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Export characteristics and output volatility: comparative firm-level evidence for CEE countries

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Abstract

The literature shows that openness to trade improves long-term growth but also that it may increase exposure to high output volatility. In this vein, our paper investigates whether exporting and export diversification at the firm level have an effect on the output volatility of firms. We use large representative firm-level databases from Estonia, Hungary, Romania, Slovakia and Slovenia over the last boom-bust cycle in 2004–2012. The results confirm that exporting is related to higher volatility at the firm level. There is also evidence that this effect increased during the Great Recession due to the large negative shocks in export markets. In contrast to the literature and empirical findings for large or advanced countries we do not find a statistically significant and consistent mitigating effect from export diversification in the Central and Eastern European countries. In addition, exporting more products or serving more markets does not necessarily result in higher stability of firm sales.

JEL Codes: F14, F43, O57

Keywords: export diversification, export share, volatility of sales, business cycle, Central and Eastern Europe, CEE

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Non-technical summary

The ability to serve foreign markets is frequently associated with higher efficiency, growth or prosperity. However, several studies have confirmed that involvement in foreign trade tends to increase output volatility. The available macro-level evidence suggests that the higher volatility is a side-effect of the specialisation induced by rising trade and of the sector-specific shocks that dominate GDP volatility. More recent literature indicates that openness to trade does not increase volatility if trade is well diversified (see e.g. Bejan (2006) and Haddad et al. (2013)).

We try to shed more light on the link between exporting, export diversification and output volatility using detailed firm-level data. The relatively scarce firm-level evidence available so far offers ambiguous conclusions. Buch et al. (2009) and Kurz and Senses (2015) find exporting to be related to lower volatility, while Vannoorenberghe (2012) and Nguyen and Schaur (2010) find exporting to be related to higher volatility. Our paper contributes to the literature by applying the exact same methodology to large representative firm-level databases from five countries. Data for manufacturing firms from Estonia, Hungary, Romania, Slovakia and Slovenia are used. These Central and Eastern European countries form a good case study as they have all experienced high volatility and openness, but have different diversification patterns.

The paper builds on the annual firm-level balance sheets and customs data from the joint ECB cross-country microdata project of CompNet (Lopez-Garcia and di Mauro (2015)). It ensures that common procedures have been applied to define the variables analysed and to clean the data from outliers in order to achieve a high rate of cross-country comparability and validity of the data. In addition, we use detailed trade flow information that allows us to define the export diversification at the 6-digit HS product (the Harmonized System of the World Customs Organization) and destination markets level. The export diversification is measured as the Herfindahl concentration index of product sales shares and market sales shares, while output volatility is measured as the standard deviation of the firm-level real sales growth rate over a period of four years.

In our baseline model we investigate the relationship between the volatility of sales during the crisis in 2009–2012 and the pre-crisis export share and diversification in 2008. This setting helps us reduce the endogeneity problem. Our set of control variables covers capital intensity, total factor productivity, employment, firm age and a foreign ownership dummy. In addition, we test whether the effect of diversification changed over the last

business cycle in 2004–2012 and whether the results are robust to alternative measures of diversification and volatility.

We find that unconditional volatility increased over the period 2004–2012 in all the sample countries, and this is related to the inclusion of the recession year 2009 in the later periods of volatility. It is also evident in most of the countries that volatility has increased substantially more for exporting firms than for non-exporting firms, while the difference between more and less diversified exporters is hardly noticeable. The conditional regression analysis confirms these findings. Firms with a higher export share are found to have higher volatility in three of the five sample countries, Hungary, Slovakia and Slovenia, and the size of the effect is also economically large. An export share that is one standard deviation higher is related to higher volatility of one fifth to one quarter of a standard deviation in volatility. Interestingly, the effect becomes economically larger during the more recent years, which also take in the Great Recession. Unlike in Estonia and Romania, where the correlation between export specialisation and volatility is less clear, the strong effects in Hungary, Slovakia and Slovenia may arise because these three countries export products like transport equipment and electronics that are subject to high volatility (see Koren and Tenreyro (2007)).

