a positive association between our variables; interestingly we find here that countries without an RCA are located more towards the upper-left quarter of the graph. This hints at the fact that they have rather lower levels of intermediate demand from MIN but higher levels of DVA KIBS. In contrast, countries with an RCA in MIN tend to have lower levels of export of KIBS.

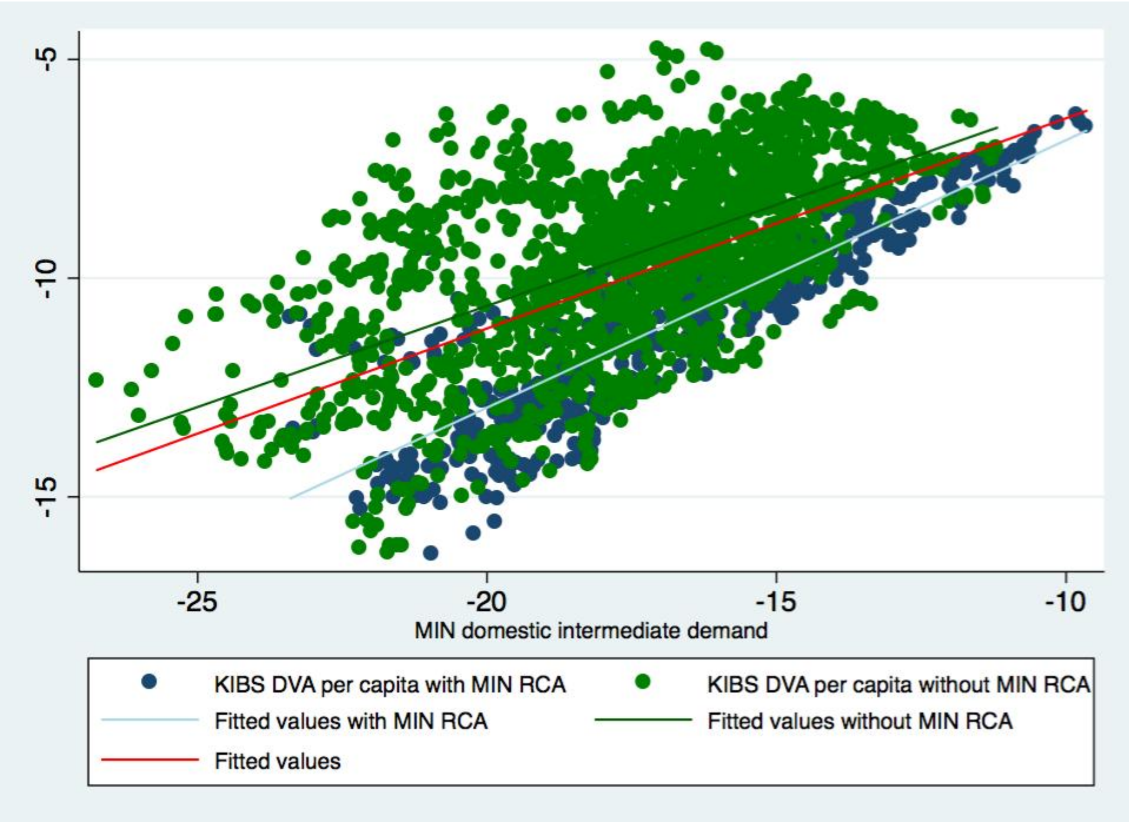

Figure 3.3: Natural logs of domestic intermediate demand per capita from MIN and natural logs of KIBS domestic value added in exports per capita.

Source: authors' own calculation with ICIO tables.
Note: figure 3.3 plots the natural log of intermediate domestic demand per capita from MIN against the natural log of KIBS DVA per capita. These are all negative because the original data from the ICIO tables are measured in millions of USD, which yields values below 1 when divided by the population to obtain per capita measures.

This descriptive analysis provides some preliminary evidence to our main conjecture on the positive effect of NRI intermediate domestic demand and DVA exported by KIBS.

Relating back to Venables' (2016) distinction between renewable (AGR) and extractive industries (MIN), we find some interesting differences. The positive relationship we detect seems to be particularly strong for the AGR sector, rather than MIN. This may suggest that the enclave thesis may apply to backward linkages from extractive NRI more than to renewable NRI. This would lend further support to Venables (2016) conclusion that renewable natural resources may have fewer negative effects on countries' economic performance.

These figures offer *prima facie* evidence about the relationship between intermediate domestic demand and DVA exports of KIBS, which is likely to be riddled with endogeneity, particularly due to reverse causality and simultaneity of the relationship. As discussed above, our econometric approach deals with these issues; we present the main results in the next section.

3.5 Econometric results

3.5.1 NRI and backward linked KIBS

In the following tables we present our main results, we also look separately at the two sectors (AGR and MIN) that are included in the NR sector. Re-computing our explanatory variables and RCA accordingly, Table A2 in the appendix summarises the list of relevant variables and the associated acronyms.

In Table 3.1 we find a positive and significant effect of intermediate demand from NRI on the per capita export of value added of KIBS, both when we look at AGR and MIN as two separate outcome variables. The interacted terms are also significant, which suggests that the positive effect of NRI intermediate demand on the export of KIBS is stronger for countries with an RCA in NRI.

Table 3.1: The effect of NRI intermediate demand on the DVA of KIBS in export per capita – System GMM estimation

VARIABLES	AGR	MIN
$dva\_kbs\_cap_{t-1}$	0.792***	0.922***
	(0.0778)	(0.0450)
dd_kbs_agr_cap	0.205**	
	(0.0952)	
dd_kbs_agr_cap*agr_rca	0.212**	
schooling	0.00572	0.00304
	(0.00348)	(0.00252)
Internet access	-0.00256	-0.000871
	(0.00256)	(0.00190)
dd_kbs_min_cap		0.0720**
		(0.0363)
dd_kbs_min_cap*min_rca		0.0738**
		(0.0359)
Constant	0	0.0937
	(0)	(0.816)
Observations	1,756	1,756
Number of geo-sectors	122	122
AR(2)	0.289	0.166
Hansen test overidentification	0.529	0.740
Difference-in-Hansen	0.680	0.865

System GMM estimation for the effect of the natural log of intermediate demand per capita of AGR (col. 1) and MIN (col. 2) on the DVA in export per capita of KIBS. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are two KIBS sectors: Computer and related activities (ITS); R&D and other business services (BZS). The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

dva and dd variables in logs

For the AR and Hansen tests the p values are reported.

Source: authors' own calculation on ICIO tables.

These results suggest that intermediate demand from the NR sector exerts a positive effect on the export of KIBS, and even more so in those countries that have an RCA in this sector.

As mentioned above, we chose the RCA index as a measure of specialisation in NRI; however, this has some implications on how these results can be interpreted. The RCA is a measure of relative specialisation: a country with an RCA in NRI above one is a country in which NRI represents a higher proportion in its exports than it does in the world's exports (Balassa 1965). The underlying idea of the RCA is that countries specialise in sectors whose production requirements they are best equipped to meet (Chor 2010), which may lead to equating specialisation and competitiveness (Hidalgo et al. 2007).

Competitiveness in a sector is often related to productivity: countries that are more efficient at producing in a given sector will be more likely to be more competitive (and specialise) in this sector (Chor 2010).

However, a country may develop a specialisation in NRI, which would only be captured by the RCA index because of its endowment in NR and lack of other sectors, regardless of the sector's productivity. This has bearing on the interpretation of our results, depending on the source of RCA in NRI:

- A very productive NR sector allows a country to develop an RCA in NRI, hence requiring more and/or higher quality KIBS inputs, therefore increasing KIBS export performance; there would thus be a 'quality' effect of the intermediate demand stemming from NRI on the export performance of KIBS;
- A very large NR sector, regardless of its productivity, provides a very large intermediate demand and this 'scale' (or quantity) effect improves KIBS export performance.

These two channels are not mutually exclusive, but it is important to disentangle them to understand for which countries our results will be relevant.

On the one hand, if improvements in the export of KIBS are conditional on the 'quality' of the intermediate demand to which they are exposed, countries relying mainly on the size of the NR sectors (which are often developing ones) will be unlikely to see their KIBS sector benefit from NRI domestic intermediate demand.

On the other hand, if the 'scale' effect is at play, countries can exploit the size of the NRI intermediate demand, regardless of its 'quality', to improve KIBS export performance.

In order to ascertain this, we need to control for the 'quality' effect that could drive countries' specialisation in NRI. We proxy the quality of the intermediate demand with an index of productivity of the NR sector[15], which we compute by dividing the domestic value added of the NR sector by its inputs, i.e. its intermediate demand. This is admittedly a crude measure of productivity, but it has the advantage of being readily computable at the sectoral level in our data[16]. It is also close to the idea of productivity as efficiency in production, as it captures how much value added is produced given the input required by the production process.

Part of the intermediate demand of the NR sector is already included in our main explanatory variable; we therefore exclude this portion of intermediate demand from the calculation of our productivity index.

$$VAIC = \frac{VA}{(IC - IC_{NR-KIBS})}$$

Where VA is domestic value added and the denominator is intermediate consumption (IC) minus the intermediate consumption met by the KIBS sectors ($IC_{NR\text{-}KIBS}$). Table 3.2 shows the results of the estimation that includes this additional control.

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[15] As above, we refer in the text to NRI in general; naturally, in the empirical analysis, we compute this measure of productivity for AGR and MIN separately.

[16] An alternative approach would have been to compute labour productivity at the sectoral level; however, employment data at the sectoral level for all the countries in our sample is not available. The world input-output tables (WIOT) would have been an alternative source as they include inter-country input-output tables and sectoral levels of employment, but they cover a significantly smaller number of countries, including few developing countries.

Table 3.2: The effect of NRI intermediate demand on the DVA of KIBS in exports per capita, controlling for NRI productivity – System GMM estimation

VARIABLES	AGR	MIN
dva_kbs_cap$_{t-1}$	0.852***	0.925***
	(0.0796)	(0.0443)
dd_kbs_agr_cap	0.206**	
	(0.104)	
dd_kbs_agr_cap*agr_rca	0.213**	
	(0.101)	
schooling	0.00155	0.00155
	(0.00336)	(0.00268)
internetaccess	-0.00470**	-0.000820
	(0.00207)	(0.00171)
vaic_agr	0.0272	
	(0.122)	
dd_kbs_min_cap		0.0520
		(0.0330)
dd_kbs_min_cap*min_rca		0.0595*
		(0.0334)
vaic_min		-0.0721
		(0.0938)
Constant	2.084	0.248
	(1.294)	(0.726)
Observations	1,756	1,756
Number of geo-sectors	122	122
AR(2)	0.665	0.217
Hansen test overidentification	0.845	0.801
Difference-in-Hansen	0.262	0.752

System GMM estimation for the effect of the natural log of intermediate demand per capita of AGR (col. 1) and MIN (col. 2) on the DVA in export per capita of KIBS. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are two KIBS sectors: Computer and related activities (ITS); R&D and other business services (BZS). The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

The two additional controls are vaic_agr and vaic_min which are the ratio between AGR and MIN, respectively, total value added divided by their respective total intermediate consumption, excluding the intermediate consumption of KIBS.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
dva, dd and vaic variables in logs
For the AR and Hansen tests the p values are reported.

Source: authors' own calculation on ICIO tables.

We find our results to be robust, in particular when looking at the agriculture sector. We find that the intermediate domestic demand has a positive effect for all countries and the interaction term is also positive and significant; this suggests that such a relationship is even stronger for countries with an RCA in the AGR sector. For the mining sector, we find significant results, at the 10% level, only for countries with an RCA in NRI.

So, the positive effect between NRI, especially AGR, intermediate domestic demand on KIBS export does not seem to be driven by the ‘quality’ of the intermediate demand: our results suggest that in countries with a specialisation in NRI, the domestic intermediate demand originating from this sector exerts a positive effect on the export of KIBS, through a scale effect, regardless of productivity. This is also supported by the fact that the productivity measures of either NRI never shows a statistically significant coefficient, suggesting that NRI productivity is unrelated to exports of domestic value added in KIBS.

In conclusion it would appear that, in contrast with a dominant view of natural resources as an enclave sector with weak domestic inter-sectoral linkages with the rest of the economy, domestic intermediate demand emanating from NRI can foster exports for value added in the KIBS sector.

Our empirical results lend support to our initial conjecture relating to the Hirschman-Linder hypothesis. Lopez-Gonzalez et al. (2015) have already shown that manufacturing intermediate demand could foster GVC participation in KIBS; we now find that the same mechanism is also valid for backward linkages from NRI.

It is important to stress, however, that these results should not be interpreted as a rationale for developing a specialisation in NRI, but rather that countries that already have an economic structure in which such industries play a pivotal role should foster the domestic backward linkages to other sectors to spur the emergence of KIBS and achieve economic diversification.

In particular we show that export diversification away from NRI may be possible through backward, rather than the more studied forward linkages, putting forward an interesting alternative to beneficiation policies, which have often proved unsuccessful.

Such policies did not focus on KIBS but on manufacturing. The rationale for this was to allow countries to use the output of their NRI as input for low-tech manufacturing activity, using it to trigger structural change and gradually upgrade to high-tech manufacturing activities. Since these were the ultimate goals of beneficiation policies, we wish to test whether backward linkages from NRI can also provide an avenue for the emergence of exports in high-tech manufacturing, as we see is the case for KIBS.

Such services can include both knowledge intensive activities in the legal and managerial domain, as well as technical services and engineering activities both for the mining and agricultural sector (Francois and Woerz, 2008; Kaplan, 2012; Varela and Hollweg, 2016).

3.5.2 NRI and backward linked High-Tech Manufacturing

As emphasised when reviewing the literature, most of the scholarship has looked at the inter-sectoral linkages originating from NRI to *downstream* manufacturing activities, often arguing that these were not a viable path to diversification towards the manufacturing sector (Auty 1986; Hausmann, B Klinger, et al. 2008). We aim here to explore the potential of *backward* linkages.

We saw in the previous section that such linkages can indeed spur the emergence of KIBS exports. We now wish to test whether this hypothesis applies to high-tech manufacturing and thus whether backward linkages can constitute a path to the emergence of high-tech and knowledge intensive sectors, both in services and manufacturing.

In this section we define high-tech manufacturing based on the OECD classification[17], and carry out the same empirical analysis as we did for DVA in KIBS in the previous section.

[17] See Table A1 in the Appendix for a full list of sectors.

In Table 3.3, we again find positive and significant effects of domestic intermediate demand on the export of high-tech manufacturing value added, for both AGR and MIN. In both these cases, the interaction terms are positive and significant, corroborating the idea that the positive relationship between NRI intermediate demand and the export of high-tech manufacturing is stronger for countries that have an RCA in NRI.

Table 3.3: The effect of NRI intermediate demand on the DVA of high-tech manufacturing in exports per capita – System GMM estimation

VARIABLES	AGR	MIN
$dva\_htm\_cap_{t-1}$	0.884***	0.891***
	(0.0686)	(0.0602)
dd_htm_agr_cap	0.0838***	
	(0.0270)	
dd_htm_agr_cap*agr_rca	0.0799***	
	(0.0276)	
schooling	0.00544	0.00466
	(0.00463)	(0.00437)
internetaccess	-0.000307	0.000230
	(0.00276)	(0.00203)
dd_htm_min_cap		0.0496***
		(0.0190)
dd_htm_min_cap*min_rca		0.0435**
		(0.0198)
Constant	-0.518	-0.633
	(1.486)	(1.213)
Observations	5,268	5,268
Number of geo-sectors	366	366
AR(2)	0.153	0.677
Hansen test overidentification	0.385	0.235
Difference-in-Hansen	0.129	0.458

System GMM estimation for the effect of the natural log of intermediate demand per capita of AGR (col. 1) and MIN (col. 2) on the DVA in export per capita of high-tech manufacturing. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are six high-tech manufacturing sectors, the full list can be found in the appendix table A1. The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

dva and dd variables in logs

For the AR and Hansen tests the p values are reported.

Source: authors' own calculation on ICIO tables.

These results expand the existing debate around beneficiation and NRI forward linkages to manufacturing, suggesting that backward linkages may be a pathway to industrialisation for countries with a specialisation in NRI.

In the previous section we discussed how an RCA in NRI may arise because the country is very efficient in the production process, or simply because the country is largely endowed and lacks other sectors of comparable size.

For this reason we now replicate in Table 3.4 the model from Table 3.3, adding our measure of productivity of the NR sector as an additional control.

Table 3.4: The effect of NRI intermediate demand on the DVA of high-tech manufacturing in exports per capita, controlling for NRI productivity – System GMM estimation

VARIABLES	AGR	MIN
$dva\_htm\_cap_{t-1}$	0.955***	0.839***
	(0.0419)	(0.0390)
dd_htm_agr_cap	0.0440	
	(0.0426)	
dd_htm_agr_cap*agr_rca	0.0379	
	(0.0403)	
schooling	0.000789	0.00732***
	(0.00254)	(0.00257)
internetaccess	0.000126	0.00127
	(0.00160)	(0.00182)
vaic_agr	-0.156	
	(0.186)	
dd_htm_min_cap		0.0415***
		(0.0140)
dd_htm_min_cap*min_rca		0.0383**
		(0.0165)
vaic_min		-0.0147
		(0.0324)
Constant	0.287	-1.200
	(0.735)	(0.734)
Observations	5,268	5,268
Number of geosecid	366	366
AR(2)	0.016	0.068
Hansen test overidentification	0.213	0.643
Difference-in-Hansen	0.147	0.817

System GMM estimation for the effect of the natural log of intermediate demand per capita of AGR (col. 1) and MIN (col. 2) on the DVA in export per capita of high-tech manufacturing. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are six high-tech manufacturing sectors, the full list can be found in the appendix table A1.

The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

The two additional controls are vaic_agr and vaic_min which are the ratio between AGR and MIN, respectively, total value added divided by their respective total intermediate consumption, excluding the intermediate consumption of high-tech manufacturing.

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

dva, dd and vaic variables in logs

For the AR and Hansen tests the p values are reported.

Source: authors' own calculation on ICIO tables.

We now find rather different results. In the case of high-tech manufacturing, intermediate backward linkages from the AGR sector do not play any significant role, once we control for the productivity of the AGR sector and thus for the 'quality' of input it demands. This suggests that the previous positive results in Table 3.3 were picking up an effect related to the productivity of AGR and that, once we account for that, the strength of the intermediate demand becomes irrelevant.

In contrast we find a positive and significant effect of the intermediate demand from the MIN sector, as well as the interaction terms with the RCA dummy. This suggests that the intermediate demand from the MIN sector does have a positive impact on the DVA export per capita of the high-tech manufacturing and that this effect is stronger for countries with an RCA in MIN.

This is an interesting result, especially when compared to the different results obtained for KIBS. Intermediate demand from the natural resource sector seems to be a successful strategy to develop exports of KIBS, regardless of whether we look at extractive (MIN) or not (AGR) industries. Exports in high-tech manufacturing in contrast seems to be affected by the intermediate demand of only the mining sectors, once we control for the productivity of NRI.

So, in the previous section we find that our Hirschman-Linder hypothesis does apply to NRI-KIBS backward linkages and that this result is robust, even when controlling for productivity in NRI. Concerning high-tech manufacturing we only find support for our Hirschman-Linder hypothesis only for the MIN sector; this is particularly interesting with respect to the well-established literature that has looked with scepticism at resource based industrialisation (RBI) strategies, focusing on forward linkages from NRI (Auty 1986; Hausmann, et al. 2008).

This Chapter puts forward new evidence suggesting to use backward, rather than forward, linkages to foster exports in high-tech manufacturing. Overall, we propose a novel and alternative way for countries with large NRI to diversify their exports towards manufacturing, relying on NRI's intermediate demand rather than output. We find this path to be viable for export diversification towards KIBS and high-tech manufacturing, though for the mining sector only.

It is also worth pointing out that while our main conjecture is borne out by the evidence concerning KIBS, this appears to be the case only for countries with a specialisation in either AGR or MIN, when we control for the NRI sectors productivity.

This in turn confirms our hypothesis that NRI backward linkages would be a driver of DVA exports in KIBS for countries with a specialisation in NRI.

3.6 Conclusions

This Chapter has offered novel empirical evidence in support of exploiting backward and forward linkages à la Hirschman (López-Gonzalez et al. 2014), in a context of emerging countries that face the opportunities and challenges of having to 'diversify away' from NRI, when NR abundant or dependent. In doing so, we aim to contribute to the old-age debate on the NR "curse", which has been recently revamped.

The topic of how to better achieve export diversification as a development strategy is of high relevance among academic and policy makers, despite it not being new. We have offered here a new angle in two respects. The first is in revisiting the issue of backward and forward linkage à la Hirschman, together with some trade scholars (see for instance, Venables et al. 2015), although in a context of NRI specialisation. The second is tackling the age-old issue of diversification via *beneficiation* – that is, the development of downstream, forward linked manufacturing industries that process raw materials and natural resources (Hausmann et al. 2008) – from the perspective of backward linkages with industries that have been relatively overlooked in the debate on NRI.

We have looked at whether specialisation in NRI overall, and separately in extractive industries and agriculture, might represent a sizeable and quality “representative domestic demand” à la Linder that can spur the creation of KIBS and high-tech manufacturing sectors as an option for export specialisation. We explore whether there is a causal link between NRI specialisation and export performance of KIBS and high-tech manufacturing. We find robust evidence in support of our conjectures.

Countries specialised in NR, most especially in agriculture, show a positive impact on KIBS and high tech manufacturing’s export performance. This result is stronger for KIBS only, in countries with a revealed comparative advantage in NRI, when we control for NRI’s productivity performance.

In the case of high-tech manufacturing, it seems that the positive impact on export performance of manufacturing of the intermediate demand of NRI is absorbed by the productivity of the NR sector itself for the AGR sector, while our results are robust when we look at the intermediate domestic demand of MIN.

This seems to support the view that – after all – vertical linkages matter when it comes to identifying patterns of diversification that “build upon” NRI rather than “away from” NRI. Looking at backward linked sectors – and especially KIBS - is a way of rewriting the narrative around NRI, and surely one that contributes to the debate around ‘premature deindustrialisation’ recently put forward (Rodrik, 2015).

While we do not explicitly provide grounded evidence for specific industrial policy tools, we hope to provide a background narrative that supports new directions of these. More in general, it is not straightforward to identify appropriate policy tools that support domestic and trade diversification in emerging countries, that allow ‘quality’ industrialisation or indeed ‘quality’ servification, all the more so when countries start from a specialisation in NR.

However, based on our results, we can offer a few general reflections on the importance of a coherent set of industrial and innovation policies that aim to support industrial development in NR-based emerging countries.

First, countries, particularly those abundant and/or specialised in NR, could exploit this to identify related backward or forward linked sectors that do not necessarily need to be on the technological frontier but nevertheless represent feasible directions for structural transformation. While this is not, in principle, new, for instance within the product space framework (Hidalgo et al. 2007; Hausmann et al. 2007), we argue that the ability of countries to transition from one set of activities to another one is based on a deliberate policy effort to support technological and sectoral upgrading (Ciarli et al. 2018).

Second, such a deliberate effort would entail a new narrative around the support to international technology transfer, via, for instance, Multinational Enterprises (MNEs) presence, most especially in NR-based countries. The development of domestic capabilities for upgrading is the result of a patient and long-term process of interaction of foreign and domestic firms, all the more so in a context of international fragmentation of production. Currently there is little reflection, and only from a few scholars, on the link between international technology transfer, export diversification, and domestic technology upgrading as an explicit policy goal that aims to ensure quality directions to structural transformation (Bell 2009; Barrientos et al. 2011; Fu et al. 2011; Pietrobelli et al. 2011). The conjecture and empirical evidence put forward in this Chapter have aimed to contribute to the narratives that might support these reflections.

4. Power and export sophistication in buyer-supplier relationships: insights from Colombian customs data

Abstract

This Chapter investigates the association between buyer-supplier international trade relationships and supplier's product upgrading. We proxy the suppliers' upgrading with a measure of product sophistication. We first propose a measure of power in the trade relationship, combining the dependence of each firm on the trading partner and their market shares. Using transaction data from Colombia, we next estimate if the measure of power relationship predicts a supplier's export sophistication, the probability of adding a new product in the trading relationship, and that of increasing export sophistication.

We find that suppliers that are highly dependent on buyer's imports are more likely to fall into a specialisation trap in low sophistication products. Buyers with large market shares trade in sophisticated products, therefore with little margin for upgrading; suppliers with large market shares are more likely to introduce new products, but trade pairs where the buyer depends on the supplier are more likely to upgrade. We further test whether these relationships hold across different destination countries, finding in particular that buyers dominating the market in the US tend to import low-sophistication products and make it harder for suppliers to upgrade.

We contribute to the recent literature on buyer-supplier relationships by explicitly including a measure of power into our analysis. In doing this, we also offer further support and complement the qualitative evidence put forward by the literature on governance in global value chains (GVCs).

4.1 Introduction

The positive association between export and growth is an established empirical regularity (Pack and Saggi 2001; Baldwin and Yan 2014; Lee 2011; Iacovone and Javorcik 2010; Iacovone and Javorcik 2009). More recently, it has been pointed out that it is not just the quantity but also the quality and sophistication of what one exports that affects growth prospects (Hausmann et al. 2007; Poncet and Starosta de Waldemar 2013; Jarreau and Poncet 2012). Increases in the sophistication of exports often means trading in more value-added products, increasing the stock of human capital and capabilities in the country, which can, in turn, foster economic development (Lall et al. 2006; Hidalgo et al. 2007; Minondo 2010; Zhu and Fu 2013).

Consistent with this view, the literature has put forward evidence of the importance of exports for firms' productivity and learning opportunities (Wu 2012; Antolín et al. 2012), stressing the importance of different products and destinations (Fontagné et al. 2018; Iacovone and Javorcik 2010; Eckel et al. 2015; Bernard et al. 2015). The literature on the relationship between exports and firm performance is very large. Martins and

Yang (2009) review the evidence and conclude that exports have larger positive impacts on firms in developing countries, especially during their first years of exporting; this makes Colombia a relevant country to study.

Trade has both increased and changed in nature in recent decades, shifting towards trade in intermediates and leading to the emergence of global value chains (GVCs).

From a development perspective, GVCs have often been regarded as a new opportunity for firms in developing countries to access the global market, tap into foreign knowledge and know-how and, ultimately, achieve upgrading (Gereffi et al. 2005; Kaplinsky 2004; Baldwin 2011).

Upgrading via trade can happen through the exchange of knowledge between buyers and suppliers, such as product specifications (Pietrobelli and Saliola 2008), and cooperation through tight relationships between the buyer and the supplier, going well beyond pure market relationships (Gereffi et al. 2005; Giuliani et al. 2005b). An implication of this is that flows of knowledge are not automatic and depend on how much the buyer relies on their supplier, how skilled the supplier is, and what kind of transactions take place between the two (Gereffi et al. 2005; Giuliani et al. 2005b). Moreover, suppliers that manage to participate in GVCs need to do so by securing and maintaining a position within the chain that is protected from other competitors and grants them bargaining power vis-à-vis their buyers (Kaplinsky 2004). For the supplier, therefore, upgrading through participation in GVCs ultimately depends on the governance under which firms operate within a GVC: power relationships along the chain shape firms' governance and, thus, upgrading (Gereffi et al. 2005; Humphrey and Schmitz 2002; Pietrobelli and Saliola 2008).

In parallel, albeit separately, with this debate, a growing literature has emerged in recent years using quantitative data on firm level transactions to explore firm heterogeneity in trade (Melitz 2003; Bernard et al. 2014; Carballo et al. 2013; Bernard et al. 2011; Eaton et al. 2007) and buyer-supplier matching (Sugita et al. 2015; Dragusanu 2014). Stemming from this, a stream of research has been using matched buyer-supplier data at the transaction level to explore the importance of relationships (which this literature also refers to as "value of the relationship"), between trading parties, especially in the context of low contract-enforceability (Macchiavello 2010; Macchiavello and Morjaria 2015; Macchiavello and Morjaria 2016; Macchiavello and Miquel-Florensa 2017).

The key finding of this literature is that as buyers and suppliers trade with each other over time, they also learn about and trust each other more; this is particularly important in context with low contract enforceability. Reputation in such a context becomes crucial and its value increases with the age of the relationship, reducing opportunistic behaviour in trade relationships.

Despite this growing evidence on the importance of relationships, this stream of literature has not directly tackled the issue of upgrading or power within buyer-supplier relationships.

This Chapter aims to remedy this with a quantitative approach; we answer the question of whether power in buyer-supplier relationships is a predictor of levels of export sophistication, the likelihood of introducing new products, and that of increasing sophistication.

We operationalise the concept of power, in particular distinguishing between the dependence of each trading party on each other and each trading party's market share. We investigate whether these two different understandings of power are related in different ways to export sophistication and upgrading, as well as whether such relationships change across destination countries.

Our main source of data is the Colombian Customs, with information on all export transactions between 2008 and 2014. We merge this with data both on exporters' financial statements and product measures of complexity from the *Atlas of Complexity*[18], compiled by Harvard University.

