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Does export complexity matter for firms' output volatility?

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QUADERNI DI RICERCA n. 407
ISSN: 2279-9575

December 2014

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Abstract

With this paper we provide, for the first time to our knowledge, micro-level evidence on the negative linkage between firm complexity and volatility. A higher sophistication level of a firm's export basket reduces its output fluctuations. When focusing on a sample of exporting and non exporting firms, the average complexity of the production mix equally affects stability of sales of both groups. The stabilising role of firms' production sophistication is driven by complex products' higher income elasticity, technological diversification and market entry barriers.

JEL: *F43, D22, E32, O12*
Keywords: Output fluctuations, Product Sophistication, Capabilities, Demand and supply channels

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Corresponding Author: Alessia Lo Turco. The data used in this work are from the Foreign Trada Data, the Annual Business Statistics and the Production Surveys provided by Turkish Statistical Office (TurkStat). All elaborations have been conducted at the Microdata Research Centre of TurkStat under the respect of the law on the statistic secret and the personal data protection. The results and the opinions expressed in this article are exclusive responsibility of the Authors and, by no means, represent official statistics. We are grateful to Bülent Tungul, Mahmut Öztürk, Kenan Orhan and Erdal Yildirim from TurkStat for their help with foreign trade data. We also thank Vedat Metin, Ülkü Ünsal and Oğuzhan Türkoğlu from dissemination department.

1 Introduction

Does a country's specialisation in more complex goods affect the stability of its growth path? With this paper we aim at answering this question by adopting a micro-level perspective.

The stability of countries' development paths affects their long run economic growth. Cross-country studies, indeed, show that there is a robust association between volatility and growth which seems to reflect the negative effect of the former on the latter (Ramey and Ramey, 1995; Hnatkovska and Loayza, 2004; Norrbin and Yigit, 2005; Lin and Kim, 2014). Recent literature, though, has stressed the importance of microeconomic dynamics as relevant drivers of aggregate fluctuations (di Giovanni and Levchenko, 2012).[1] Within an economy, idiosyncratic shocks to firms, especially to the largest or/and the most interconnected ones (Gabaix, 2011; Acemoglu et al., 2012; di Giovanni et al., 2014), significantly contribute to aggregate output volatility. Hence, a few firms' growth paths can affect a country's long run growth perspectives.

Among the determinants of growth, great attention has been devoted to the key role played by international trade. More specifically, an important strand of literature has delivered an unambiguous and robust finding: the sophistication level of exports, captured by their income/productivity content, rather than their value, would explain countries' economic growth (Hausmann et al., 2007). This evidence is corroborated when the notion of product sophistication, instead of being linked to exporters' income level, rests on the set of diverse capabilities needed in the production process of goods, which is considered to be negatively related to their ubiquity in countries' export baskets (Hausmann and Hidalgo, 2009). However, in line with recent development in trade theory (Melitz, 2003; Melitz and Ottaviano, 2008), aggregate exports are driven by a few top exporters and the relative export performance of countries at the macro level is positively correlated with the relative productivity of their firms measured at the micro level (Ottaviano and Mayer, 2007). Hence, export sophistication of countries ultimately rests on export sophistication of a bunch of their firms. The trade-growth nexus, thereby, hinges on the impact of firms' export sophistication on their growth trajectories.

The goal of this work is, therefore, studying the effect of firms' export complexity on their output volatility. In particular, we aim at making three main contributions.

First of all, to the best of our knowledge, this is the first piece of research dealing with the role of export complexity for their output volatility at micro level. Previous works have either explored this relationship at aggregate level (Krishna and Levchenko, 2013) or investigated the impact of an economy's complexity on firm performance, in particular in terms of export growth (Poncet and de Waldemar, 2012). We, instead, show that a firm's comparative advantage in more complex and sophisticated goods acts as a relevant stabiliser for its turnover. While across countries differences in comparative advantage in more sophisticated goods can hinge on international differences in institutional quality and human capi-

[1] Part of literature (Acemoglu and Zilibotti, 1997) has proposed models of financial diversification which predict a negative relationship between aggregate and microeconomic volatility. In financially developed countries, firms could engage in more risky businesses and investments which increase their volatility, but as long as performance of firms are weakly correlated, a reduction in the macro-volatility is consequential. However, Davis et al. (2007) find that the reduction in aggregate volatility in the US economy between the mid 1980s and the mid 2000s was mainly caused by a reduction of firm level volatility. Empirically, microeconomic and macroeconomic volatility seems to co-move.

tal endowments (Costinot, 2009; Nunn, 2007; Levchenko, 2007)[2], our single country firm level analysis aims at highlighting whether, in the absence of any difference in institutions and/or access to human capital and further production factors, export complexity is still an important source of heterogeneity across very similar - in terms of productivity, size, etc. - firms which are active within very narrowly defined sectors and territories and if such a heterogeneity significantly affects firms' growth stability. If this were the case, our work would call for the implementation of micro-policies directed at the development of within firm capabilities (OECD, 2005) to upgrade production and, thus, favour higher aggregate stability and growth.

Second, our focus is on the Turkish manufacturing sector which, we believe, represents a particularly suitable context in which to develop the analysis. In general, firm level dynamics are more relevant for the macroeconomy of smaller and emerging countries, where few firms account for the lion's share in the economy, and the economic structure is fragile and exposed to external shocks. In this framework, exporting firms play a prominent role. On the one hand, they are among the largest firms in an economy and are the ones that typically benefit more from deeper international integration and increased trade openness. On the other hand, export markets are the main drivers of the ups and downs of the internal economy, as emerging countries' manufacturing is rather export oriented and internal demand is only weakly able to cushion the swings of international markets. Investigating the determinants of exporters' volatility is then relevant for these economies, as it could ultimately have severe repercussions on the economic stability of the aggregate system. Turning more specifically to the Turkish emerging economy, during the last decades it has experienced dramatic changes in its economic structure (Hidalgo, 2009), sustained growth and a rapid and increasing integration in the world trade network. Hence, we expect such a dynamic context to deliver important insights on the firm level complexity-volatility nexus under analysis.

Third, by measuring product complexity á la Hausmann and Hidalgo (2009), we further contribute by shedding light on the black-box of product complexity. We, indeed, explore different supply and demand side channels through which a higher complexity of firms' production may translate into a more stable path of their output growth. We, therefore, extend and depart from existing industry level empirical evidence which shows that a lower complexity, meant as a smaller set of inputs used by an output sector, makes its growth more volatile, due to a higher exposition to input-specific shocks (Krishna and Levchenko, 2013). In particular, we argue that the technological diversification of products is not the only mechanism at work and other mechanisms contribute to explain the complexity-volatility nexus. As a further supply-side channel we explore the role of high fixed and sunk costs which could characterise production processes of more complex goods and, therefore, constitute relevant entry barriers. Firms producing these goods could, then, face less competition and, hence, higher stability of their sales. We, furthermore, move the attention to the demand side and inspect the contribution of the good's price and income elasticities. Complex and more sophisticated goods, generally, are less substitutable, due to their higher technological diversification, and are purchased by high-income countries (Hallak, 2006) and, within countries, by those segments of consumers which are less exposed to shocks and may guarantee a more stable demand. As their consumers are less sensitive to price and to income shocks, more complex goods could then present lower demand and, hence, production fluctuations.

The work is structured as follows: the next section briefly reviews the existing literature on

[2] Nonetheless, countries' export complexity has a very low correlation with their rule of law index or with their population's average years of schooling (Hausmann and Hidalgo, 2011).

the effects of product complexity and the drivers of volatility. Section 3 presents the data and our empirical strategy, Section 4 reports our baseline results and robustness checks. Finally in Section 6 we look for the channels behind the complexity-volatility nexus and Section 7 concludes.

2 Literature Review

This article is related to a number of works in the literature dealing with the trade-volatility nexus at the country, industry and firm level. At the macro level, some contributions have dealt with the consequences of countries' international integration on volatility, by disclosing an important role for both international trade (Easterly et al., 2000) and financial integration (Kose and Terrones, 2003). Trade openness can increase a country's volatility by favouring specialisation in comparative advantage sectors at the cost of production diversification and by making the economy more exposed to external shocks (Blattman et al., 2007; Novy and Taylor, 2014). This is in line with the evidence shown by di Giovanni and Levchenko (2009). By exploiting industry-level panel data set of manufacturing production and trade, they find that increased specialisation induced by trade turns into higher aggregate volatility. However, the degree of export specialisation is not the only mechanism behind the nexus between trade and macroeconomic volatility since the export patterns also matter. di Giovanni and Levchenko (2011), indeed, discover that countries are characterised by a heterogeneous level of export risk content according to their export basket composition. Some countries may then be specialised in low risky sectors, thus recording low variation in their growth even if their production is concentrated in a few sectors.[3]

A growing number of studies, though, have recently highlighted the importance of the dynamics at micro level in the explanation of shocks experienced by countries and sectors. Gabaix (2011) demonstrates that, if an economy is granular, shocks to single firms can explain an important part of aggregate fluctuations. Building on this work, di Giovanni and Levchenko (2012) develop and calibrate a multi-country model where aggregate volatility is driven by firms' idiosyncratic shocks. Besides explaining the negative relationship between country size and volatility, the model highlights a positive linkage between volatility and country's trade openness. Small economies' larger firms account for a relevant share of aggregate output and, as a consequence, their fluctuations have a large impact on aggregate volatility. Since trade integration promotes and expands the weight of large firms it also makes an economy more sensitive to shocks faced by single firms. Although trade affects volatility at the macro level, in the model a firm's entry in foreign markets would not impact its own volatility. This finding is at odds with the existing scant empirical firm level evidence on the relationship between exporting and volatility. On a sample of German manufacturing firms over the period 1980-2001, Buch et al. (2009) find that exporters are in general charac-

[3] Koren and Tenreyro (2007), more generally, try to explain the higher volatility of poor countries by focusing on the importance of production specialisation in more risky sectors, their exposition to macroeconomic shocks and the existing correlation between the sectoral and macroeconomic fluctuations. Countries when developing tend to diversify their production, thus reducing their volatility. However, after a certain income level threshold, diversification decreases, thus confirming the U-shaped relationship between specialisation and development (Imbs and Wacziarg, 2003), and this turns into a further reduction of volatility because more developed countries tend to increase their specialisation in less volatile sectors.

terised by a lower volatility. They may indeed present different input and output elasticities and react differently to demand, technology and supply shocks. However, by focusing on the relationship between export share, on one side, and export and domestic sales volatility, on the other side, Vannoorenberghe (2012) finds that firms with a large export share have more volatile domestic sales and less volatile exports. This finding hinges on the negative correlation between output variations in the domestic and export markets.

