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

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Abstract

This paper 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).

Keywords: Global Value Chains, Buyer-Supplier relationships, Power, Trade.

JEL: F14, D22, L14, L25

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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 2010a; 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 2010b; 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 (Baldwin 2011; Gereffi et al. 2005; Kaplinsky 2004).

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 2003a; Bernard et al. 2014; Carballo et al. 2013; Bernard et al. 2011; Eaton et al. 2007) and buyer-supplier matching (Sugita et al. 2015a; 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 2009; 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.

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. 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 paper aims to remedy this with a quantitative approach; our overarching goal is to study the relationship between power and upgrading in buyer-supplier relationships.

We wish therefore to bridge the literature on firm level trade with the theoretical insights put forward by the GVC literature, to include power and upgrading in the quantitative literature on buyer-supplier relationships. The key contribution of this paper is to test in a quantitative setting the theoretical insights from the GVC literature. We therefore put forward an approach to study both power and upgrading in export relationships using transaction level data.

From this, we derive the following research question:

1. Is power in buyer-supplier relationships a predictor of upgrading?

The literature has shown that power is a multifaceted concept with a relational and a market aspect (Shervani et al. 2016). In accordance with this view, a second, crucial contribution of our approach is opening up the black box of power in buyer-supplier relationships, distinguishing between the dependence of each trading party on each other and each trading party's market share. In accordance with this, this paper also investigates the following question:

2. Does this relationship between power and export upgrading change depending on different aspects of power?

Both power and upgrading present significant challenges in terms of operationalisation, which this paper strives to deal with, making a third methodological contribution.

Despite the very large literature on upgrading in GVCs (Gereffi et al. 2005; Humphrey and Schimitz 2002; Giuliani et al. 2005a; Morrison et al. 2006) there remains 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 allows to capture differences among new products that a firm introduces and 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. In order to shed light on our research questions however, 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.

Our main source of data is the Colombian Customs, with information on all export transactions between 2008 and 2014.. Transaction level data rarely include qualitative information on power in buyer-supplier relationships, but, in contrast, allow the identification of each individual pair of buyers and suppliers, which is what our approach exploits.

We combine our measures of power with the complexity measure from the *Atlas of Complexity*[1], compiled by Harvard University, to empirically investigate the relationship between 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. 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.

[1] The terms 'complexity' and 'sophisticated' can be used interchangeably. For clarity 's sake, however, in the remainder of the paper 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*.

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. Interestingly, 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.

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.

The remainder of the paper is structured as follows: the next section deals with the relevant literature. The following section presents the paper'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. The penultimate section discusses the results from our empirical analysis, and the last section concludes.

1. 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.

1.1: 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 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 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 on trade, using micro level data, focusing in particular on the recent work that has recognised the importance of buyer-supplier relationships (Macchiavello and Morjariay 2014). We detail this in the next subsection, emphasising the theoretical insights from the GVC literature, and power in particular, have remained broadly unexplored.

1.2 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. 2015a; 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 Morjariay 2014). 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 Morjariay 2014), 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.

The reason why it is crucial to include power into the analysis of buyer-supplier relationship is that firms may very well engage in long-lasting relationships, but there may be captive ones, leaving them with very little chance of improving their trade performance and upgrade. In contrast, and crucially to our purpose, 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).

Trade relationships with similar duration can thus be qualitatively very different, which has however fundamental consequences on firms' prospects for upgrading. This crucial aspect however has remained largely overlooked in the literature on trade and buyer-supplier relationships, both empirically and theoretically. This is why it is of high interest to test the theoretical insights from the literature on GVCs in a new, quantitative, empirical setting.

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. We explore the relevant literature dealing with this issue in the following subsection.

1.3: 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.

1.3.1: 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.

The literature on supply chain management takes a different view, stemming 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.

1.3.2: 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 paper.

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 paper's research questions and contributions in the following section.

2. 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[2] 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.[3]

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 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[4] 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.

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; therefore it is crucial that changes in complexity measure are driven

[2] 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.
[3] Henceforth we will use exporter and importer interchangeably with supplier and buyer, respectively.
[4] The deflators compiled by DANE are available from the Colombian Central Bank webstie: http://www.banrep.gov.co/es/ipp

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[5]. 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 paper 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 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 (like "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

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

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 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 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.