In our analysis we provide some descriptive evidence on the relationship between power within buyer-supplier pairs and the sophistication of the products traded. This is

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[18] The terms 'complexity' and 'sophisticated' can be used interchangeably. For clarity 's sake, however, in the remainder of the thesis we use the term 'sophistication' in line with the literature on export sophistication and upgrading. We revert to complexity (or complexity measure) when explicitly referring to the product complexity index (*pci*) from the *Atlas of Complexity*.

supported by a regression analysis to produce more comprehensive results, controlling for supplier's productivity and buyer-supplier pairs' characteristics.

Therefore, our level of analysis is the pair, for which we observe both the buyer and the supplier, and the products and quantities they exchange. However, our main interest lies with the supplier, which is the one ultimately engaging in upgrading. For this reason we also rely on financial data on the suppliers from the SIREM database, which allows controlling for time varying characteristics of the suppliers.

We find that when a supplier trades with a powerful buyer, both the level of sophistication and the chances of upgrading will vary depending on the source of the buyer's power. If this is due to the fact that the supplier is heavily dependent on the buyer, the supplier will usually be trading in low-sophistication products and have little chance of upgrading.

If, instead, the buyer's power is due to its own large market share it is more likely that the buyer will be purchasing sophisticated products. However, this will also leave little room for the supplier to further upgrade, arguably because it is already at the frontier. This relationship is reversed when we look at relationships between Colombian exporters and US importers, which suggests that firms exporting to buyers dominating the market in high-income countries may find it harder to both trade in sophisticated products and improve their export sophistication. This is interesting because it suggests that destination countries, and knowledge asymmetries among these, may have an impact on how buyer-supplier relationships are related to export sophistication.

Concerning powerful suppliers, we find that when power comes from a large market share, they are more likely to introduce new products. However, it is the dependence of the buyer on the supplier that is positively related to increases in sophistication of the supplier's export and upgrading.

We also expand the existing quantitative evidence on the value of the relationship in trade at the firm and transaction level. This is done by including the concepts of power into our analysis, which the established literature on GVCs has put forward as a determinant of upgrading and, ultimately, economic development.

In doing this, we also add to this mainly qualitative literature on GVCs: we carry out new quantitative analysis of transaction level trade data to offer support to the view that power is relevant to trade relationships' outcomes.

We also contribute to this literature by disentangling the mechanisms through which power manifests itself in buyer-supplier relationships.

The remainder of the Chapter is structured as follows: section 2 deals with the relevant literature. Section 3 presents the Chapter's research questions and contributions; we then turn to the data and the construction of the variables and describe Colombian buyer-supplier relationships in terms of power and sophistication in section 4. The penultimate section discusses the results from our empirical analysis, and the section 6 concludes.

4.2 Literature review

This section starts by reviewing the literature on GVCs, emphasising the theoretical and empirical contributions on power in buyer-supplier relationships and upgrading. We integrate these concepts into the analysis of transaction level trade data, which has only recently started to explore the importance of buyer-supplier relationships. In order to include power into this growing strand of work, we draw on the measurement of this provided in the literature on industrial organisation and supply chain management.

4.2.1: Global value chains: power and upgrading

The international fragmentation of production has raised attention on the relationships among firms across borders, and the extent to which local suppliers (often in developing countries) can learn from global suppliers (Gereffi 1994; Humphrey and Schmitz 2002).

The GVC framework views this learning process as tightly linked to innovation and firms' access to new technology. Within this, it is argued that power within buyer-supplier relationships affects the availability of knowledge to suppliers.

One of the main contentions of this literature is that the nature of the relationship between buyers and suppliers can influence suppliers' scope for progressing in the value chain. Within this framework, scholars refer to the nature of the relationship as its governance; this determines "who does what", "when" and "how much". Humphrey and Schmitz (2002) put forward an initial taxonomy including (i) networks in which all firms hold similar levels of power and share their capabilities along the chain, (ii) quasi-hierarchical value chains are characterised by independent firms where one holds a considerably larger amount of power over the others, and (iii) hierarchical value chains characterised by direct ownership.

Building on this, Gereffi et al. (2005) propose a further refined taxonomy identifying:

- *Arm's length* market relationships, with little level of commitment and low switching costs;
- *Modular* value chains in which the supplier takes care of all the process technology and delivers a turnkey product. However, it does so with generic machinery and low levels of transaction-specific investment;
- *Relational* value chains are within sophisticated relationships between buyer and supplier and high level of mutual dependence, usually relying on spatial proximity of trust that is built up over time;
- *Captive* value chains in which small suppliers are dependent on large buyers, with a degree of control and monitoring on the buyer's part;
- *Hierarchical* value chains, where there is a direct ownership link between headquarters and subsidiaries.

This categorisation of different kinds of governance and buyer-supplier relationships lends itself very well to qualitative studies; however, it does not provide a clear-cut definition of the concept of power or a measurement that would ensure comparability across cases. We later discuss contributions from other strands of literature that put forward different approaches to power that lend themselves more to measurement and synthesis.

The other main focus of the GVC literature is opportunities for suppliers to engage in upgrading; however, this remains rather elusive and not clearly defined. In its broadest definition, upgrading refers to the improvement of firms' performance, through "making better products, making them more efficiently or moving into more skilled activities" (Giuliani et al. 2005, p.552).

The value chain scholarship has adopted a framework to encompass the different ways in which upgrading can take place. *Process* and *product* upgrading are closely related to product and process innovation, and correspond to a supplier introducing a new product or a new production process, respectively. *Function* upgrading refers to the inclusion of new, higher-value added activities within the GVC of which a supplier is already a part, while *value chain* upgrading usually implies a moving to a new value chain altogether (Humphrey and Schmitz 2002; Gereffi et al. 2005).

While these issues are very relevant to GVC analysis, many studies do not provide any explicit definition of what they exactly mean by upgrading (Morrison et al. 2006). The concept of upgrading is still very broad: it is particularly hard to distinguish from innovation and whether the two co-occur or one is the consequence of the other (Morrison et al. 2006). As a consequence upgrading has often been operationalised in many different ways across the literature (Morrison et al. 2006).

The fuzziness around the definition of these concepts represents a considerable obstacle to providing evidence based on large quantitative samples, which would favour the generalisation of the insights from the GVC literature.

The literature has tried to overcome this problem by constructing measures of sophistication, or complexity, which we use henceforth interchangeably. Focusing mainly on the country level, there is an established literature emphasising the importance for economies to introduce new products into their export portfolio (Amiti and Freund 2010; Koujianou Goldberg et al. 2010; Klenow and Hummels 2005; Broda and Weinstein 2006). The growing literature on export sophistication expands on this by qualifying the new varieties included in the export portfolio, positing that it is not only about including more products in the export portfolio, but also including more sophisticated (and thus, in this approach, of higher quality) ones (Zhu and Fu 2013; Minondo 2010; Hausmann et al. 2007; Hidalgo et al. 2007).

Lall et al. (2006) are among the first to devise a methodological approach to measuring export sophistication by inferring the sophistication of a product from the characteristics of the country exporting it, mainly its average income, rather than the product's characteristics. Building on this approach, the most remarkable attempt to compute a measure of sophistication is arguably in the contribution from Hidalgo et al. (2007), who propose a data-driven approach to capabilities. This is further developed in Hidalgo and Hausmann (2009), where they detach the measure of sophistication from income per capita – as was case in Lall et al. (2006) and Hidalgo et al. (2007) – rather relying on a product's ubiquity and the exporter's diversification.

The most sophisticated products are those that are being exported by few and highly diversified countries. The intuition behind this is that sophistication can be inferred through a product's ubiquity and countries' diversification. The most sophisticated economies will have a large set of capabilities and therefore will export many products. On the other hand, sophisticated products will be exported by few countries (i.e. they will show low ubiquity) with a large set of capabilities and a highly diversified export basket.

In this approach, therefore, countries' and products' complexity define each other through measures of diversification and ubiquity, respectively.

Hidalgo and co-authors resort therefore to algorithms based on the method of reflection, to compute a complexity measure for both products (based on their ubiquity and the diversification of the economies exporting them) and economies (based on the diversification of their export portfolio and the ubiquity of the products they export).

This measure of complexity has been used in the literature at mainly the country or municipality level (Bustos et al. 2012; Poncet and Starosta de Waldemar 2013). However, the complexity index refers to products and can also be applied to micro level data to study changes in exporters' portfolio to capture upgrading.

This would allow carrying out quantitative analysis at the firm level, proxying upgrading through complexity measures and studying its relationship with buyer-supplier relationships' characteristics. It would thus be possible to test the insights from the GVC literature reviewed in this section in a quantitative setting, concerning the importance of power in buyer-supplier's relationships as a determinant of upgrading.

To do this, it is important to first review the contributions of the recent literature to firms' heterogeneity and exports, using micro level data, focusing in particular on the recent work that has recognised the importance of buyer-supplier relationships (Macchiavello and Morjaria 2015).

4.2.2 Exploring the value of buyer-supplier relationships with micro data.

The literature on trade at the firm level starts from rather different theoretical premises from the GVC literature. In fact, it initially focused on trade models of firms' heterogeneity, stemming from Melitz's (2003) seminal work, emphasising that firms' different characteristics impact trade patterns and behaviour.

This has then led scholars to study how heterogeneous buyers and suppliers match in the first place, i.e. assortative matching, what are the factors influencing this matching process, and how costly it is to switch trade partner (Sugita et al. 2015; Bernard et al. 2011; Bernard et al. 2014; Blum et al. 2014; Eaton et al. 2007).

However, a subset of this literature has focused on the importance of long-lasting relationships, which is related to ideas of trust and, crucially to our purpose here, acknowledges that relationships can be of a different nature. We revisit these contributions here and emphasise the overlap with the focus of the GVC literature discussed in the previous section.

A first major contribution from this literature concerns the importance for buyers and suppliers to acquire information about each other. Evidence has shown that firms trading in differentiated products tend to switch suppliers more often, either because they are more likely to find more competitive suppliers or because the supplier fails to meet their requirements (Monarch and Schmidt-Eisenlohr 2015). The search efforts are also higher in markets in which there is a higher heterogeneity of suppliers (Grossi Cajal 2016).

The matching process is often unsuccessful, and even when it is the literature has shown that as a relationship's duration increases so does the likelihood of it breaking down (Macchiavello 2010). However, long-lasting relationships are important because firms in such trading relationships tend to trade with higher FOB prices (Macchiavello 2010). Moreover, while long-lasting relationships are a small proportion of the total number of relationships, they account for a significant share of total trade flows (Monarch and Schmidt-Eisenlohr 2015).

Mutual knowledge and trust are crucial to long-lasting relationships and become even more important factors in the context of low contract enforceability (Macchiavello and Morjaria 2015). Further support for this is also offered by Macchiavello and Miquel-Florensa (2017) who study the likelihood of exporters selling outside the relationship and how trading partners need assurances concerning the persistence of both demand and supply in a low contract-enforceability context. They find that long term relationships provide such assurances, although not as much as vertical integration.

There is an increasing body of evidence on buyer-supplier relationships and how the trust within these is relevant to trade flows and patterns. These show that not all buyer-supplier relationships are the same and that their importance, which many contributions in this strand of work refer to as value (Monarch and Schmidt-Eisenlohr 2015; Macchiavello and Morjaria 2015), increases over time.

As mentioned in the previous section, the literature on GVCs also posits that not all trade relationships are the same and that trust and mutual knowledge build over time: it emphasises the importance of power asymmetries within buyer-supplier relationships.

Despite the proximity in both topics and concepts, there is still very little quantitative evidence looking explicitly at GVCs at the transaction level, with few exceptions looking at global supply chains and production networks.

Dragusanu (2014) develops a model of sequential production to explore assortative matching, which she finds to be particularly strong for downstream products, i.e. close to final use. Bernard et al. (2014) refer to production networks, using the extension of a high-speed train line in Japan to show that the searching activity of trading partners is the outcome of their geographic location and access to many partners. Finally, Bernard and Moxnes (2018) review the existing literature on firm-to-firm connections in trade and emphasise how research on production networks is sorely needed, both at the firm and macro level.

This literature has mainly looked at determinants of the matching process between buyers and suppliers and the importance of long-lasting relationships. The GVC literature reviewed previously, however, suggests that it is not only mutual knowledge and trust that will affect a firm's trade and performance, but that power may also be a relevant dimension.

Firms may indeed engage in long-lasting, captive relationships, with very little chance of improving their trade performance and upgrade. In contrast, relational GVC relationships are also long-lasting but usually entail more balanced power relationships and involvement of suppliers in the production process. This would be through frequent interactions and knowledge exchange, therefore favouring upgrading of the supplier (Gereffi et al. 2005; Humphrey and Schmitz 2002).

To the best of our knowledge, virtually no contribution has so far incorporated upgrading and power into an analysis with transaction level data. The reason for this lack of quantitative evidence is likely that power and upgrading are not easily defined, let alone uniquely measured in a quantitative context.

4.2.3: Quantitative approaches to power in buyer-supplier relationships

In this section we draw on contributions outside of the GVC literature that distinguish the sources of power. These have to do with features of the market in which the buyer-supplier relationship takes place, as well as with specific aspects of the buyer-supplier match. In addition to a theoretical discussion of the concept of power, we focus on the empirical approaches and indicators put forward to measure it.

4.2.3.a: Understanding power: market and relational aspects

In the economic literature, market power is often referred to as a firm's ability to sell at prices above their marginal cost and obtain profits through a mark-up. Market power is usually the result of market structure: in perfect competitions there are a large number of firms displaying atomistic behaviour, none of which can sell at a price higher than the marginal cost, lest all customers prefer its competitors.

On the other hand, if there is a low level of competition, firms enjoy market power and can sell at prices above their marginal cost and enjoy profits above zero. Based on this, the literature on industrial organisation often regards market structure as an outcome of power; in particular, market concentration and firms' shares in a given sector or industry are considered tell-tale signs of market power. This view on market power is more concerned with firms' ability to charge prices above the marginal cost. This has however bearing on firms' ability to engage in upgrading too, since firms benefitting market power will be have a larger amount of resources to invest in product development and upgrading. Moreover, as firms in concentrated industries are able to exact higher prices from their customers, they can also appropriate larger shares of value added along the chain, as discussed in the previous subsection (Kaplinsky, 2004; Gereffi et al, 2005)

The literature on supply chain management takes a different view, which is closer to the GVC literature's view of power and stems from other disciplines such as sociology and political science, which look at power as a relational concept. In the context of inter-firm relationships, this translates as the ability of buyers (or suppliers) to coerce their suppliers (or buyers) to their will.

These two views on market power are well examined by Shervani et al. (2016), who define market structure's power as a firm's market or bargaining power in product-market or industry. Henceforth, We refer to this as the "market aspect" of power. Inter-firms' market power is defined as a firm's power within the inter-firm relationships or a specialised network of firms. Henceforth, we refer to this as the "relational aspect" of power.

4.2.3.b: Quantitative approaches to buyer-supplier relationships and power

From a methodological point of view, the majority of the literature in supply chain management relies on surveys (Liu et al. 2009; Shervani et al. 2016; Leiblein and Miller 2003). This approach allows for a very nuanced characterisation of power relationships between buyers and suppliers.

For instance, power can be mediated, with buyers deploying explicit strategies towards their suppliers, or non-mediated and based on relational aspects (Zhao et al. 2008). Benton and Maloni (2005) provide a thorough discussion of these two kinds of power and many different subcategories that can affect buyer-supplier relationships.

The literature on supply chain management explores inter-firm relationships without making explicit reference to the GVC literature. One of the first papers to directly engage with the literature on GVCs is the contribution by Pietrobelli and Saliola (2008) using a Private Investment Environment Survey (PICS) administered by the World Bank in Thailand. They try to proxy for GVC governance using questions included in the PICS on whether buyers had given the suppliers detailed specifications for production and how much they depended on them.

More recently, some studies have used firm level data from a survey (the MET dataset) compiled by the Italian Statistical Office (ISTAT). This included information on whether Italian exporters were engaged in long-term relationships with their buyers, and whether they were involved in the designing of the products they were exporting.

Brancati et al. (2017) rely on this information to investigate different GVC governances and the impact on suppliers' performance. They argue that firms involved in long-lasting relationships, and in the design of products, are operating under what Gereffi et al. (2005) refer to as "relational" governance. They find that such firms are more likely to carry out innovative activities and prove to be more resilient to the 2008 financial crisis.

Using the same source of data, Giovannetti et al. (2015) explore the effect of being part of a value chain, which they define as "participation in a specific supply chain, implying a continuative contribution of the firm to specific productions, provided that this activity constitutes the majority of the firm's turnover''(Giovannetti et al. 2015, p.848). They find that firms integrated in a supply chain are also more likely to gain access to international markets, and joining GVCs.

These recent studies rely on specific questions from a specific survey, which allows distinguishing market-based relationships from trade in GVCs. However, they do not explore the role of power in such relationships, which is pivotal in GVC analysis – and the purpose of this Chapter.

Another limitation of the contributions reviewed so far is that they rely on survey data, which makes their methodology difficult to apply to transaction level data. This is because survey data often rely on qualitative assessments, using small samples and are not always accessible, limiting the replicability of the results. Also, and crucially to our purpose, survey data usually rely on answers given by either the buyer or the supplier with respect to its trade partners; this means they do not allow observing each single buyer-supplier pair but only an overview of the relationships in which a firm engages.

In contrast, transaction level data provide information on suppliers' and buyers' identities and cover large samples (if not the entire population). The main drawback of this kind of data is usually the lack of qualitative insights, providing information only on the duration of the relationship and the volumes and values exchanged.

There are, however, studies that do not rely on qualitative surveys. Fabbri and Klapper (2008), for example, rely on survey data compiled by the World Bank providing quantitative data on the market structure in which a sample of Chinese SMEs operate. The focus of their study is around the lack of market power for suppliers and, accordingly, they construct a set of dummy variables to study the (weak) market power of the supplier. It is also noteworthy that while these dummies are constructed based on a survey, they can also be computed with transaction data, providing information on sales between each buyer and supplier. Moreover, they include information on both the dependence of the supplier vis-à-vis the buyer and the structure of the market, proxying the concentration with market shares of the supplier.

Emphasising the importance of market structure, research on industrial organisation has also put forward a range of measures; the most widely known measure is probably the Herfindahl-Hirschman index (HHI) in computing, consisting of the sum of the squares of the market shares of each firm in a given sector.

Alternatively, the Lerner index is based on the difference between sale price and marginal cost, rather than the concentration of the market structure: it consists of taking the difference between the price and marginal cost divided by the price. Datta et al. (2013) use this index to explore the relationship between market concentration and management's earnings. This index may prove hard to compute with matched buyer-supplier data, because these usually only include thorough information on one side of the transaction, i.e. either the supplier or the buyer. This means that it would be possible to compute the Learner index only for one of the two trading parties.

A rather interesting application of the HHI is provided by Cowley (1988). He uses the Profit Impact of Market Strategies (PIMS) dataset and computes the HHI for the suppliers as well as, interestingly, the relative size of the supplier, i.e. the supplier's market share divided by its largest competitor's market share. He also looks at the buyer concentration, i.e. the number of buyers taking in a total 50% of the seller's revenue.

This is a particularly interesting approach because it takes into account both the supplier and buyer side, using quantitative indexes, rather than data obtained through surveys or interviews.

In conclusion, we have two views of power in the context of inter-firm relationships. The dyadic and relational aspect of buyer-supplier relationships is a relatively well-established fact in the literature on supply chain management, where information is usually gathered concerning both parties involved in the relationship (Liu et al. 2010; Nyaga et al. 2013). This can be captured by looking at the share that the purchases (sales) of the buyer (supplier) represent in the sales (purchases) of the supplier (buyer). A potential drawback of this approach is that dependence may include more than simply sale shares measured in trade volume: a supplier may depend on their buyer's knowledge or other assets. However, transaction level data do not typically include such information for both trade parties, which makes it hard to circumvent this obstacle. A second limitation of only looking at the relational aspect of power is that it does not take into account each firms' position within their market; some firms may have a strategic position that makes them particularly important for their trade partners.

For this reason, it is also worthwhile including the market aspect in the analysis. This is to take into account each trading partner's importance with respect to other actors in the same market and can be captured with market shares (Cowley 1988). This may represent a challenge for firms that trade in more than one product, since their market shares may change across these products. A remedy to this is to take the average of market shares across products, weighted on how much each product represents of the firms' total trade. Market share will not, however, capture all factors underlying market power. This can also depend on capabilities, intellectual property or other assets; still, they have the advantage of being relatively easy to compute with values of transaction level trade data.

We try to take stock on both these views of power in buyer-supplier relationships in our empirical approach, which we detail later. We discuss the Chapter's research questions and contributions in the following section.

4.3 Chapter's research questions and contributions

This Chapter's overarching goal is to study the relationship between power and upgrading in buyer-supplier relationships. The scholarship has mainly studied this with a GVC approach largely based on case studies; this has led to the view that power shapes different kinds of governance that, in turn, shape suppliers' possibilities to upgrade (Gereffi et al. 2005; Humphrey and Schimitz 2002; Giuliani et al. 2005a; Morrison et al. 2006).

There remains, however, some ambiguity around the concept of upgrading, which is particularly hard to disentangle from innovation and generally lacks an agreed definition in the scholarship. Recent contributions have put forward the measure of complexity (Hidalgo and Hausmann 2009), which has been used to study export upgrading (Zhu and Fu 2013; Jarreau and Poncet 2012).

Concerning power, there is no unanimous definition or measure in the scholarship. A burgeoning literature has been studying trade at the firm level, focusing on how heterogeneous firms match with each other (Sugita et al. 2015; Eaton et al. 2015; Eslava et al. 2015; Grossi Cajal 2016), and emphasising the importance of long-lasting relationships (Monarch and Schmidt-Eisenlohr 2015; Macchiavello and Morjaria 2015; Macchiavello and Miquel-Florensa 2017).

However, trade relationships may have similar duration and levels of trust but very different power dynamics, leading also to different outcomes in terms of trade performance and export upgrading. So far, this has not been acknowledged by the scholarship studying firm heterogeneity in trade and the buyer-supplier matching process.

By testing hypotheses from the GVC literature with buyer-supplier transaction level data we wish to bridge these two strands of work, to include power and upgrading in the quantitative literature on buyer-supplier relationships. We also aim to take into account that power entails different aspects that may be related to upgrading in different ways. We specifically aim to answer the two following questions:

1. Is power in buyer-supplier relationships a predictor of upgrading?
2. Does this relationship change depending on different aspects of power?

In order to shed light on these questions it is crucial to devise a way of proxying for power in the context of buyer-supplier relationships. The literature has often studied power relying on surveys providing qualitative information on the kinds of relationships buyers and suppliers were forming. Transaction level data rarely include such kinds of information, but, in contrast, allows the identification of each individual pair of buyers and suppliers.

Our second research question implies that there are different kinds of power. This is in turn based on the view put forward in the literature that power is a multifaceted concept with a relational and a market aspect (Shervani et al. 2016); this is captured through dependence measures and market shares, respectively.

By taking this approach we also try to open up the black box that power is often in GVC analysis. We unpack whether the buyer's (or supplier's) power comes from market issues that have to do with the concentration of the market, or from relational aspects that are specific to the buyer-supplier relationship.

In the next section we detail how we use computed measures of dependence and market shares to capture the relational and market aspects of power, respectively.

We combine these measures with the complexity measure to empirically investigate the relationship between the two aspects of power and, (i) the level of sophistication of exports, (ii) the likelihood of introducing new products, and (iii) the likelihood of increasing export sophistication, which we use to identify upgrading.

Finally, we also explore whether these relationships between power and upgrading vary across destination countries, shedding light on the importance of country specific factors for suppliers' upgrading prospects.

4.4 The data and variables

We use data from the Colombian Customs (DIAN) on all export transactions from Colombia to the rest of the world for the years 2007-2014. We match these data with data from SIREM[19] on firms' financial balance sheets, and with data from the Atlas of Complexity for Colombia (DATLAS henceforth, http://datlascolombia.com).

The DIAN data provide information on each transaction between a Colombian exporter and an importer from the rest of the world (RoW). The supplier is identified by its national tax number (NIT); the buyer is identified by the company name, country, city and address, as reported by the exporter.[20]

Each transaction is identified by a product code. Colombia uses the NANDINA system to identify products, which matches the Harmonised System (HS) at 6-digits. We

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[19] SIREM is a public body in charge of financial surveillance, to which all firms that are not publicly listed and have either turnover or total asset larger than 30 times the minimum monthly wage must disclose their financial statements.

[20] Henceforth we will use exporter and importer interchangeably with supplier and buyer, respectively.

aggregate products to 4-digit level industries based on the 1992 HS, to match them with the data on complexity from DATLAS.

Our data also provide information on the quantity of products traded in each transaction, in units, gross and net weight as well as value in Colombian pesos (COP). We retrieved deflators for the export sector[21] from the Colombian National Bureau of Statistics (DANE), which we use to make product values comparable across years, taking 2009 as the reference year.

SIREM data are made publicly available by SIREM and provide useful information on firms' characteristics, which we use to compute productivity; these can be readily matched with the NIT in the DIAN data.

It is important to stress that our data cover all transactions between firms (direct purchases from individuals abroad have been excluded from our analysis) and do not allow clear distinction between trade *tout court* and trade in GVCs. The literature at the macro and sectoral level distinguishes these two concepts by referring to gross export (for the former) and trade in value added (for the latter); at the micro level the debate on how to capture such distinction is still on-going and no single approach has been put forward (Johnson, 2017).

The ideal approach would consist in measuring firms' value added content in their exports, but the DIAN data (nor, to the best of our knowledge, any other data source) do not provide such information. However they do allow observing the interactions between Colombian exporters and their suppliers and to understand these in GVC framework, by focusing on power relationships.

This section details how we match the data from DIAN with our other sources, how we use complexity measures as proxies of export sophistication, as well as our approach to capturing power relationships based on our theoretical discussion in section 4.2 and the rich information at our disposal on transactions between buyers and suppliers in Colombia.

[21] The deflators compiled by DANE are available from the Colombian Central Bank webstie: http://www.banrep.gov.co/es/ipp

In the previous section we discussed the difficulty of measuring firms' capabilities and upgrading, highlighting the interesting approach taken by Hidalgo and Hausmann (2009). The Harvard University's Centre for International Development (CID) has compiled the DATLAS dataset for Colombia, with complexity indexes for products at the 4-digit level of disaggregation, from 2008 to 2014.

This index relies on goods' ubiquity and countries' export diversification. As a consequence it is computed separately each year and changes could be driven by changes in other countries' export portfolio. However, it seems reasonable to consider the complexity of a product as a time invariant characteristic; we therefore take the average across years for each product. This is important because we wish to use these data as a proxy for upgrading, which also happens over time; therefore it is crucial that changes in complexity measure are driven by changes in the product mix in which a firm trades and not by the change of complexity index of products from one year to another.

We exclude from our data all transactions involving mining and oil and gas products[22]. This is because the large majority of these transactions did not report any information on the buyer, so our analysis only refers to the manufacturing and agriculture sector.

So far, we have used the term relationship in a rather loose way to refer to both the buyer-supplier pairs and to buyer-supplier-product combinations. For the sake of clarity, in the remainder of our discussion we identify a relationship as a pair of buyer and supplier, trading in a given destination country, in a given year and a given product. In the remainder of the thesis we will refer to buyer-supplier pairs (or simply pairs) as buyer-supplier matches, i.e. including all the products they exchange. To give an example, two firms trading three products in a given year would constitute three *relationships* but only one *pair*.

After matching year by year with the exporter in the DIAN and SIREM data, using their NIT, in the data we observe 4,956,935 export transactions between a Colombian exporter and an importer from the rest of the World. Importers are identified using the company name and country of shipment (the addresses are noisy and therefore

[22] This includes all transactions falling under the 2-digit product category 27 in the harmonised system.

are not used to clean the list of firms). Due to misspelling and the use of different names to refer to the same company, two transactions between one pair may appear in the data as two transactions between one exporter and two different importers, yielding duplicate importers. To correctly identify the importer, we proceed with cleaning their names, by country.

As a first step we harmonise the importer names, excluding common words, such as SPA, SRL, LTD, and country specific names, such as names of cities (such as “Arequipa”) or adjectives of nationality like “Peruana” (which translates to “Peruvian”).

Some companies are reported with two names, distinguished by “Y/O”, which is Spanish for “and/or”. There is no way of understanding which of the two companies listed is the correct one so we drop these observations. This amounts to 5% of the total transactions and 5.2% of total exports covered in our sample.

After this initial harmonisation we perform a fuzzy matching between the 181,535 unique importers’ names in our data and the full list of firms with positive turnover available in ORBIS (approximately 8 million companies), i.e. firms’ official name.

After checking manually on a subsample of firms, we chose to use the Jaro distance to measure similarity across firm names in our dataset and in ORBIS. This choice is also supported by the literature (Van der Loo 2014); the Jaro distance is in fact designed to deal with human-made typing mistakes in strings of short length, such as names and addresses, which is very close to our case.

The Jaro distance goes from 0 (two strings are identical) to 1 (two strings have no elements in common). We tried different thresholds to identify a match and found 0.15 to be the one to minimise the number of false positives and negatives.

We perform this first round of fuzzy matching as follows: for each firm in our data we select the closest match in ORBIS and we also report the Jaro distance as a score of the quality of the match. While 0.15 is the threshold we identified as optimal, we choose to be slightly less conservative and automatically reject the closest matches with a score above 0.16, while manually checking all other matches.