In contrast to the results in the macro-level literature, the effect of diversification on output volatility that we have identified at firm level remains statistically insignificant for most of the cases. The diversification effect occasionally becomes statistically significant for the Hungarian and Slovenian sample, where more diversified firms experience lower volatility. In general however, control variables such as firm productivity, size and age are much more strongly related to firm volatility than export diversification. The results are similar for the diversification of products and diversification of destination markets. Our results support the idea that diversification of exports has an ambiguous effect on output volatility, meaning that exporting more products or serving more markets is not necessarily related to higher stability for firm sales. This finding is in line with our theoretical specification, especially during a joint global shock represented by the recent economic crisis, when the impact of the synchronised shocks outweighs the impact of the diversification. Our results remain robust to different robustness tests.

Contents

1. Introduction

Since the influential work by Ramey and Ramey (1995), many empirical studies have been concerned that higher volatility can lead to lower growth. In the global economy, the issue often translates to the view in academic and policy discussions that openness to international trade leads to higher GDP volatility. This view hinges on the two assumptions that openness to trade increases specialisation and that GDP volatility is dominantly led by sector-specific shocks. However, Bejan (2006) and Haddad et al. (2013) show that openness to trade does not necessarily increase growth volatility if the export basket is diversified.

The same assumption was called into question by several empirical studies (e.g. Koren and Tenreyro (2007)) that showed that country-specific shocks, shocks common to all sectors in a given country, are at least as important as sector-specific shocks. Subsequently, Caselli et al. (2012) highlighted how the sign and size of the effect of exporting on GDP volatility depend on the volatility of shocks in the trading partners of the country and the correlation between those shocks and the shock affecting the domestic economy. More specifically, higher volatility arises when foreign markets are more volatile than the domestic market and when there is a high correlation between country-specific shocks.

Although macro level studies are quite abundant, empirical evidence on exporting and volatility at the firm level is scarce and inconclusive. In this paper we study the relationship between exporting and export diversification and output volatility at the firm level using comparative microdata from five countries. Our contribution to the literature is threefold. First, we apply an identical methodology to large representative firm-level databases from five countries. Data for manufacturing firms from Estonia, Hungary, Romania, Slovakia and Slovenia are used. These five countries form a good case study because they have all experienced fast growth and high volatility, but they have different diversification patterns. Second, we test whether the effect of exporting and diversification on volatility changed over the business cycle. The time period analysed covers the recent business cycle of 2004–2012 for most of the sample countries. There are rich dynamics in firm sales during this time, making it possible to study the effect of exporting and diversification on volatility over the boom and bust period. Finally, we apply several external and internal control variables, such as firm productivity, size, age, ownership, and homogeneity of destination markets, to test the robustness of the explanatory variables, which are exporting and export diversification

Our results show that exporting has a positive effect on firm-level output volatility, meaning that exporting a higher share of sales leads to higher sales

volatility for firms. The positive effect of exporting on volatility increases during the Great Recession and is the strongest in Hungary, Slovakia and Slovenia. This result is most likely related to the strong negative shock in export markets during the recession. However, we do not find that exporters that are more diversified have lower volatility. The diversification effects are weak and rarely statistically significant in terms of the variety of products or the variety of destination markets. The strongest diversification effect is observed in Hungary and Slovenia where exporting to many destination markets reduces volatility, while the effect is ambiguous for the rest of the countries. There is evidence that other factors like firm productivity, size and age are more strongly negatively correlated with volatility than export diversification is.

Our paper adds to the growing evidence on the granular nature of aggregate growth volatility, found in e.g., Gabaix (2011), which has shed light on the importance of the firm heterogeneity that lies behind the macro aggregates. In this vein, di Giovanni et al. (2014) analyse the link between export diversification and volatility by applying the Melitz (2003) model of heterogeneous firms with export entry costs. Di Giovanni et al. (2014) study the role of firms in the business cycle by disentangling the role of country, sector and firm-specific shocks. They argue that synchronisation of the business cycles of destination countries, or cross-sector correlation due to input-output linkages, increases aggregate volatility, whereas diversification across markets and sectors reduces aggregate volatility. Similarly, firm-level co-movement of sales and the higher volatility of larger firms are factors making the contributions of firm-specific shocks to aggregate volatility higher. Kramarz et al. (2014) find similar results by examining networks.