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's country level.

We use the cleaned data to compute measures of pair's sophistication and power. We have computed four product invariant measures of pair's sophistication[6]:

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[7]. 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 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

[6] 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.
[7] Remember that relationships are identified at the buyer-supplier-product level, with pairs simply at the buyer-supplier level.

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.

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

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 1 below, detailing the sources of both buyer and supplier's power, together with the literature that has emphasised this.

Table 1: Power's components indexes

Power Types by Source	Literature	
Relational: Supplier's dependence on the buyer (*sdp*).	Supply chain management lit.	Buyer's power in the GVC literature
Market: Buyer's market share (*bsh*).	Industrial Organisation lit.	
Relational: Buyer's dependence on the supplier (*mdp*).	Supply chain management lit.	Supplier's power in the GVC literature
Market: Supplier's market share (*ssh*).	Industrial Organisation lit.	

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 import 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[8]. From Table 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.

Table 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 3, we report the distribution of all four measures; the complexity measure is bound between -4.6560 and 5.3018. 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.

[8] 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. In the table 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 3: Complexity measure 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.

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.

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 sophistication of exports from Colombia to its three main partners as can be seen in Table 5 below.

Table 5: Export Categories from Colombia to its Three Main Trading Partners – 1-digit product categories, excluding fuels, lubricant and related materials[9]

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%

Note: percentages are of countries' total export in 2014.

Source: Atlas of Complexity: http://atlas.cid.harvard.edu

[9] 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.

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

3. 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, (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. We shed light on these questions with an OLS approach (for the first question) and with a linear probability model (for the remaining two).

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 first 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 Morjariay 2009; 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)[10] 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.

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.

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.

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.

[10] 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.*

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[11].

This model is very likely to be affected by reverse causality and does not allow us to draw any significant 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, it tells 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 (i) the probability of a supplier introducing a new product and (ii) increasing its sophistication. We estimate the following equation:

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

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:

[11] 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 a theme. 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.

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[12];
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 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

[12] 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.

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 the Appendix we also run a battery of robustness checks, finding our results to be solid.

3.1 Power components and levels of export sophistication

Turning now to our main results, Table 5 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 (cfr. Table 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 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 5: 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.

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 1 and 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.

3.2 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 6, the first column has as outcome variable as 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.

Table 6: 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 be 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 2016a; 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, 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 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 7.

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 negative relationship we detect. 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 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 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.

3.3 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 7 *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.

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.

Table 7: 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.

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[13].

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 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. Trust and duration of the relationship are very likely to play a role.

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

[13] 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 3.2. Specifically, the coefficients for the supplier's dependence in Table 3.7 are 2-5 times smaller than the coefficients for the buyer's dependence. In Table 3.2 the average buyer's dependence is three times smaller than the average supplier's dependence.

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.

3.4 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 3 supports this conjecture. This we now explore 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 three countries separately. 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 the appendix. We now discuss the results for the US subsample of pairs in more depth.

Table 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. In contrast, 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 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 6 in Table 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[14]

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

Table 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.

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 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 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[15], 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 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.

[15] This table can be found in the appendix.

Table 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.

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.

This being said, this paper 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.

References

Abowd, J.M., Kramarz, F. & Margolis, D.N., 1999. High wage workers and high wage firms. *Econometrica*.

Amiti, M. & Freund, C., 2010. The Anatomy of China's Export Growth. *NBER Chapters*.

Antolín, M.M. et al., 2012. Export intensity and the productivity gains of exporting. *Applied Economics Letters*, 20(8), pp.804–808.

Baldwin, J. & Yan, B., 2014. *Global Value Chains and the Productivity of Canadian Manufacturing Firms*, Ottawa.

Baldwin, R., 2011. *Trade and Industrialisation after Globalisation's 2nd Unbundling: How Building and Joining a Supply Chain is Different and Why it Matters*,

Benguria, F., 2014. *Production and Distribution in International Trade : Evidence from Matched Exporter-Importer Data*,

Benton, W.C. & Maloni, M., 2005. The influence of power driven buyer/seller relationships on supply chain satisfaction. *Journal of Operations Management*, 23(1), pp.1–22.