During this check we noted that some matches with high Jaro distance were correct, which hinted at the possibility of a large number of false negatives. To address this we ran a second round of fuzzy matching between firms in the data that had not matched with ORBIS and firms that were matched with ORBIS.

We consider a match a firm that, despite not having matched with ORBIS, is quite similar to another firm that has matched with ORBIS. Like before, we automatically reject the matches with a score above 0.16 and manually check the matches below this threshold.

While manually checking the matches we have also created a list of well-known and commonly recurring firm names (such as Panasonic, L'Oréal, Schneider Electric).

We use this to further harmonise our data, grouping all firms containing these names. In this way we group together importers' names that are likely to correspond to the same firm, but that the automatic matching did not pick up. We therefore take an approach of relying on automated fuzzy matches, while the hand-checking procedure ensures that firms recurring under different names, and that have not been matched with the automated procedure, are correctly clustered together.

Using the harmonised list of matched company names we perform a clustering procedure based again on the Jaro distance. We create clusters of firms whose names have a string distance below 0.15, by country. We end up with 74,856 buyer-country clusters. We match these with the exporters and aggregate our initial 4,965,935 transactions by buyer-supplier-product-country (relationships) obtaining 286,225 relationships over 7 years yielding an unbalanced panel of 527,010 observations.

There are only 7,093 exporters, although when we look at exporters by destination country the number rises to 40,003. When we aggregate this across products we obtain a panel with 267,320 pairs, i.e. buyer-supplier-country combinations (pairs).

Because we identify the importers at the country level, assuming that two importers in two different countries are, from a trade relations stand point, two different importers, we compute our power measures at the importer-country level.

We use the cleaned data to compute measures of pair's sophistication and power. We have also computed four product invariant measures of pair's sophistication[23]:

1. the upper bound sophistication of the pair, i.e. the most sophisticated (i.e. the one with the higher complexity index) product exchanged in a given year within the pair;
2. the lower bound sophistication of the pair, i.e. the least sophisticated product exchanged in a given year within the pair;
3. the median sophistication of the pair: this is the median product, based on sophistication, weighted on trade value in the pair. This variable captures the sophistication of the "core" of trade taking place in a pair;
4. the average sophistication of the pair is the average of the sophistication of each product traded within the pair, weighted on the trade value of each product in the pair. This is an alternative measure of the "core" sophistication of the pair, although it should be noted that the number of products traded within the pair also affects this measure. As a consequence, a pair exporting two products will have a higher average sophistication than another pair exporting the same two products plus another one with sophistication below the average of the other two products traded.

We now turn to power and how to measure it. Bear in mind that power has been conceptualised in the literature as having both a "relational" aspect (inherent to the power asymmetry of a supplier vis-à-vis its buyer), and a "market" aspect with regards to the supplier's (buyer's) position within the market (Shervani et al. 2016).

To take full account of these two facets of market power, we compute the following four measures.

The components of the buyer's power are:

1. the supplier's dependence vis-à-vis the buyer in a given relationship[24]. This is computed as the share that sales *x* of product *p* from supplier *s* to buyer *b* represents in all the sales (i.e. across all products) of supplier *s.* This is bound between 0 and 1; when it approaches the latter it means that the supplier exports most of its product *p* to the buyer *b* and has a high level of dependence vis-à-vis its buyer. This measure thus increases the buyer's power. We are using here the total export of our supplier as a denominator; an alternative option would have been to use the total sales, i.e. both domestic and foreign. We decided against this, because we also wish to compute the same dependence

[23] In the section on our empirical approach we discuss these measures more at length, focusing in particular on the extent to which these can capture upgrading of the supplier.

[24] Remember that relationships are identified at the buyer-supplier-product level, with pairs simply at the buyer-supplier level.

index for the buyer (see point 3 below), for which however we can only rely on its purchases from Colombia.

To ensure that our two dependence indexes are computed in a coherent way and are as symmetric as possible, we choose to look at foreign sales for the supplier and foreign purchases for the buyer. This still leaves unresolved the fact that while we observe all export destinations for the suppliers we only observe what the buyers import from Colombia. We detail how we deal with this later in this section.

$$sdp_{sbp} = \frac{x_{sbp}}{\sum_{bp} x_{sbp}}$$

2. The market share of buyer *b* in product *p*, i.e. the share that the purchases *x* of buyer *b* in product *p* of total export (i.e. across all suppliers) of product *p* from Colombia, i.e. the degree of monopsony. A higher market share of the buyer increases the market component of the buyer's power over the supplier.

$$bsh_{bp} = \frac{\sum_{s} x_{sbp}}{\sum_{sb} x_{sbp}}$$

The two components of the supplier's power are computed in a specular way as follows:

3. The buyer's dependence vis-à-vis the supplier in a given relationship. This is the share that the purchases *x* of product *p* of buyer *b* from supplier *s* represents in all the purchases of buyer *b* in Colombia. When it gravitates towards 1 it means that buyer *b* imports most of product p from supplier s, i.e. is highly dependent on its supplier, which increases its power over the buyer.

$$bdp_{sbp} = \frac{x_{sbp}}{\sum_{sp} x_{sbp}}$$

4. The market share of supplier *s* in product *p*, i.e. the share that sales *x* of supplier *s* in product *p* represents of total exports (i.e. across all suppliers) of product *p* from Colombia. This measure captures the market aspect of power and reflects the position that the supplier occupies in the market of the product traded. As the measure approaches 1 it means that the supplier represents a higher share of the market and has therefore a higher market power.

$$ssh_{sp} = \frac{\sum_{b} x_{sbp}}{\sum_{b} x_{sbp}}$$

Based on the discussion above, we distinguish different kinds of power depending on its source. We argue that buyers' (and suppliers') power is determined by a "relational" aspect (or source), captured here with the dependence of the supplier (buyer) vis-à-vis the buyer (supplier) and by a "market" aspect. This is not based on the bargaining power in a buyer-supplier dyad, but is the outcome of the market structure that we proxy here with the market share of the buyer (supplier). We summarise this in Table 4.1 below, detailing the sources of both buyer and supplier's power, together with the literature that has emphasised this.

Table 4.1: Power's components indexes

<table>
<tr><th>Power Types by Source</th><th colspan="2">Literature</th></tr>
<tr><td>Relational:
Supplier's dependence on the buyer (sdp).</td><td>Supply chain management lit.</td><td rowspan="2">Buyer's power in the GVC literature</td></tr>
<tr><td>Market:
Buyer's market share (bsh).</td><td>Industrial Organisation lit.</td></tr>
<tr><td>Relational:
Buyer's dependence on the supplier (mdp).</td><td>Supply chain management lit.</td><td rowspan="2">Supplier's power in the GVC literature</td></tr>
<tr><td>Market:
Supplier's market share (ssh).</td><td>Industrial Organisation lit.</td></tr>
</table>

Source: Author's own taxonomy.

The power indexes presented above are computed at the relationship level, while our sophistication measures are at the pair level. Therefore, we aggregate the power indexes at the pair level, taking the averages across the products exchanged within each pair in each year, weighting this on each product's share in total COP traded within each pair.

Because of the nature of our data, as mentioned above, we also face another challenge in creating the power measures. We only have information on exports from Colombia to the rest of the world; however, foreign buyers may be purchasing from other suppliers in third countries, which remains unobserved. This is likely to create an upward bias for the measures of buyer dependence and supplier's market share.

To mitigate this, we limit our analysis to the buyer-supplier pairs between Colombian suppliers and buyers in the three main destination countries, i.e. the US, Venezuela and Ecuador. We then compute the share that Colombian exports represent in the imports of all products for each of these three countries. This captures how likely buyers are to find other suppliers in third countries; we multiply the buyer's dependence and the supplier's market share by these shares, like this respectively:

$$bdp_{sbp} = \frac{x_{sbp}}{\sum_{sp} x_{sbp}} * Msh_{cp}$$

$$ssh_{sp} = \frac{\sum_{b} x_{sbp}}{\sum_{sb} x_{sbp}} * Msh_{cp}$$

Where Msh_c is the share that exports from Colombia represent in the total imports of product *p* by country *C* (which can be: US, Venezuela or Ecuador).

A caveat of this approach that is worth mentioning is that in adjusting these two indexes we are not considering buyers' individual diversification or size. A buyer in a sector of which Colombia represents a small share of the country's total imports, say optical lenses, may be very small and thus depend heavily on its Colombian importer. To avoid this shortcoming, however, we would need to observe buyers' true size, which are not included in our data.

Finally, despite focusing only on three destination countries, our subsample still accounts for 45% of total COP traded and 34% of the total number of transactions in our sample, after cleaning.

Now that we have presented our core measures, we provide some descriptive evidence to explore our data and sketch some stylised facts. We start by looking at the distribution of the power indexes.

All these indexes are bound between 0 and 1[25]. From Table 4.2 we see that suppliers tend to be more dependent on buyers (col. 1) than vice versa (col. 3). At the same time, buyers' share (col. 2) tends to be larger than that of the suppliers (col. 4). This suggests that, in our data, buyers are overall more powerful than suppliers. We also note that the distribution of these indexes is rather skewed; positively for all power indexes except the supplier's dependence, which shows a negative skew. This means that most pairs are made up of trading partners with little power, while a few pairs consist of very powerful trading partners.

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[25] The index is bound (0;1] because, for a pair to exist, some trade flows must exist between the buyer and the supplier; this means that the buyer will always account for more than 0% of the supplier's sale and vice versa. In the Table 4.2 we find that the minimum of the distribution of the indexes is 0, but this is simply due to rounding down of very small indexes.

Table 4.2: Distribution of power indexes

Supplier's dependence (sdp)		Buyer's market share (bsh)		Buyer's dependence (mdp)		Supplier's market share (ssh)	
Min.:	0.00000	Min.:	0.000000	Min.:	0.000000	Min.:	0.000000
1st Qu.:	0.01408	1st Qu.:	0.002606	1st Qu.:	0.002567	1st Qu.:	0.000963
Median:	0.09040	Median:	0.019883	Median:	0.023596	Median:	0.005093
Mean:	0.27170	Mean:	0.102890	Mean:	0.098896	Mean:	0.037449
3rd Qu.:	0.44111	3rd Qu.:	0.110813	3rd Qu.:	0.122374	3rd Qu.:	0.025470
Max.:	1.00000	Max.:	1.000000	Max.:	1.000000	Max.:	1.000000

Source: Author's own calculation

Our main variable of interest is the complexity index, which we use here to proxy for the sophistication of supplier's exports. In Table 4.3, we report the distribution of all four measures; the complexity measure is bounded between -4.6560 and 5.3018, it is worth recalling that these are computed through the method of reflection and are therefore not meaningful per se, they give us however an idea of the upper and lower bounds between which our measure varies; this index is therefore meaningful only in relative terms, consistently with this in our analysis we focus on comparing levels of complexity and estimating the likelihood of increases. Upper bound complexity covers the whole span of the measure, meaning that there are some firms that are exporting only the least complex product. In contrast, we note that the lower bound complexity never reaches 5.3018, which suggests that pairs trading in the most complex products are also trading in other less complex products.

Table 4.3: Complexity measures distribution

Upper bound Sophistication		Lower bound Sophistication		Median Sophistication		Average Sophistication	
Min.:	-4.6560	Min.:	-4.6560	Min.:	-4.6560	Min.:	-4.6560
1st Qu.:	-1.5106	1st Qu.:	-2.2427	1st Qu.:	-2.1339	1st Qu.:	-2.0857
Median:	1.1494	Median:	0.2720	Median:	0.6860	Median:	0.9186
Mean:	0.7371	Mean:	0.1469	Mean:	0.3317	Mean:	0.4235
3rd Qu.:	2.6369	3rd Qu.:	1.9461	3rd Qu.:	2.0800	3rd Qu.:	2.1646
Max.:	5.3018	Max.:	4.9684	Max.:	4.9684	Max.:	5.0313

Source: Author's own calculation

This suggests that the number of products and the sophistication are related to each other. This is relevant because we know that the measure of complexity is computed based on economies' diversification, together with the ubiquity of products (Hidalgo and Hausmann 2009).

We are carrying out our analysis here at the firm level, so there is no mechanical link between how a product's sophistication is computed (with export data at the country level) and suppliers' (buyers') diversification. It is nonetheless interesting to explore how these two measures are related since firms' diversification relates to the power measures.

Table 4.4 details the distribution of three measures of diversification: the number of products traded within each pair, the number of buyers for each supplier and, vice versa, the number of suppliers for each buyer.

Table 4.4: Distribution of diversification measures

Number of products traded		Number of buyers		Number of suppliers	
Min.:	1.000	Min.:	1.00	Min.:	1.00
1st Qu.:	1.000	1st Qu.:	5.00	1st Qu.:	1.00
Median:	1.000	Median:	14.00	Median:	4.00
Mean:	2.034	Mean:	30.41	Mean:	10.83
3rd Qu.:	2.000	3rd Qu.:	35.00	3rd Qu.:	12.00
Max.:	113.000	Max.:	324.00	Max.:	128.00

Source: Author's own calculation

We see that more than half the pairs only trade in one product (col. 1): suppliers also appear to be more diversified (col. 2) than the buyers (col. 3). This is to be expected since with our data we observe all the buyers that the suppliers sell to, but not all the suppliers the buyers buy from; this is because we only observe the transactions between Colombia and the rest of the world. These proportions are also similar to what has been found in the literature (Bernard et al. 2014)[26], which is reassuring with respect to our methodology to clean the names of the buyers, avoiding a too high number of duplicates.

It is worth noting that looking at the diversification measures the buyers appear to be less diversified than the suppliers, which would suggest that they have, on average, a higher level of dependence than that of the suppliers. In Table 4.2 we saw that this is not the case; the reason for this is the fact that we adjust the two components (i.e. the

[26] Bernard et al. (2014) find lower numbers of both exporters and importers, because they propose evidence for each destination country separately. Here we are looking at the total number of buyers that a supplier has across all destination countries.

buyer's dependence and the supplier's market share) of our supplier's power index by the shares of Colombia imports, as previously described.

None of the issues discussed above affects the number of products traded, so we start exploring the relationship between this measure and sophistication. We first focus on this in the two following figures.

First, in Figure 4.1 we plot the number of products against the upper bound complexity with the line of best fit, using lower bound complexity to colour the dots. In Figure 4.2 we plot the number of products traded within each pair against the lower complexity and use upper bound complexity to colour.

In Figure 4.1 we see a slightly positive relationship between our two measures. Interestingly we can also see that while there are pairs trading at all levels of sophistication regardless of the number of products, we find that there are pairs trading in many products only when they have high levels of upper bound complexity.

However, as the number of products increases, the lower bound complexity seems to decrease and we only find pairs with low levels of lower bound complexity (coloured in light blue) for low numbers of traded products.

This suggests that as a supplier diversifies the number of products they sell to their buyer, they tend to include more unsophisticated products in their basket. However, suppliers that only trade in sophisticated products (i.e. with high levels of both upper and lower bound complexity) trade a small number of products.

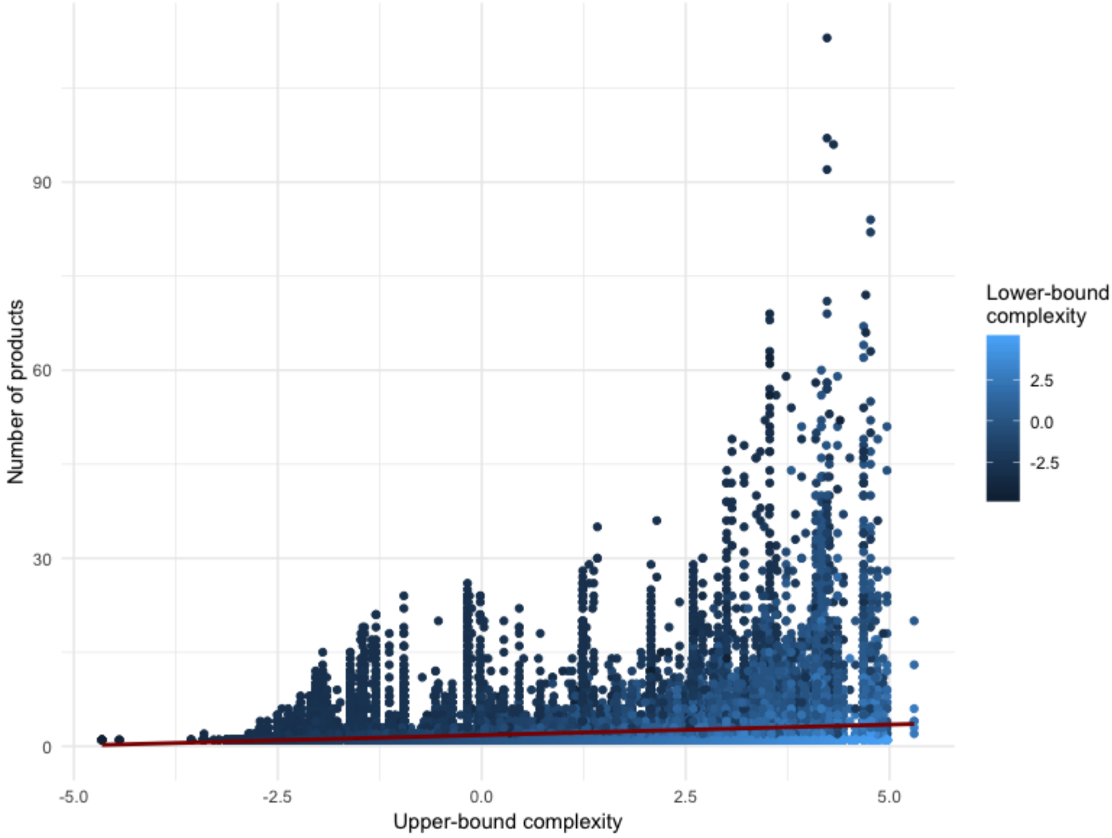

Figure 4.1: Upper bound complexity and number of traded products

Source: Author's own calculation

Note: The figure plots the upper bound complexity of each buyer-supplier pair against the number of products traded, using the lower bound complexity of the pair to colour the dots.

Figure 4.2 offers further support to this conjecture, showing a slightly negative relationship between the number of products and the lower bound complexity. Looking at the colouring of the dots, we see a clear positive relationship between the number of products being traded and the upper bound complexity.

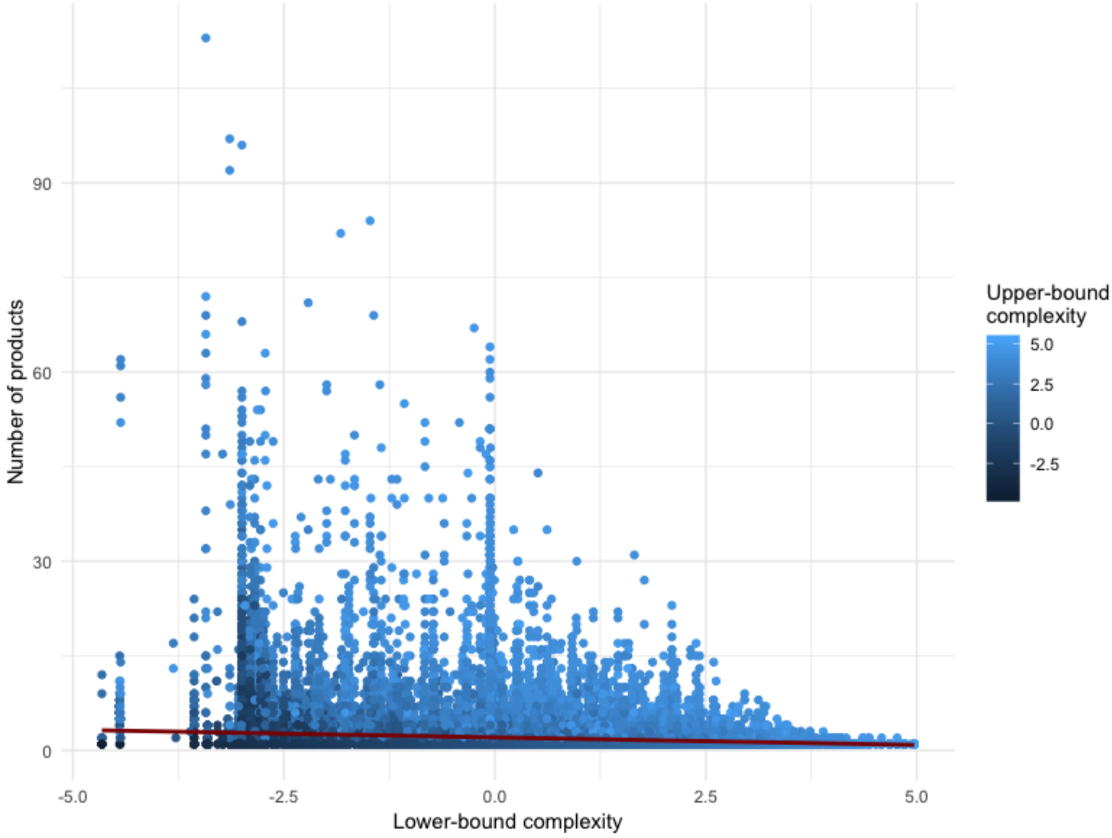

Figure 4.2: Lower bound complexity and number of traded products

Source: Author's own calculation

Note: The figure plots the lower bound complexity of each buyer-supplier pair against the number of products traded, using the upper bound complexity of the pair to colour the dots.

As in Figure 4.1, we find that products that have both high upper bound and lower bound complexity (i.e. those in light blue towards the right-hand side of the graph) are concentrated at the bottom of the graph. This means that these pairs trade in a small number of products.

So, a first stylised fact we can draw from these figures is that as suppliers diversify by increasing the number of products they sell to their buyers, this is positively related to both the upper and lower bound complexity of their export. This means that product diversification does not necessarily improve the overall sophistication of a supplier's exports, but is attained by introducing both more and less sophisticated products.

We now include into our analysis another kind of diversification - looking at the number of trading partners both buyers and suppliers have and whether this is related to the sophistication of their exports.

In Figure 4.3 we plot the number of traded products by each supplier against the number of buyers and colour this based on the centile in which the supplier falls in terms of upper bound complexity.

We find that suppliers that trade many products tend to be not very diversified in terms of buyers and vice versa. This means that suppliers either sell a large number of products to few buyers, or a small number of products to a large number of buyers.

This suggests that suppliers able to cater to many buyers tend to do so by selling few products that are likely to be fairly unsophisticated (such as commodities). This is supported by Figure 4.3 with the majority of the dots coloured in dark blue (which corresponds to low complexity) being clustered on the left-hand side of the graph.

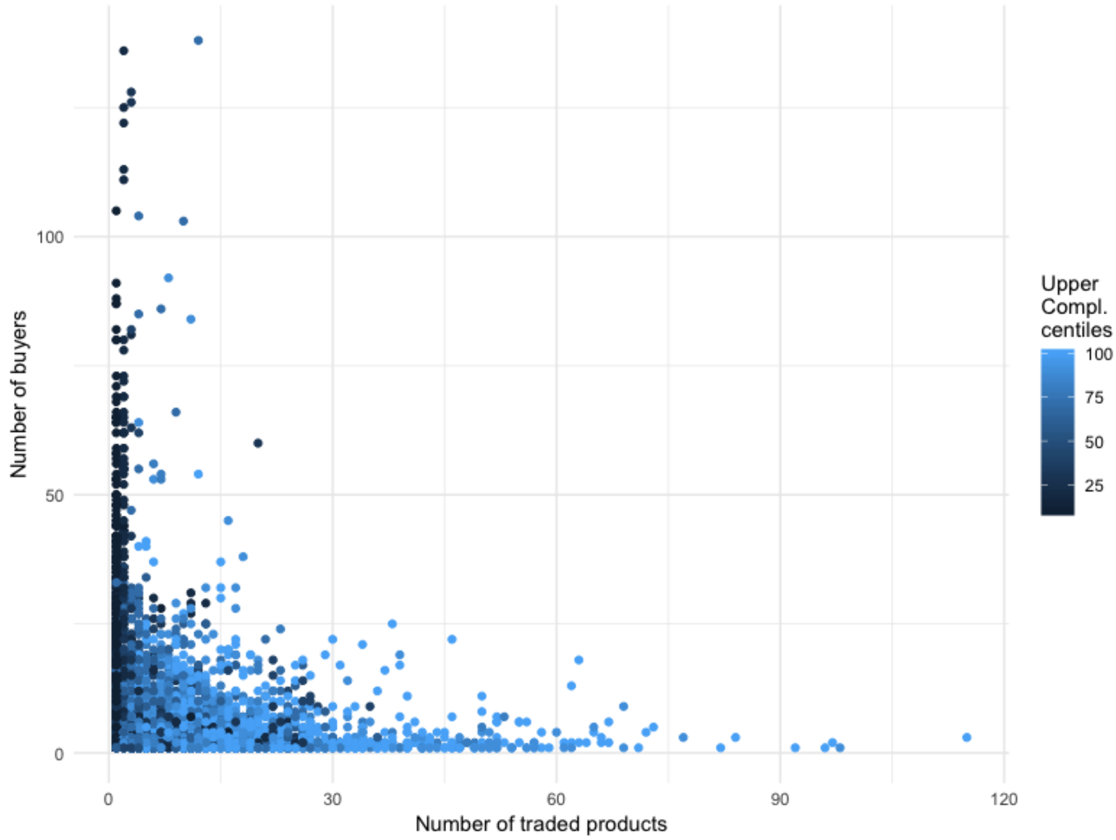

Figure 4.3: Suppliers' number of traded products and number of buyers

Source: Author's own calculation

Note: The figure plots the traded products of each supplier against the number of buyers, coloured with the upper bound complexity of each supplier.

When we turn to the relationship between the number of suppliers and products that buyers have, we find a similar pattern (see Figure 4.4), although there are a few buyers with high upper bound complexity that manage to have both a large number of suppliers and of products they purchase.

Overall, however, we find here again that buyers either buy many products from few suppliers with high sophistication levels (the dots in light blue at the bottom of the graph) or few, unsophisticated, products from a variety of suppliers.

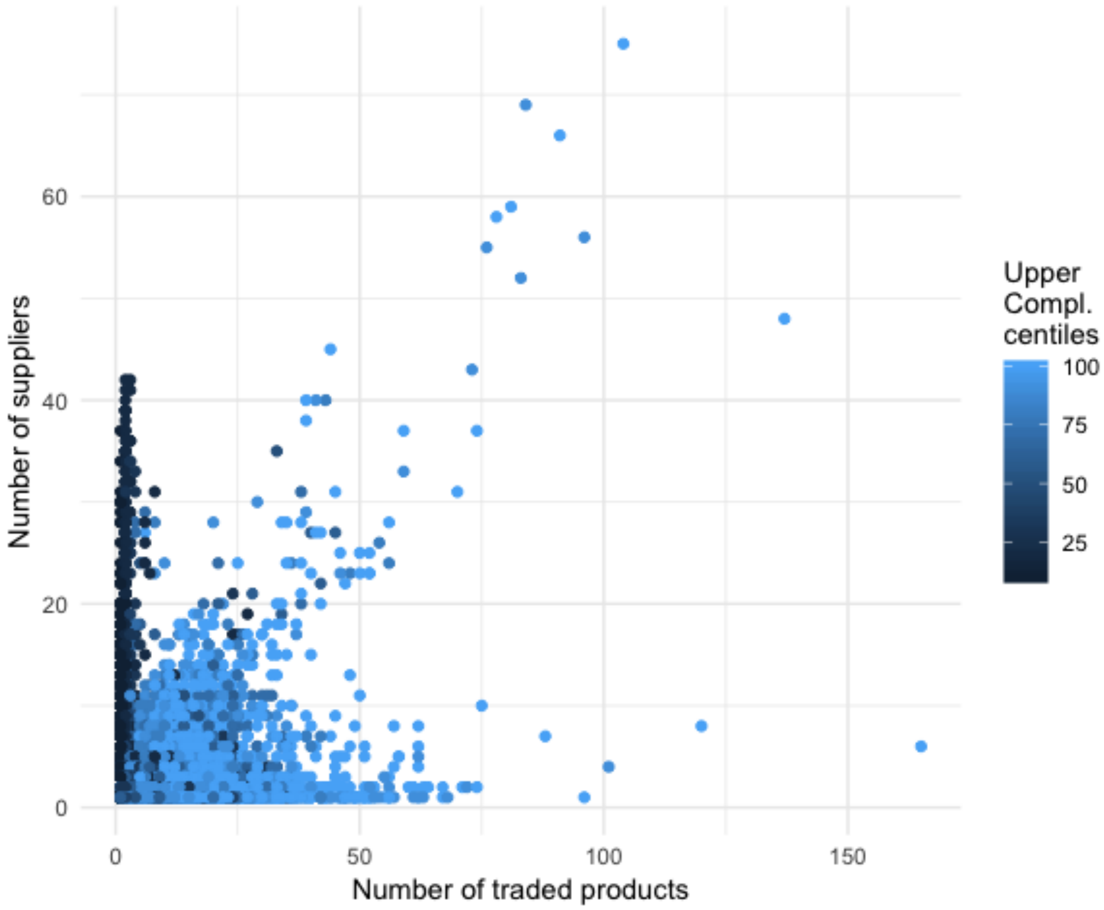

Figure 4.4: Buyer's number of traded products and number of suppliers

Source: Author's own calculation

Note: The figure plots the number of traded products against the number of suppliers of each buyer, coloured with the upper bound complexity of the buyer. The scale of shades is based on the centile in which the buyer falls, from lowest (darkest) to highest (lightest).