In this framework, we move a step further and try to dissect how the "nature" of a firm's exports affects its growth path stability. In this respect, our work contributes to building a bridge between the empirical literature showing a negative linkage between output volatility and economic growth (Ramey and Ramey, 1995; Hnatkovska and Loayza, 2004; Norrbin and Yigit, 2005; Lin and Kim, 2014) and the one disclosing the positive impact of export complexity on countries' development (Hausmann et al., 2007; Poncet and de Waldemar, 2012).[4] If complexity is positively related to a country's growth and negatively related to volatility, it may emerge as one of the drivers behind the negative nexus between volatility and country development generally found in the literature. This line of enquiry has been investigated at the industry level by Krishna and Levchenko (2013), who have shown that more complex sectors - i.e. sectors exploiting a larger set of inputs - present lower volatility[5] and that the higher stability of developed countries, indeed, rests on their comparative advantage in more complex goods. This specialisation pattern would stem from the availability of better institutions and higher human capital endowment: while the former allow to easily deal with the problem of imperfect contract enforcement, which particularly affects those productions requiring a larger number of inputs and contracts (Nunn, 2007; Levchenko, 2007), the latter entails lower learning costs which are relatively more important in complex productions (Costinot, 2009). Nonetheless, our work departs from this research in two important aspects. First, our firm level analysis shows that complexity is heterogeneous not only across sectors, but also across very similar firms sharing the same institutional framework and having access to the same pool of human capital. Indeed, we show that such a heterogeneity determines a different performance of rather similar firms in terms of output stability. Secondly, by measuring product complexity á la Hausmann and Hidalgo (2009), we extend the view on complexity from the sector to the product level and, more importantly, we enlarge the scope of the channels through which product sophistication can affect firms' volatility. On the one hand, besides technological diversification, we explore a further supply side mechanism by accounting for differences in entry barriers across products with heterogeneous complexity levels. On the other hand, we allow demand factors to contribute to drive the export complexity-volatility nexus. In this respect, Kraay and Ventura (2007) have calibrated a model in which rich countries specialise in more technology and skilled labour intensive sectors. As their industries

[4] In particular, Hausmann et al. (2007) measure the sophistication level of the country's exports by means of the income level associated with the goods and show that a higher sophistication of production is positively associated with faster growth. Also, Poncet and de Waldemar (2012) use the Hausmann and Hidalgo's indicator of economic complexity to measure the extent of export sophistication in China. They find that cities' economic complexity is a much more robust growth determinant than is export sophistication measured à la Hausmann et al. (2007). Furthermore, it is mainly the complexity associated with ordinary export activities undertaken by domestic firms, which are well embedded in the local economy, to significantly affect the growth.

[5] This is consistent with the work by Koren and Tenreyro (2013), who formalise and calibrate a model where more developed countries are less volatile thanks to a higher degree of technological diversification (which translate into a wider set of inputs).

face inelastic product demands and labour supplies, country-specific supply shocks have moderate income effects. The opposite is true in poor countries. From their model, differences in demand elasticity emerge as more important than differences in labour supply elasticity in the explanation of the heterogeneous volatility level across countries. We, therefore, explore whether firms exporting more complex goods actually benefit from these products' low demand elasticity which translates into more stable sales. Finally, we also account the higher income elasticity of complex goods.

3 Data and Descriptive Statistics

3.1 Data sources and sample

The data we use in this work originate from the matching of Turkish Structural Business Statistics (SBS) and Foreign Trade Statistics provided by the Turkish Statistical Office (TurkStat). The first data source contains data on output, input costs, employment, and location over the period 2003-2009 for the whole population of firms with more than 20 employees and for a representative sample of firms with less than 20 employees. The second one, instead, provides information on firms' export and import activities for the period 2002/2009. Firm foreign trade flows are recorded by 12-digit GTIP product and export destination/import source country, thus allowing us to compute for each firm its export/import sophistication indicators and number of export/import countries and products.

Our estimation sample is made up of all Turkish manufacturing firms[6] with more than 20 employees exporting in 2002 and whose economic activity, in terms of total (export and domestic) turnover, was continuously observed in the 2003-2008 year time span. We measure firm output volatility, $gvol$, as the log standard deviation of firm yearly growth output rates (Koren and Tenreyro, 2013; di Giovanni and Levchenko, 2012) over a 5-year time span. Output is calculated by deflating turnover by means of 4 digit sector level production price indexes and correcting for changes in inventories. [7] The focus on a 5-year, or slightly longer, period for the computation of volatility is pretty standard in micro-level literature on output fluctuations, due to the limited short time spans typically available in firm level panel data. Buch et al. (2009) analyse standard deviations of output growth over rolling five-year windows for German firms. Vannoorenberghe (2012), on an unbalanced panel for the period 1998-2007, considers all firms with at least 5years of information of output growth. (Kalemli-Ozcan et al., 2014) investigate the standard deviation of growth over the years 2002/2008 for firms in 16 European countries. Finally, (García-Vega et al., 2012) also focus on volatility computed on 5-year time spans.
Our final[8] sample of 4,168 firms represents 47% of manufacturing employment referrable to

[6]We only exclude firms in manufacturing NACE Rev 1 sectors 16 and 23. Firms in these sectors are very few - about 60 - and we exclude them due to the peculiarity of their economic activities. Nonetheless, their inclusion in the estimation sample does not affect our evidence at all. Results are available upon request.

[7]We decided to stop our analysis at 2008, thus excluding the 2009 global crisis year which could distort the linkage between micro level complexity and volatility in a short-time span.

[8]We excluded outliers by trimming our data at 1% below and above the volatility distribution. As alternative data cleaning procedure, we winsorised the data at the same centile of distribution and the insights from the following analysis are unchanged. The same is true when no data cleaning is applied. Results are available upon request.

firms with more than 20 employees and about 55% of output produced by them. Also, firms in our sample are responsible for about 73% of employment and 78% of output respectively employed and produced by manufacturing exporters with more than 20 employees in 2002. It is worth mentioning that in Turkish manufacturing, the correlation between firm level and aggregate two digit sector level output volatility is around 0.60, thus pointing at the relevance of micro-level output dynamics for aggregate phenomena. Furthermore, the focus on the manufacturing sector is of particular relevance for an emerging country such as Turkey. As a matter of fact, manufacturing has a growing role in emerging markets' economies, and thus largely contributes to aggregate volatility.[9]

3.2 Measuring export product complexity

To measure firm export complexity we use the indicators suggested by Hausmann and Hidalgo (2009). They adopt the so-called *Method of Reflections* which exploits information gathered from the bipartite (country-product) network of world trade. The main assumption is that the higher the number of products a country exports with Revealed Comparative Advantage (RCA), the higher its economic complexity. At the same time, a product that is exported by fewer countries with RCA and is, thus, less ubiquitous can be considered more complex than a product that is exported by a higher number of countries with RCA. The underlying idea is that a country can export a particular product with RCA if it is endowed with the necessary and suitable capabilities. Thus, a country with more diversified export baskets has more capabilities. Similarly, a product that is less ubiquitous requires more exclusive capabilities. Complexity of products and countries, therefore, is associated with the set of capabilities required by a product and with the set of capabilities that are available to an economy. For each country *c* the diversification index, $K_{c,0}$, is calculated as the summation over products of the RCA dummy, d_{RCA}, that is equal to 1 for product *p* a country exports with RCA and zero otherwise:

$$K_{c,0} = \sum_{p} d_{RCA\ cp}$$

Similarly, for each product *p* the extent of ubiquity is given by the number of countries that export *p* with RCA:

$$K_{p,0} = \sum_{c} d_{RCA\ cp}$$

Starting with these measures of a country's diversification, $K_{c,0}$, and a product's ubiquity, $K_{p,0}$, the *Method of Reflections* consists in refining these complexities' indicators by calculating jointly and iteratively the average value of the measure computed in the preceding iteration (Felipe et al., 2012). By jointly using diversification and ubiquity information in succeeding iterations, thus, one can add information on the extent of ubiquity of the products a country produces to the original information on its diversification and can refine the information on products' ubiquity by adding information on the diversification of countries exporting them. After *n* iterations, these measures are then given by:

[9] Koren and Tenreyro (2007) show that manufacturing sectors present intermediate levels of volatility compared to the agriculture sector, which is characterised by the highest volatility, and the services which are characterised by lower fluctuations.

$$K_{c,n} = \frac{1}{K_{c,0}} \sum_{p} d_{RCA\ cp} * K_{p,n-1}$$

$$K_{p,n} = \frac{1}{K_{p,0}} \sum_{c} d_{RCA\ cp} * K_{c,n-1}$$

Iterations stop when no more information can be drawn, that is the relative rankings of countries and products do not vary between iterations *n* and *n+1*. For product level index, even numbered iterations give measures of a product's ubiquity, while odd numbered iterations give measures of the diversification of its exporters. The two indicators identify, then, a country's complexity by means of its specialisation in products that are not only less ubiquitous but also exported by complex countries - which export a larger number of less ubiquitous products - and a product's complexity by means of its presence in the export basket of fewer complex countries.

As we are interested in investigating the role of firms' product complexity, or, better still, of the complexity of firms' comparative advantage products, we focus on the standardised product complexity indicator $K_{p,15}$, gathered after $n = 15$ iterations.

The attractiveness of this indicator lies in its ability to capture different features of complexity. It could indeed reflect different elements contributing to the complexity of a good: technological diversification, the need for specific investments, a higher human capital content, a lower competition in its supply. All these elements indeed translate into the fact that just a small number of countries (i.e. the most rich and advanced ones) are able to produce and export (with comparative advantage) that good, and that these countries present a high level of product diversification. Also, this indicator has the advantage to allow for the assessment of the sophistication of products defined at a very detailed and disaggregated level. Nonetheless, this indicator has the shortcoming of being an ex-post measure of complexity whose real sources, i.e. firms' endowments of capabilities, remain unmeasured and, therefore, untested in our work.

Among roughly 4,500 HS products our indicator ranks in the top 5% radiography or radiotherapy apparatus based on the use of X-rays, optical instruments for inspecting semiconductor wafers, and particle accelerators, while among the bottom 5% we can find pyjamas, matting, plywood and statuettes of wood.

Then, firm *i*'s export complexity is computed as a simple and weighted average complexity across all exported products:

$$K_{it} = \frac{\sum_{p=1}^{N_{it}^{exp}} K_{p,15}}{N_{it}^{exp}} \tag{1}$$

$$K_{it}^{w} = \sum_{p=1}^{N_{it}^{exp}} K_{p,15} * \frac{x_{ipt}}{\sum_{p=1}^{N_{it}^{exp}} x_{ipt}} \tag{2}$$

where N_{it}^{exp} is the number of products exported by firm i at time t, and x_{ipt} is the value of product p exported by firm i at time t.