Bernard, A., Moxnes, a & Saito, Y., 2014. Production Networks, Geography and Firm Performance.

Bernard, A.B. et al., 2011. *The Empirics of Firm Heterogeneneity and International Trade*, NBER Working Papers.

Bernard, A.B., Grazzi, M. & Tomasi, C., 2015. Intermediaries in International Trade: Products and Destinations. *The Review of Economics and Statistics*, 97(October), pp.916–920.

Bernard, A.B. & Moxnes, A., 2018. *Networks and Trade*, NBER Working Paper

Bernard, A.B., Moxnes, A. & Ulltveit-Moe, K.H., 2014. Two-Sided Heterogeneity and Trade. *NBER Working Paper 20136*.

Blum, B.S., Claro, S. & Horstmann, I., 2014. Facts and Figures on Intermediated Trade Facts and Figures on Intermediated Trade. *American Economic Review*, 100(2), pp.419–423.

Brancati, E., Brancati, R. & Maresca, A., 2017. Global value chains, innovation and performance: Firm-level evidence from the Great Recession. *Journal of Economic Geography*, 17(5), pp.1039–1073.

Broda, C. & Weinstein, D.E., 2006. Globalization and the Gains from Variety. *The Quarterly Journal of Economics*, 121(2), pp.541–585.

Bustos, S. et al., 2012. The dynamics of nestedness predicts the evolution of industrial ecosystems. *PloS one*, 7(11), p.e49393.

Carballo, J., Ottaviano, G. & Volpe Martincus, C., 2013. *The Buyer Margins of Firms ' Exports*,

Cowley, P.R., 1988. Market Structure and Business Performance: an Evaluation of Buyer/Seller Power in the PIMS Database. *Strategic Management Journal*, 9(3), pp.271–278.

Datta, S., Iskandar-Datta, M. & Singh, V., 2013. Product market power, industry structure, and corporate earnings management. *Journal of Banking and Finance*, 37(8), pp.3273–3285.

Dragusanu, R., 2014. Firm-to-Firm Matching Along the Global Supply Chain. , 2014(December).

Eaton, J. et al., 2007. *Export Dynamics in Colombia: Frim-Level Evidence*, NBER Working Paper

Eaton, J. et al., 2015. Two-sided Search in International Markets. , NBER Working Paper.

Eckel, C. et al., 2015. Multi-product firms at home and away: Cost- versus quality-based competence. *Journal of International Economics*, 95(2), pp.216–232.

Eslava, M., Fieler, A.C. & Xu, D.Y., 2015. (Indirect) Input Linkages. *American Economic Review: Papers & Proceedings*, 105(5), pp.662–666.

Fabbri, D. & Klapper, L., 2008. *Market Power and the Matching of Trade Credit Terms*,

Fontagné, L., Secchi, A. & Tomasi, C., 2018. Exporters' product vectors across markets. *European Economic Review*, 110, pp.150–180.

del Gatto, M., di Liberto, A. & Petraglia, C., 2011. Measuring productivity. *Journal of Economic Surveys*, 25(5), pp.952–1008.

Gaure, S., 2013. OLS with multiple high dimensional category variables. *Computational Statistics and Data Analysis*.

Gereffi, G., 1994. The organization of buyer-driven global commodity chains: How U.S. retailers shape overseas production networks. In *Commodity Chains and Global Capitalism*. Westport, CT: Praeger, pp. 95–122.

Gereffi, G., Humphrey, J. & Sturgeon, T., 2005. The governance of global value chains. *Review of International Political Economy*, 12(1), pp.78–104.

Giovannetti, G., Marvasi, E. & Sanfilippo, M., 2015. Supply chains and the internationalization of small firms. *Small Business Economics*, 44(4), pp.845–865.

Giuliani, E., Pietrobelli, C. & Rabellotti, R., 2005a. Upgrading in global value chains: Lessons from Latin American clusters. *World Development*, 33(4), pp.549–573.