So, while product diversification (i.e. increases in the number of products traded within a pair) seems to be associated both to increases in the upper bound complexity and decreases in the lower bound complexity, diversification in terms of trading partners seems to be negatively associated with upper bound complexity.

This is purely explorative evidence. As mentioned above, the components of power (both for the buyer and the supplier) are also likely to be related to each other. For example, a supplier that trades with buyers with a large market share is also likely to be dependent on their buyer and, conversely, suppliers with a large market share are more likely to trade with buyers that depend on them.

We find both of these conjectures to be borne out in the data, although with a significant variability, as shown in Figures 4.9 and 4.10. In these two figures we plot the supplier's (buyer's) dependence against the buyer's (supplier's) market share, i.e. the two components of the buyer's (supplier's) market power. In contrast with the other figures here each observation is a buyer-supplier pair, which means that we have a very high number of observations; to maximise readability of the graphs we have therefore use a transparency parameter alpha, which allows plotting overlapping observations by making these a slightly transparent. This, coupled with a high diversity of the relationships we observe, causes a blur in the visualisation of these relationships. To mitigate this we have therefore added the line of best fit to provide an indication of the direction of the relationship. We find in both figures that the two components of buyer's (supplier's) market power are positively correlated with each other.

Interestingly, we note quite a few observations clustering along the 45-degree line. Taking the example of the buyer's power, dots on the 45-degree line correspond to pairs in which the supplier does not have rivals in his market. Therefore his dependence, which is computed across products, vis-à-vis his buyer will also correspond to the buyer's share of the market. In this way, a pair in which the supplier depends on the buyer for, say, 50% of its sales and the buyer also accounts for 50% of the market.

This very same mechanism applies when plotting the supplier's power components, i.e. buyer's dependence and supplier's market share, shown in Figure 4.10. Unlike in Figure 4.9 we find here less variability, with our observations being more clustered around the bottom-left area of the graph, i.e. suppliers with small market shares and buyers with little dependence on the suppliers, and a few on the 45-degree line.

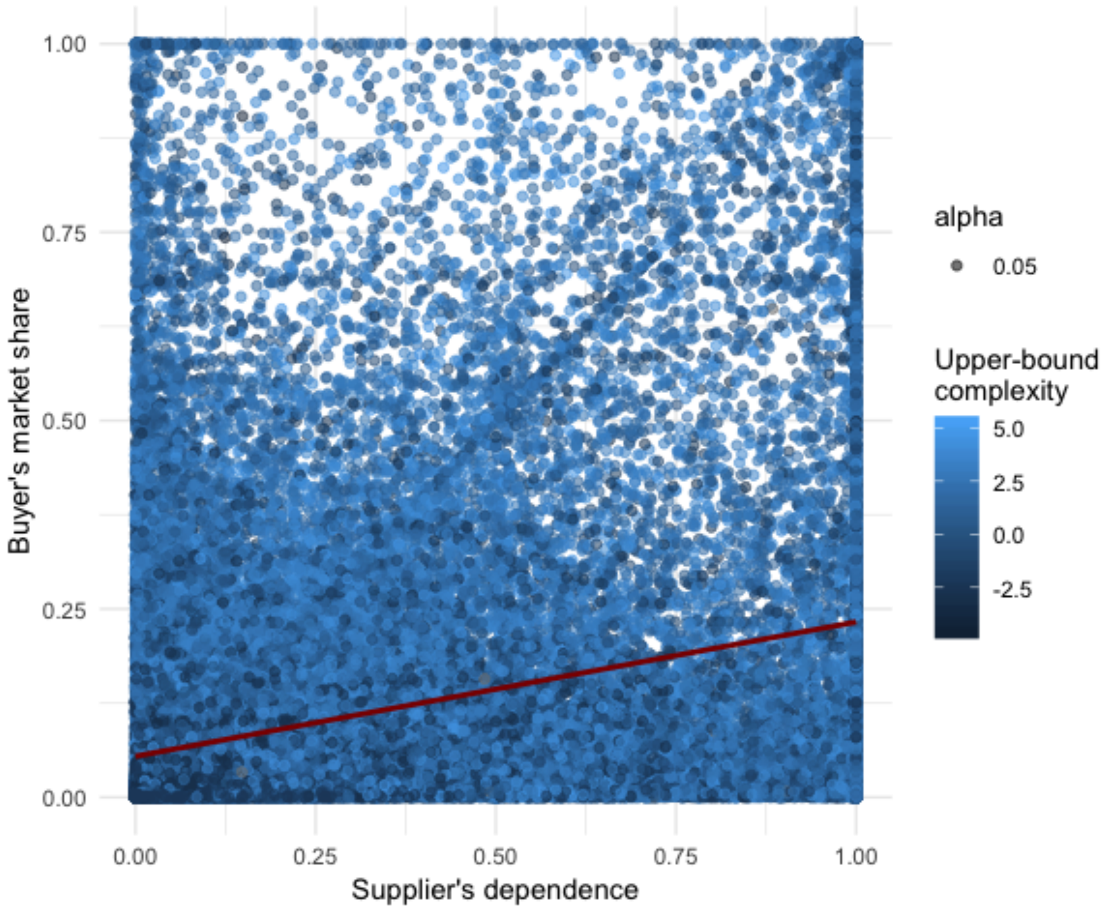

Figure 4.9: Suppliers' dependence and buyers' market share

Source: Author's own calculation

Note: The figure plots for each buyer-supplier pair the supplier's dependence and the buyer's market share, coloured with the pair's upper bound complexity. Alpha is a transparency parameter, commonly used to make dense scatterplots easier to interpret.

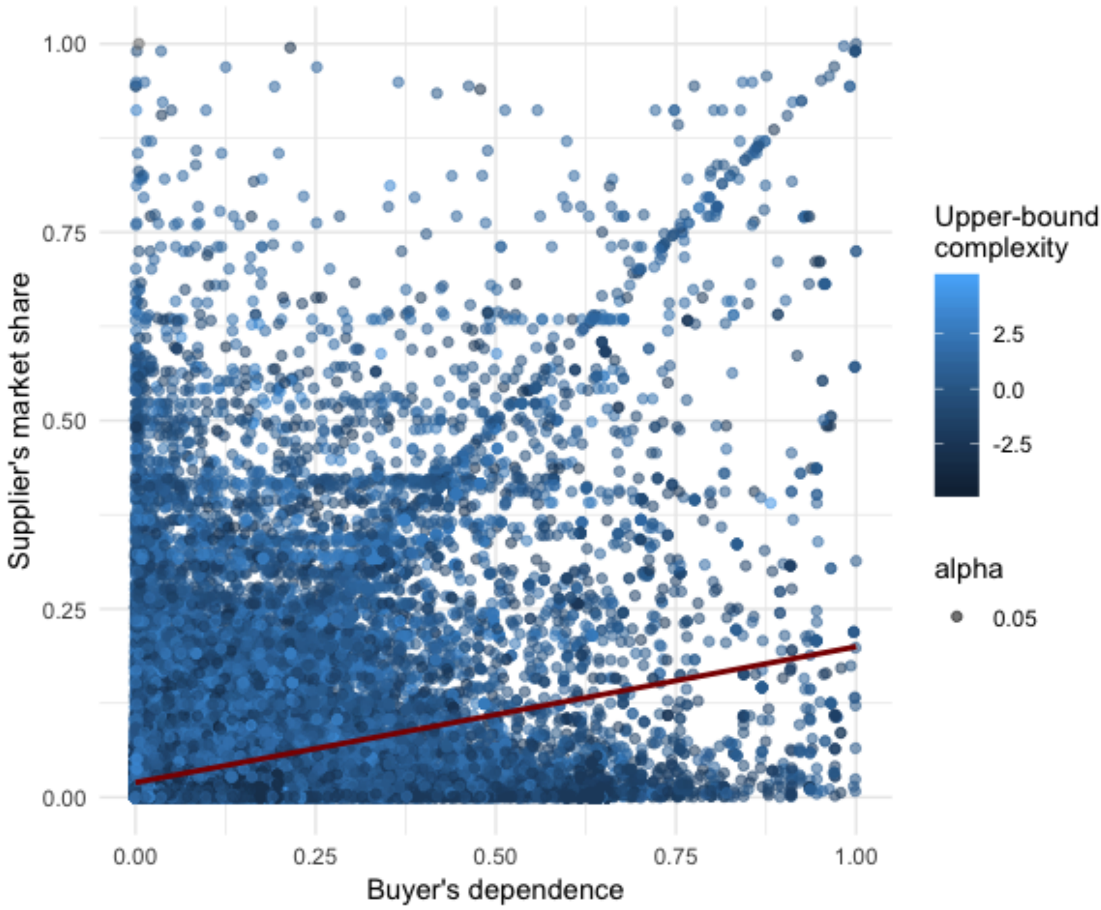

Figure 4.10: Buyers' dependence and suppliers' market share

Source: Author's own calculation

Note: The figure plots for each buyer-supplier pair the buyer's dependence and the supplier's market share, coloured with the pair's upper bound complexity. Alpha is a transparency parameter, commonly used to make dense scatterplots easier to interpret.

So far we have looked at all relationships across the three main destination countries, i.e. the US, Venezuela and Ecuador. We can however expect that relationships will vary considerably across these countries, especially in terms of sophistication.

Looking at the three destination countries in our subsamples, we can see, for example, that there is a stark difference in the average upper and lower bound complexity of exports of Colombian suppliers to the US as opposed to Ecuador and Venezuela.

In Figures 4.11 and 4.12, we look at the average sophistication of export of Colombian suppliers across the three main destination countries. We find that suppliers in Colombia on average export less sophisticated products to US than to Ecuador and Venezuela. A possible explanation for this finding is that importers from the US purchase sophisticated products from other countries that are at the frontier in those products, and that Colombian exporters only manage to trade with US importers in unsophisticated goods. In contrast, buyers in Ecuador and Venezuela, that both neighbour Colombia and have much lower income levels than the US, are more likely to import sophisticated goods from Colombia.

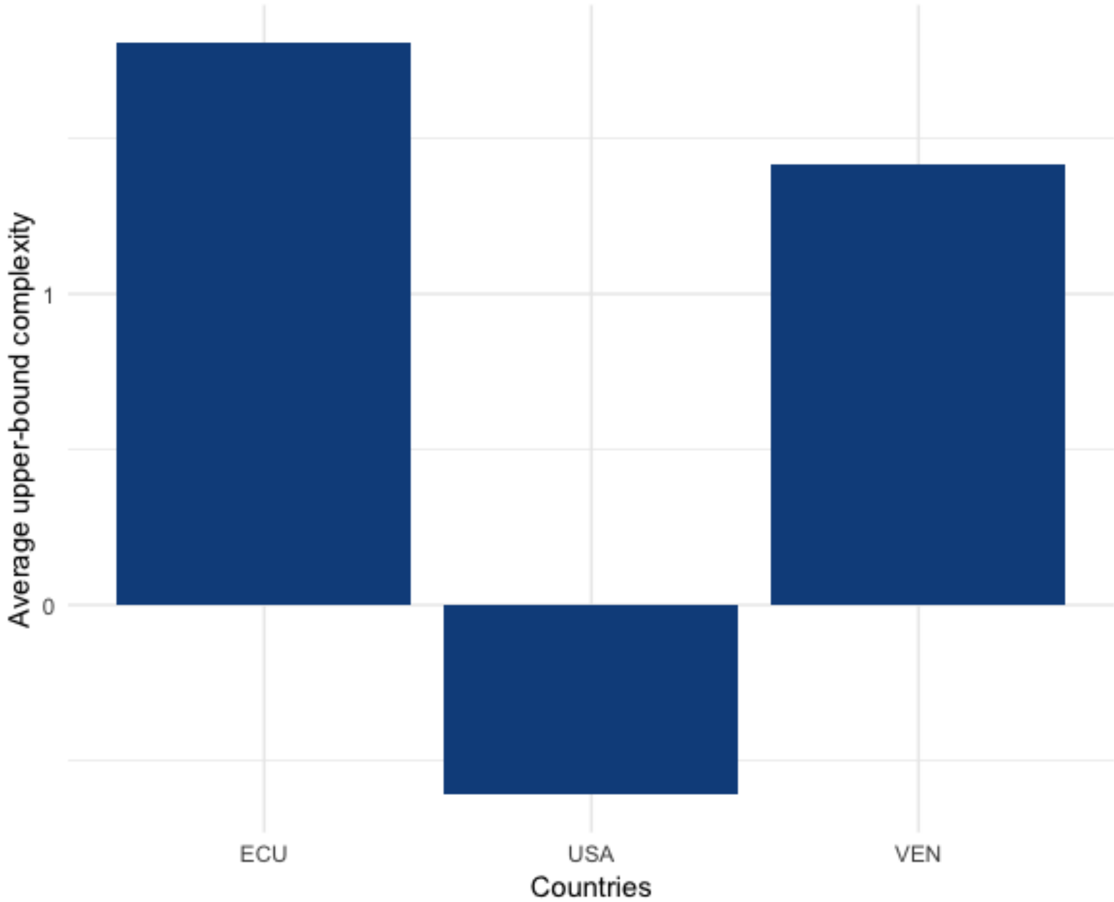

Figure 4.11: Average upper bound complexity across destination countries

Source: Author's own calculation

Note: The figure shows the average upper bound complexity of the buyer-supplier pairs taking place between Colombian exporters and buyers based in the three destination countries: Ecuador, USA and Venezuela.

These differences may thus reflect different entry points in GVCs for Colombian exporters. Trade with the US is essentially in unsophisticated products, while Colombia may be able to compete in more sophisticated goods in countries that are its neighbours, have similar income levels, and are more likely to demand the same varieties of products.

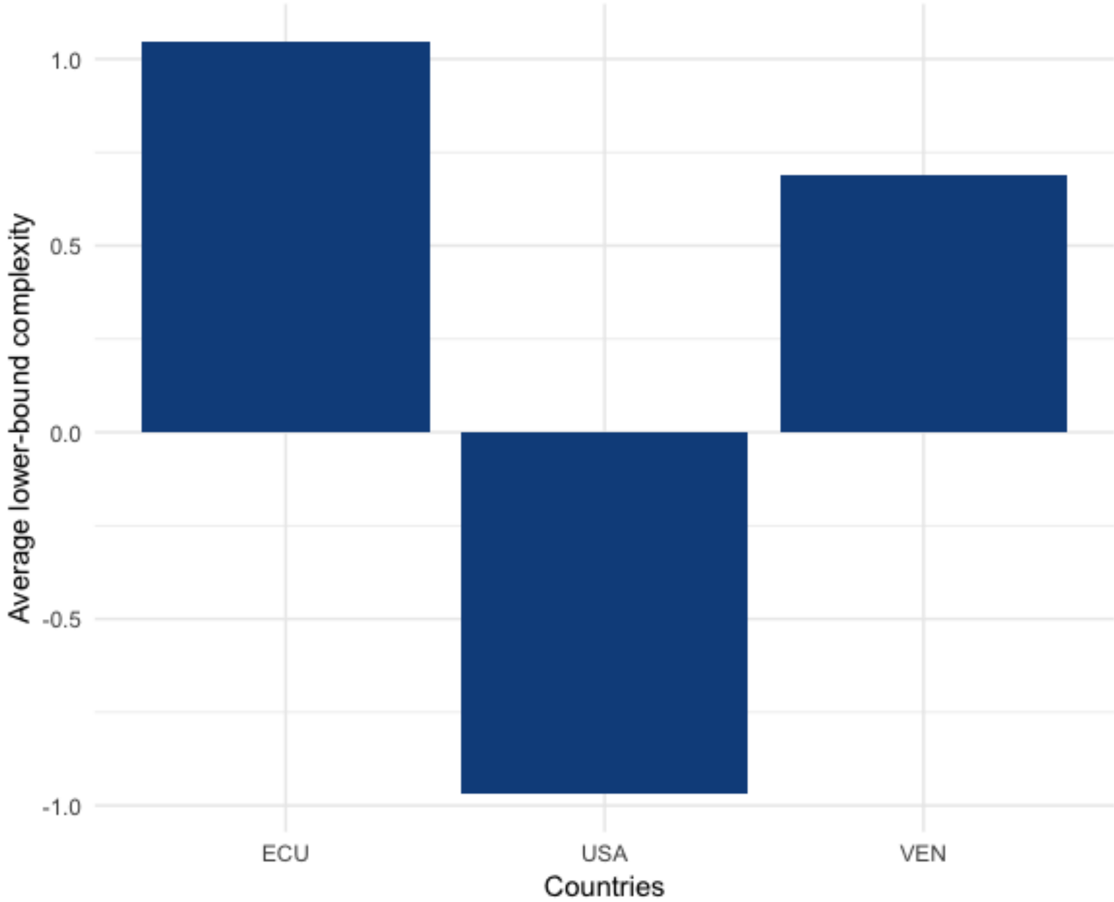

Figure 4.12: Average lower bound complexity across destination countries

Source: Author's own calculation

Note: The figure shows the average lower bound complexity of the buyer-supplier pairs taking place between Colombian exporters and buyers based in the three destination countries: Ecuador, USA and Venezuela.

These figures are also consistent with data from the Atlas of Complexity, according to which the US had an economic complexity index of 1.53 in 2014, Colombia ranks in the middle with -0.067, followed by Venezuela with -0,897 and Ecuador with -1.17

To give more concrete examples, Colombia tends to export more sophisticated products to its less sophisticated trade partners, as can be seen in Table 4.5 below.

Table 4.5: Export Categories from Colombia to its three main trading partners, 1-digit product categories, excluding fuels, lubricant and related materials[27]

Destination Country	First product category	Second product category	Third product category
USA	Other (mainly gold, non-monetary): 30.82%	Food and live animals for food: 28.62%	Crude materials (mainly animal and vegetable materials): 14.48%
Venezuela	Chemicals and related products: 37.60%	Food and live animals for food: 27.06%	Manufactured goods: 21.04%
Ecuador	Chemicals and related products: 32.48%	Manufactured goods: 22.95%	Machinery and transport: 22.63%

Source: Atlas of Complexity: http://atlas.cid.harvard.edu
Note: percentages are of countries' total export in 2014.

In the next section we try to explore these relationships in more depth through regression analysis. We also discuss our empirical approach and results.

4.5 Empirical approach and results

In this section we present the empirical strategy used to study how our measures of power are related to (i) levels of export sophistication, to investigate static relationships between power and export sophistication, as well as the dynamic effects by looking at (ii) the likelihood of introducing a new product, and (iii) the likelihood of increasing export sophistication, which we equate in our approach to export upgrading.

While we focus on the relationship between export sophistication and the four measures of power discussed in the previous section, we also introduce a set of controls, which we present in this section.

[27] We have excluded export of oil, fuel and lubricants, because this sector is not covered in our data. It is worth noting, however, that this is also a low sophistication sector that represents the bulk of exports to the US.

It is worth emphasising from the onset that our empirical analysis is carried out here at the pair level; its focus is however the sophistication of the products traded by the supplier to the buyer. We estimate the following equation:

$$(1) \qquad y_{rt} = \beta_1 nhs4_{rt} + \beta_2 sdp_{rt} + \beta_3 bsh_{rt} + \beta_4 bdp_{rt} + \beta_5 ssh_{rt} + \beta_6 ntrans_{rt} + \beta_7 tfp_{rt} + \beta_8 age_{rt} + \tau_r + \tau_t + \varepsilon_{pt}$$

Where, for pair *r* and year *t*:

- the outcome variable *y* is one of the four sophistication measures;
- sdp is the supplier dependence vis-à-vis the buyer in pair *r*;
- *bsh* is the buyer's market share;
- *bdp* is the buyer dependence vis-à-vis the supplier in pair *r*;
- *ssh* is the supplier market share.

We also include four controls:

- *nhs4* is the number of products (at the 4-digit level in the HS) traded within the pair;
- *ntrans* is the number of transactions taking place within the pair;
- *tfp* is the total factor productivity of the supplier;
- *age* is the duration of the relationship, measured in consecutive years.

The duration of the relationship is an important determinant of firms' behaviour: as trading partners acquire information about each other, they also build trust (Macchiavello and Morjaria 2015; Monarch and Schmidt-Eisenlohr 2015).

In addition to the duration of the relationship, it is also important to take into account that pairs of buyers and suppliers that trade more frequently with each other are also likely to build trust more quickly; for this reason we also look at the number of transactions taking place within each pair in every year. This variable is likely to be related to the characteristics of the product traded, e.g. fresh cut flowers demand a higher number of transactions per year than, say, furniture.

To deal with this, the number of transactions is standardised across products and then aggregated at the pair level. This captures how often two firms interact with each other and can proxy the level of trust existing between a buyer and a supplier. This is likely to affect both the power in the relationship and the sophistication of the products exchanged.

In addition to the duration and frequency of a relationship, we are also interested in looking at the breadth of it, by looking at the number of products being traded within each pair. This is for three reasons; first, the higher the number of products two firms trade, the more likely they are to learn about each other; second, trading in more products also means that the two partners will be operating in more than one market in which the market aspect of power may vary and, third, our complexity measures are related to diversification itself, therefore one might expect that more diversified relationships are also more likely to be trading in more sophisticated products.

Total factor productivity (TFP) is included because more productive suppliers are likely to be more sophisticated and productivity is also a determinant of the governance (and power relationships) under which firms are likely to operate (Gereffi et al. 2005).

We computed TFP using data from balance sheets provided by SIREM. This includes information on fixed costs, i.e. those costs firms will have to sustain regardless of its production level, such as wages and variable costs that are, in contrast, a function of the production such as inputs.

We follow Wooldridge (2009)[28] and estimate a Cobb Douglas production function where total revenue is a function of total fixed costs to capture wages (free variable), total asset captures capital (state variable) and inputs as a proxy variable for productivity itself.

In this framework two assumptions are made: (i) that productivity is an unknown function of the state variable and the proxy, and (ii) it is also an unknown function of its lagged levels. Under these assumptions, a GMM approach is performed to use past levels of these variables as instruments for productivity[29].

Finally, we also include time and pair dummies, τ_t and τ_p respectively to take into account trends and pair-wise idiosyncratic time invariant effects; crucially, this also accounts for buyers' and suppliers' fixed effects.

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[28] We provide more details, together with the equation we estimate, in the appendix. For full details on this procedure the reader can refer to the Wooldridge (2009)paper and the vignette of the R package *prodest.*

[29] Section 4.2 of the Appendix provides further details on the estimation of productivity

A challenge posed by fixed effects with such a large number of dummy variables is that this will yield a very sparse matrix, i.e. with very few non-zero elements; this may prevent computing a generalised inverse of the estimation matrix.

To estimate this model with high-dimensionality, categorical variables such as the dummy for each pair, we follow Grossi Cajal (2016) and Abowd et al. (1999), as well as Gaure (2013) for the implementation in R[30].

This model is very likely to be affected by reverse causality and does not allow us to draw any conclusions on causal relationships. To mitigate this we take the lag of all our explanatory variables except the pair duration (*age*) and TFP.

Despite this attempt to moderate the effect of reverse causality, we refrain from any direct inference on causality; nonetheless, our main objective is to test whether the hypotheses put forward by the GVC literature, regarding power in buyer-supplier relationships as related to supplier's upgrading perspectives, are supported by a quantitative approach relying on a large sample and highly disaggregated transaction data. Our approach allows this to be done, while also contributing to the growing body of evidence at the transaction level, emphasising the importance of buyer-supplier relationships for trade patterns.

The measures of complexity we have presented so far, of course, capture the *level* of sophistication at which each supplier is trading with a buyer. However, they tell us little on the supplier's perspective of improving, which is more closely related to the concept of upgrading. To also include this more dynamic dimension into our study, we perform a linear probability model to see whether (lagged) levels of the four power components are related to the probability of a supplier introducing a new product and increasing its sophistication. We estimate the following equation:

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[30] Abowd et al. (1999) develop this method to retrieve the fixed effects for employers and employee, and Grossi Cajal (2016) applies this to buyer-supplier matched trade data.
We are not interested here in estimating such effects, but merely to control for them. To do this, we use specifically the package *lfe* in R, which is designed to yield the same results of a standard OLS, but uses the Method of Alternating projections to sweep out multiple group effects, years and pairs in our case, dealing with the problem of sparse matricesm, as described in Gaure (2013). For more details on how the package works, we refer the reader to the vignette freely available from the CRAN repository: https://cran.r-project.org/web/packages/lfe/lfe.pdf.

$$(2) \qquad y_{rt} = \beta_1 nhs4_{rt} + \beta_2 sdp_{rt} + \beta_3 bsh_{rt} + \beta_4 bdp_{rt} + \beta_5 ssh_{rt} + \beta_6 ntrans_{rt} + \beta_7 tfp_{rt} + \beta_8 age_{rt} + \tau_r + \tau_t + \varepsilon_{pt}$$

The introduction of new products has been at the centre of a growing literature on trade (Goldberg et al. 2010; Iacovone and Javorcik 2009, 2010b), although there is a paucity of evidence concerning power in trade relationships as a determinant. We also take our search further and explore how changes in the product portfolio of the supplier affect the sophistication of exports, which here is a proxy for upgrading.

While the explanatory variables remain unchanged, we use as outcome variables y_{rt} the following six dummy variables computed as follows:

1. a dummy variable taking value 1 if the pair introduced a new product with respect to the previous year;
2. a dummy variable taking value 1 if the pair introduced a new product that the supplier was not exporting the year before[31];
3. a dummy variable taking value 1 if the upper bound complexity of the pair has increased from the previous year;
4. a dummy variable taking value 1 if the lower bound complexity of the pair has increased from the previous year;
5. a dummy variable taking value 1 if the median complexity of the pair has increased from the previous year;
6. a dummy variable taking value 1 if the average complexity of the pair has increased from the previous year.

Concerning the first two dummy variables, we assume here that the choice of the buyer to start purchasing a new product is not related to the power relationship with its suppliers. These factors are also relevant for the choice of whether the new product should be purchased from the supplier with which the buyer is already trading.

While we do not have enough information on the buyers to estimate what factors could be impacting their purchasing strategy, it seems unlikely that the power relationship with its supplier would be a factor in the choice of the buyer starting to purchase new products.

It is in contrast more likely that buyers that are already planning on buying a new product will choose whether they want to switch to a new supplier or stick to those

[31] Our data only provide information on the products *exported*, so we cannot observe whether a firm was already producing a given good and selling it on the domestic market.

they already have and introduce a new product, based on the power ruling their relationship with their existing supplier.

With respect to the last four dummy variables, we recognise that these would only capture a fraction of what one could consider upgrading. Referring back to the four kinds of upgrading spelled out in the GVC framework (product, process, function and value chain) (Gereffi et al. 2005), upper bound complexity and the introduction of new products would capture product upgrading, and possibly function and value chain upgrading depending on what the new product introduced is and how different it is from what the pair was exchanging in the past.

Lower bound, median and average complexity do not necessarily refer to upgrading *per se*, as they might be the outcome of a pair simply dropping an unsophisticated product, although one might expect that as firms move up in the value chain they would specialise away from low-sophistication products. Average and median complexity in particular have the advantage of capturing the sophistication level of the bulk of the export flows within a given pair.

So, to be sure, our complexity measures will not capture the whole spectrum of upgrading. However, they offer a so far untapped opportunity to look at sophistication of exports for very disaggregated product categories, using transaction level data to provide new quantitative evidence based on a large sample of buyer-supplier relationships.

We present the different results in the remainder of this section, in separate subsections, starting with the relationship between power and sophistication, then the likelihood of introducing a new product and, finally, the likelihood of increasing export sophistication, i.e. engaging in export upgrading. In section 4.3 of the Appendix we also run a battery of robustness checks, finding our results to be solid.

4.5.1 Power components and levels of export sophistication

Turning now to our main results, Table 4.6 shows the relationship between the lagged four measures of the power and the four measures of complexity.

Concerning the two components of the buyer's power (see Table 4.1), these results suggest that pairs with a supplier that is heavily dependent on their buyer tend to trade in less sophisticated products. In contrast pairs with a buyer with a large market share (i.e. purchasing a large share of product exported by the export with which they trade) tend to trade in more sophisticated products, both at the upper and lower bounds and when looking at the median and average sophistication. Notwithstanding the caveats mentioned above, these results are consistent with the (qualitative evidence-based) intuition put forward in the GVC literature that large buyers tend to be larger firms purchasing more sophisticated products, while suppliers that are heavily dependent on their buyers tend to be smaller firms trading in low-sophistication products.

Table 4.6: Power components and sophistication

	Upper bound	Lower bound	Median	Average
nhs4	0.0096 *** (0.0017)	-0.0133 *** (0.0016)	-0.0006 (0.0011)	-0.001 (0.0009)
sdp	-0.0835 *** (0.0243)	-0.0475 * (0.0235)	-0.0442 ** (0.0161)	-0.0428 ** (0.0133)
bsh	0.1119 ** (0.0364)	0.0948 ** (0.0352)	0.0707 ** (0.0242)	0.0429 * (0.02)
bdp	-0.0045 (0.0518)	-0.0702 (0.05)	-0.0575 ° (0.0343)	-0.0531 ° (0.0284)
ssh	-0.0094 (0.0856)	-0.0882 (0.0828)	-0.2238 *** (0.0568)	-0.2172 *** (0.0469)
tfp	0.0685 *** (0.0155)	-0.0038 (0.015)	-0.0057 (0.0103)	-0.0175 * (0.0085)
ntrans	0.0038 ** (0.0012)	-0.0025 * (0.0011)	-0.0011 (0.0008)	-0.0009 (0.0006)
age	-0.0009 (0.0062)	0.0018 (0.006)	-0.0041 (0.0041)	-0.0004 (0.0034)
N. obs.	42741	42741	42758	42758
R2	0.94	0.94	0.97	0.98

OLS regression results with time and buyer-supplier pair dummies.