Ubiquity measures are computed at 6digit-HS product level by exploiting BACI export data collected by CEPII and available for a large number of countries and a large time span. We then match this information with our micro-level information on firms' exports available at a more disaggregated level.[10]

From Figure A.1 in the appendix it emerges that more and less complex firms differ all along the whole volatility distribution. The kernel distributions of output volatility for firms with high (above the median) and low (below the median) complexity levels, *K*, in 2002 reveal that more complex firms appear to be systematically less volatile and this evidence is confirmed by a two-sample Kolmogorov-Smirnov test for equality of distribution functions.[11]

4 The empirical analysis of the firm level complexity-volatility nexus

4.1 Empirical Model

To investigate the complexity-volatility nexus we estimate the following empirical model by means of OLS:

$$gvol_{i,2008/2004} = \alpha + \beta K_{i,2002} + \omega X_{i2003} + \gamma_j + \epsilon_i \tag{3}$$

where $gvol$ represents firm *i*'s output growth volatility, which, as previously mentioned, is calculated as the logarithm of the standard deviation of growth rates measured on output levels observed in the 2003-2008 period. X is a set of relevant firm characteristics which are all measured in the base year 2003 and are: size, l, measured as the log number of employees, labour productivity, lp, measured as log of value added over number of persons employed, log of average wage, w, import status, imp, measured as a dummy variable equal to one if firm reports positive imports and to zero otherwise, and investments in tangible, I_{tang}, and intangible, I_{intang}, assets, measured by means of dummy variables equal to one when the firm reports a non zero value of investments and zero otherwise. Finally, in the model, γ_j represents a 2-digit sector fixed effect. Table 1 presents descriptive statistics for our estimation sample and shows that output volatility varies substantially across firms. Also, a large heterogeneity exists in product complexity across firms' export baskets and cross firm averages of standardised complexity indicators show that Turkish firms actually export products that are less complex than the world average and that, within firms' export baskets, lower complexity goods have higher shares. The Table reports descriptives for the further above mentioned firm level right hand side variables that, besides export complexity, will be included in the baseline specification of our empirical model. As our sample is made up of exporters, firms are on average larger compared to the average size of Turkish manufacturing firms and importers constitute 84% of our observations. Investors in tangible assets are about 81%, while investors in intangibles only represent one third of the total sample.

Our interest is on the coefficient associated to K, that is firm *i*'s export complexity. K is measured in the pre-sample year 2002 in order to attenuate reverse causality issues for which

[10] The first 6 digit of GTIP classification correspond to the HS classification. Since our analysis covers the period 2002-2008, we harmonised product codes in order to take into account the update the HS classification underwent in 2006.

[11] We obtain the same evidence when using firms' weighted average export product complexity, K^w.

Table 1: Evolution of Firm Volatility and Export Complexity

Variable	Obs	Mean	Std. Dev.	Min	Max
$gvol$	4168	-1.34	0.60	-2.80	0.21
K	4168	-0.23	0.90	-2.37	2.32
K^w	4168	-0.30	0.98	-2.43	2.32
l	4168	4.34	1.02	2.08	9.75
lp	4049	9.74	1.13	1.39	14.08
imp	4168	0.84	0.37	0	1
I_{tang}	4168	0.81	0.39	0	1
I_{intang}	4168	0.34	0.47	0	1
$wage$	4168	8.85	0.58	7.17	12.09

$gvol$ is the standard deviation of the firm annual growth rates over the period 2004-2008.
K and K^w represent the firm simple and weighted average of product complexity across all exported products.

more stable firms could select into more complex products and we test for both the simple and the weighted average of complexity across all products that the firm exports.

4.2 Baseline Results

Table 2 shows the baseline results on the impact of firm export complexity on its output volatility. The message emerging from the estimates is clear: firms specialised in more complex goods are less exposed to external shocks and present a higher stability in their overall sales. This evidence is robust to the inclusion of other firm level characteristics and to the use of both firm simple and weighted average of product complexity. It is worth highlighting that the result on firm size mimics the coefficient estimates available in the literature stemming from a log-log specification of the relationship between firm size and volatility (Stanley et al., 1996; Sutton, 2002). Labour productivity is not significantly related to firm volatility, while importing or investing in tangible assets reduces volatility by 8.8% and 10%, respectively. The result on import status could originate from productivity gains enjoyed by importers if foreign markets provide firms with the opportunity to exploit a higher variety of inputs and/or inputs characterised by a lower price and a higher technological and quality content. The resulting higher efficiency could translate into higher competitiveness and increased ability to react to external shocks and defend their own market shares. This interpretation could explain why firm labour productivity is not directly related to volatility. Furthermore, the access to foreign input markets allows firms to cushion negative shocks in the domestic upstream sectors which may importantly and negatively affect firms' productive processes. Finally, firm average wage is also negatively related to growth volatility. In this respect, *ceteris paribus*, as higher share of skilled employees often translate in higher average wages (Bernard and Jensen, 2004), we could then interpret this finding as higher firm skill intensity reducing firm volatility. This explanation would be in line with those studies explaining the nexus between countries' comparative advantage and their volatility on the basis of their endowment of human capital (Costinot, 2009; Krishna and Levchenko, 2013).

Turning to the economic meaning of our complexity indicators, in order to grasp an idea of the magnitude of the effects, we take as reference the descriptive statistics shown in Table 1. A one standard deviation increase in complexity would reduce a firm's growth rate standard deviation by roughly 10%, which corresponds to about one sixth of the volatility variability, as measured by its standard deviation in Table 1. Also, if a firm with a complexity level equal to the observed mean complexity jumped to the maximum complexity level observed in our sample, its volatility would decrease by about 25% which is slightly less than half of the volatility standard deviation. More intuitively, if a firm moved from the production of tungsten halogen lamps to the production of arc-lamps, its volatility would fall by 6.2%. Moving from the production of pocket-size radio cassette-players to radar apparatus or, alternatively, switching from electrically operated alarm clock to pacemakers would, instead, deliver larger effects, as firm volatility would drop by 13.1% and 22%, respectively.

Figure A.2 in Appendix A shows the distribution of predicted volatility from estimates of model 3 under four alternative scenarios concerning firms' complexity level. First of all, we plot the distribution of predicted volatility for the observed firm complexity levels, then we explore how such a distribution would change if all firms increased their complexity by 10% and by one standard deviation. Finally, we plot the distribution under the hypothesis that all firms were able to reach the maximum complexity recorded in sample within their 2digit sector. From the picture it emerges that only important changes in firms' complexity levels are able to considerably reduce their volatility. In this respect, this picture conveys an important message: large resources need to be devoted to the sophistication of manufacturing production, as far as it becomes rewarding in terms of growth path stabilisation.

Table 2: Firm Volatility and Export Complexity: Baseline

	(1)	(2)	(3)	(4)	(5)	(6)
K	-0.134***	-0.114***	-0.098***			
	[0.017]	[0.016]	[0.017]			
K^w				-0.102***	-0.102***	-0.090***
				[0.015]	[0.015]	[0.015]
l		-0.134***	-0.099***		-0.140***	-0.103***
		[0.009]	[0.010]		[0.009]	[0.010]
lp			0			0
			[0.009]			[0.009]
imp			-0.086***			-0.088***
			[0.026]			[0.026]
I_{Tang}			-0.109***			-0.107***
			[0.025]			[0.025]
I_{Intang}			-0.001			-0.004
			[0.020]			[0.020]
w			-0.089***			-0.090***
			[0.020]			[0.020]
$Const.$	-1.381***	-0.742***	0.056	-1.370***	-0.719***	0.079
	[0.037]	[0.054]	[0.162]	[0.037]	[0.053]	[0.160]
Observations	4168	4168	4049	4168	4168	4049
R-squared	0.071	0.12	0.136	0.066	0.12	0.136

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level.
Robust standard errors in brackets.
All specifications include 2 digit NACE Rev 1.1 sector dummies and year fixed effects.

5 Robustness checks

Alternative Volatility Indicators and Instrumental Variables- To further check the robustness of the relationship between firms' export complexity and their volatility, in Table 3 we use alternative measures of volatility as left hand side variables which have usually been used in the literature on firm volatility (Kalemli-Ozcan et al., 2014). In particular, we use the log of the coefficient of variation (columns 1 to 4), the log of the standard deviation of discrete growth rates which could better approximate firm growth patterns (columns 5 to 8) and the log of the absolute value of the residual of a firm growth regression on time and firm fixed effects (columns 9 to 12) (Blanchard and Simon, 2001; Buch et al., 2009). It is worth stressing that when the latter *conditional* volatility measure is used, it does not rely on a time window of five years and all firms exporting in 2002 are included in the estimation sample, regardless of their survival across the whole five year time span that we chose as our baseline estimation sample. Therefore, we consider results in columns [9]-[12] as a test of sample selection which could affect and, thus, cast doubts on our main result.

Our baseline results hold even when we adopt alternative volatility indicators and, following an increase of firm complexity by one standard deviation, they all imply a decrease of volatility whose magnitude is consistent with estimate from the baseline specification.

An important issue to investigate is whether the significant impact of past complexity on subsequent firm output volatility is driven by the omission of the firm's past growth pattern. In other words, a potential endogeneity concern stems from the fact that firms with heterogeneous volatility levels could sort themselves into products with different extent of complexity. On the one hand, more stable firms could more easily start and continue more complex productions and this would imply a downward bias in our estimates, on the other hand, if higher firm volatility reflects lower risk aversion, then, more volatile firms could be more likely to start producing more sophisticated goods and in this case we would underestimate the stabilising effect of product complexity. If this is the case, it is then important to account for autocorrelation in the observed firm's growth pattern to purge residuals from any unaccounted persistence in firms' growth rates. Although we are not able to account for firms' output growth patterns before 2003, we estimate a model of firm growth rates in the time span at our disposal where, besides firm and year fixed effects, we alternatively include one first and one first and one second order autoregressive term. Estimates are shown in Table 4 for log-squared residuals obtained from continuous and discrete firm level growth rates and our main findings are largely confirmed.[12] This empirical approach, by cleansing the turnover evolution from autocorrelation dynamics, together with the use of pre-sample measures of firm complexity, makes us more confident about the existence of a causal nexus running from complexity to volatility. Furthermore, when accounting for a second order autoregressive growth process, coefficients on complexity indicators increase in absolute value, thus hinting at a systematic sorting of less stable firms into more complex products.