Giuliani, E., Pietrobelli, C. & Rabellotti, R., 2005b. Upgrading in Global Value Chains: Lessons from Latin American Clusters. *World Development*, 33(4), pp.549–573.

Goldberg, P.K. et al., 2010. Imported Intermediate Inputs and Domestic Product Growth: Evidence from India. *The Quarterly Journal of Economics*, 125(4), pp.1727–1767.

Grossi Cajal, J., 2016. Searching for Trade Partners in Developing Countries : Testing Firms in the "Fast Fashion" Industry., Mimeo University of Warwick.

Hausmann, R., Hwang, J. & Rodrik, D., 2007. What you export matters. *Journal of Economic Growth*, 12(December 2006), pp.1–25.

Hausmann, R. & Rodrik, D., 2003. Economic development as self-discovery. *Journal of Development Economics*, 72(2), pp.603–633.

Hidalgo, C.A. et al., 2007. The Product Space Conditions the Development of Nations. *Science*, 317, pp.482–487.

Hidalgo, C.A. & Hausmann, R., 2009. The Building block of Economic Complexity. In *The Health service journal*. p. 15.

Humphrey, J; Schimitz, H., 2002. Developing Country Firms in the World Economy : Governance and Upgrading in Global Value Chains. *INFE Report*, 61, pp.1–35.

Humphrey, J. & Schmitz, H., 2002. *Governance and Upgradin: Linking Industrial Cluster and Global Value Chain Research*,

Iacovone, L. & Javorcik, B.S., 2010a. Multi-Product Exporters : Product Churning , Uncertainty and Export Discoveries. *The Economic Journal*, 120, pp.481–499.

Iacovone, L. & Javorcik, B.S., 2010b. Multi-Product Exporters : Product Churning , Uncertainty and Export Discoveries. *The Economic Journal*, 120, pp.481–499.

Iacovone, L. & Javorcik, B.S., 2009. *Shipping good tequila out : Investment , domestic unit values and entry of multi-product plants into export markets*,

Iacovone, L. & Javorcik, B.S., 2009. *Shipping good tequila out : Investment , domestic unit values and entry of multi-product plants into export markets*,

Jarreau, J. & Poncet, S., 2012. Export sophistication and economic growth: Evidence from China. *Journal of Development Economics*, 97(2), pp.281–292.

Kaplinsky, R., 2004. Sustaining income Growth in a Globalising World: the Search for the Nth Rent. , (January).

Klenow, P.P.J. & Hummels, D., 2005. The Variety and Quality of a Nation ' s Exports. *American Economic Review*, 95(3), pp.704–723.

Koujianou Goldberg, P. et al., 2010. Imported Intermediate Inputs and Domestic Product Growth: Evidence from India. *The Quartely Journal of Economics*, (November), pp.1727–1767.

Lall, S., Weiss, J. & Zhang, J., 2006. The "sophistication" of exports: A new trade measure. *World Development*, 34(2), pp.222–237.

Lee, J., 2011. Export specialization and economic growth around the world. *Economic Systems*, 35(1), pp.45–63.

Leiblein, M.J. & Miller, D.J., 2003. An empirical examination of transaction-and firm-level influences on the vertical boundaries of the firm. *Strategic Management Journal*, 24(9), pp.839–859.

Levinsohn, J. & Petrin, A., 2003. Estimating Production Functions Using Inputs to Control for Unobservables Estimating Production Functions Using Inputs to Control for Unobservables. *Review of Economic Studies*.

Liu, Y., Li, Y. & Zhang, L., 2010. Control mechanisms across a buyer-supplier relationship quality matrix. *Journal of Business Research*, 63(1), pp.3–12.

Liu, Y., Luo, Y. & Liu, T., 2009. Governing buyer-supplier relationships through transactional and relational mechanisms: Evidence from China. *Journal of Operations Management*, 27(4), pp.294–309.

van der Loo, M., 2014. The stringdist Package for Approximate String Matching. *The R Journal*, 6(1), pp.111–122.

Macchiavello, R., 2010. *Development Uncorked: Reputation Acquisition in the New Market for Chilean Wines in the UK*,

Macchiavello, R. & Miquel-Florensa, J., 2017. Vertical Integration and Relational Contracts: Evidence from the Costa Rica Coffee Chain. , pp.1–76.