Dependent variables are upper-, lower bound, median and average complexity of the pair, based on data from http://www.datlascolombia.com

All explanatory variables are lagged, except TFP and age, which is the duration (number of consecutive years) of the pair.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses

Source: Author's own calculation.

These opposing relationships between the two components of the buyer's power show that a nuanced view of a buyer's power may be required when looking at buyer-supplier relationships. A pair in which the power of the buyer comes from high dependence on the part of the supplier is likely to be trading in unsophisticated products, while the opposite will be true for pairs in which the buyer's market share is the source of its power.

The supplier's power components seem to have a significant relationship only with respect to the median and average complexity; this relationship is negative for both variables, suggesting that pairs with a strong supplier tend to trade in unsophisticated products. An intuitive explanation may have to do with the sectors in which suppliers with large market shares in Colombia are likely to be concentrated, such as commodities like coffee and flowers. However, time-invariant effects from these macro sectors are likely to be accounted for by the supplier level fixed effect.

Another possible explanation for our results could be that suppliers in Colombia are more likely to obtain large market shares in commodity-based, low-sophistication products. On the one hand, these are easier to enter than more sophisticated products and, on the other hand, enjoy large economies of scale that explain the high level of concentration and the large market shares of the incumbents.

While this explanation may not apply to all countries, it is likely to be a predicament in which many other small emerging economies (such as Peru and Ecuador for example) are likely to find themselves.

As expected from Figures 4.1 and 4.2, we see that pairs trading in more products tend to have a higher upper bound complexity. We also detect a negative association with the lower bound complexity, while no relationship is detected with our two measures of centrality of sophistication, i.e. median and average complexity.

This suggests that a larger number of products traded is not necessarily associated with a higher level of capabilities, but rather to a diversification towards both more and less sophisticated products.

The same seems to hold for the number of transactions: pairs with high frequencies tend to trade with a larger range of complexity at both ends, which again hints at diversification rather than upgrading *per se*.

Total factor productivity (TFP) shows a positive association with upper bound complexity, which was to be expected. We find, however, a negative association with the average complexity of the pair; while this may seem counter-intuitive at first, a possible explanation for this is that more productive suppliers also tend to be more diversified, which is likely to drive down the average complexity; it is also possible that exporters in Colombia are more productive in low-complexity products, which would also explain these results.

The four complexity measures used so far capture characteristics of the distribution of the sophistication of products traded within each pair, in particular the maximum, minimum, the median and the average. They shed light on the products' feature of different pairs, based on the characteristics of the power relationship the suppliers and buyers establish with each other, controlling for each other, and a number of other control variables.

4.5.2 Power measures and the introduction of new products in buyer-supplier pairs

Aside from sophistication levels, we are also interested in exploring the dynamic aspects of this, in particular to see whether buyer-supplier pairs introduce new products to their product portfolio; to explore this possibility we also perform a linear probability model with two different outcome variables. These are the first two dummy variables we have already introduced as additional outcome variables.

In Table 4.7, the first column has as outcome variable a dummy taking value 1 if the pair introduces a new product from the year before; we refer to this as a product new-to-the-pair. We add here the past level of upper bound complexity (*pci*) as a covariate, to control for past levels of sophistication of the pair. The second and third columns have an outcome variable taking value 1 if the pair introduces a product that is not only new to the pair but also to the supplier, i.e. the supplier was not exporting this product in the year before. We refer to this as a product new-to-the-supplier. In column three of Table 4.7 we also control for a dummy nhs_d taking value one if the pair has introduced a new product it was not exporting in the previous year.

Table 4.7: Linear probit on the power components and the introduction of new products in the pair

	New to the pair	New to the supplier	New to the supplier
nhs4	-0.0109 *** (0.0011)	-0.0069 *** (0.001)	0.0004 (0.0006)
pci	-0.0818 *** (0.0041)	-0.0413 *** (0.0036)	0.0137 *** (0.0024)
sdp	0.0149 (0.015)	0.1083 *** (0.0133)	0.0983 *** (0.0086)
bsh	-0.0375 ° (0.0225)	-0.048 * (0.0198)	-0.0228 ° (0.0129)
bdp	0.0219 (0.0319)	-0.0197 (0.0282)	-0.0344 ° (0.0183)
ssh	-0.0295 (0.0528)	0.0705 (0.0466)	0.0903 ** (0.0303)
tfp	0.0395 *** (0.0096)	0.0365 *** (0.0085)	0.01 ° (0.0055)
ntrans	-0.0001 (0.0007)	-0.0002 (0.0006)	-0.0001 (0.0004)
age	-0.0122 ** (0.0038)	-0.0084 * (0.0034)	-0.0002 (0.0022)
nhs_d			0.6718 *** (0.0037)
N. obs.	42739	42739	42739
R2	0.37	0.37	0.73

Linear probability model with year and buyer-supplier pair dummies.

Dependent variable in col. 1 is a dummy taking value 1 if the pair introduces a new product, col. 2 and 3 use a dummy taking value 1 if the pair introduces a new product that the supplier wasn't exporting in the year before.

All explanatory variables are lagged, except TFP and age.

pci is the lagged level of upper bound complexity; nhs_d is a dummy taking value one if the pair has introduced a new product, i.e. the outcome variable in column 1.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses

Source: Author's own calculation.

Concerning the four power components, we find that only the buyer's market share is significantly associated to the likelihood of introducing a new product, with a negative sign. This suggests that, in line with the GVC literature, buyers with large market shares are less likely to be persuaded by the supplier to purchase new products and will stick to their current portfolio of products.

When we focus on our second outcome variable, a product new to the exporter, we see that a lot changes when we control for the dummy for the introduction of new products. Unsurprisingly, this new control is strongly correlated with our outcome variable, and the R-squared of our model increases from 0.37 to 0.73.

We also find all four components of the power relationships to be significantly related, although with different signs.

A possible explanation for the significance of the coefficients for our power indexes, when looking at new-to-the-supplier products but not at the new-to-the-pair, could have to do with the risk of the introduction of products that the supplier has not produced in the past, and the switching cost of finding a new trading partner, which is well documented in the literature (Grossi Cajal 2016; Eaton et al. 2015; Sugita et al. 2014; Dragusanu 2014).

Therefore, when a buyer and a supplier are negotiating on whether to introduce a new product into their pair[32], if the supplier is already exporting that product it is likely that the buyer will not be willing to sustain the switching cost of looking for a new supplier and that the product will be introduced in the pair, regardless of the power in the pair. The exception is the buyer's share, which we have already discussed.

In contrast, when the product being introduced is new to the supplier, the risk of the product not meeting the buyer's requirements will make it more appealing for the buyer to sustain the cost of looking for a new supplier, and power will be a factor taken into account in that decision. Naturally, the final outcome of this negotiation

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[32] Bear in mind that the subject of the negotiation we refer to here is whether the buyer will purchase the new product from its current supplier, rather than whether the buyer will decide to purchase a new product to begin with. We have already discussed that we consider this latter choice to be independent from the buyer-supplier power relationships.

between the buyer and the supplier will depend on all of the four power indexes. We discuss them here one by one as factors shaping the incentives of the buyer and the supplier.

In particular, pairs with high supplier dependence seem more likely to introduce products that the supplier has not previously exported. This may be because a supplier's dependence on the buyer means that it has more at stake and will make sure to comply with the buyer's requirements, which in turn may convince the buyer to "trust" the supplier with the production of the new product. We address the issue of whether these new products also correspond to an increase in the capabilities in Table 4.8.

The buyer's share is negatively associated with the introduction of products new to the pair and to the supplier. We have already pointed out that this is in line with the GVC literature, arguing that large buyers will be hard to convince to introduce new products and are more likely to have access to a larger pool of suppliers.

The dependence of the buyer is also another factor that is at play in choosing whether to introduce a product new to the supplier. Since the product is new to the supplier, and sticking with it does not necessarily decrease the risk that the new product will not meet the buyer's requirements, buyers that are heavily dependent on their suppliers may be inclined to find new suppliers in order to avoid increasing their dependence. This explains why the index is negatively related to our outcome variable.

Finally, a large market share for the supplier will make it more likely that the supplier will convince the buyer to purchase a product that the supplier has not produced before; this explains the positive relationship we detect in column 3 of Table 4.7. A possible explanation for this is that suppliers that achieve large market shares are also likely to be large companies with significant resources (on which the buyers can rely). They are also more likely to be successful at introducing new products to their export portfolio.

Turning to the control variables, in the first column of Table 4.7 we see that the number of products exported in the previous period, the upper bound complexity (*pci*), and age are negatively associated with the likelihood of introducing a new product in the pair. This could be interpreted as a sort of "catching-up" effect, showing that young pairs exporting few, unsophisticated products are more likely to introduce new ones.

TFP has a positive association throughout our table, which suggests that more productive firms are also those who are more likely to introduce new products.

With respect to the likelihood of introducing a product new to the supplier, we find a positive relationship with past levels of the upper bound complexity. This suggests that pairs that had high sophistication in the past are less likely to introduce a new product (as shown in column 1 of Table 4.7), but when they do this, the product is more likely to be new to the supplier.

In addition to the likelihood of introducing new products, we also want to shed light on how these products compare with the existing portfolio of products traded within the pair and whether they impact the pair's sophistication. To further explore this issue, we also look at how the power components are related to the likelihood of observing an increase in the four complexity measures.

4.5.3 Power in buyer-supplier relationships and upgrading

In these models we also include the lagged level of the sophistication measure we used to compute the relevant dummy variable as controls. This means that depending on the dummy variable that we use as outcome variable, we have different controls; however, to make the table more compact we report these controls as one row, which we call *lagged_level*. So, for example, in Table 4.8 *lagged_level* represents the lagged level of upper bound sophistication for the first column, but then represents lower bound sophistication in the second column, and so on.

Table 4.8: Linear probit on the power components and the likelihood of increases in the sophistication of the pair

	Increase in the upper bound sophistication	Increase in the lower bound sophistication	Increase in the median sophistication	Increase in the average sophistication
nhs4	-0.0056 *** (0.0009)	0.0071 *** (0.0008)	0.0102 *** (0.001)	0.0045 *** (0.0012)
lagged_level	-0.2223 *** (0.0032)	-0.2425 *** (0.0032)	-0.3769 *** (0.0056)	-0.4016 *** (0.0085)
sdp	-0.0193 ° (0.0117)	-0.0201 ° (0.0113)	-0.0555 *** (0.0141)	-0.0328 ° (0.0177)
bsh	-0.0103 (0.0175)	0.0214 (0.0169)	-0.0126 (0.0211)	0.023 (0.0265)
bdp	0.0569 * (0.0249)	-0.1067 *** (0.0239)	-0.1281 *** (0.03)	0.0019 (0.0379)
ssh	-0.0163 (0.0412)	-0.0095 (0.0396)	-0.0568 (0.0496)	-0.0279 (0.0624)
tfp	0.0218 ** (0.0075)	-0.0109 (0.0072)	0.0035 (0.009)	0.0024 (0.0113)
ntrans	0.0006 (0.0006)	-0.0006 (0.0005)	-0.0005 (0.0007)	-0.0002 (0.0009)
age	-0.0024 (0.003)	0.0049 ° (0.0029)	0.0036 (0.0036)	0.0006 (0.0045)
N. obs.	42724	42724	42758	42758
R2	0.24	0.28	0.32	0.2

Linear probability model with year and buyer-supplier pair dummies.

Dependent variables in columns 1-4 are dummy variables taking value one if the pair experiences an increase in upper-, lower bound, median and average complexity from the previous year, respectively.

All explanatory variables are lagged, except TFP and age.

Lagged_level is the lagged level of the sophistication measure on which the outcome variable is based: col. 1: lagged level of upper bound complexity; col. 2: lagged level of lower bound complexity; col. 3: lagged level of median complexity; col. 4: lagged level of average complexity.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses.

Source: Author's own calculation.

We see a consistent negative association between the dependence of the supplier and the likelihood of experiencing increases in any measure of complexity.

In the previous tables we have seen that pairs with a highly dependent supplier tend to trade in unsophisticated products, but are more likely to introduce new products. This new finding suggests, however, that the new products introduced are unlikely to be more sophisticated than those in which the pair is already trading; this again hints at the risk for highly dependent suppliers of being stuck in low-sophistication activities. This is something very much in line with the findings of the GVC literature, stressing how highly dependent suppliers are unlikely to upgrade.

In contrast, the dependence of the buyer has a negative relationship with the likelihood of increasing the median and lower bound complexity, but a positive one with the probability of increasing the upper bound complexity. This suggests that high levels of buyer's dependence are positively related to upgrading at the top, i.e. including new more sophisticated products, but negatively related to upgrading at the bottom, i.e. it is less likely that the pair will drop low-sophistication products. Because average complexity is influenced by both upper and lower bound sophistication, it is not surprising that we do not find a significant relationship with the buyer's dependence.

From these results it would seem that dependence of the buyer and the supplier are the two main factors (negatively) associated with the likelihood of changes in the pair's sophistication. We see that as both dependencies increase the chances of increasing either the median or the lower bound sophistication decrease[33].

This suggests that the higher the dependence in a pair, the less likely the pair is to drop low-sophistication products. However, we see that when the buyer is dependent on the supplier it is more likely to improve the upper bound complexity of the pair.

These findings are relevant to the GVC literature, which posit that highly mutually dependent buyers and suppliers tend to cooperate more towards upgrading, as is the

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[33] It is also worth noting that the coefficients for the buyer's dependence are much larger than those for the supplier's dependence. However, this is to be expected since the buyer's dependence is on average much lower than that of the supplier, as we saw in Table 4.2. Specifically, the coefficients for the supplier's dependence in Table 4.7 are 2-5 times smaller than the coefficients for the buyer's dependence. In Table 4.2 the average buyer's dependence is three times smaller than the average supplier's dependence.

case for relational governance (Gereffi et al. 2005). Our results suggest that such a scenario would depend on the buyer's, rather than the supplier's dependence.

We have found that when a buyer depends heavily on the supplier it is less likely that the pair will introduce a product that is new to the supplier; this is because the buyer will have an incentive to diversify and trust a new supplier. The fact that we now find a positive effect on the likelihood of increasing the pair's upper bound sophistication suggests that, when it comes to introducing a new product with a high level of sophistication (which is likely to be even riskier), buyers are likely to stick to the supplier from which they are currently buying a large share of their total purchases. So, we can conjecture that while buyers that are heavily dependent would try to introduce new products buy turning to new suppliers to diversify their trade partner portfolio, they stick to the suppliers they know when it comes to sophisticated products that are riskier to introduce.

Concerning the controls, we find a positive relationship between TFP and increases in the upper bound sophistication, which is to be expected. Interestingly we also see that as pairs increase the duration of their partnership, the likelihood of dropping low-sophistication products also increases, thus increasing the pair's lower bound complexity.

Past levels of the sophistication measure are negatively associated with the likelihood of this measure to increase. This again hints at a sort of "catching-up", and thereby upgrading, where pairs that are at lower levels of sophistication are more likely to experience an increase in this measure.

Finally, we see a negative association between the number of products traded in the pair and the likelihood of increasing the upper bound complexity. However the sign of this relationship changes when we look at the probability of increasing the other three measures of complexity. This hints at the possibility of a catching up with highly diversified pairs already exporting sophisticated products, therefore struggling to increase their upper bound complexity. They are, however, more likely to drop low-complexity products, thereby improving the other complexity measures.

4.5.4 Buyer-supplier relationships across destination countries

So far we have looked at the average associations between our power measures across all destination countries. The time invariant effects of the destination countries, such as the demand for imports and the destination countries innovativeness are controlled for by the pair fixed effects, because pairs are identified as buyer-supplier-country. There might, however, be significant differences in the kind of power relationships that suppliers are likely to establish with their buyers, as well as in the kind of products that each country tends to demand. This will depend on the countries' income, geographic position, innovation system, and regulations. This will naturally affect the kind of products that suppliers will export, as well as their sophistication level and upgrading perspectives.

The preliminary evidence presented in Section 4.4 supports this conjecture. We now explore this by investigating whether our results change significantly when we look at buyer-supplier relationships with trade partners located in a sophisticated and distant economy (US), as compared to those located in closer economies with similar or lower sophistication (Venezuela and Ecuador).

We estimate therefore the same relationships as in equations 1 and 2 for the US and for Ecuador and Venezuela. When looking at Ecuador and Venezuela as destination countries, these are globally consistent with the results of our main model and are therefore reported in section 4.3 of the Appendix. We now discuss the results for the US subsample of pairs in more depth.

Table 4.9 replicates equation 1, looking at the association between past levels of our power measures on the current complexity measures. With respect to our initial model, the starkest difference is the sign of the association of the buyer's market share. We find in fact that while there is no significant association with the upper bound complexity, suppliers in pairs dominated by a buyer with a large market share in the US tend to trade at lower levels of complexity for the other three measures. This suggests therefore that buyers from the US with large market shares tend to trade in less sophisticated products than those from Ecuador and Venezuela.

On average, and accounting for destination countries' fixed effects, buyers with large market shares are associated with higher levels of export sophistication. However, buyers dominating the market in high-income countries import low-sophistication products from emerging economies, such as Colombia, and are less likely to trade in sophisticated products.

Table 4.9: Power components and sophistication, US subsample

	Upper bound	Lower bound	Median	Average
nhs4	0.0047 (0.0032)	-0.0165 *** (0.0026)	-0.0039 * (0.0017)	-0.0029 * (0.0015)
sdp	-0.1404 *** (0.04)	-0.0309 (0.0318)	-0.0228 (0.0211)	-0.0348 ° (0.0182)
msh	0.0762 (0.0595)	-0.1075 * (0.0473)	-0.0732 * (0.0315)	-0.0688 * (0.0271)
mdp	0.0156 (0.0819)	0.0112 (0.0651)	-0.0088 (0.0433)	-0.0215 (0.0373)
ssh	0.5698 (0.7233)	0.1148 (0.575)	-1.3587 *** (0.3821)	-1.4402 *** (0.3292)
tfp	0.0493 ** (0.0187)	0.0095 (0.0148)	0.0242 * (0.0099)	0.0027 (0.0085)
ntrans	0.0053 *** (0.0015)	-0.0019 (0.0012)	-0.0008 (0.0008)	-0.0006 (0.0007)
age	-0.0159 (0.0109)	-0.0045 (0.0087)	-0.0111 ° (0.0058)	-0.0038 (0.005)
N. obs.	16642	16642	16650	16650
R2	0.95	0.96	0.98	0.99

OLS regression results with time and buyer-supplier pair dummies. Estimates based on pairs with US based buyers only.

Dependent variables are upper-, lower bound, median and average complexity of the pair, based on data from http://www.datlascolombia.com

All explanatory variables are lagged, except TFP and age.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses.

Source: Author's own calculation.

We now turn to the likelihood of introducing a new product, replicating Table 4.6 in Table 4.10 below. Overall, we find rather similar results, with some minor loss of significance. The signs of the coefficients are essentially unchanged, which suggests that our main results' interpretation applies regardless of the destination country[34]

Table 4.10: Linear probit on the power components and the introduction of new products in the pair, US subsample

	New to the pair	New to the supplier	New to the supplier
nhs4	-0.0127 *** (0.002)	-0.0089 *** (0.0017)	-0.0007 (0.0011)
pci	-0.0676 *** (0.0061)	-0.0249 *** (0.0052)	0.0187 *** (0.0035)
dsp	0.0134 (0.023)	0.0773 *** (0.0198)	0.0687 *** (0.013)
msh	-0.046 (0.0342)	-0.0619 * (0.0294)	-0.0322 ° (0.0194)
mdp	0.0071 (0.047)	-0.0208 (0.0404)	-0.0253 (0.0266)
ssh	0.348 (0.4157)	0.6559 ° (0.3568)	0.4313 ° (0.2353)
tfp	0.0232 * (0.0107)	0.0234 * (0.0092)	0.0084 (0.0061)
ntrans	0.0003 (0.0009)	0.0003 (0.0007)	0.0001 (0.0005)
age	-0.0153 * (0.0063)	-0.0072 (0.0054)	0.0027 (0.0036)
nhs_d			0.6453 *** (0.0059)
N. obs.	16640	16640	16640
R2	0.39	0.39	0.74

Linear probability model with year and buyer-supplier pair dummies. Estimates based on pairs with US based buyers only.

Dependent variable in col. 1 is a dummy taking value 1 if the pair introduces a new product, col. 2 and 3 use a dummy taking value 1 if the pair introduces a new product that the supplier wasn't exporting in the year before.

[34] The results excluding the US are also very consistent with our main model.

All explanatory variables are lagged, except TFP and age.

pci is the lagged level of upper bound complexity; nhs_d is a dummy taking value one if the pair has introduced a new product, i.e. the outcome variable in column 1.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses

Source: Author's own calculation.

When we turn to the likelihood of pairs increasing their sophistication through increases of the complexity measures, we find that the buyer's dependence is no longer significant. In contrast it seems that the market shares of both the buyers and suppliers show negative and significant associations, as shown in Table 4.11.

In particular, we see that the buyer's market share is again negatively associated to the likelihood of increasing the upper bound complexity. This suggests that suppliers trading with buyers with large market shares from the US are likely to have low export sophistication (as seen in Table 4.9), and are also less likely to drop unsophisticated products and thus increase their lower bound complexity measure.

The supplier's market share is also strongly significant with large coefficients. We find that suppliers with large market shares are less likely to drop unsophisticated products and thus to increase their lower bound, median and average complexity. This can be because suppliers exporting to the US with large market shares are often trading in unsophisticated products and have little chance to upgrade in other US markets, due to supply constraints. Therefore, their large market share makes them unlikely to drop the unsophisticated products they are already exporting; however, this does not help them in including more sophisticated products that would increase their upper bound complexity.

Interestingly, when we exclude US buyers from our sample[35], we find that the supplier's market share has a positive relationship with the likelihood of dropping unsophisticated products.

This suggests that large suppliers from Colombia do not manage to upgrade with buyers from the US and therefore remain "trapped" in what they do, using their large

[35] The results of this specification are presented in Table A18 in section 4.3 of the Appendix.

market share to retain their current export portfolio. In contrast, when exporting to buyers in Ecuador or Venezuela, they manage to concentrate the bulk of their export towards more sophisticated products, dropping the least complex ones.

Table 4.11: Linear probit on the power components and the likelihood of increases in the sophistication of the pair, US subsample

	Increase in the upper bound sophistication	Increase in the lower bound sophistication	Increase in the median sophistication	Increase in the average sophistication
nhs4	-0.0073 *** (0.0016)	0.0069 *** (0.0014)	0.0142 *** (0.0016)	0.0108 *** (0.0022)
lagged_level	-0.2032 *** (0.005)	-0.2538 *** (0.0052)	-0.3572 *** (0.0088)	-0.3314 *** (0.0144)
sdp	-0.0143 (0.0187)	-0.0244 (0.0161)	-0.0433 * (0.0199)	-0.027 (0.0282)
msh	0.0221 (0.0278)	-0.0401 ° (0.024)	-0.0375 (0.0296)	-0.0485 (0.0419)
mdp	0.0364 (0.0382)	-0.0316 (0.0329)	-0.0379 (0.0407)	0.0431 (0.0577)
ssh	0.1618 (0.338)	-0.648 * (0.2907)	-1.2648 *** (0.3597)	-0.8463 ° (0.5094)
tfp	0.0092 (0.0087)	0.0113 (0.0075)	0.0209 * (0.0093)	0.0296 * (0.0131)
ntrans	0.0007 (0.0007)	0.0002 (0.0006)	-0.0006 (0.0007)	-0.0005 (0.001)
age	-0.0026 (0.0051)	0.0023 (0.0044)	0.0001 (0.0054)	0.0108 (0.0077)
N. obs.	16633	16633	16650	16650
R2	0.24	0.32	0.34	0.21

Linear probability model with year and buyer-supplier pair dummies. Estimates based on pairs with US based buyers only.

Dependent variables in columns 1-4 are dummy variables taking value one if the pair experiences an increase in upper-, lower bound, median and average complexity from the previous year, respectively.

All explanatory variables are lagged, except TFP and age.

Lagged_level is the lagged level of the sophistication measure on which the outcome variable is based: col. 1: lagged level of upper bound complexity; col. 2: lagged level of lower bound complexity; col. 3: lagged level of median complexity; col. 4: lagged level of average complexity.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses.

Source: Author's own calculation.

Overall, we have seen that power in buyer-supplier pairs is an important element with respect to both suppliers' sophistication and upgrading perspectives.

Different kinds of power are also associated in different ways to upgrading, depending on whether they are based on the dyadic mutual dependence of the two trading parties or the market share that each buyer and supplier has.

We have also shown that these associations are likely to change depending on the destination countries. When looking at the US, which is a high-income country and well integrated in the global market, we find that Colombian exporters tend to trade in less sophisticated products, and that the association with the buyer's market share is different from when we control for destination countries' fixed effects.

4.6 Conclusions

Based on the wealth of evidence presented, we now attempt to draw some conclusions on how power in buyer-supplier relationships is related to the sophistication of products that the supplier exports, as well as to the likelihood of new products being introduced and upgrading taking place.

Our overarching contribution consists of testing insights from the GVC literature on power and sophistication in a quantitative setting, providing a measurable definition of power and evidence from a large sample of firms from a developing country, i.e. Colombia. In doing this we also enrich the scholarship on trade among heterogeneous firms, which has largely overlooked the importance of power and upgrading in trade patterns.

In an attempt to measure the relevance of power in buyer-supplier relationships more consistently, we conceptualise power as the result of both relational and dyadic aspects linked to the relationship between buyer and supplier, and market aspects that have to do with the position of each trading partner in the market in which the relationships are taking place. We operationalise these two sources of power in this context as a combination of market shares and dependence, on both the buyer and supplier side for each pair.

Our interest lies in the level of sophistication of the products that each supplier trades with each buyer, as being affected by power structure. Export sophistication has attracted significant attention in the recent literature because it is often positively related to countries' economic development (Hidalgo et al. 2007; Zhu and Fu 2013; Klenow and Hummels 2005; Broda and Weinstein 2006). We measure sophistication following Hidalgo and Hausmann (2009), and use the measure of complexity computed in the Atlas of Complexity for Colombia.

Sophistication describes the features of a product, so we analyse the distribution of such measure for each supplier's export portfolio. In particular we consider the complexity of the most, least, median and average product traded within each pair. Additionally, we also investigate how our power variables are related to the probability of a pair introducing new products and of seeing their sophistication increase.

Interestingly, we find that neither buyer's nor supplier's power has a straightforward relationship to the level of sophistication, the introduction of new products and upgrading, and that their two components (relational and market) show at times opposing associations. This suggests that powerful buyers (or suppliers) may be associated with different patterns of capabilities and upgrading, depending on the source of their power.

Concerning the buyer's power, we find that supplier's dependence vis-à-vis the buyer is consistently negatively associated with all four measures of complexity, which suggests that pairs with heavily dependent suppliers tend to trade in unsophisticated products. Moreover, we also find a positive association with the likelihood of introducing new products, but a negative one with seeing the pair's sophistication increase.

These results suggest that pairs in which the buyer's power is due to a highly dependent supplier are likely to be stuck in low-sophistication activities, where despite introducing new products, these are not more sophisticated than those they already export. This is consistent with the insights from the GVC literature (Kaplinsky 2004).

When we look at the other component of the buyer's power, i.e. its market share, we find in contrast that pairs with buyers accounting for a large share in the market tend to trade in relatively sophisticated products, but are not likely to introduce new products. This suggests that such pairs are less prone to introduce new products or increase their sophistication. However, this is probably because pairs with buyers with large market shares are already at the frontier of sophistication and therefore have less room for improvement.

Consistent with this, when we look at the likelihood of introducing a new product, we find that pairs already trading in sophisticated products are less likely to introduce new products, although when they do they are more likely to introduce products that are new to the supplier.

The power of the supplier also shows heterogeneous correlations between its two components and our complexity measures. We find that pairs with a strong supplier, either because of large market shares or a dependent buyer, tend to trade in low sophistication products. However, pairs in which the source of the supplier's power is its market share are more likely to introduce products that are new to the supplier, but we do not detect any relationship with the likelihood of increasing any of the complexity measures.

In contrast, we find that pairs in which the power of the supplier comes from the dependence of the buyer are more likely to increase their upper bound complexity, although without changes in the other measures of complexity. This suggests that these pairs are unlikely to drop unsophisticated products.

These results apply to the entirety of our sample, when controlling for time-invariant features of the destination countries. We have, however, explored whether there are differences across destination countries, focusing in particular on countries that have a significantly higher level of economic complexity and are likely to be at a larger technological distance from Colombia, i.e. the US.

We have found that US-Colombia trade is, on average, less sophisticated than trade between Colombia and the other two main destinations, i.e. Ecuador and Venezuela, with lower, though closer, levels of economic complexity.