To further inspect this issue, we perform an instrumental variable estimation where we use two alternative sets of instruments for firm complexity. First, we use the complexity of goods, different from the goods exported by the firm, that are exported by other firms within the same 4digit sectors and located both in the same NUTS3 province and in other provinces. To

[12]We also used employment and labour productivity growth volatility. Furthermore, to account for heterogeneous sectoral growth patterns, we calculated a firm's growth relative to its 2 digit and 4 digit sector output growth and measured a firm's volatility on the basis of this relative output growth. As baseline results are largely confirmed, we do not show this set of estimates for the sake of brevity, nonetheless, it is available from the authors upon request.

allow for higher variation of complexity, we consider only exports to high income countries. We assume that other firms' export complexity exerts positive spillover effects on firms' product sophistication, and we expect this effect to be magnified by geographical proximity. Complex goods require more capabilities and skills for their production and it is likely that knowledge flows among neighbouring firms performing similar activities. Nonetheless, a competition effect - which would reduce the complexity of produced goods - could also be at work and prevail if firms could actually try to respond to low/high complexity neighbours' competition by upgrading/downgrading their product sophistication. In the estimation we control for 4digit sector effects and NUTS3 province fixed effects. Second, we instrument a firm's complexity by means of the share of women in its workforce and by the number of mosques per 1000 inhabitants in its NUTS3 province of location. As far as the former instrument is concerned, women in developing and emerging economies' manufacturing are usually endowed with lower education and technical skills, hence, a higher feminisation of manufacturing production is expected to be characterised by a lower degree of complexity (Barrientos et al., 2004). By the same token, turning to the latter instrument, we expect a higher number of mosques per 1000 inhabitant to reflect a lower extent of product sophistication of firms in the province. Empirical evidence has shown, in general, that countries' economic growth responds negatively to church attendance (Barro and McCleary, 2003). Turning to the specific role of Islam for economic performance, some literature regards a reduction of religious diversity as the major historical factor hampering innovation, science evolution and technological upgrading within the muslim world (Chaney, 2008). In particular, some specific values of islamic religion would foster a diminished capacity for adaptation and innovation, would discourage an individualist economic morality, would favour an educational system that limits curiosity and innovation and would reduce the role of public discourse, hence, discouraging individuals from questioning (Kuran, 1997). These traits can importantly affect the accumulation of advanced and sophisticated capabilities, therefore we expect firms in provinces with a higher number of potential practising muslims to have a lower extent of product complexity. Results from the IV strategy are presented in Table 5. For the sake of brevity, they only concern simple average of firms' complexity.[13] First stage evidence in the lower panel of the Table, actually, fulfils our expectations about the relationship between product complexity, on one side, and neighbouring firms' complexity, female employment share and the muslim *intensity* of a firm's location province, on the other. Also instrument validity is corroborated by standard testing shown in the Table. Findings from second stage, in turn, corroborate and reinforce the existence of a negative causal nexus between a firm's complexity and its volatility. In particular, IV coefficient estimates reveal a higher stabilising impact of complexity on volatility, thus, confirming an upward bias in OLS estimates stemming from selection of more volatile firms into more complex products. OLS complexity coefficient, then, represents a conservative estimate of the real stabilising effect of firms' complexity.

[13] Insights are the substantially unchanged when firms' weighted average of export product complexity is used. Results are available upon request.

Table 3: Firm Volatility and Export Complexity: Further Volatility Measures

	Log (Coeff. Var.)				Discrete Growth Rates				Log (Residual)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
K	-0.140***	-0.139***			-0.131***	-0.091***			-0.112***	-0.060***		
	[0.029]	[0.030]			[0.018]	[0.017]			[0.015]	[0.015]		
K^w			-0.116***	-0.117***			-0.098***	-0.086***			-0.081***	-0.057***
			[0.026]	[0.027]			[0.016]	[0.016]			[0.014]	[0.014]
l		-0.014		-0.019		-0.118***		-0.121***		-0.107***		-0.110***
		[0.020]		[0.020]		[0.011]		[0.011]		[0.009]		[0.009]
lp		0.029*		0.028*		-0.011		-0.011		-0.005		-0.006
		[0.017]		[0.017]		[0.009]		[0.009]		[0.010]		[0.010]
imp		-0.094*		-0.097**		-0.092***		-0.093***		-0.087***		-0.088***
		[0.049]		[0.049]		[0.029]		[0.029]		[0.023]		[0.023]
I_{Tang}		0.022		0.024		-0.123***		-0.122***		-0.091***		-0.091***
		[0.045]		[0.045]		[0.027]		[0.027]		[0.022]		[0.022]
I_{Intang}		0.017		0.013		0.007		0.005		-0.019		-0.02
		[0.040]		[0.040]		[0.022]		[0.022]		[0.018]		[0.018]
w		0.02		0.018		-0.098***		-0.098***		-0.090***		-0.091***
		[0.037]		[0.037]		[0.022]		[0.021]		[0.020]		[0.020]
$Const.$	1.191***	0.844***	1.197***	0.898***	-1.312***	0.416**	-1.300***	0.438**	-1.918***	-0.388**	-1.909***	-0.370**
	[0.064]	[0.300]	[0.064]	[0.298]	[0.039]	[0.176]	[0.039]	[0.174]	[0.037]	[0.161]	[0.038]	[0.160]
Observations	4,168	4,048	4,168	4,048	4,168	4,051	4,168	4,051	22,835	22,201	22,835	22,201
R-squared	0.028	0.03	0.027	0.03	0.066	0.144	0.062	0.145	0.023	0.043	0.022	0.043

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets.
All specifications include 2 digit NACE Rev 1.1 sector dummies and year fixed effects.

Table 4: Firm Volatility and Export Complexity: Log-residuals from AR model of firm growth

	Continuous Growth Rates				Discrete Growth Rates			
	AR(1)		AR(2)		AR(1)		AR(2)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
K	-0.082**		-0.115***		-0.072**		-0.089**	
	[0.035]		[0.041]		[0.036]		[0.041]	
K^w		-0.094***		-0.116***		-0.090***		-0.097***
		[0.031]		[0.036]		[0.031]		[0.037]
l	-0.215***	-0.219***	-0.232***	-0.236***	-0.222***	-0.225***	-0.233***	-0.237***
	[0.021]	[0.021]	[0.024]	[0.024]	[0.021]	[0.021]	[0.024]	[0.024]
lp	-0.037	-0.037	-0.083***	-0.083***	0.051**	0.052**	0.008	0.008
	[0.023]	[0.023]	[0.029]	[0.028]	[0.024]	[0.024]	[0.028]	[0.028]
imp	-0.145***	-0.144***	-0.177***	-0.176***	-0.094*	-0.092*	-0.157***	-0.156***
	[0.052]	[0.052]	[0.060]	[0.060]	[0.053]	[0.053]	[0.060]	[0.060]
$wage$	-0.180***	-0.179***	-0.027	-0.028	-0.314***	-0.313***	-0.262***	-0.263***
	[0.047]	[0.047]	[0.054]	[0.054]	[0.047]	[0.047]	[0.055]	[0.055]
I_{tang}	-0.159***	-0.159***	-0.194***	-0.194***	-0.107**	-0.107**	-0.049	-0.049
	[0.051]	[0.051]	[0.058]	[0.058]	[0.050]	[0.050]	[0.057]	[0.057]
I_{intang}	-0.052	-0.052	-0.028	-0.029	-0.075*	-0.075*	-0.088*	-0.088*
	[0.040]	[0.040]	[0.045]	[0.045]	[0.040]	[0.040]	[0.046]	[0.046]
$cons$	-0.700*	-0.706*	-1.955***	-1.939***	-0.47	-0.486	-0.716	-0.719*
	[0.372]	[0.369]	[0.421]	[0.419]	[0.376]	[0.373]	[0.438]	[0.436]
Observations	17,973	17,973	13,562	13,562	17,700	17,700	13,335	13,335
R^2	0.047	0.047	0.047	0.047	0.041	0.041	0.045	0.046

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets.
All specifications include 2 digit NACE Rev 1.1 sector dummies and year fixed effects.

Import complexity and Export Diversification - To further prove the robustness of our findings in Table 6 we include additional firm level controls which could affect a firm's stability and which capture different dimensions of the firm's involvement in foreign markets.

First, we explore the role of import complexity. In the baseline specification we tested for the access to foreign source markets, by means of a dummy for importer status and we found that the opportunity to purchase inputs abroad reduces the firm volatility. Nonetheless, this could not be a sufficient control for the effective firm import activity, as the type of inputs imported by firms matters for the extent of their export sophistication (Manova and Zhang, 2012), and could be relevant for their output stability as well. On the one hand, more complex inputs could prove more efficient and lead to more sophisticated and stable productions. On the other hand, dependence on more complex goods could make production more volatile since a supplier's substitution would be difficult in case of negative shocks affecting her, thus driving to a break or a drop in production. Then, to account for the possible omission of import sophistication from the model, we include import complexity together with export complexity in the baseline specification. We, thus, restrict the analysis to the sample of firms that in addition to being exporters are also importers in 2002. We find that the impact of export complexity is still preserved even controlling for the import complexity, while import complexity, when significant, has a mild negative effect which is, however, not robust across specifications.

Table 5: Firm Volatility and Export Complexity: Instrumental Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				SECOND STAGE RESULTS				
K	-0.256**	-0.259*	-0.246**	-0.253*	-0.268*	-0.290*	-0.353**	-0.329**
	[0.128]	[0.135]	[0.127]	[0.134]	[0.152]	[0.151]	[0.141]	[0.145]
Firm Level Controls[a]		YES		YES		YES		YES
4digit Nace FE	YES	YES	YES	YES				
NUTS3 FE	YES	YES	YES	YES				
2digit Nace FE					YES	YES	YES	YES
Underidentification test	77.647	69.362	78.103	69.944	46.535	46.727	53.791	50.081
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Weak identification test	92.650	80.535	48.278	42.153	47.883	48.083	28.269	26.031
Stock-Yogo 10%	16.38	16.38	19.93	19.93	16.38	16.38	19.93	19.93
1stage Ftest	92.65	80.53	48.28	42.15	47.88	48.08	28.27	26.03
Hansen test	-	-	0.167	0.023	-	-	2.156	1.071
Hansen P-val	-	-	0.6829	0.879	-	-	[0.142]	[0.301]
				FIRST STAGE RESULTS				
			K			K		
K^{Prov}	0.261***	0.241***	0.252***	0.232***				
	[0.027]	[0.027]	[0.028]	[0.028]				
$K^{OtherPRov}$			-0.057	-0.055				
			[0.042]	[0.040]				
fem_sh					-0.350***	-0.348***	-0.355***	-0.352***
					[0.051]	[0.050]	[0.051]	[0.050]
$mosques^{Prov}$							-0.042***	-0.027*
							[0.014]	[0.014]
Observations	3539	3445	3488	3399	3700	3598	3700	3598

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets. All specifications include year fixed effects. Columns 1, 2, 5 and 6 present estimates from just identified models, for which Hansen test is, therefore, not available.

[a] firm level controls are firm size, l, labour productivity, lp, import status, imp, average wage w, and tangibles and intangibles investor dummies, I_{tang} andI_{intang}.

Second, we control for firm export diversification in terms of foreign destinations. Exporting to several markets allows firms to diversify the risk of potential market-specific shocks and to move the activity towards other destinations when a country experiences a drop in the demand. Also, it is likely that more complex firms have access to a large number of countries, thanks to their larger size, better human capital, better access to financial resources and so on (Manova and Zhang, 2012). We, then, control if our main findings are affected by the inclusion of a firm level indicator of diversification, as expressed by the number of export destination, Nc^{exp}, in order to exclude that the effect we are capturing is the volatility-reducing effect of diversification and from Table 6 the linkage between export complexity and firm volatility proves to be robust to the control for export diversification. This evidence also confirms the interpretation of findings in the work by Buch et al. (2009): the authors state that the lower volatility of exporters compared to non exporters may be due to the low correlation between domestic and foreign shocks which would lead to gains from diversification. While they are not able to empirically investigate this hypothesis, we show that exposition to a larger number of destinations, indeed reduces a firm's volatility, thus suggesting a negative correlation among shocks experienced by different countries.