Macchiavello, R. & Morjaria, A., 2016. Competition and Relational Contracts : Evidence from Rwanda ' s Coffee Mills.

Macchiavello, R. & Morjariay, A., 2009. The value of relational contracts : evidence from a supply shock to Kenyan flower exporters. *American Economic Review*, (February).

Macchiavello, R. & Morjariay, A., 2014. The value of relational contracts : evidence from a supply shock to Kenyan flower exporters. *American Economic Review*, (February).

Martins, P.S. & Yang, Y., 2009. The impact of exporting on firm productivity: A meta-analysis of the learning-by-exporting hypothesis. *Review of World Economics*, 145(3), pp.431–445.

Melitz, M.J., 2003a. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, 71(6), pp.1695–1725.

Melitz, M.J., 2003b. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, 71(6), pp.1695–1725.

Minondo, A., 2010. Exports' quality-adjusted productivity and economic growth. *Journal of International Trade and Economic Development*.

Morrison, A., Pietrobelli, C. & Rabellotti, R., 2006. *Global Value Chains and Technological Capabilities : A Framework to Study Industrial Innovation in Developing Countries*,

Nyaga, G.N. et al., 2013. Power asymmetry, adaptation and collaboration in dyadic relationships involving a powerful partner. *Journal of Supply Chain Management*, 49(3), pp.42–65.

Pack, H. & Saggi, K., 2001. Vertical technology transfer via international outsourcing. *Journal of*

Development Economics, 65, pp.389–415.

Pietrobelli, C. & Saliola, F., 2008. Power relationships along the value chain: Multinational firms, global buyers and performance of local suppliers. *Cambridge Journal of Economics*, 32(6), pp.947–962.

Poncet, S. & Starosta de Waldemar, F., 2013. Export upgrading and growth: The prerequisite of domestic embeddedness. *World Development*, 51, pp.1–15.

Schmidt-Eisenlohr, T., & Monarch, R. (2015). Learning and the Value of Relationships in International Trade. In *2015 Meeting Papers* (No. 668). Society for Economic Dynamics

Shervani, T.A., Frazier, G. & Challagalla, G., 2016. The Moderating Influence of Firm Market Power on the Transaction Cost Economics Model: an Empirical Test in a Forward Channel Integration Context. *Strategic Management Journal*, 37(1), pp.116–132.

Sugita, Y. et al., 2015 Assortative Matching of Exporters and Importers. NBER Working Paper , 10700.

Wooldridge, J.M., 2009. On estimating firm-level production functions using proxy variables to control for unobservables. *Economics Letters*.

Wu, H.R., 2012. Empirically Revisiting the Learning-by-Exporting Theory Using Data on Chilean Manufacturing Plants. *The Ohio State University*, 12(334), pp.0–35.

Zhao, X. et al., 2008. The impact of power and relationship commitment on the integration between manufacturers and customers in a supply chain. *Journal of Operations Management*, 26(3), pp.368–388.

Zhu, S. & Fu, X., 2013. Drivers of Export Upgrading. *World Development*, 51, pp.221–233.

Appendix – Robustness checks

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

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).

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 replicate the results in Table A1, using all variables in changes, instead of lags and without using dummies for buyer-supplier pairs.

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 A1: Table 5 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)	-0.0011233	-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 A2: Table 6 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 A3: Table 7 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 *** (0.0009)	0.0072 *** (0.0008)	0.0103 *** (0.001)	0.0046 *** (0.0012)
lagged_level	-0.2224 *** (0.0032)	-0.2425 *** (0.0032)	-0.3769 *** (0.0056)	-0.4016 *** (0.0085)
sdp	-0.0194 ° (0.0117)	-0.0203 ° (0.0113)	-0.0557 *** (0.0141)	-0.0329 ° (0.0177)
msh	-0.0103 (0.0175)	0.0213 (0.0169)	-0.0126 (0.0211)	0.023 (0.0265)
mdp	0.0569 * (0.0249)	-0.1066 *** (0.0239)	-0.1281 *** (0.03)	0.002 (0.0379)
ssh	-0.0176 (0.0412)	-0.0119 (0.0396)	-0.0581 (0.0496)	-0.0296 (0.0624)
tfp	0.0237 ** (0.0077)	-0.0075 (0.0074)	0.0054 (0.0093)	0.0047 (0.0117)
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)
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 6, 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 6 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 A4: Table 6 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 A5 we replicate Table 7, looking at the likelihood of increasing pair's sophistication, although controlling now for the supplier's sophistication levels as we did in Table 15.