Moreover, in US-Colombia pairs the buyer's market share is negatively associated with both the level of export sophistication and the likelihood of improving the pair's lower bound complexity, while the opposite is true for our main results and when looking at pairs with buyers from Ecuador and Venezuela.

This suggests that, on the one hand, buyers in the US purchase unsophisticated products from Colombia, and this is particularly the case for buyers with large market shares. Such buyers are also less likely to increase the sophistication of their purchases. A tentative explanation for this is that buyers in the US are more integrated in the global market and will purchase sophisticated products from suppliers from other countries at the frontier in such markets. This conjecture would also be in line with the GVC literature that shows that suppliers' capabilities (crudely proxied here by countries' economic complexity) are taken into account by lead firms in GVCs, when establishing governance along the GVC (Gereffi et al. 2005).

In contrast, buyers in sophisticated economies like the US will buy unsophisticated products such as coffee and cut flowers from Colombian exporters (Hausmann and Rodrik 2003).

Consistent with this, we find that suppliers with large market shares are more likely to export unsophisticated products to US buyers, and their market share is not associated with the likelihood of introducing a new more sophisticated product (arguably because of a lack of demand), while it makes them less likely to drop the unsophisticated products they are already exporting and improve their lower bound complexity.

So, we find general support for the main conjecture of the GVC literature, that power is an important element in shaping firms' prospects of upgrading through participation to GVCs. It seems particularly important for suppliers not to depend too much on their buyers to avoid being stuck in low-sophistication products with little prospect of upgrading.

Our results are a first attempt at exploring these issues with a quantitative approach and through statistical analysis; more complete data would help to account for ownership linkages across firms as well as to identify firms' foreign buyers with more certainty. Future research efforts should also be devoted to disentangling the causal relationship between power and export sophistication.

A limitation of the data used in this study is the impossibility of identifying the proportion of value added that each firm contributes to its own product; this would allow us to distinguish between firms that carry out the whole production process in-house and those who are mere assemblers depending on foreign imports. Unfortunately our data only allows to observe transactions between firms, but we do not know whether these concern final or intermediate demand.

This being said, this Chapter does not only confirm some of the general findings from the GVC literature with novel, quantitative and generalisable evidence; we also offer a more nuanced view of both buyer's and supplier's power, distinguishing between market and relational sources and showing that these are associated in different ways with suppliers' export sophistication and capabilities.

We also explore these associations across destination countries, finding relevant differences, especially between high-income countries at the technological frontier and other neighbouring emerging economies.

In doing this we also expand the growing literature using transaction level data to explore the buyer-supplier relationship. Starting from the insights of the GVC literature on power and upgrading, we integrate these concepts with the evidence on the buyer-supplier matching process and heterogeneity in trade. As part of this effort, we also put forward a novel empirical approach to compute power and sophistication with transaction level trade data from customs, which are a recent and increasingly available source of data for researchers interested in exploring the micro level mechanisms shaping trade patterns and growth.

5. Conclusions

The overall goal of this thesis was to explore the relationship between GVCs participation and structural change at the macro, meso- and micro level. We have delved in particular into the issues of (i) countries' specialisation and their performance in GVCs, (ii) the opportunities the domestic structure, and intermediate domestic demand from natural resource industries in particular, offers to diversify through GVC participation in KIBS and, finally, (iii) the association between power in trade relationships and export sophistication.

We now review our main findings and draw some conclusions with a focus on the policy implications, which are particularly relevant following the recent re-ignition of the debate around industrial policy, its pertinence and scope (Hausmann and Rodrik 2003; Lin 2009; Lin and Chang 2009; Stiglitz et al. 2013).

5.1 Domestic productive structure and global value chains

This thesis has shown that the emergence of GVCs requires re-thinking the importance of countries' economic structure and the transformation process it undergoes as countries develop. Economies' specialisation trajectories have become the outcome of cross-country interdependencies, in which all countries are co-producers in GVCs, rather than the result of independent domestic production processes. As a consequence of this, the relationship between export specialisation and the underlying domestic productive structure has changed, as gross exports are increasingly the outcome of both foreign import and domestic production.

Based on this novel theoretical understanding of the relationship between economic structure, its transformation process and GVCs, we have explored the relationship between trade specialisation and performance with a value-added approach.

In doing this, we not only looked at the direction of countries' specialisation, i.e. in which sectors countries specialise, but also the speed at which such transformation takes place. This is crucial because it allows observing the dynamic, rather than static, effects of trade specialisation trajectories.

Our results show the importance of a value-added approach, rather than simply gross exports, in observing both countries' specialisation and their domestic contribution to exports. The emergence of GVCs has widened the gap between what a country exports and what it actually produces; policies trying to infer countries' domestic structure based on gross export risk being based on misleading premises.

Despite the optimism that GVCs have sparked in terms of providing easier and faster access to the global market, we find that specialisation trajectories countries take in participating in GVCs do have an impact on their economic performance; this is relevant for policy makers implementing export oriented policies.

Concerning the direction of countries' trade patterns, while in the past countries specialising in low-tech, labour intensive, manufacturing have been able to upgrade towards high-tech and more capital intensive manufacturing (Lin and Monga 2010), our results suggest that specialising in low-tech activities now exerts a negative effect on countries' growth in domestic value added (DVA) exported.

In addition, high-tech manufacturing also seems a difficult specialisation trajectory from a development standpoint: while we find a positive effect during the crisis period, we find no evidence over the whole time span of our sample.

This evidence suggests that policies aimed at fostering specialisation in low-tech manufacturing in order to then move onto high-tech manufacturing may not lead to the same positive outcome of the past.

Concerning services, despite the recent optimism about the new specialisation possibilities stemming from the increasing offshoring of these activities (Gereffi and Fernandez-Stark 2010; Hernandez et al. 2014), we find little evidence in support for policies favouring a GVC specialisation in services.

Acceleration in the specialisation in KIBS seems, in fact, to have a positive effect on the growth of DVA, although only during the crisis period, i.e. between 2008 and 2014. We find no evidence that such a specialisation trajectory may have long-term positive effects on countries' exports in DVA.

To some extent, this supports Rodrik's (2015b) concerns regarding developing countries' tendency to specialise in KIBS at increasingly early stages of development, and casts some doubt on policies favouring developing countries' participation in service GVCs.

5.2 Inter-sectoral linkages: a platform for export?

Another crucial conclusion from this thesis is that countries' domestic structure is not only relevant in shaping their export performance, but also in promoting the emergence of new sectors.

Revisiting Hirschman's (1958) contribution on inter-sectoral linkages, this thesis has explored in particular whether natural resource industries (NRI) can provide large enough domestic intermediate demand to foster the emergence of other sectors. This is particularly interesting because natural resources have often been associated with stagnant economic growth, and are considered as enclave sectors with few linkages with the rest of the economy.

Policies based on natural resources have traditionally focused on forward linkages that should help countries to move towards downstream manufacturing industries, yielding mixed (Morris et al. 2012), although often unsatisfactory, results (Hausmann, B Klinger, et al. 2008; Auty 1986).

In this thesis we have focused on a specular avenue, looking at backward linkages stemming from NRI to KIBS, as well as high-tech manufacturing. Chapter 2 shows that both have proved to be hard specialisation avenues for developing countries (see Figure 2.3).

Taking again a value added approach, we find the strength of domestic backward linkages to have a positive effect on the export of DVA in KIBS; interestingly, we find these effects to be even stronger for countries with a revealed comparative advantage in NRI. We find similar results for high-tech manufacturing, although the effect vanishes once we account for the productivity in NRI.

The thesis revisits the debate around the existence of a natural resource curse and, more specifically, contributes to the growing body of evidence emphasising the importance of services backward-linked to NRI in countries with natural resource-based economies (Marin et al. 2009; Marin and Smith 2010; Marin and Benavente 2011; Urzua 2012).

Within this stream of work, we propose a novel path for countries to take advantage of their NRI to spur exports in other sectors. Instead of looking at forward linked manufacturing activities, we show that countries with large NRI can use backward linkages to KIBS to foster this sector's exports. We complement the qualitative work testing this hypothesis (Kaplan 2012; Bloch and Owusu 2012) by offering quantitative evidence with input-output data.

In terms of policy implications, it is crucial to be clear that this evidence should not be interpreted as new support for specialisation in NRI. Rather, it suggests that countries that already have a specialisation in such industries should foster domestic backward linkages to increase their possibilities of diversifying their exports towards KIBS.

5.3 Global value chains: power and export sophistication at the micro-level

In order to study GVCs at the micro level, we use transaction level data from the Colombian Customs and match these with complexity measures from the Atlas of Complexity for Colombia. This measure of complexity has been used to compute export sophistication and upgrading (Zhu and Fu 2013; Poncet and Starosta de Waldemar 2013; Jarreau and Poncet 2012).

The transaction data provide information on what each Colombian exporter is trading, in what amount, and with which buyer. We use this information to operationalise power focusing on two different aspects, which we refer to relational and market power respectively.

First, the dyadic and relational features of each buyer-supplier pair computing how much the buyer depends on its supplier and vice versa.

Second, we also acknowledge that power may be related to the position each of the two firms in a trade relationship occupies in the market. Therefore we compute the market share for each buyer and supplier.

Our main finding is that power in trade relationships is correlated to the sophistication of the products traded with each buyer-supplier pair. Beyond this static association, we also find that our power measures are correlated to the likelihood of both trading in new products and increasing their sophistication.

Interestingly, we find that depending on the kind of power we consider – relational or market – its association to export sophistication and upgrading will vary. We find in fact that when the buyer's power stems from a high dependence on the part of the supplier on the buyer, it is likely that the supplier will be trading in unsophisticated products, with a higher probability of introducing new products in the pair, but low probability that these new products will improve the supplier's export sophistication. The combination of these three findings suggests that highly dependent suppliers risk being stuck in low-sophistication activities.

In contrast, suppliers trading with a buyer that draws its power from a large market share tend to export more sophisticated products. However, they have a smaller chance of introducing new products, arguably because the buyer is already trading in many sophisticated products, and is unlikely to be convinced to introduce new products. Interestingly, the positive correlation between the buyer's market share and the level of export sophistication is reversed when we only look at trading relationships with the US; this suggests that the association between power and sophistication is likely to change depending on the size, sophistication and level of integration of the destination country.

Concerning the power of the supplier, while we find that both kinds of power are negatively associated to the sophistication level of exports, we find different associations when looking at the possibility of introducing new products and that of increasing export sophistication. In fact, while we see that suppliers with a large market power are more likely to introduce new products, it is the buyer's dependence that is positively associated with increases of export sophistication.

Our findings are very relevant to firms first of all, who should choose carefully through which segments of the GVC they want to gain access to global markets.

They also suggest that export oriented policies should also take into account the risk of domestic firms being stuck in a dependence vis-à-vis their buyers, with few possibilities for upgrading.

5.4 Conclusions and new research avenues

The overall conclusion of this thesis is that joining GVCs is not a guaranteed avenue for export upgrading and development. This is true at the macro level, as we have seen that domestic specialisation and inter-sectoral linkages shape countries' export performance in GVCs, as well as the emergence of new sectors; at the micro level, we have offered evidence that power in buyer-supplier relationships is related to export sophistication.

Chapter 2 of this thesis shows that GVCs have significantly changed the relationship between domestic productive structure and trade specialisation, requiring a different understanding and empirical approach. Regardless, we still find trade specialisation to be a relevant determinant of countries' trade performance.

In addition to Rodrik's (2015a) concerns for developing countries' premature deindustrialisation in favour of services, we also find support for the idea that manufacturing as an engine of growth may be running at less than full power (Rodrik 2016a). In fact, we find low-tech manufacturing to have a detrimental effect on countries' trade performance, and only modest support in favour of increases in the specialisation in high-tech manufacturing.

So, the emergence of GVCs has made it very important to understand how value added is distributed across countries and sectors in each GVC.

Fragmentation of production is in fact heterogeneous across sectors and countries, and so is the distribution of value added across value chain segments. Exploring this further will provide useful insights for both firms and policy makers as to which GVCs to target in order to promote countries' gainful integration in the global economy.

Relatedly, the international fragmentation of production in segments also raises the question of whether new patterns of specialisation may open up to countries (based on specific tasks in GVCs), rather than industries as a whole; this in turn is related to the degree of fragmentation of each value chain and how value is distributed across its tasks. Our data do not allow the investigation of this specific issue, because input-output tables allow tracking value added across industries at an aggregate level, without providing information at the task level.

How value added is distributed across sectors and tasks in GVCs is also important to understand how countries GVC participation is impacting technological dynamics and skill requirements in the labour market at the domestic level. While the data used in this thesis did not allow us to address this question, other sources of data have become available that could shed light on the technological intensity of countries' GVC participation and, in particular, whether importing value added from high- or low-tech sectors will impact countries' performance, as well as domestic employment and skills requirements.

A further limitation of the ICIO data is the short time span covered; going back to the mid-1990s, this considerably limits researchers' ability to explore longer-term phenomena, especially related to structural change.

Finally, not only do ICIO data not provide information on tasks and employment, especially in developing countries, they also do not allow the carrying out of research at the micro level. Chapter 4 of this thesis reverts therefore to custom data to observe a full picture of Colombian export transactions with foreign buyers.

To the best of our knowledge, while some scholars have relied on surveys (Pietrobelli and Saliola 2008; Giovannetti and Marvasi 2016; Del Prete et al. 2017), this is the first attempt to use data from administrative sources such as customs to compute power relationships between buyers and suppliers, and to study their relationship with export sophistication.

There are, however, some limitations to the information available in our data: in fact, we do not observe firms' ownership, which means that we cannot distinguish between domestically owned firms and foreign companies' subsidiaries. While both the GVC literature (Gereffi et al. 2005) and the literature on business and management have long ago established that the ownership relationship between headquarters and subsidiaries is an important determinant of how knowledge and technology are localised and transferred (Blomström and Kokko 1998; Gao et al. 2007; Figueiredo 2010), little quantitative evidence has been put forward to study this in a GVC framework. Further research, with a quantitative approach, is thus needed to investigate how power and export sophistication are related to foreign ownership.

A second limitation of our data has to do with the fact that, in this thesis, we can only rely on suppliers' gross exports, which we have seen may not necessarily be very representative of firms' actual contribution in value added terms.

While an obvious possibility would be to include import data in the analysis, the challenge would remain of how to link imports with exports across products and markets. While some work has been done on this (Boehm et al. 2016; Goldberg et al. 2010), the understanding of input-output linkages at the firm level is a crucial research avenue to which more work should be devoted in the future.

Relatedly, more efforts are needed to trace value added within firms' production processes to be able to examine whether GVC participation differs from trade *tout court*. It would be particularly interesting to study whether firms that import to export, for example in special economic zones, behave in a different way from domestic producers that also engage in international markets. It would be particularly important to assess whether firms' linkages with the domestic economy will also be playing a role in their ability to benefit from GVC participation, as hinted by Poncet and Starosta de Waldemar (2013).

In conclusion, future research at the micro level would benefit greatly from constructing buyer-supplier transaction level datasets with information on both suppliers and buyers, including ownership ties, to fully account for firm heterogeneity in trade along GVCs.

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Appendix

Appendix to Chapter 2

Appendix 2.1 – Data and variables

We present here some more detailed information on the data we use, in particular which sectors are included in our four macro-sectors and how we compute our measures.

In Table A1 below we present which sectors have been aggregated into the four sector groups. NR, LTMF and HTMF have been compiled following OECD sector classification.

Table A.1: Macro sector groups and ISIC codes

Sector groups	Included sectors	ISIC codes
KIBS	Computer and related activities; R&D and other business services.	C72, C73T74.
NR	Agriculture, hunting, forestry and fishing; Mining and quarrying.	C01T05, C10T14.
LTMF	Food products, beverages and tobacco; Textiles, textile products, leather and footwear; Wood, products of wood, and cork; Pulp, paper, and paper products; Coke, refined petrol products, and nuclear fuel; Rubber and plastic products; Other non-metallic mineral products; Basic metals; Fabricated metal products; Manufacturing nec and recycling.	C15T16, C17T19, C20, C21T22, C23, C25, C26, C27, C28, C36T37.
HTMF	Chemicals and chemical products; Machinery and equipment; Computer, electric, and optical equipment; Electrical machinery and apparatus; Motor vehicles, trailers, and semi-trailers; Other transport equipment.	C24, C29, C30T33X, C31 C34 C35

Source: Author's taxonomy, based on OECD technological intensity definitions.

Table A2 below gives the list of countries included in the high-income group in our analysis. As many of our countries become high-income over time, we report in the second column of the table the number of years they are among the high-income countries.

Table A.2: High-income countries

Country	Number of years
ARG	1
AUS	17
AUT	17
BEL	17
BRA	1
BRN	17
CAN	17
CHE	17
CHL	2
CYP	17
CZE	7
DEU	17
DNK	17
ESP	17
EST	6
FIN	17
FRA	17
GBR	17
GRC	16
HKG	17
HRV	5
HUN	5
IRL	17
ISL	17
ISR	17
ITA	17
JPN	17
KOR	12
LTU	3
LUX	17
LVA	3
MLT	9
NLD	17

NOR	17
NZL	17
POL	3
PRT	11
RUS	1
SAU	7
SGP	17
SVK	6
SVN	9
SWE	17
USA	17

Note: The second column of the table reports the number of years each country has a GDP per capita above US$ 12,236 and is therefore considered as high-income for the purpose of our empirical analysis.

Source: Author's own calculation using ICIO tables.

The three figures below compare RCAs computed with gross exports and DVA for NR, LTM and HTM respectively. We observe that for all these three sectors, in addition to KIBS (cfr Figure 2.1), DVA RCAs compared to their gross export homologue do not simply "deflate" the RCA. In contrast, we observe that some countries have higher RCAs when we compute these with DVA compared to gross exports. This offers further support to the view that measuring trade specialisation in DVA changes the distribution of RCAs, and that choosing a value added approach will change the analysis's results.

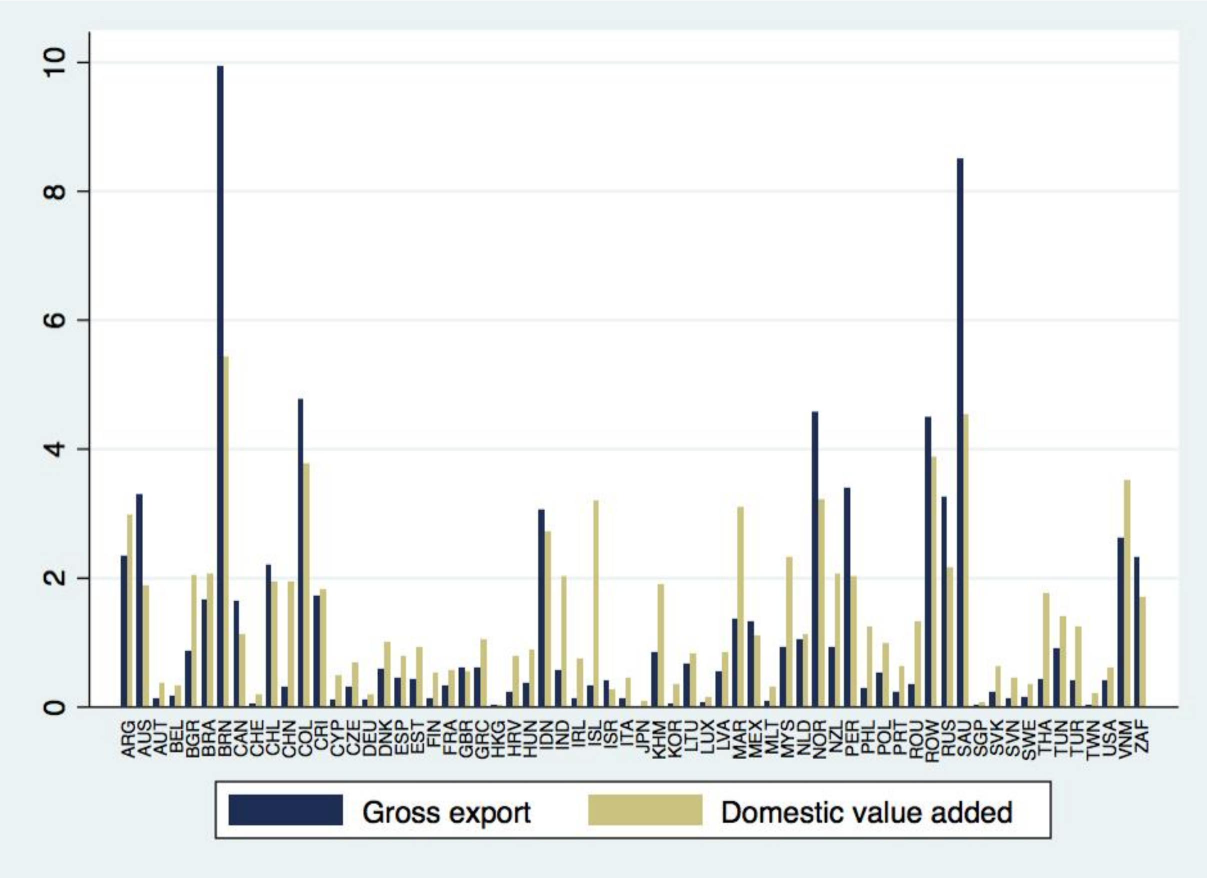

Figure A.1: Country Average RCA in NR across years in gross exports and domestic value added

Note: Figure A.1 compares countries' average RCA in NR across years in our sample, using gross exports and domestic value added in exports.

Source: Author's own calculation using ICIO tables.

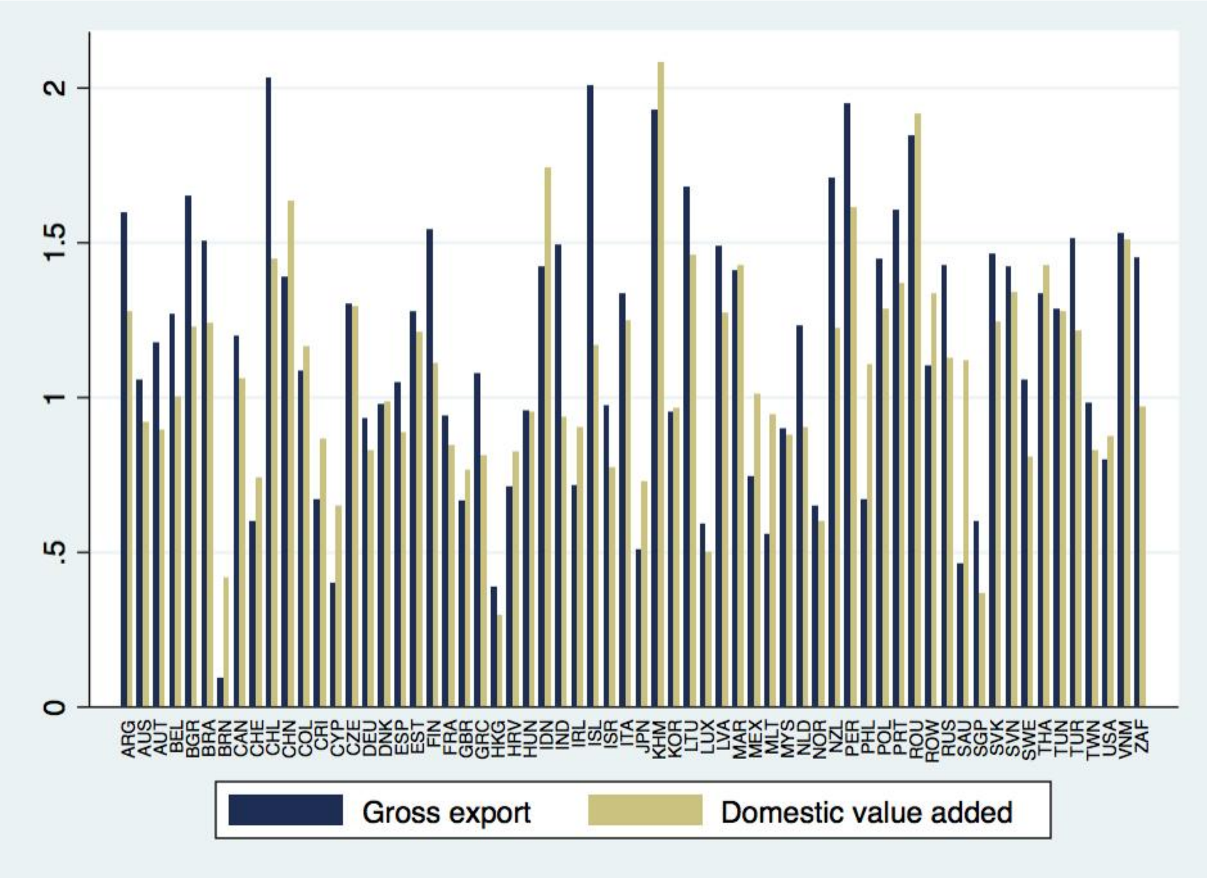

Figure A.2: Country Average RCA in LTM across years in gross exports and domestic value added

Note: Figure A.2 compares countries' average RCA in LTM across years in our sample, using gross exports and domestic value added in exports.

Source: Author's own calculation using ICIO tables.

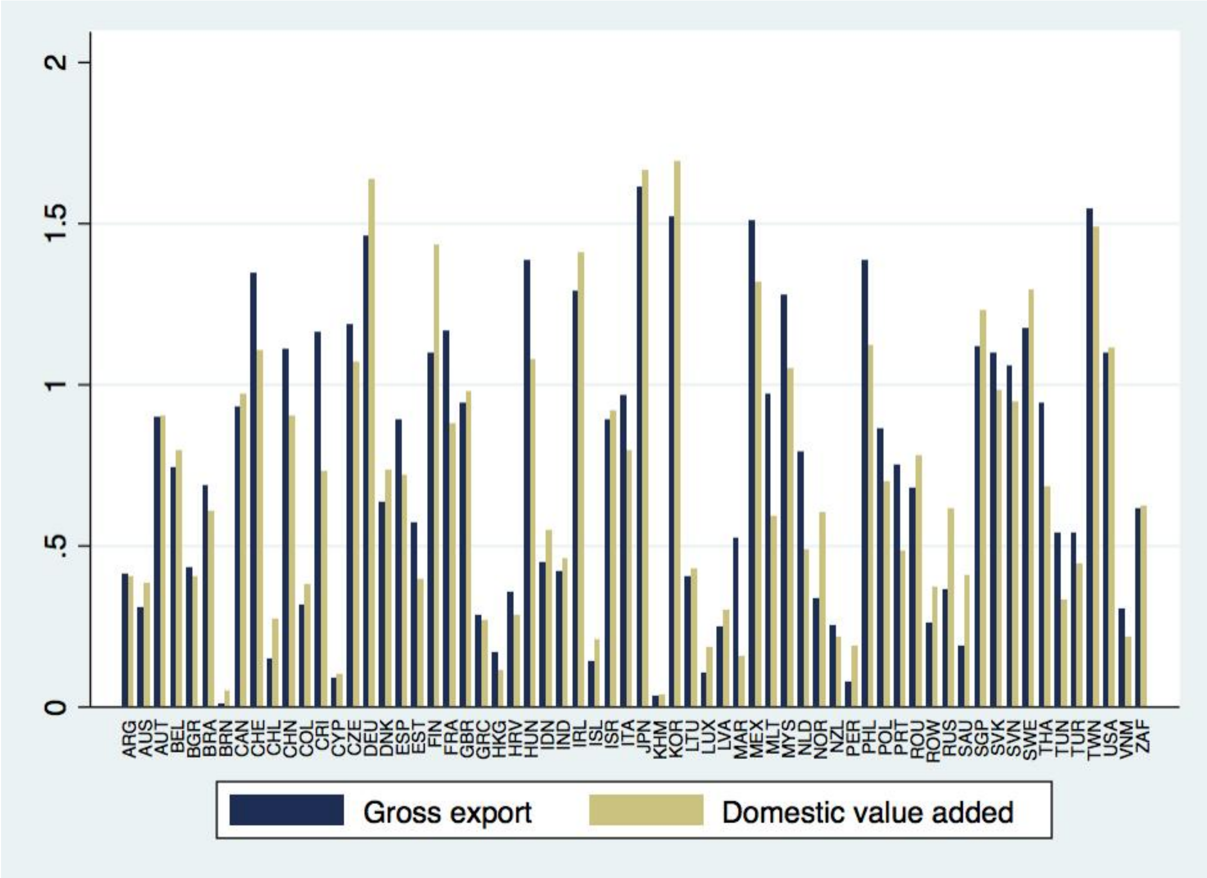

Figure A.3: Country Average RCA in HTM across years in gross exports and domestic value added

Note: Figure A.3 compares countries' average RCA in HTM across years in our sample, using gross exports and domestic value added in exports.

Source: Author's own calculation using ICIO tables.

Figure 2.2 shows specialisation trends across high-income and developing countries, for completeness's sake we reproduce here the same figure without distinguishing countries based on income per capita. Figure A.4 shows the average RCA across countries over years in our four sector groups. There is a clear trend of moving away from natural resources and low-tech manufacturing, while the trend seems to be positive, although less strong for high-tech manufacturing. Specialisation in KIBS initially decreases, but then picks back up again from 2005 onwards.