Third, we test and confirm that the finding of a negative nexus between complexity and volatility holds even when we check for the number of exported products, $N^{Products}$. As for firms serving multiple destinations, a multi-product exporter could better cushion the negative shock on a product by intensifying the export of the remaining goods. We show this is the case, as the number of exported products is negatively associated with firm volatility. However, by no means does this have an effect on size and significance of export complexity. Nonetheless, when the number of export products and destinations are included in the same specification, only the latter stays significant.[14]

Further Robustness - In Table 7 we further show that the relationship between export complexity and firm volatility is robust to the inclusion of both NUTS 2 level region dummies (columns 1-4), and 4-digit NACE Rev 1.1 sector fixed effects (columns 5-8), to the substitution of regressor averages across the 2003-2008 period for their 2003 level (columns 9-12), and to the inclusion of further firm level controls (columns 13-16). As far as firm level controls are concerned, from the wider specifications of columns 13 and 16 we find that subcontractors are more volatile, while firms outsourcing part of their production process have a more stable output growth path. The firm's share of $R\&D$ employees, instead, does not directly affect output volatility.

Furthermore, in Table 8 we test two relative export complexity measures obtained by dividing the firm product complexity by the 4digit average complexity.[15] Relative measures of export complexity with respect to the 4digit sectoral average, indeed, confirm that export complexity is a further important source firm heterogeneity. As a matter of fact, from our results it emerges that across firms with comparable size and productivity which perform similar activities, those producing and exporting relatively more complex goods are indeed less volatile. This result holds regardless of the inclusion of 4-digit sector fixed effects and of controlling for export diversification. Thus, the type of specialisation does not only matter for countries but for firms too. We, thus, conclude that within the same country and narrowly

[14] As further diversification indicators we use the Herfindahl index calculated across a firm's destinations and across a firm's products and results are not affected. Results are not shown here for the sake of brevity, but they are available from the authors upon request.

[15] These indicators (X) are then normalised by implementing the following transformation: (X-1)/(X+1).

defined sector and within the same territories, firms which are more specialised than others in complex goods perform better in terms of reduced volatility.

Finally, it is worth mentioning that our results are robust to the adoption of further complexity indicators that are similar, although not coincident, to the complexity measure adopted in this study. First, we alternatively use the export share of products with a complexity index above the median or the 75th percentile of the product complexity distribution. Second, we adopt the PRODY indicator proposed by Hausmann et al. (2007) which assesses the income content of products. Third, we use the measure of product ubiquity proposed by Tacchella et al. (2013) which adjusts the Hausmann and Hidalgo's definition of product complexity by accounting for the fact that if a poorly diversified country is able to export a given product, very likely this product has a low level of sophistication. Fourth, we use the indicator we gather after an even-numbered iteration, K_{p12}, which conveys information about the product's ubiquity and the ubiquity of related products which are exported - with RCA - by the same countries. Results in all cases corroborate our evidence and are not shown for the sake of brevity, nonetheless they are available upon request.[16]

[16]Besides this set of estimates and results presented in this section, we ran several further robustness checks, consisting in the inclusion among the right hand side variables of region-sector controls, of the firm's average growth, total export value and a dummy for firms changing (adding/dropping/switching) the product basket. These results are not show for brevity, but they are available from the authors upon request.

Table 6: Firm Volatility and Export Complexity: Import Complexity and Export Diversification

	Import Complexity				Number of Destinations& Products									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
K	-0.111***	-0.098***			-0.125***	-0.101***			-0.133***	-0.100***			-0.126***	-0.101***
	[0.019]	[0.019]			[0.016]	[0.016]			[0.016]	[0.016]			[0.016]	[0.016]
K^w			-0.080***	-0.086***			-0.110***	-0.097***			-0.114***	-0.096***		
			[0.017]	[0.017]			[0.015]	[0.015]			[0.015]	[0.015]		
K_M	-0.053**	-0.022												
	[0.022]	[0.023]												
K_M^w			-0.040**	-0.029										
			[0.018]	[0.018]										
$N^{Destinations}$					-0.111***	-0.054***	-0.116***	-0.057***					-0.102***	-0.054***
					[0.008]	[0.010]	[0.008]	[0.010]					[0.011]	[0.012]
$N^{products}$									-0.074***	-0.027***	-0.080***	-0.031***	-0.013	-0.001
									[0.008]	[0.009]	[0.008]	[0.009]	[0.011]	[0.011]
l		-0.102***		-0.107***		-0.080***		-0.083***		-0.090***		-0.093***		-0.079***
		[0.011]		[0.011]		[0.011]		[0.011]		[0.010]		[0.010]		[0.011]
lp		0		0		0.004		0.004		0.001		0.001		0.004
		[0.010]		[0.010]		[0.009]		[0.009]		[0.009]		[0.009]		[0.009]
imp						-0.068**		-0.068**		-0.083***		-0.084***		-0.068**
						[0.027]		[0.027]		[0.026]		[0.026]		[0.027]
I_{Tang}		-0.100***		-0.097***		-0.106***		-0.104***		-0.109***		-0.108***		-0.106***
		[0.029]		[0.029]		[0.025]		[0.025]		[0.025]		[0.025]		[0.025]
I_{Intang}		-0.003		-0.006		0.004		0.002		0.002		0		0.004
		[0.023]		[0.023]		[0.020]		[0.020]		[0.021]		[0.021]		[0.020]
w		-0.075***		-0.077***		-0.079***		-0.079***		-0.087***		-0.087***		-0.079***
		[0.022]		[0.022]		[0.020]		[0.020]		[0.020]		[0.020]		[0.020]
$Const.$	-1.349***	-0.111	-1.348***	-0.074	-1.211***	-0.102	-1.202***	-0.094	-1.294***	0.009	-1.285***	0.021	-1.208***	-0.102
	[0.042]	[0.190]	[0.042]	[0.188]	[0.039]	[0.165]	[0.039]	[0.164]	[0.038]	[0.163]	[0.038]	[0.161]	[0.039]	[0.165]
Observations	3,237	3,138	3,237	3,138	4168	4049	4168	4049	4,168	4,049	4,168	4,049	4,168	4,049
R-squared	0.068	0.113	0.063	0.113	0.107	0.143	0.106	0.144	0.088	0.138	0.086	0.139	0.107	0.143

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets.
All specifications include 2 digit NACE Rev 1.1 sector dummies and year fixed effects.

Table 7: Firm Volatility and Export Complexity: Further Robustness Checks

	NUTS 2 REGION FE				4 DIGIT SECTOR FE				2003-2008 AVERAGED REGRESSORS				FURTHER REG		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	
K	-0.129***	-0.094***			-0.109***	-0.060***			-0.187***	-0.119***			-0.126***	-0.098***	
	[0.017]	[0.017]			[0.020]	[0.019]			[0.024]	[0.023]			[0.017]	[0.016]	
K^w			-0.096***	-0.086***			-0.072***	-0.056***			-0.107***	-0.086***			-0
			[0.015]	[0.015]			[0.018]	[0.017]			[0.019]	[0.018]			[
l		-0.099***		-0.103***		-0.110***		-0.112***		-0.105***		-0.109***		-0.096***	
		[0.010]		[0.010]		[0.011]		[0.011]		[0.012]		[0.012]		[0.010]	
lp		-0.001		-0.001		-0.008		-0.008		-0.015		-0.016		-0.003	
		[0.009]		[0.009]		[0.009]		[0.009]		[0.020]		[0.020]		[0.009]	
imp		-0.081***		-0.082***		-0.076***		-0.077***		-0.080*		-0.083*		-0.084***	
		[0.026]		[0.026]		[0.027]		[0.027]		[0.045]		[0.045]		[0.026]	
I_{Tang}		-0.099***		-0.098***		-0.112***		-0.111***		-0.230***		-0.233***		-0.104***	
		[0.025]		[0.025]		[0.025]		[0.025]		[0.051]		[0.051]		[0.025]	
I_{Intang}		0.002		-0.001		0.005		0.004		0.021		0.018		0	
		[0.021]		[0.021]		[0.021]		[0.021]		[0.037]		[0.037]		[0.021]	
w		-0.093***		-0.093***		-0.084***		-0.084***		-0.083***		-0.088***		-0.093***	
		[0.020]		[0.020]		[0.020]		[0.020]		[0.031]		[0.031]		[0.021]	
$foreign$													-0.103***	0.057	-0
													[0.035]	[0.037]	[
$subcontractor$													0.051	0.105***	
													[0.034]	[0.033]	[
$multiplant$													-0.025	-0.004	
													[0.020]	[0.020]	[
$outsourcer$													-0.124***	-0.065***	-0
													0.002	0.003	
$R\&D$													[0.018]	[0.018]	[
													[0.002]	[0.002]	[
$Const.$	-1.433***	0.045	-1.423***	0.07	-0.695***	0.577***	-0.696***	0.590***	-1.460***	0.258	-1.426***	0.349	-1.291***	0.131	-1
	[0.040]	[0.166]	[0.040]	[0.165]	[0.001]	[0.162]	[0.001]	[0.161]	[0.041]	[0.219]	[0.041]	[0.216]	[0.039]	[0.173]	[
Observations	4168	4049	4168	4049	4,168	4,049	4,168	4,049	2962	2962	2962	2962	4,168	4,049	
R-squared	0.084	0.147	0.079	0.147	0.16	0.221	0.157	0.221	0.082	0.153	0.072	0.152	0.085	0.142	

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets.
Specifications in columns [1]-[4] and [13]-[16] include 2 digit NACE Rev 1.1 sector dummies and year fixed effects.
Specifications in columns [5]-[8] include 4 digit NACE Rev 1.1 sector dummies and year fixed effects.