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 A5: Table 7 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 *** (0.0009)	0.0237 *** (0.0009)	0.0119 *** (0.0011)	0.0052 *** (0.0013)
lagged_level	-0.0644 *** (0.0027)	-0.0918 *** (0.0027)	-0.157 *** (0.0062)	-0.2547 *** (0.0099)
sdp	-0.0343 ** (0.0127)	-0.0031 (0.0123)	-0.0644 *** (0.0152)	-0.0264 (0.0183)
msh	-0.0199 (0.0189)	0.0381 * (0.0183)	-0.0091 (0.0227)	0.0307 (0.0274)
mdp	0.1443 *** (0.0269)	-0.106 *** (0.0261)	-0.0474 (0.0323)	0.1087 ** (0.0389)
ssh	-0.0413 (0.0445)	-0.0616 (0.0431)	-0.0571 (0.0533)	-0.0762 (0.0644)
tfp	0.0185 * (0.0081)	-0.0163 * (0.0078)	-0.0014 (0.0097)	-0.0005 (0.0117)
ntrans	0.0002 (0.0006)	-0.0007 (0.0006)	-0.0005 (0.0007)	-0.0002 (0.0009)
age	-0.0024 (0.0032)	0.0094 ** (0.0031)	0.0089 * (0.0039)	0.0054 (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.

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 A6: 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 A7: Power components and sophistication, Ecuador and Venezuela subsample

	Upper-bound	Lower-bound	Median	Average
nhs4	0.011 *** (0.0021)	-0.0125 *** (0.0021)	0.0003 (0.0015)	-0.0005 (0.0012)
sdp	-0.0592 ° (0.0308)	-0.0503 (0.0317)	-0.0509 * (0.0219)	-0.0444 * (0.0179)
msh	0.1269 ** (0.0462)	0.1771 *** (0.0476)	0.1316 *** (0.0329)	0.093 *** (0.0269)
mdp	-0.0091 (0.0666)	-0.0951 (0.0686)	-0.0648 (0.0474)	-0.0538 (0.0388)
ssh	-0.0069 (0.0935)	-0.1014 (0.0962)	-0.2239 *** (0.0665)	-0.2125 *** (0.0544)
tfp	0.0887 *** (0.0247)	-0.0156 (0.0254)	-0.0391 * (0.0176)	-0.0394 ** (0.0144)
ntrans	0.0024 (0.0017)	-0.003 ° (0.0018)	-0.0012 (0.0012)	-0.001 (0.001)
age	0.0042 (0.0076)	0.0036 (0.0079)	-0.0022 (0.0054)	0.0007 (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 A8: 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
nhs4	-0.0101 *** (0.0014)	-0.0061 *** (0.0012)	0.0008 (0.0008)
pci	-0.0884 *** (0.0054)	-0.0487 *** (0.0048)	0.0115 *** (0.0031)
sdp	0.0144 (0.0195)	0.1203 *** (0.0174)	0.1105 *** (0.0112)
msh	-0.0348 (0.0292)	-0.0421 (0.0261)	-0.0183 (0.0169)
mdp	0.0265 (0.0422)	-0.0241 (0.0377)	-0.0422 (0.0244)
ssh	-0.0341 (0.0591)	0.0696 (0.0527)	0.0928 ** (0.0341)
tfp	0.0582 *** (0.0157)	0.0485 *** (0.014)	0.0088 (0.009)
ntrans	-0.0007 (0.0011)	-0.0008 (0.001)	-0.0003 (0.0006)
age	-0.0119 * (0.0048)	-0.0091 * (0.0043)	-0.001 (0.0028)
nhs4_d			0.6808 *** (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 A9: 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.

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