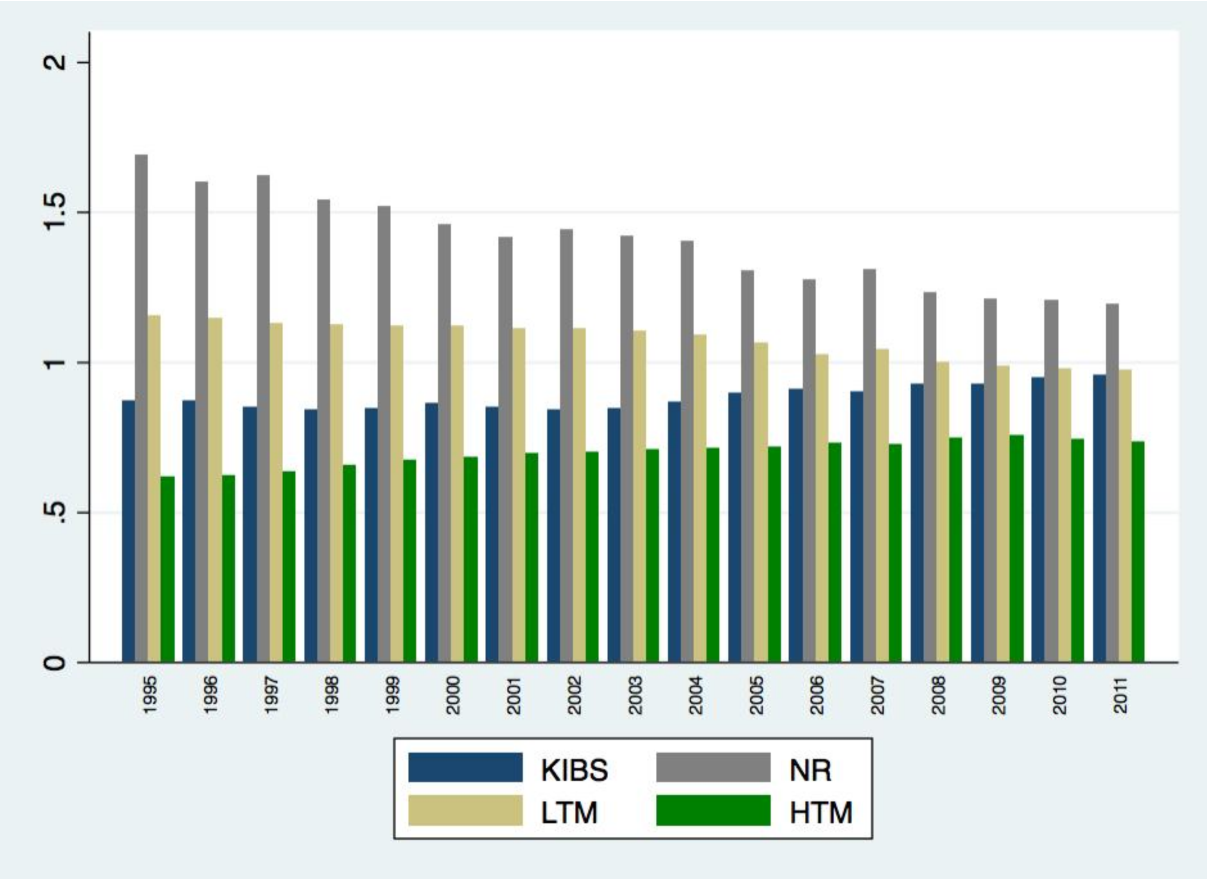

Figure A.4: Average RCA Across countries and over years

Note: Figure A.4 shows trend in the average RCA, computed with domestic value added in exports, across countries in our sample, for four sector groups: knowledge business services (KIBS), natural resources (NR), low-tech manufacturing (LTM), and high-tech manufacturing (HTM).

Source: Author's own calculation using ICIO tables.

It is also worth stressing that the RCA of countries in a given sector need not to sum to a given value (as it would be the case) for market shares for example; therefore cross-country averages of RCAs provide a meaningful idea of how countries' specialisation evolves over time, on average.

Appendix 2.2 – Computation of domestic value added in exports

We now turn to how we compute our variables based on value added. The usual formula to look at value added in production is the following:

$$V'BF$$

Where V' is a diagonalised vector of value added shares, B is the usual Leontief inverse that reallocates value added based on the sector of production, and F is a vector of final demand.

If we take an example with three countries, *a*, *b*, and *c*, this can be depicted as follows:

$$(v_a\ 0\ 0\ 0\ v_b\ 0\ 0\ 0\ v_c\ ) *\ (b_{aa}\ b_{ab}\ b_{ac}\ b_{ba}\ b_{bb}\ b_{bc}\ b_{ca}\ b_{cb}\ b_{cc}\ ) \\ *\ (f_{aa}\ f_{ab}\ f_{ac}\ f_{ba}\ f_{bb}\ f_{bc}\ f_{ca}\ f_{cb}\ f_{cc}\ )$$

The letters in subscript refer to countries: when there are two of them it means that value added is flowing from the former to the latter; so b_{ab} is the intermediate demand going from *a* to *b*'s production, while f_{ab} is the final demand in *b* triggering production in *a.* The matrix multiplication above yields:

$$(v_a b_{aa}\ v_a b_{ab}\ v_a b_{ac}\ v_b b_{ba}\ v_b b_{bb}\ v_b b_{bc}\ v_c b_{ca}\ v_c b_{cb}\ v_c b_{cc}\ ) \\ *\ (f_{aa}\ f_{ab}\ f_{ac}\ f_{ba}\ f_{bb}\ f_{bc}\ f_{ca}\ f_{cb}\ f_{cc}\ )$$

Which in turn is equal to:

$$\big(v_a b_{aa} f_{aa} + v_a b_{ab} f_{ba} + v_a b_{ac} f_{ca}\ v_a b_{aa} f_{ab} + v_a b_{ab} f_{bb} + v_a b_{ac} f_{cb}\ v_a b_{aa} f_{ac} + v_a b_{ab} f_{bc} \\ + v_a b_{ac} f_{cc}\ v_b b_{ba} f_{aa} + v_b b_{bb} f_{ba} + v_b b_{bc} f_{ca}\ v_b b_{ba} f_{ab} + v_b b_{bb} f_{bb} \\ + v_b b_{bc} f_{cb}\ v_b b_{ba} f_{ac} + v_b b_{bb} f_{bc} + v_b b_{bc} f_{cc}\ v_c b_{ca} f_{aa} + v_c b_{cb} f_{ba} \\ + v_c b_{cc} f_{ca}\ v_c b_{ca} f_{ab} + v_c b_{cb} f_{bb} + v_c b_{cc} f_{cb}\ v_c b_{ca} f_{ac} + v_c b_{cb} f_{bc} + v_c b_{cc} f_{cc}\ \big)$$

In the matrix above, each column represents the final demand of each country across origins. On the other hand, rows indicate the origin of value added across uses, i.e. different final demand and the intermediate demand it goes through.

For example, the first element in the top-left: $v_a b_{aa} f_{aa} + v_a b_{ab} f_{ba} + v_a b_{ac} f_{ca}$ is final demand consumed by *a* and originated entirely by country *a* divided as follows:

1. $v_a b_{aa} f_{aa}$ Value added produced and consumed within *a*, i.e. never exported.
2. $v_a b_{ab} f_{ba}$ Value added produced by *a,* for the production of country *b* that satisfies final demand in *a*, i.e. value added exported and re-imported in *a.*

3. $v_a b_{ac} f_{ca}$ It is the same as 2 but with country *c*.

From the matrix above, the components that are included in our DVA measure are those in bold in the matrix below:

$$\big(v_a b_{aa} f_{aa} + v_a b_{ab} f_{ba} + v_a b_{ac} f_{ca}\ v_a b_{aa} f_{ab} + v_a b_{ab} f_{bb} + v_a b_{ac} f_{cb}\ v_a b_{aa} f_{ac} + v_a b_{ab} f_{bc} + v_a b_{ac} f_{cc}\ v_b b_{ba} f_{aa} + v_b b_{bb} f_{ba} + v_b b_{bc} f_{ca}\ v_b b_{ba} f_{ab} + v_b b_{bb} f_{bb} + v_b b_{bc} f_{cb}\ v_b b_{ba} f_{ac} + v_b b_{bb} f_{bc} + v_b b_{bc} f_{cc}\ v_c b_{ca} f_{aa} + v_c b_{cb} f_{ba} + v_c b_{cc} f_{ca}\ v_c b_{ca} f_{ab} + v_c b_{cb} f_{bb} + v_c b_{cc} f_{cb}\ v_c b_{ca} f_{ac} + v_c b_{cb} f_{bc} + v_c b_{cc} f_{cc}\big)$$

This is achieved by computing a vector of export for each country *i* that includes only final demand from other countries, and is multiplied by the V'B matrix, selecting then only the relevant rows belonging to country *i*.

Appendix to Chapter 3

In this Appendix we present some more detailed information on the data we use in Chapter 4, as well as the most relevant robustness checks we have performed to establish the reliability of our results.

Appendix 3.1 – Variables and data

In Table A3 below we present what sectors have been aggregated into the sector groups: KIBS, natural resources (NR), low-tech and high-tech manufacturing (LTMF and HTMF respectively).

Table A.3: Sector groups and ISIC codes

Sectors groups	Sector names	Sector codes
KIBS	Computer and related activities; R&D and other business services.	C72, C73T74.
NR	Agriculture, hunting, forestry and fishing; Mining and quarrying.	C01T05, C10T14.
HTMF	Chemicals and chemical products; Machinery and equipment; Computer, electric and optical equipment; Electrical machinery and apparatus; Motor vehicles, trailers and semi-trailers; Other transport equipment.	C24, C29, C30T33X, C31 C34 C35

Source: Authors' own classification based on the OECD Technology intensity definition

Note: the ICIO data are an aggregated version of the 2-digits ISIC Rev.3, so we have identified high-tech manufacturing based on the high and medium-high technology intensity as defined by the OECD https://www.oecd.org/sti/ind/48350231.pdf

We also present a table recapitulating the variables used in the paper and the respective abbreviations, as well as a correlation table for our main model.

Table A. 4: List of variables and acronyms

Variable name	Explanation	Source
dva_kbs_cap	Domestic value added (DVA) exported by KIBS, excluding the portion of DVA exported through exports of NR or AGR or MIN	Authors' own calculations with the OECD ICIO tables
dd_kbs_agr_cap	Domestic intermediate demand from the AGR sector for KIBS	Authors' own calculations with the OECD ICIO tables
dd_kbs_min_cap	Domestic intermediate demand from the MIN sector for KIBS	Authors' own calculations with the OECD ICIO tables
vai_agr	Productivity measure for the AGR sector	Authors' own calculations with the OECD ICIO tables
vaic_min	Productivity measure for the MIN sector	Authors' own calculations with the OECD ICIO tables
dva_htm_cap	DVA exported by high-tech manufacturing (HTM) excluding the portion of DVA exported through export of NR or AGR or MIN.	Authors' own calculations with the OECD ICIO tables
dd_htm_agr_cap	Domestic intermediate demand from the AGR sector for HTM	Authors' own calculations with the OECD ICIO tables
dd_htm_min_cap	Domestic intermediate demand from the MIN sector for HTM	Authors' own calculations with the OECD ICIO tables
agr_rca	Dummy taking value 1 if the country has an RCA in AGR	Authors' own calculations with the OECD ICIO tables
min_rca	Dummy taking value 1 if the country has an RCA in MIN	Authors' own calculations with the OECD ICIO tables

schooling	Gross enrolment in secondary education	World Bank World Development Indicators
internetaccess	Internet users per thousand inhabitants	World Bank World Development Indicators

Source: authors own classification

Below we report a correlation matrix of all the variables included in our econometric analysis.

Table A. 5: Correlation matrix of main variables

	dva_kbs _cap	dd_kbs _agr	dd_kbs _min	school ing	internetac cess
dva_kbs _cap	1				
dd_kbs _agr	0.7412*	1			
dd_kbs _min	0.6035*	0.7363*	1		
schooling	0.6159*	0.5574*	0.4882*	1	
internetac cess	06293*	0.4270*	0.3737*	0.476 5*	1

* = p-value <0.05

All dva and dd variables are in natural logs.

Source: authors' own calculation with the ICIO tables.

Appendix 3.2 – Detailed tables of countries with RCAs

We include below three tables, detailing which countries had an RCA in NRI, AGR and MIN in our sample, to give a more complete picture of what observations in our data have the RCA dummy variables taking value 1.

Table A.6: Countries with RCA in AGR

Country	Number of Years with RCA
ARG	17
AUS	17
BGR	17
BRA	17
CAN	10
CHL	17
CHN	17
COL	17
CRI	17
CYP	1
CZE	1
DNK	7
ESP	16
EST	14
FIN	8
FRA	1
GRC	17
HRV	15
HUN	17
IDN	17
IND	17
IRL	4
ISL	17
KHM	17
LTU	15
LVA	17
MAR	17
ME1	3
MYS	17
NLD	15
NZL	17
PER	17
PHL	17
POL	5

PRT	12
ROU	16
ROW	17
SVK	5
THA	17
TUN	17
TUR	17
VNM	17
ZAF	7

Source: authors' own calculation with the ICIO tables.

Note: the second column of the table reports the number of years in which each country has an RCA in AGR.

Table A. 7: Countries with RCA in MIN

Country	Number of Years with RCA
ARG	9
AUS	17
BRA	2
BRN	17
CAN	17
CHL	11
CHN	1
COL	17
IDN	17
MAR	6
ME1	17
MYS	17
NOR	17
PER	17
POL	2
ROW	17
RUS	17
SAU	17
TUN	13
VNM	17
ZAF	17

Source: authors' own calculation with the ICIO tables.

Note: the second column of this table reports the number of years in which each country has an RCA in MIN.

Appendix 3.3 – Robustness checks

Our main specification relies on per capita measures. This is to take into account different size of countries to make flows of value added across countries comparable. The underlying assumption is that countries with larger populations will also have larger production of KIBS and high-tech manufacturing; they will also have a larger intermediate demand emanating from the NR sector. However, this assumption may not necessarily be true for the NR sector in particular, whose size can be driven by endowment of natural resources that need not be tightly related to the population of a country. The input-output tables allow for another way of accounting for countries' size when looking at intermediate domestic demand. That is, using the coefficients from the Leontieff inverse matrix for the two NR sectors, AGR and MIN. These will capture the sector's intensity in KIBS and high-tech manufacturing.

We now present our main models using these coefficients instead of the per capita measures to check for the robustness of our results. Because the intensity of the NR sector is unlikely to be related to the country's size, we use as outcome variables the DVA in exports in absolute terms.

Table A.8: The effect of NRI intermediate demand on the DVA of KIBS in exports, using Leontieff Inverse coefficients – System GMM estimation

VARIABLES	AGR	MIN
dva_kbs_{t-1}	0.838***	0.989***
	(0.0753)	(0.0583)
dd_kbs_agr	0.155**	
	(0.0787)	
dd_kbs_agr*agr_rca	0.185**	
	(0.0831)	
schooling	0.00314	-0.000914
	(0.00219)	(0.00259)
internetaccess	-0.00280*	-0.00338
	(0.00147)	(0.00232)
dd_kbs_min		0.0700
		(0.0607)
dd_kbs_min*min_rca		0.0996**
		(0.0468)
Constant	2.185***	0.478
	(0.816)	(0.424)
Observations	1,756	1,756
Number of geo-sectors	122	122
AR(2)	0.180	0.346
Hansen test overidentification	0.954	0.470
Difference-in-Hansen	0.792	0.607

System GMM estimation for the effect of Inverse Leontieff coefficient of uses of AGR (col. 1) and MIN (col. 2) of KIBS on the DVA in export of KIBS. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are two KIBS sectors: Computer and related activities (ITS); R&D and other business services (BZS). The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

dva and dd variables in logs

For the AR and Hansen tests the p values are reported.

Source: authors' own calculation with the ICIO tables.

We find very robust results, with agriculture intermediate demand having a positive and significant impact on the export of KIBS value added; such effects are even larger for countries with an RCA.

In contrast, mining does not show the same positive relationship we detected in Table 3.1, except for countries with an RCA, in which case the domestic KIBS intensity of the mining sector does have a positive effect on the export of KIBS value added.

Overall these additional results support our conjecture that intermediate domestic demand emanating from the NR sectors can indeed spur the export of KIBS, and that this is particularly true for countries with a specialisation in NRI.

As for KIBS, we now look at our main model for high-tech manufacturing using Leontieff Inverse coefficients in Table A9. We find, globally speaking, consistent results with our main model for high-tech manufacturing: intermediate demand, captured here as NRI production's intensity in high-tech manufacturing, has a positive effect on the export of high-tech manufacturing value added.

This effect is even stronger for countries with an RCA in NRI, both for agriculture and mining sectors.

Table A.9: The effect of NRI intermediate demand on the DVA of high-tech manufacturing in exports, using Leontieff Inverse coefficients – System GMM estimation

VARIABLES	AGR	MIN
dva_htm_{t-1}	0.867***	0.697***
	(0.0702)	(0.169)
dd_htm_agr	0.0609**	
	(0.0275)	
dd_htm_agr*agr_rca	0.0685**	
	(0.0312)	
Schooling	0.00204	0.00851
	(0.00567)	(0.00899)
Internetaccess	-0.000810	0.000361
	(0.00349)	(0.00395)
dd_htm_min		0.0782*
		(0.0463)
dd_htm_min*min_rca		0.0854*
		(0.0472)
Constant	1.170	1.398
	(0.721)	(1.229)
Observations	5,268	5,268
Number of geo-sectors	366	366
AR(2)	0.350	0.634
Hansen test overidentification	0.616	0.499
Difference-in-Hansen	0.482	

System GMM estimation for the effect of Inverse Leontieff coefficient of uses of AGR (col. 1) and MIN (col. 2) of high-tech manufacturing on the DVA in export of high-tech manufacturing. The analysis is carried out at the geo-sector level, i.e. for each country-sector combination, where the sectors are six high-tech manufacturing sectors, the full list can be found in the appendix table A1. The variables agr_rca and min_rca are binary variables taking value 1 if the country has an RCA (in value added terms, rather than gross export) in AGR or MIN, respectively. Schooling is gross enrolment in secondary education and internet access is internet users per thousand inhabitants.

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

dva and dd variables in logs

For the AR and Hansen tests the p values are reported, column two does not report the

Hansen-in-Difference test because the estimation relies on the first to fourth lag of the endogenised variables, which is too few instruments of calculate the Hansen-in-Difference test. A set of other lag combinations has been tried but this one was the one passing the other two tests, i.e. second order autocorrelation (AR2) and the Hansen test for overidentification.

Source: authors' own calculation with the ICIO tables.

Appendix to Chapter 4

Appendix 4.1 – Variables and descriptive evidence

Table A.10: correlation table of the main variables

	pci	mpci	mdpci	avpci	sdp	mdp	ssh	msh	nhs4
pci	1	0.842 **	0.917 **	0.94 **	0.218 **	-0.156 **	0.095 **	0.217 **	0.229 **
mpci	0.842 **	1	0.962 **	0.948 **	0.217 **	-0.125 **	0.074 **	0.15 **	-0.153 **
mdpci	0.917 **	0.962 **	1	0.993 **	0.224 **	-0.145 **	0.074 **	0.178 **	0.009 *
avpci	0.94 **	0.948 **	0.993 **	1	0.224 **	-0.151 **	0.077 **	0.186 **	0.027 **
sdp	0.218 **	0.217 **	0.224 **	0.224 **	1	-0.052 **	-0.097 **	0.328 **	-0.003
mdp	-0.156 **	-0.125 **	-0.145 **	-0.151 **	-0.052 **	1	0.321 **	-0.135 **	-0.061 **
ssh	0.095 **	0.074 **	0.074 **	0.077 **	-0.097 **	0.321 **	1	0.158 **	0.023 **
msh	0.217 **	0.15 **	0.178 **	0.186 **	0.328 **	-0.135 **	0.158 **	1	0.098 **
nhs4	0.229 **	-0.153 **	0.009 *	0.027 **	-0.003	-0.061 **	0.023 **	0.098 **	1
Signif. Code: 0.01 *; 0.001 **									

Source: Author's own calculation.

While the variable names are unchanged from the tables in the main body of the text, we report hereunder the abbreviations for the four measures of complexity:

- pci: upper bound complexity
- mpci: lower bound complexity
- mdpci: median complexity
- avpci: average complexity

We have explored in Chapter 4 the relationship between diversification (in terms of number of traded products and trade partners) and the sophistication of export, in figure 4.3 and 4.4.

Related to this, we wish to push our analysis further and explicitly look at the power relationships between buyers and suppliers and the association with sophistication, captured by our complexity measures. In Figures 4.5-4.8 we show how each of the four components of power is related to upper bound complexity (plotted against) and lower bound complexity (coloured). Because of the high number of observations, to ensure the readability of the graph, we plot the graph with a transparency element alpha.

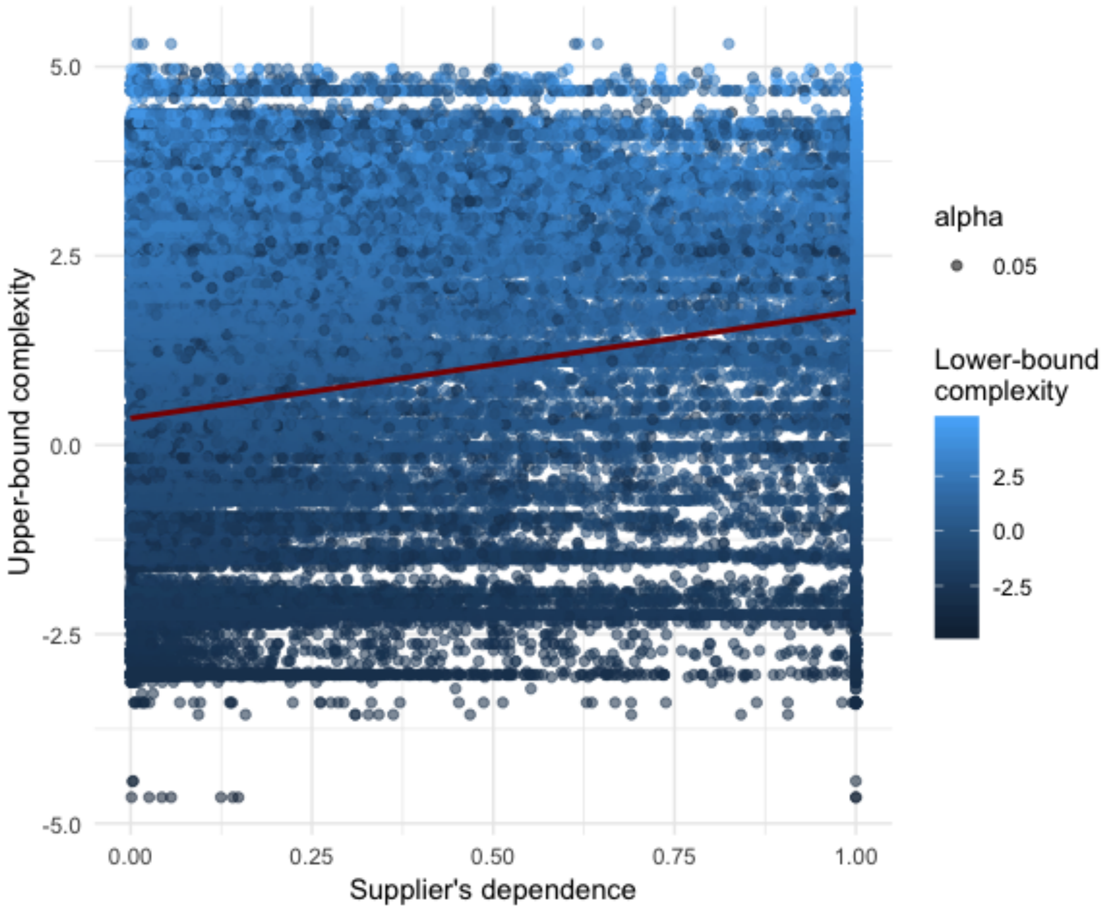

Figure A.5: Suppliers' dependence and complexity.

Source: Author's own calculation

Note: The figure plots for each buyer-supplier pair the supplier's dependence and the upper bound complexity of the pair, coloured with the pair's lower bound complexity. Alpha is a transparency parameter that makes each dot transparent and ensures that overlapping dots are readable.

We detect a positive effect between the supplier's dependence and both upper and lower bound sophistication (Figure 4.5). This is somewhat at odds with what the GVC literature predicts, according to which suppliers that depend on buyers would be likely to find themselves stuck in low value added and low sophistication activities. This is, of course, a simple association that does not control for other confounding factors. These factors include the supplier's own characteristics or other measures of power, especially the market share of the buyer, which we have seen is the other source of the buyer's power.

Figure 4.6 shows that the buyer's market share has indeed a similar relationship with both upper and lower bound complexity. We find a positive association between the market share of the buyer and both the upper and lower bound complexity. This is in line with the literature on transaction level data in trade, which has emphasised that large buyers tend to account for a large share of trade, purchasing many sophisticated products from a variety of suppliers (Sugita et al. 2015; Benguria 2014; Eaton et al. 2007).

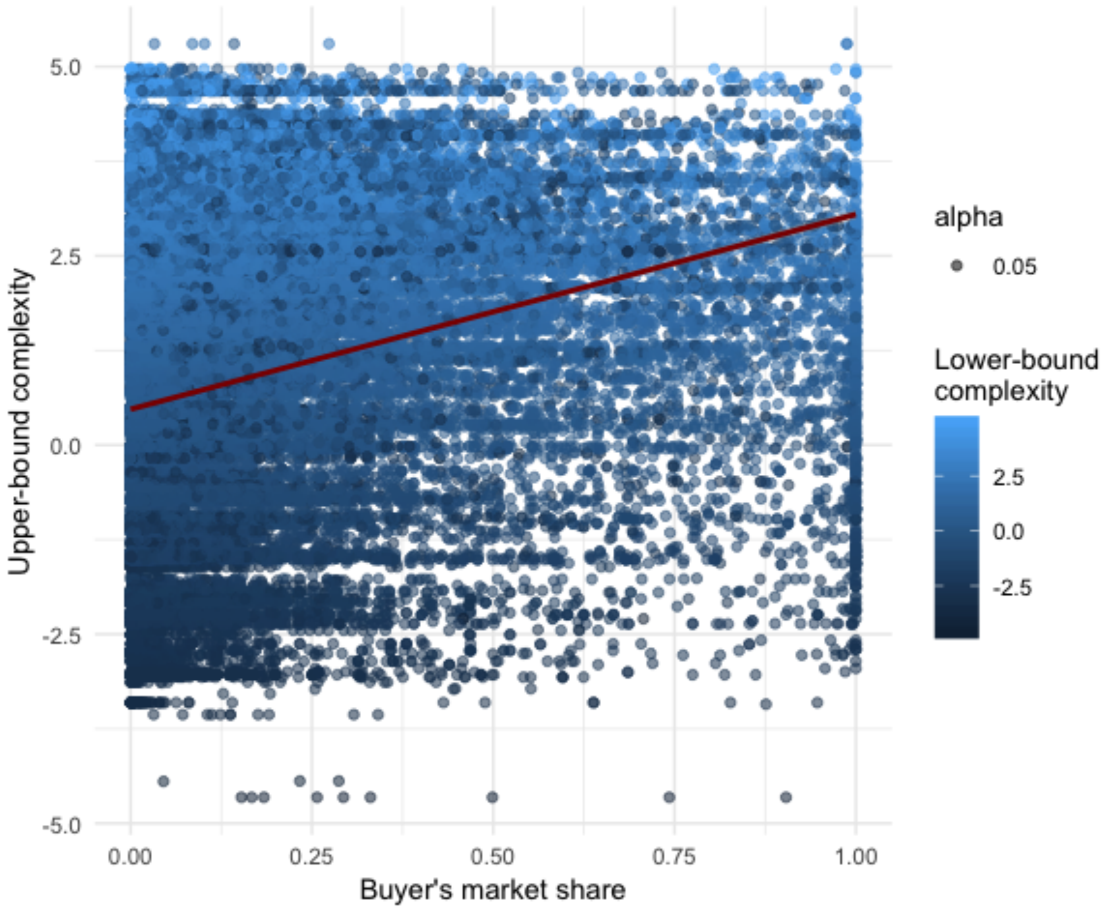

Figure A.6: Buyers' market share and complexity

Source: Author's own calculation

Note: The figure plots for each buyer-supplier pair the buyer's market share and the upper bound complexity of the pair, coloured with the pair's lower bound complexity. Alpha is a transparency parameter, commonly used to make dense scatterplots easier to interpret.

We now turn to the two components of a supplier's power: the buyer's dependence and the supplier's market share. In Figure 4.7 we find a negative relationship between the former and complexity measures (both upper and lower bound); this may be because suppliers that trade with very dependent buyers may lack the incentive to upgrade and introduce new, more sophisticated products.