Table 8: Firm Volatility and Export Complexity: Relative Complexity Measures

	2 DIGIT FE				4 DIGIT FE				4 DIGIT FE + # DEST&PRODUCTS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
K_{Rel4d}	-0.861***	-0.482***			-0.871***	-0.494***			-0.740***	-0.506***		
	[0.149]	[0.147]			[0.149]	[0.144]			[0.146]	[0.143]		
K^{w}_{Rel4d}			-0.580***	-0.444***			-0.570***	-0.447***			-0.648***	-0.512***
			[0.136]	[0.134]			[0.137]	[0.131]			[0.134]	[0.132]
l		-0.097***		-0.100***		-0.109***		-0.112***		-0.088***		-0.090***
		[0.010]		[0.010]		[0.011]		[0.011]		[0.011]		[0.011]
lp		-0.001		-0.001		-0.008		-0.008		-0.004		-0.004
		[0.009]		[0.009]		[0.009]		[0.009]		[0.009]		[0.009]
imp		-0.092***		-0.093***		-0.076***		-0.077***		-0.059**		-0.058**
		[0.026]		[0.026]		[0.027]		[0.027]		[0.027]		[0.027]
I_{Tang}		-0.107***		-0.107***		-0.112***		-0.111***		-0.109***		-0.108***
		[0.025]		[0.025]		[0.025]		[0.025]		[0.025]		[0.025]
I_{Intang}		-0.004		-0.006		0.005		0.003		0.011		0.009
		[0.021]		[0.021]		[0.021]		[0.021]		[0.021]		[0.021]
w		-0.096***		-0.096***		-0.084***		-0.084***		-0.072***		-0.071***
		[0.020]		[0.020]		[0.020]		[0.020]		[0.020]		[0.020]
$N^{Destinations}$									-0.106***	-0.056***	-0.109***	-0.057***
									[0.011]	[0.012]	[0.011]	[0.012]
$N^{products}$									-0.009	0.001	-0.013	-0.002
									[0.011]	[0.011]	[0.011]	[0.011]
$Const.$	-1.305***	0.178	-1.303***	0.194	-0.688***	0.578***	-0.692***	0.593***	0.334**	-0.315***	0.335**	-0.311***
	[0.036]	[0.161]	[0.036]	[0.160]	[0.002]	[0.161]	[0.002]	[0.161]	[0.168]	[0.036]	[0.168]	[0.036]
Observations	4168	4049	4168	4049	4,168	4,049	4,168	4,049	4049	4168	4049	4168
R-squared	0.064	0.131	0.06	0.131	0.161	0.222	0.157	0.221	0.228	0.217	0.228	0.215

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets.
Specifications in columns [1]-[4] include 2 digit NACE Rev 1.1 sector dummies and year fixed effects.
Specifications in columns [5]-[12] include 4 digit NACE Rev 1.1 sector dummies and year fixed effects.

5.1 Export or Product Complexity?

The above findings show a robust negative relationship between exporters' specialisation in complex goods and volatility. Nonetheless, such linkage is supposed to hold independently of a firm's export status. To validate this hypothesis we repeat the baseline analysis by estimating a model of production volatility on the basis of production data available from TurkStat's PRODCOM database for all Turkish manufacturing firms with more than 20 employees for the period 2005-2009. In this database, firms' products are recorded at the 10 digit PRODTR classification level which we converted into HS in order to classify them in terms of their complexity level. As from PRODCOM database firm production growth rates are only available for the four year period 2006-2009 and the global turmoil heavily hit Turkey in 2009 (Lo Turco and Maggioni, 2014), we present two set of estimates concerning both output and production volatility by focusing on the 2006-2008 only. Results are shown in Table 9 and reveal that the negative coefficient on product complexity holds, regardless of a firm's exporter status. Nonetheless, from the interaction term between a firm's export status and the complexity indicator it emerges that, *ceteris paribus*, exporters seem to enjoy an additional premium from complex production in terms of reduced volatility. When we relax the *ceteris paribus* assumption and allow for structural differences between exporters and non exporters by running separate estimates for the two groups of firms in Table 10, indeed we find that, after we control for a number of firm level covariates, no statistically significant difference emerges among them in the relationship between product complexity and volatility.[17]

[17] Results of production volatility are not shown for brevity, nonetheless they are available from the authors upon request.

Table 9: Firm Volatility and Product Complexity: Production Data 2005-2008

	Output Volatility: 2006/2008						Production Volatility: 2006/2008					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
K	-0.045***	-0.050***	-0.055***				-0.052***	-0.048***	-0.048***			
	[0.016]	[0.016]	[0.016]				[0.017]	[0.018]	[0.018]			
$K * exp$	-0.067***	-0.063***	-0.047***				-0.045***	-0.042**	-0.027			
	[0.016]	[0.016]	[0.016]				[0.017]	[0.017]	[0.017]			
K^w				-0.039**	-0.046***	-0.052***				-0.050***	-0.050***	-0.049***
				[0.016]	[0.016]	[0.016]				[0.016]	[0.017]	[0.018]
$K^w * exp$				-0.067***	-0.063***	-0.046***	-0.197***	-0.073***	-0.052***	-0.199***	-0.074***	-0.054***
				[0.015]	[0.015]	[0.016]	[0.016]	[0.017]	[0.019]	[0.016]	[0.017]	[0.019]
exp	-0.215***	-0.138***	-0.105***	-0.215***	-0.138***	-0.105***				-0.050***	-0.046***	-0.032*
	[0.015]	[0.016]	[0.017]	[0.015]	[0.016]	[0.017]				[0.016]	[0.017]	[0.017]
l		-0.137***	-0.104***		-0.137***	-0.105***		-0.133***	-0.101***		-0.133***	-0.101***
		[0.008]	[0.009]		[0.008]	[0.009]		[0.008]	[0.010]		[0.008]	[0.010]
lp			-0.056***			-0.056***			-0.041***			-0.041***
			[0.009]			[0.009]			[0.010]			[0.010]
imp			-0.036**			-0.037**			0.004			0.004
			[0.018]			[0.018]			[0.020]			[0.020]
I_{Tang}			-0.067***			-0.067***			-0.103***			-0.103***
			[0.018]			[0.018]			[0.020]			[0.020]
I_{Intang}			-0.046***			-0.047***			-0.032*			-0.032*
			[0.018]			[0.018]			[0.019]			[0.019]
w			-0.067***			-0.067***			-0.086***			-0.086***
			[0.019]			[0.019]			[0.019]			[0.019]
$Const.$	-1.490***	-0.983***	0.061	-1.485***	-0.977***	0.069	-0.869***	0.883***	2.055***	-0.867***	0.883***	2.051***
	[0.024]	[0.038]	[0.148]	[0.024]	[0.038]	[0.148]	[0.100]	[0.036]	[0.163]	[0.100]	[0.036]	[0.162]
Observations	11511	11509	10987	11511	11509	10987	11,774	10,759	10,274	11,774	10,759	10,274
R-squared	0.049	0.072	0.087	0.048	0.072	0.087	0.045	0.059	0.07	0.046	0.06	0.07

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets.

Table 10: Firm Volatility and Product Complexity: Exporters vs Non Exporters

	Output Growth Volatility: 2006/2008											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	$exp=1$	$exp=0$	$exp=1$	$exp=0$	$exp=1$	$exp=0$	$exp=1$	$exp=0$	$exp=1$	$exp=0$	$exp=1$	$exp=0$
K	-0.107***	-0.043**	-0.107***	-0.047**	-0.091***	-0.056***						
	[0.017]	[0.021]	[0.017]	[0.021]	[0.017]	[0.021]						
K^w							-0.102***	-0.037*	-0.103***	-0.041**	-0.089***	-0.050**
							[0.016]	[0.020]	[0.016]	[0.020]	[0.016]	[0.020]
l			-0.153***	-0.098***	-0.119***	-0.064***			-0.153***	-0.098***	-0.120***	-0.064***
			[0.009]	[0.017]	[0.011]	[0.018]			[0.009]	[0.017]	[0.011]	[0.018]
lp					-0.064***	-0.041***					-0.064***	-0.041***
					[0.012]	[0.015]					[0.012]	[0.015]
imp					-0.044*	-0.049*					-0.044*	-0.049*
					[0.025]	[0.027]					[0.025]	[0.027]
I_{Tang}					-0.068***	-0.069***					-0.068***	-0.069***
					[0.025]	[0.026]					[0.025]	[0.026]
I_{Intang}					-0.033	-0.080**					-0.034	-0.080**
					[0.021]	[0.032]					[0.021]	[0.032]
w					-0.064***	-0.065**					-0.064***	-0.065**
					[0.024]	[0.028]					[0.024]	[0.028]
$Const.$	-1.621***	-1.544***	-0.943***	-1.192***	0.192	-0.318	-1.615***	-1.539***	-0.937***	-1.186***	0.2	-0.311
	[0.039]	[0.030]	[0.055]	[0.067]	[0.190]	[0.246]	[0.038]	[0.030]	[0.055]	[0.067]	[0.190]	[0.246]
Observations	11511	11511	11509	11509	10987	10987	11511	11511	11509	11509	10987	10987
$\beta_{exp=1} = \beta_{exp=0}$:												
P -value		0.017		0.023		0.18		0.012		0.016		0.142

6 Looking for the channels: what drives the export complexity-volatility nexus?

In this section, we inspect the mechanisms lying behind the negative relationship between firm export complexity and output volatility. In particular, we explore the drivers of export complexity by building on different streams of existing literature and, thus, shed light on both demand and supply side factors associated with complex productions which may favour higher stability of output growth.

On the one hand, export complexity could reflect different conditions in demand. First, more sophisticated goods can enjoy lower demand and substitution elasticities because they are less ubiquitous. As a consequence, we expect their demand to be less affected by external shocks. Krishna and Levchenko (2013) corroborate this prediction by showing that the elasticity of substitution of sectors is significantly and positively related to their volatility. However, they are interested in isolating the impact of the number of required inputs on firms' volatility, by cleansing the effect from the existing differences in demand conditions among sectors. We test, instead, whether a good's higher complexity is associated with a lower elasticity of substitution/demand and whether this represents a potential channel of the stabilising effect of product complexity for a firm's output growth. Second, more complex goods are characterised by a higher income elasticity. As a matter of fact, they are mainly consumed by richer countries (Hallak, 2006) - and, within each country, by richer consumers - whose income is less volatile. Hence, we expect that a the higher income elasticity of complex goods, reflected in higher consumption shares of richer countries in the products, could be a further relevant demand side channel driving the above robust complexity-volatility nexus at firm level.

On the other hand, turning to the supply side, since our complexity indicator hinges on countries' diversification and products' ubiquity, it could capture the notion of technological diversification, meant as the number of inputs required by a good's production process. Firms' complexity would, then, stabilise their turnover, due to a minor impact of an input-specific shock on the production outcome. Furthermore, entry into production of complex goods could entail higher fixed and sunk costs. Entry barriers reduce the extent of competition and, hence, increase market concentration. For this reason, firms involved in these productions could enjoy higher stability. In this respect, Irvine and Pontiff (2009) find that increased competition, driven by both the entry of foreign firms and deregulation processes, is one of the main sources at the basis of the rise in idiosyncratic volatility over the period 1964-2003.

In order to shed light on the factors behind the product complexity-volatility nexus at firm level, we proceed in two steps.

First, we estimate the following model for the determinants of firm i's production complexity, K_i:

$$K_i = \theta + \delta_0 \sigma_i + \delta_0 Impsh_i^{HI} + \delta_1 N_i^{input} + \delta_2 Herf_i + \epsilon_i \tag{4}$$

Here, σ_i is the average elasticity of substitution of a firm's product, as measured by Broda and Weinstein (2006) for the U.S. economy at 5 digit SITC level and converted into HS 2002. $Impsh_i^{HI}$ represents the share of consumption by rich economies and is calculated as the average share, across 6 digit HS products exported by the firm in 2002, of imports by High income economies in total world imports. Import data are from COMTRADE- WITS-World Bank online database. N_i^{input} captures the extent of technological diversification and is measured as the log average of the number of inputs needed by each of the products produced by the firm. The number of inputs is computed from the 2002 US commodity-by-commodity Total Requirements Input-Output tables, available at IO code level which is converted to HS 2002 level.[18] Differently from standard IO tables, the Total Requirement ones also take into account the indirect use of inputs in the production of each commodity. This measure, thus, rests on a broader definition of inputs although direct and indirect inputs were only considered when they accounted for at least 1/1000 of a dollar of production of each commodity available to final consumption. $Herf_i$ is the average value of the Herfindahl index in countries' exports of products which are in the export basket of firm i. This indicator aims at capturing the presence and/or level of entry barriers in production and is retrieved, at HS product level for the year 2002, from the World Bank Exporters' Dynamics Database (EDD). All supply and demand determinants at firm level are computed as simple averages across all products exported by Turkish firms as in equation 1.[19]

Table 11 shows the results of the estimation of equation 4 by means of OLS. The exploration of the drivers of product complexity suggests that both demand and supply factors represent important drivers behind the complexity of firms. Indeed, the import share of high income economies, the number of inputs required by each product and the extent of concentration in their supply all present the expected and strongly significant coefficient which persists as they are jointly included in the specification. The elasticity of substitution is not significant when singularly included in the specification, nonetheless, its coefficient turns significant and with the expected negative sign when it is introduced in conjunction with the remaining channels.

[18] Testing for a Herfindahl index which captures the concentration level of the input purchases by product delivers similar insights. Also, results are not affected if log of the average number of inputs employed by firm i's products is computed on the basis of the US industry by commodity Total Requirements Table for 2002.

[19] Results are unaffected when weighted averages are used. This set of estimates is not shown for the sake of brevity, nonetheless it is available from the authors upon request.

Table 11: The drivers of Firm Product Complexity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			K					K^w		
σ	0.000				-0.012***	0.004				-0.009**
	[0.005]				[0.004]	[0.004]				[0.004]
$Impsh^{HI}$		106.323***			133.678***		34.565***			75.532***
		[14.479]			[16.172]		[12.317]			[11.271]
N^{input}			7.059***		6.155***			6.198***		5.609***
			[0.201]		[0.221]			[0.177]		[0.186]
$Herf$				2.778***	1.861***				2.307***	1.534***
				[0.163]	[0.158]				[0.138]	[0.129]
$cons$	-0.031	-0.295***	-35.741***	-1.358***	-31.812***	-0.154***	-0.321***	-31.481***	-1.233***	-28.999***
	[0.033]	[0.015]	[1.014]	[0.071]	[1.084]	[0.031]	[0.016]	[0.894]	[0.062]	[0.919]
Observations	4061	4168	4168	4139	4035	4061	4168	4168	4139	4035
R-squared	0.01	0.012	0.34	0.089	0.383	0.006	0.002	0.308	0.077	0.343

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets.
Dependent variable Product Complexity, K_p, at HS level.
σ: average, across products exported by the firm in 2002, elasticity of substitution. σs are sourced from Broda and Weinstein (2006).
$Impsh^{HI}$: average, across products exported by the firm in 2002, of the share of imports by High income economies in total world imports for the product. Imports at 6 digit HS 2002 for year 2002 come from COMTRADE-WITS-World Bank online database.
N^{input}: log of average, across products exported by the firm in 2002, number of inputs employed by product p computed by exploiting the US commodity-commodity Total Requirements Table for 2002.
$Herf$: average, across products exported by the firm in 2002, product Herfindahl index retrieved from EDD of World Bank for 2002.

Second, we estimate our firm volatility model by including in equation 3 all firm level variables capturing the channels we have just investigated. Results are shown in table 12 where we first include each indicator at a time and, then, explore how and if its impact changes when firm complexity is added to the specification. This comparison allows to understand whether each channel is actually at work. From columns 1-4 in the Table, indeed, supply side factors significantly contribute to reduce firms' volatility, while, at first sight, it would seem that demand side channels do not drive the stabilising effect of higher complexity. As a matter of fact, when firm complexity is included in the specification in columns 5-8, the coefficient on N^{input} loses its significance and the one on $Herf$ is dramatically downsized when controlling for firm complexity. This implies they constitute two important channels driving the negative effect of firm complexity on volatility. Nonetheless, from this set of results it also emerges that the share of imports purchased by high income economies turns significant and positive. This implies that firm complexity does indeed capture the stabilising effect of exporting high income elasticity goods. Once this effect is purged, the positive coefficient could reveal the higher riskiness of exporting goods that are typically produced and sold internationally by more advanced economies. This interpretation is in line with literature showing that richer countries specialize in high-income elastic goods (Fieler, 2011; Caron et al., 2012; Feenstra and Romalis, 2014). When channels are included altogether in the specification of column 9, they all turn non significant, thus showing that their impact on volatility only works through complexity. This holds true even when controlling for further firm level covariates in column 10.[20]

[20]These findings are confirmed when we simultaneously estimate equation 4 and equation 3 by means of three stages least squares. We assume that export complexity depends on the number of stages required in the production process of goods the firm export, their elasticity of substitution, rich countries' import share and the degree of competition in the product. Results are not shown for brevity, but they are readily available from the authors upon request.

Table 12: Firm Volatility and Export Complexity: The Channels

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
σ	-0.002				-0.001				-0.001	0.000
	[0.004]				[0.003]				[0.003]	[0.004]
$Impsh^{HI}$		7.408				19.819**			5.884	16.793
		[9.544]				[9.832]			[10.688]	[11.366]
N^{input}			-0.457***				0.029		0.144	0.055
			[0.170]				[0.180]		[0.160]	[0.161]
$Herf$				-0.525***				-0.229**	-0.16	0.082
				[0.096]				[0.098]	[0.117]	[0.118]
K					-0.135***	-0.117***	-0.135***	-0.107***	-0.119***	-0.104***
					[0.017]	[0.010]	[0.018]	[0.010]	[0.013]	[0.013]
l										-0.090***
										[0.010]
lp										-0.006
										[0.009]
imp										-0.083***
										[0.027]
I_{tang}										-0.110***
										[0.025]
I_{intang}										0.01
										[0.021]
$wage$										-0.098***
										[0.020]
Constant	-1.256***	-1.347***	1.025	-1.132***	-1.356***	-1.382***	-1.531*	-1.277***	-2.005**	-0.225
	[0.044]	[0.011]	[0.865]	[0.040]	[0.045]	[0.011]	[0.921]	[0.041]	[0.796]	[0.816]
hline										
Observations	4061	4168	4168	4139	4061	4168	4168	4139	4035	3919
R-squared	0.056	0	0.057	0.007	0.071	0.031	0.071	0.031	0.032	0.096

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Robust standard errors in brackets.
σ: average, across products exported by the firm in 2002, elasticity of substitution. σs are sourced from Broda and Weinstein (2006).
$Impsh^{HI}$: average, across products exported by the firm in 2002, of the share of imports by High income economies in total world imports for the product. Imports at 6 digit HS 2002 for year 2002 come from COMTRADE-WITS-World Bank online database.
N^{input}: log of average, across products exported by the firm in 2002, number of inputs employed by product p computed by exploiting the US commodity-commodity Total Requirements Table for 2002.
$Herf$: average, across products exported by the firm in 2002, product Herfindahl index retrieved from EDD of World Bank for 2002.

7 Conclusions

With this work we have contributed to empirical literature on the role of countries' trade specialisation for economic growth.

By using firm level data on Turkish manufacturing sectors we have shown, for the first time to our knowledge, that firms' higher export complexity reduces their volatility and this finding is robust to several sensitivity checks. Furthermore, we have found that specialising in complex productions positively affects firms' output stability, regardless of their involvement in export markets. The potential consequences of product sophistication for an economy are, therefore, sizeable. Finally, by measuring product complexity according to the Hausmann and Hidalgo's (2009) indicator we have enlarged the scope of possible channels through which specialisation in more sophisticated goods can promote more stable growth. As a matter of fact, we have found that the stabilising effect of firm complexity works both through demand and supply side channels. Besides wider technological diversification which allows cushioning input specific shocks, higher income elasticity and entry barriers drive the negative effect of firms' product complexity on their volatility. The former allows for more stable sales, due to reduced exposition of richer consumers' incomes to external shocks, the latter, instead, reduce the extent of competition in the market for product and, then, curb incumbents' turnover fluctuations.

Two main insights emerge from our work.

First, as long as trade integration across countries involved in global production networks confines emerging countries' firms in less complex productions, the growth path of these economies is doomed to be unstable and this could be detrimental for their long run growth perspectives.

Second, product complexity is a further important dimension of heterogeneity across firms with very similar relevant observable characteristics. More specifically, our evidence shows that such heterogeneity matters for the stability of firms sharing the same institutional framework and all having access to the same production factors. Differences in complexity levels across firms encompass product differences in technological diversification, in the extent of entry barriers and in the price and income elasticities. Complexity appears then to be importantly determined by firms' time-varying unobservables, among which managerial and workforce competencies and skills undoubtedly play a key role.

As firm product sophistication could importantly affect a country's overall economic growth performance, our evidence suggests that micro policies for growth could be relevant. Promoting creation, upgrading and diffusing entrepreneurial human capital and managerial skills could allow firms to upgrade production and hook onto a more stable growth path. This would promote less volatile and, hence, higher aggregate growth.

Future research should be devoted to delving further into the notion of firm complexity. In particular, the most important goal would be to map firms' capabilities into their product baskets. The availability of linked employer-employee database would allow to measure and identify firms' capabilities on the bases of their workforce's skills and competencies. Then, one could verify if more complex firms are less volatile due to their wider range of capabilities which allows them to be more flexible and to more easily adjust production to external shocks.

References

Acemoglu, D., Carvalho, V.M., Ozdaglar, A., Tahbaz-Salehi, A., 2012. The Network Origins of Aggregate Fluctuations. Econometrica 80, 1977–2016.

Acemoglu, D., Zilibotti, F., 1997. Was prometheus unbound by chance? risk, diversification, and growth. Journal of Political Economy 105, 709–51.

Barrientos, S., Kabeer, N., Hossain, N., 2004. The gender dimensions of the globalization of production. World Commission on the Social Dimension of Globalization - Working Papers 17. International Labour Office - Policy Integration Department.

Barro, R.J., McCleary, R., 2003. Religion and Economic Growth. NBER Working Papers 9682. National Bureau of Economic Research, Inc.

Bernard, A., Jensen, J., 2004. Why some firms export. The Review of Economics and Statistics , 561–569.

Blanchard, O., Simon, J., 2001. The Long and Large Decline in U.S. Output Volatility. Brookings Papers on Economic Activity 32, 135–174.

Blattman, C., Hwang, J., Williamson, J.G., 2007. Winners and losers in the commodity lottery: The impact of terms of trade growth and volatility in the Periphery 1870-1939. Journal of Development Economics 82, 156–179.

Broda, C., Weinstein, D.E., 2006. Globalization and the Gains from Variety. The Quarterly Journal of Economics 121, 541–585.