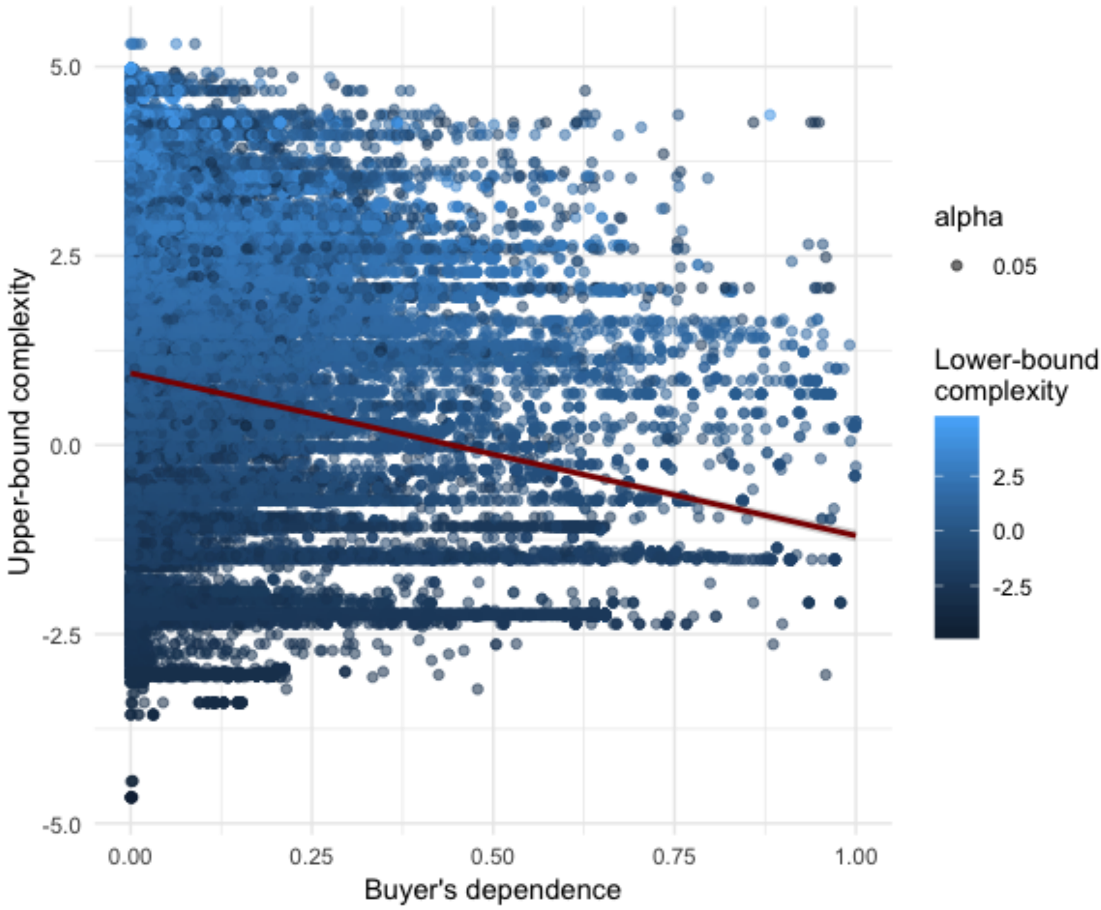

Figure A.7: Buyers' dependence and complexity

Source: Author's own calculation

Note: The figure plots for each buyer-supplier pair the buyer's dependence and the upper bound complexity of the pair, coloured with the pair's lower bound complexity. Alpha is a transparency parameter, commonly used to make dense scatterplots easier to interpret.

In contrast, in Figure 4.8 we see a positive relationship between the second component of the supplier's power (its market share) and sophistication. This suggests that suppliers with significant market power also tend to trade in sophisticated products and, according to GVC literature, would be able to introduce new more sophisticated products.

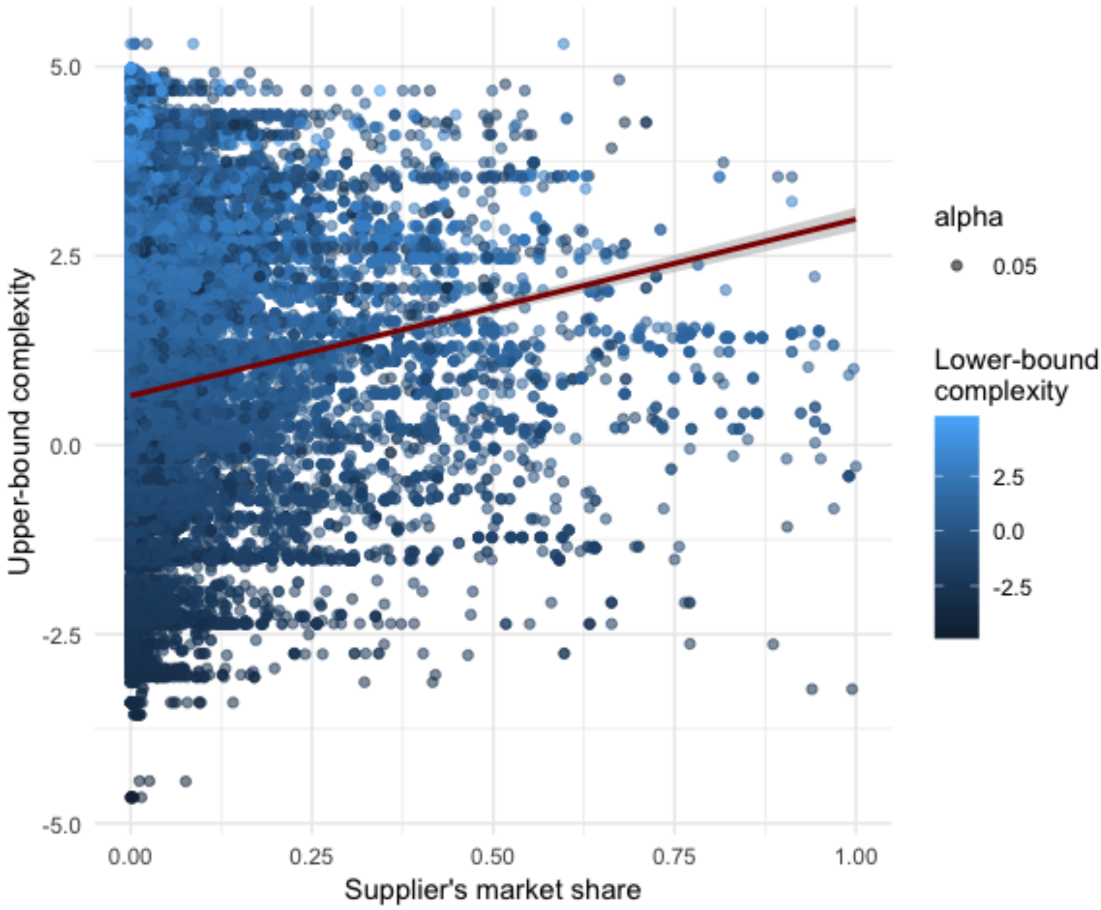

Figure A.8: Suppliers' market share and complexity

Source: Author's own calculation

Note: The figure plots for each buyer-supplier pair the supplier's market share and the upper bound complexity of the pair, coloured with the pair's lower bound complexity. Alpha is a transparency parameter, commonly used to make dense scatterplots easier to interpret.

Appendix 4.2 – Productivity estimates

We now provide some more detail on the how we estimate the productivity of suppliers. One of the main challenges in estimating productivity at the micro level is that productivity is unobserved by the research but observed by the firm, and it will affect the use that the firm makes of its inputs, creating a "transmission bias" (del Gatto et al. 2011). We therefore take a proxy variable method, looking at the traces that productivity leaves in a variable that we can observe, in our case the intermediate inputs of the suppliers (Levinsohn and Petrin 2003).

We follow Wooldridge (2009) and implement this in R with the *prodest* package, developed by Rovigatti. We estimate a Cobb-Douglas production function for each supplier *i* at time *t*:

$$y_{it} = \alpha + w_{it}\beta + k_{it}\gamma + \omega_{it} + \varepsilon_{it}$$

Where y_{it} is the (log of) output, w_{it} is a vector of free variables, k_{it} is a vector of state variables and ε_{it} is the error term. ω_{it} is the unobserved technical efficiency parameter, evolving according to a first-order Markov process.

The method relies on the following assumptions:

- $\omega_{it} = g(x_{it}, p_{it})$ is an unknown function *g()* of the state and a variable proxying productivity. In particular we assume that our proxy variable (inputs) react to TFP and that, conditional on the state variable (total asset in this case), the proxy variable is increasing in ω_{it}
- $E(\omega_{it} \mid \omega_{it-1}) = f[\omega_{it-1}]$ Productivity is an unknown function *f()* of its own lag.

We choose in particular to follow Levinsohn and Petrin (2003) and use inputs as a proxy variable because this is closer to economic theory. This is because inputs are typically not state variables, and our data (as balance sheet data often do) report zero investment for many firms (del Gatto et al. 2011).

Appendix 4.3 - Robustness checks

We now present the following robustness checks:

1. we control for size of the supplier, measured as firm's turnover;
2. we also control for the supplier sophistication in the linear probability models;
3. we also run another linear probability model to study the probability of improving the supplier's (rather than the pair) sophistication;
4. we present our main results excluding the pairs with US-based buyers.

Adding income as a control variable leaves our results essentially unchanged. This is probably because of two reasons: on the one hand the market share of the supplier already accounts for a large part of the size effects and, on the other hand, size measured in total size may not necessarily be strongly correlated with export performance to the extent that there are firms with large domestic sales that export very little.

Table A.11: Table 4.6 controlling for size

	Upper bound	Lower bound	Median	Average
nsh4	0.0096 *** (0.0017)	-0.0132 *** (0.0016)	-0.0006 (0.0011)	-0.0009 (0.0009)
sdp	-0.0838 *** (0.0243)	-0.0478* (0.0235)	-0.0443 ** (0.0161)	-0.043 ** (0.0133)
msh	0.1119 ** (0.0364)	0.0948 ** (0.0352)	0.0707 ** (0.0242)	0.0429 * (0.02)
mdp	-0.0044 (0.0518)	-0.0701 (0.05)	-0.0575 (0.0343)	-0.0531 (0.0284)
ssh	-0.0121 (0.0857)	-0.0909 (0.0828)	-0.2255 *** (0.0568)	-0.2192 *** (0.047)
tfp	0.0724 *** (0.0161)	0 (0.0155)	-0.0033 (0.0107)	-0.0148 (0.0088)
ntrans	0.0038 ** (0.0012)	-0.0025 * (0.0011)	-0.0011 (0.0008)	-0.0009 (0.0006)
age	-0.0009 (0.0062)	0.0018 (0.006)	-0.0041 (0.0041)	-0.0004 (0.0034)
income	0 (0)	0 (0)	0 (0)	0 (0)
N. obs.	42741	42741	42758	42758
R2	0.94	0.94	0.97	0.98

OLS regression results with time and buyer-supplier pair dummies, with suppliers' size as additional control, measured as suppliers' total income (i.e. sales).

Dependent variables are upper-, lower bound, median and average complexity of the pair, based on data from http://www.datlascolombia.com

All explanatory variables are lagged, except TFP and age.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses

Source: Author's own calculation.

Table A. 12: Table 4.7 controlling for size

	New to the pair	New to the supplier	New to the supplier
nhs4	-0.0109 *** (0.0011)	-0.0069 *** (0.001)	0.0004 (0.0006)
pci	-0.0819 *** (0.0041)	-0.0414 *** (0.0036)	0.0136 *** (0.0024)
sdp	0.0149 (0.015)	0.1082 *** (0.0133)	0.0982 *** (0.0086)
msh	-0.0375 ° (0.0225)	-0.048 * (0.0198)	-0.0228 ° (0.0129)
mdp	0.0219 (0.0319)	-0.0197 (0.0282)	-0.0344 ° (0.0183)
ssh	-0.03 (0.0528)	0.0693 (0.0467)	0.0895 ** (0.0303)
tfp	0.0403 *** (0.0099)	0.0383 *** (0.0088)	0.0112 * (0.0057)
ntrans	-0.0001 (0.0007)	-0.0002 (0.0006)	-0.0001 (0.0004)
age	-0.0122 ** (0.0038)	-0.0084 * (0.0034)	-0.0002 (0.0022)
income	0 (0)	0 (0)	0 (0)
nhs4_d			0.6718 *** (0.0037)
N. obs.	42739	42739	42739
R2	0.37	0.37	0.73

Linear probability model with year and buyer-supplier pair dummies with suppliers' size as additional control, measured as suppliers' total income (i.e. sales).

Dependent variable in col. 1 is a dummy taking value 1 if the pair introduces a new product, col. 2 and 3 use a dummy taking value 1 if the pair introduces a new product that the supplier wasn't exporting in the year before.

All explanatory variables are lagged, except TFP and age.

pci is the lagged level of upper bound complexity; nhs_d is a dummy taking value one if the pair has introduced a new product, i.e. the outcome variable in column 1.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses

Source: Author's own calculation.

Table A.13: Table 4.8 controlling for size

	Increase in the upper bound sophistication	Increase in the lower bound sophistication	Increase in the median sophistication	Increase in the average sophistication
nhs4	-0.0055 ***	0.0072 ***	0.0103 ***	0.0046 ***
	(0.0009)	(0.0008)	(0.001)	(0.0012)
lagged_level	-0.2224 ***	-0.2425 ***	-0.3769 ***	-0.4016 ***
	(0.0032)	(0.0032)	(0.0056)	(0.0085)
sdp	-0.0194 °	-0.0203 °	-0.0557 ***	-0.0329 °
	(0.0117)	(0.0113)	(0.0141)	(0.0177)
msh	-0.0103	0.0213	-0.0126	0.023
	(0.0175)	(0.0169)	(0.0211)	(0.0265)
mdp	0.0569 *	-0.1066 ***	-0.1281 ***	0.002
	(0.0249)	(0.0239)	(0.03)	(0.0379)
ssh	-0.0176	-0.0119	-0.0581	-0.0296
	(0.0412)	(0.0396)	(0.0496)	(0.0624)
tfp	0.0237 **	-0.0075	0.0054	0.0047
	(0.0077)	(0.0074)	(0.0093)	(0.0117)
ntrans	0.0006	-0.0006	-0.0005	-0.0002
	(0.0006)	(0.0005)	(0.0007)	(0.0009)
age	-0.0024	0.0049 °	0.0036	0.0006
	(0.003)	(0.0029)	(0.0036)	(0.0045)
income	0	0	0	0
	(0)	(0)	(0)	(0)
N. obs.	42724	42724	42758	42758
R2	0.24	0.28	0.32	0.2

Linear probability model with year and buyer-supplier pair dummies with suppliers' size as additional control, measured as suppliers' total income (i.e. sales).

Dependent variables in columns 1-4 are dummy variables taking value one if the pair experiences an increase in upper-, lower bound, median and average complexity from the previous year, respectively.

All explanatory variables are lagged, except TFP and age.

Lagged_level is the lagged level of the sophistication measure on which the outcome variable is based: col. 1: lagged level of upper bound complexity; col. 2: lagged level of lower bound complexity; col. 3: lagged level of median complexity; col. 4: lagged level of average complexity.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses.

Source: Author's own calculation.

We now present the results for our linear probability models exploring the introduction of new products and the increase of the pair's sophistication. Our main model controls for past levels of sophistication of the pair; in these tables we control instead for the past sophistication levels of the *supplier*.

Table A4 replicates Table 4.7, looking at how the power indexes are related to the probability of introducing a new product into the pair and whether this product is simply new to the pair or to the supplier too. We find overall consistent results, except for the sign of the correlation between the supplier's upper bound sophistication, *exp_pci*, with the probability of introducing a product new to the supplier. While the pair's upper bound sophistication, *pci*, in Table 4.7 is positively associated to the probability of trading products that are new to the supplier; here we find a negative relationship.

This suggests that the most sophisticated pairs are more likely to introduce products that have not been traded by the supplier in the previous year. However, this relationship works for suppliers that have not yet reached high levels of sophistication: thus, being in very sophisticated relationships is particularly beneficial for suppliers that are not very sophisticated themselves.

Interestingly, we also find that there is a positive association between the dependence of the buyer and the likelihood of introducing a new product to the pair. This again suggests that of the two components of the supplier's power, buyer's dependence is the crucial element for upgrading.

Table A.14: Table 4.7 controlling for supplier's sophistication

	New to the pair	New to the supplier	New to the supplier
nsh4	-0.0181 *** (0.0011)	-0.0098 *** (0.0009)	0.0023 *** (0.0006)
exp_pci	-0.0084 * (0.0032)	-0.0181 *** (0.0029)	**-0.0126 ***** **(0.0018)**
sdp	0.0185 (0.0152)	0.1025 *** (0.0134)	0.0901 *** (0.0087)
msh	-0.0452 * (0.0226)	-0.0489 * (0.0199)	-0.0187 (0.0129)
mdp	**0.0545** **(0.0322)**	-0.0043 (0.0282)	-0.0408 * (0.0183)
ssh	-0.0399 (0.0532)	0.0669 (0.0467)	0.0936 ** (0.0303)
tfp	0.037 *** (0.0097)	0.0354 *** (0.0085)	0.0106 (0.0055)
ntrans	-0.0004 (0.0007)	-0.0003 (0.0006)	0 (0.0004)
age	-0.0125 ** (0.0038)	-0.0084 * (0.0034)	0 (0.0022)
nhs_d			0.669 *** (0.0036)
N. obs.	42758	42758	42758
R2	0.36	0.36	0.73

Linear probability model with year and buyer-supplier pair dummies.

Dependent variable in col. 1 is a dummy taking value 1 if the pair introduces a new product, col. 2 and 3 use a dummy taking value 1 if the pair introduces a new product that the supplier wasn't exporting in the year before.

All explanatory variables are lagged, except TFP and age.

exp_pci is the lagged level of upper bound complexity of the supplier, rather than the pair; nhs_d is a dummy taking value one if the pair has introduced a new product, i.e. the outcome variable in column 1.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses

Source: Author's own calculation.

In Table A.15 we replicate Table 4.8, looking at the likelihood of increasing pair's sophistication, although controlling now for the supplier's sophistication levels as we did in Table A.14.

Overall we again find consistent results, although there are some changes in the significance levels of the relationships between the supplier's dependence. This is now only significantly and negatively associated to increases in the upper bound and median sophistication of the pair.

We also detect some changes in the significance of the coefficients of the buyer's dependence, which is insignificant for the probability of increases in the median sophistication but positively and significantly associated to increases in the average sophistication.

Table A.15: Table 4.8 controlling for supplier's sophistication

	Increase in the upper bound sophistication	Increase in the lower bound sophistication	Increase in the median sophistication	Increase in the average sophistication
nhs4	-0.023 ***	0.0237 ***	0.0119 ***	0.0052 ***
	(0.0009)	(0.0009)	(0.0011)	(0.0013)
lagged_level	-0.0644 ***	-0.0918 ***	-0.157 ***	-0.2547 ***
	(0.0027)	(0.0027)	(0.0062)	(0.0099)
sdp	-0.0343 **	-0.0031	-0.0644 ***	-0.0264
	(0.0127)	(0.0123)	(0.0152)	(0.0183)
msh	-0.0199	0.0381 *	-0.0091	0.0307
	(0.0189)	(0.0183)	(0.0227)	(0.0274)
mdp	0.1443 ***	-0.106 ***	-0.0474	0.1087 **
	(0.0269)	(0.0261)	(0.0323)	(0.0389)
ssh	-0.0413	-0.0616	-0.0571	-0.0762
	(0.0445)	(0.0431)	(0.0533)	(0.0644)
tfp	0.0185 *	-0.0163 *	-0.0014	-0.0005
	(0.0081)	(0.0078)	(0.0097)	(0.0117)
ntrans	0.0002	-0.0007	-0.0005	-0.0002
	(0.0006)	(0.0006)	(0.0007)	(0.0009)
age	-0.0024	0.0094 **	0.0089 *	0.0054
	(0.0032)	(0.0031)	(0.0039)	(0.0047)
N. obs.	42724	42724	42758	42758
R2	0.11	0.15	0.21	0.15

Linear probability model with year and buyer-supplier pair dummies.

Dependent variables in columns 1-4 are dummy variables taking value one if the pair experiences an increase in upper-, lower bound, median and average complexity from the previous year, respectively.

All explanatory variables are lagged, except TFP and age.

Lagged_level is the lagged level of the sophistication measure of the supplier, rather than pair, on which the outcome variable is based: col. 1: lagged level of upper bound complexity of the supplier; col. 2: lagged level of lower bound complexity of the supplier; col. 3: lagged level of median complexity of the supplier; col. 4: lagged level of average complexity of the supplier.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses.

Source: Author's own calculation.

We now run a similar linear probability model to the ones above, but we study the probability of increasing the four measures of sophistication at the supplier level, rather than the pair. The main difference with the models present so far is that the outcome variables have always been at the pair level, while in this case we look at suppliers.

In table A.16 we find the number of products exported by the pair to have unchanged coefficients with respect to previous specifications. The lagged level of the supplier's sophistication is also consistently negatively associated, as has been detected in the previous tables.

We find that the dependence of the supplier is negatively correlated, as was often the case in similar specifications, with the likelihood of increases of the lower bound, median and average sophistication of the supplier, although not with the upper bound sophistication. This suggests that the dependence of the supplier vis-à-vis its buyer has an impact on the upper bound sophistication of the pair, but not the supplier.

The buyer's market share is positively associated with increases in the lower bound and median sophistication, which suggests that pairs with a large buyer are more likely to see the supplier drop low-productivity products, although the same cannot be said of the probability of introducing products that are more sophisticated than those already exported by the supplier.

Interestingly, the buyer's dependence is no longer significant, which hints at the fact that dependence of the buyer does not affect the sophistication at the supplier level, but only the sophistication within the pair.

Table A.16: Linear probit on power components and increases in supplier's sophistication

	Increase in the upper bound sophistication	Increase in the lower bound sophistication	Increase in the median sophistication	Increase in the average sophistication
nhs4	-0.0039 *** (0.001)	0.0033 ** (0.0011)	0.0029 ** (0.001)	0.0045 ** (0.0014)
lagged_level	-0.2159 *** (0.0031)	-0.1481 *** (0.0041)	-0.1695 *** (0.0057)	-0.4997 *** (0.0107)
sdp	0.0112 (0.0146)	-0.1533 *** (0.0145)	-0.0289 * (0.0145)	-0.1075 *** (0.0197)
msh	-0.0069 (0.0217)	0.0544 * (0.0217)	0.0431 * (0.0217)	0.0317 (0.0295)
mdp	-0.0171 (0.0308)	0.0418 (0.0308)	-0.0375 (0.0309)	0.0009 (0.042)
ssh	0.0645 (0.0509)	0.0789 (0.0509)	-0.1527 ** (0.0511)	0.1111 (0.0694)
tfp	0.0137 (0.0092)	0.0087 (0.0092)	0.0073 (0.0093)	0.0188 (0.0126)
ntrans	0.001 (0.0007)	0.0009 (0.0007)	-0.0004 (0.0007)	0.0003 (0.0009)
age	-0.0041 (0.0037)	-0.0051 (0.0037)	-0.0006 (0.0037)	-0.0009 (0.005)
N. obs.	42758	42739	42758	42758
R2	0.21	0.14	0.21	0.18

Linear probability model with year and buyer-supplier pair dummies.

Dependent variables in columns 1-4 are dummy variables taking value one if the supplier, rather than the pair, experiences an increase in upper-, lower bound, median and average complexity from the previous year, respectively.

All explanatory variables are lagged, except TFP and age.

Lagged_level is the lagged level of the sophistication measure on which the outcome variable is based: col. 1: lagged level of upper bound complexity; col. 2: lagged level of lower bound complexity; col. 3: lagged level of median complexity; col. 4: lagged level of average complexity.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses.

Source: Author's own calculation.

For completeness we also report hereunder the results for the Ecuador and Venezuela subsample, which are globally consistent with the results from our main model.

Table A.17: Power components and sophistication, Ecuador and Venezuela subsample

	Upper bound	Lower bound	Median	Average
nhs4	0.011 ***	-0.0125 ***	0.0003	-0.0005
	(0.0021)	(0.0021)	(0.0015)	(0.0012)
sdp	-0.0592 °	-0.0503	-0.0509 *	-0.0444 *
	(0.0308)	(0.0317)	(0.0219)	(0.0179)
msh	0.1269 **	0.1771 ***	0.1316 ***	0.093 ***
	(0.0462)	(0.0476)	(0.0329)	(0.0269)
mdp	-0.0091	-0.0951	-0.0648	-0.0538
	(0.0666)	(0.0686)	(0.0474)	(0.0388)
ssh	-0.0069	-0.1014	-0.2239 ***	-0.2125 ***
	(0.0935)	(0.0962)	(0.0665)	(0.0544)
tfp	0.0887 ***	-0.0156	-0.0391 *	-0.0394 **
	(0.0247)	(0.0254)	(0.0176)	(0.0144)
ntrans	0.0024	-0.003 °	-0.0012	-0.001
	(0.0017)	(0.0018)	(0.0012)	(0.001)
age	0.0042	0.0036	-0.0022	0.0007
	(0.0076)	(0.0079)	(0.0054)	(0.0044)
N. obs.	26099	26099	26108	26108
R2	0.89	0.89	0.94	0.96

OLS regression results with time and buyer-supplier pair dummies. Estimates based on pairs with non-US based buyers only.

Dependent variables are upper-, lower bound, median and average complexity of the pair, based on data from http://www.datlascolombia.com

All explanatory variables are lagged, except TFP and age.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses

Source: Author's own calculation.

Table A.18: Linear probit on the power components and the introduction of new products in the pair, Ecuador and Venezuela subsample

	New to the pair	New to the supplier	New to the supplier
	-0.0101 ***	-0.0061 ***	0.0008
nhs4	(0.0014)	(0.0012)	(0.0008)
	-0.0884 ***	-0.0487 ***	0.0115 ***
pci	(0.0054)	(0.0048)	(0.0031)
	0.0144	0.1203 ***	0.1105 ***
sdp	(0.0195)	(0.0174)	(0.0112)
	-0.0348	-0.0421	-0.0183
msh	(0.0292)	(0.0261)	(0.0169)
	0.0265	-0.0241	-0.0422
mdp	(0.0422)	(0.0377)	(0.0244)
	-0.0341	0.0696	0.0928 **
ssh	(0.0591)	(0.0527)	(0.0341)
	0.0582 ***	0.0485 ***	0.0088
tfp	(0.0157)	(0.014)	(0.009)
	-0.0007	-0.0008	-0.0003
ntrans	(0.0011)	(0.001)	(0.0006)
	-0.0119 *	-0.0091 *	-0.001
age	(0.0048)	(0.0043)	(0.0028)
			0.6808 ***
nhs4_d			(0.0046)
N. obs.	26099	26099	26099
R2	0.35	0.35	0.73

Linear probability model with year and buyer-supplier pair dummies. Estimates based on pairs with non-US based buyers only.

Dependent variable in col. 1 is a dummy taking value 1 if the pair introduces a new product, col. 2 and 3 use a dummy taking value 1 if the pair introduces a new product that the supplier wasn't exporting in the year before.

All explanatory variables are lagged, except TFP and age.

pci is the lagged level of upper bound complexity; nhs_d is a dummy taking value one if the pair has introduced a new product, i.e. the outcome variable in column 1.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses

Source: Author's own calculation.

Table A. 19: Linear probit on the power components and the likelihood of increases in the sophistication of the pair, Ecuador and Venezuela subsample

	Increase in the upper bound sophistication	Increase in the lower bound sophistication	Increase in the median sophistication	Increase in the average sophistication
nhs4	-0.0048 *** (0.0011)	0.0071 *** (0.0011)	0.0091 *** (0.0012)	0.0027 (0.0015)
lagged_level	-0.2311 *** (0.0041)	-0.2396 *** (0.004)	-0.3833 *** (0.0071)	-0.4273 *** (0.0106)
sdp	-0.0237 (0.015)	-0.016 (0.0149)	-0.0589 ** (0.0188)	-0.0322 (0.0227)
msh	-0.0235 (0.0225)	0.0469 * (0.0224)	-0.0016 (0.0282)	0.0593 (0.0341)
mdp	0.0609 (0.0325)	-0.1335 *** (0.0323)	-0.1642 *** (0.0407)	-0.0142 (0.0494)
ssh	-0.014 (0.0454)	0.0128 (0.0453)	-0.027 (0.057)	-0.0161 (0.069)
tfp	0.0364 ** (0.012)	-0.0358 ** (0.012)	-0.018 (0.0151)	-0.0311 (0.0182)
ntrans	0.0005 (0.0008)	-0.0012 (0.0008)	-0.0001 (0.0011)	0.0004 (0.0013)
age	-0.0025 (0.0037)	0.0062 (0.0037)	0.0047 (0.0047)	-0.003 (0.0056)
N. obs.	26091	26091	26108	26108
R2	0.24	0.28	0.3	0.18

Linear probability model with year and buyer-supplier pair dummies. Estimates based on pairs with non-US based buyers only.

Dependent variables in columns 1-4 are dummy variables taking value one if the pair experiences an increase in upper-, lower bound, median and average complexity from the previous year, respectively.

All explanatory variables are lagged, except TFP and age.

Lagged_level is the lagged level of the sophistication measure on which the outcome variable is based: col. 1: lagged level of upper bound complexity; col. 2: lagged level of lower bound complexity; col. 3: lagged level of median complexity; col. 4: lagged level of average complexity.

Signif. Codes: 0 ***; 0.001 **; 0.01 *; 0.05 °

Standard errors in parentheses.

Source: Author’s own calculation.