Buch, C.M., Döpke, J., Strotmann, H., 2009. Does Export Openness Increase Firm-level Output Volatility? The World Economy 32, 531–551.

Caron, J., Fally, T., Markusen, J.R., 2012. Skill Premium and Trade Puzzles: a Solution Linking Production and Preferences. NBER Working Papers 18131. National Bureau of Economic Research, Inc.

Chaney, E., 2008. Tolerance, Religious Competition and the Rise and Fall of Muslim Science. mimeo. Harvard University.

Costinot, A., 2009. On the origins of comparative advantage. Journal of International Economics 77, 255–264.

Davis, S.J., Haltiwanger, J., Jarmin, R., Miranda, J., 2007. Volatility and Dispersion in Business Growth Rates: Publicly Traded versus Privately Held Firms, in: NBER Macroeconomics Annual 2006, Volume 21. National Bureau of Economic Research, Inc. NBER Chapters, pp. 107–180.

Easterly, W., Islam, R., J. E., S., 2000. Shaken and stirred: Explaining growth volatility. mimeo .

Feenstra, R.C., Romalis, J., 2014. International prices and endogenous quality. The Quarterly Journal of Economics .

Felipe, J., Kumar, U., Abdon, A., Bacate, M., 2012. Product complexity and economic development. Structural Change and Economic Dynamics 23, 36 – 68.

Fieler, A.C., 2011. Nonhomotheticity and Bilateral Trade: Evidence and a Quantitative Explanation. Econometrica 79, 1069–1101.

Gabaix, X., 2011. The granular origins of aggregate fluctuations. Econometrica 79, 733–772.

García-Vega, M., Guariglia, A., Spaliara, M.E., 2012. Volatility, financial constraints, and trade. International Review of Economics & Finance 21, 57–76.

di Giovanni, J., Levchenko, A.A., 2009. Trade Openness and Volatility. The Review of Economics and Statistics 91, 558–585.

di Giovanni, J., Levchenko, A.A., 2011. The Risk Content of Exports: A Portfolio View of International Trade, in: NBER International Seminar on Macroeconomics 2011. National Bureau of Economic Research, Inc. NBER Chapters, pp. 97–151.

di Giovanni, J., Levchenko, A.A., 2012. Country Size, International Trade, and Aggregate Fluctuations in Granular Economies. Journal of Political Economy 120, 1083 – 1132.

di Giovanni, J., Levchenko, A.A., Mejean, I., 2014. Firms, destinations, and aggregate fluctuations. Econometrica .

Hallak, J.C., 2006. Product quality and the direction of trade. Journal of International Economics 68, 238–265.

Hausmann, R., Hidalgo, C., 2011. The network structure of economic output. Journal of Economic Growth 16, 309–342.

Hausmann, R., Hidalgo, C.A., 2009. The building blocks of economic complexity. Proc. Natl. Acad. Sci. 106, 10570–10575.

Hausmann, R., Hwang, J., Rodrik, D., 2007. What you export matters. Journal of Economic Growth 12, 1–25.

Hidalgo, C., 2009. The dynamics of economic complexity and the product space over a 42 year period. Working Papers 189. Center for International Development, Harvard University.

Hnatkovska, V., Loayza, N., 2004. Volatility and growth. Policy Research Working Paper Series 3184. The World Bank.

Imbs, J., Wacziarg, R., 2003. Stages of Diversification. American Economic Review 93, 63–86.

Irvine, P.J., Pontiff, J., 2009. Idiosyncratic Return Volatility, Cash Flows, and Product Market Competition. Review of Financial Studies, Society for Financial Studies 22, 1149–1177.

Kalemli-Ozcan, S., Sorensen, B., Volosovych, V., 2014. Deep financial integration and volatility. Journal of the European Economic Association .

Koren, M., Tenreyro, S., 2007. Volatility and Development. The Quarterly Journal of Economics 122, 243–287.

Koren, M., Tenreyro, S., 2013. Technological Diversification. American Economic Review 103, 378–414.

Kose, M. A., E.S.P., Terrones, M.E., 2003. inancial integration and macroeconomic volatility. mimeo .

Kraay, A., Ventura, J., 2007. Comparative Advantage and the Cross-section of Business Cycles. Journal of the European Economic Association 5, 1300–1333.

Krishna, P., Levchenko, A.A., 2013. Comparative advantage, complexity, and volatility. Journal of Economic Behavior & Organization 94, 314–329.

Kuran, T., 1997. Islam and Underdevelopment: An Old Puzzle Revisited. Journal of Institutional and Theoretical Economics 153, 41–71.

Levchenko, A.A., 2007. Institutional Quality and International Trade. Review of Economic Studies 74, 791–819.

Lin, S.C., Kim, D.H., 2014. The link between economic growth and growth volatility. Empirical Economics 46, 43–63.

Lo Turco, A., Maggioni, D., 2014. The micro evolution of trade and turnover in turkey under the global crisis. Economic Systems .

Manova, K., Zhang, Z., 2012. Export prices across firms and destinations. The Quarterly Journal of Economics 127, 379–436.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71, 1695–1725.

Melitz, M.J., Ottaviano, G.I.P., 2008. Market size, trade, and productivity. Review of Economic Studies 75, 295–316.

Norrbin, S.C., Yigit, F.P., 2005. The Robustness of the Link between Volatility and Growth of Output. Review of World Economics (Weltwirtschaftliches Archiv) 141, 343–356.

Novy, D., Taylor, A.M., 2014. Trade and Uncertainty. NBER Working Papers 19941. National Bureau of Economic Research, Inc.

Nunn, N., 2007. Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade. The Quarterly Journal of Economics 122, 569–600.

OECD, 2005. Micro-policies for growth and productivity. Technical Report. OECD.

Ottaviano, G., Mayer, T., 2007. The happy few: the internationalisation of European firms. Number 12 in Blueprints, Bruegel.

Poncet, S., de Waldemar, F.S., 2012. Export upgrading and growth: the prerequisite of domestic embeddedness. Working Papers 2012-26. CEPII research center.

Ramey, G., Ramey, V.A., 1995. Cross-Country Evidence on the Link between Volatility and Growth. American Economic Review 85, 1138–51.

Stanley, M.H., Amaral, L.A., Buldyrev, S.V., Havlin, S., Leschhorn, H., Maass, P., Salinger, M.A., Stanley, H.E., 1996. Scaling behaviour in the growth of companies. Nature 379, 804–806.

Sutton, J., 2002. The variance of firm growth rates: the 'scaling' puzzle. Physica A 312, 577–590.

Tacchella, A., Cristelli, M., Caldarelli, G., Gabrielli, A., Pietronero, L., 2013. Economic complexity: Conceptual grounding of a new metrics for global competitiveness. Journal of Economic Dynamics and Control 37, 1683 – 1691.

Vannoorenberghe, G., 2012. Firm-level volatility and exports. Journal of International Economics 86, 57 – 67.

Appendix

A Additional Figures and Tables

Figure A.1: Observed Firm Volatility by Export Complexity Levels

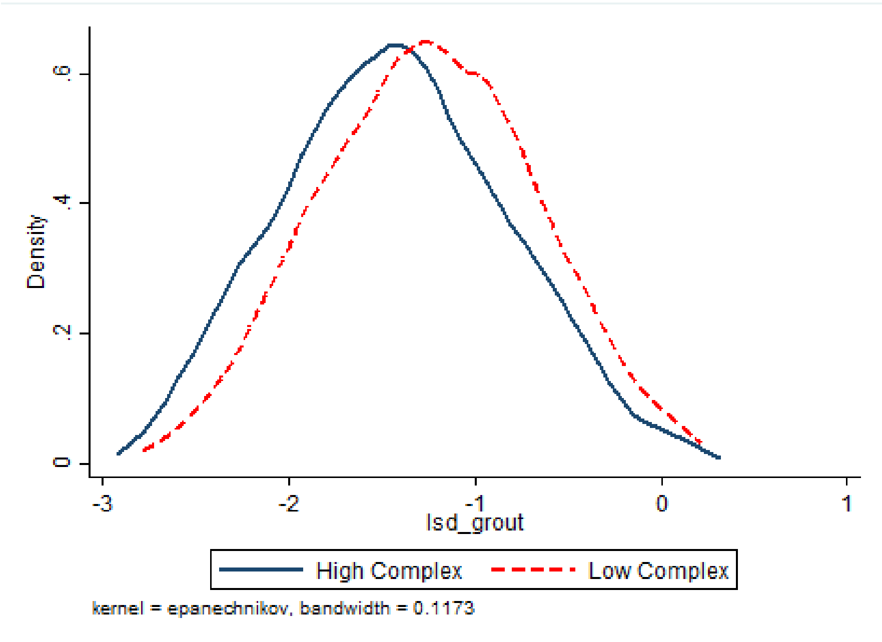

Table A.1: Firm Volatility and Export Complexity: The Channels - Three Stages Least Squares

	K				K^w			
	(1)		(2)		(3)		(4)	
	gvol	K	gvol	K	gvol	K^w	gvol	K^w
K/K^w	-0.101**		-0.104**		-0.099**		-0.098**	
	[0.044]		[0.042]		[0.050]		[0.048]	
σ		-0.204***		-0.153***		-0.190***		-0.148***
		[0.024]		[0.023]		[0.023]		[0.023]
N^{CC}_{TR}		6.652***				5.850***		
		[0.165]				[0.153]		
N^{IC}_{TR}				6.051***				5.330***
				[0.130]				[0.123]
$Herf$		1.271***		1.024***		1.163***		0.976***
		[0.127]		[0.122]		[0.114]		[0.110]
l	-0.094***		-0.094***		-0.098***		-0.098***	
	[0.010]		[0.010]		[0.010]		[0.010]	
lp	-0.003		-0.003		-0.004		-0.004	
	[0.009]		[0.009]		[0.009]		[0.009]	
imp	-0.092***		-0.092***		-0.093***		-0.094***	
	[0.027]		[0.027]		[0.027]		[0.027]	
I_{tang}	-0.106***		-0.106***		-0.105***		-0.105***	
	[0.024]		[0.024]		[0.024]		[0.024]	
I_{intang}	0.006		0.006		0.003		0.003	
	[0.021]		[0.021]		[0.021]		[0.021]	
$wage$	-0.092***		-0.093***		-0.093***		-0.093***	
	[0.020]		[0.020]		[0.020]		[0.020]	
$cons$	0.081	-33.988***	0.084	-31.665***	0.108	-30.002***	0.111	-28.013***
	[0.177]	[0.816]	[0.175]	[0.657]	[0.179]	[0.756]	[0.178]	[0.622]
Observations	3919	3919	3919	3919	3919	3919	3919	3919
R^2	0.133	0.373	0.133	0.429	0.133	0.34	0.133	0.387
year FE	yes	yes	yes	yes	yes	yes	yes	yes
2digit NACE FE	yes	no	yes	no	yes	no	yes	no

Notes: * Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Standard errors in brackets.

Figure A.2: Actual and Predicted Volatility - Different Counterfactual