Our paper is more closely linked to the empirical studies, although the evidence on the contribution of firm-level openness is still ambiguous. On one side are the results of Buch et al. (2009) and Kurz and Senses (2015), which show that exporters have lower volatility, and that this effect stems mostly from the extensive margin and not from the intensive margin (Buch et al. (2009)), while in the other camp are Vannoorenberghe (2012) and Nguyen and Schaur (2010), who find that a large export share is related to higher sales volatility. Vannoorenberghe (2012) also shows that the sales to domestic and foreign markets are negatively correlated, indicating the simultaneity of the diversification decision and volatility. Kurz and Senses (2015) study the effect of the number of export products and markets on employment volatility and find that diversification reduces volatility. Evidence also points to the importance of firm size. Vannoorenberghe et al. (2014) find the export diversification patterns to be different for small and large firms as export diversification is related to higher volatility in small firms and to lower vola-

tility in large firms. The main channel making export volatility higher for small firms is that smaller firms occasionally export to new markets.

These micro-level empirical studies are based almost exclusively on information on firms from large advanced countries like the USA, Germany or France. The only empirical studies on the export diversification effect (Vannoorenberghe et al. (2014) and Kurz and Senses (2015)) use Chinese and US firm-level data.

Our paper is organised as follows. The next section provides the background for the study by presenting a theoretical model motivating the empirical specification and the characteristics of the sample countries. The third section describes the empirical specification and the data. The fourth section presents the results together with a number of robustness tests, and the last section summarises the results.

2. Background of the study

2.1. Theoretical setting

This section presents a simple theoretical model to show how various shocks can affect the volatility of output of firms. We build on Buch et al. (2009), who consider a neoclassical model where firms maximise profits in an exogenous environment. Firm i produces output Y_{it} using the Cobb-Douglas production function with constant returns to scale and with domestic labour L_{it} and domestic capital K_{it} as inputs:

$$Y_{it} = A_{it} L_{it}^{\alpha} K_{it}^{1-\alpha} \tag{1}$$

where α denotes the labour share and A_{it} is the parameter capturing technology. Unlike in Buch et al. (2009) we allow productivity shocks to be firm-specific and not common to all the firms in the country. This extension does not change the main outcome of the theoretical model, but is in line with our empirical specification where total factor productivity is measured at the firm level. As in the model, we assume that the firm sells a time-invariant share of output, λ_i , domestically and exports the rest. The firm can sell to one or more foreign markets k with the sum of foreign market shares, $\sum_{k=1}^{K} \lambda_{ki}^{*}$, totalling $1-\lambda_i$. The firm's profit in time t is then defined as:

$$\pi_{it} = [p_t \lambda_i + \sum_{k=1}^{K} (p_{kt}^{*} - c_{kt}) \lambda_{ki}^{*}] Y_{it} - w_t L_{it} - r_t K_{it} \tag{2}$$

where p_t and p^*_{kt} denote the prices of products sold in the domestic and in the foreign market k respectively; variable c_{kt} represents the per-unit cost of exporting to the foreign market k, and w_t and r_t denote the prices of labour and capital respectively.

The prices of the product in the domestic market p_t and in foreign markets p^*_{kt} are given to the firm and so is the exporting cost per unit of product for each destination market, c_{kt}. The firm finds the optimal demand for labour given that the market shares, λ_i and λ^*_{ki}, and capital, K_{it}, are fixed in the short run. Taking the first-order conditions for the profit maximisation function (2) and solving for labour yields:

$$L^D_{it} = \left(\frac{w_t}{[p_t\lambda_i + \sum_{k=1}^{K}(p^*_{kt} - c_k)\lambda^*_{ki}]\alpha A_{it}}\right)^{\frac{1}{\alpha-1}} = \left(\frac{w_t}{d_{it}\alpha A_{it}}\right)^{-\eta^D} \quad (3)$$

where $d_{it} = [p_t\lambda_i + \sum_{k=1}^{K}(p^*_{kt} - c_k)\lambda^*_{ki}]$ denotes demand conditions in domestic and foreign markets and $-\eta^D = 1/(\alpha-1)$ denotes the value of the labour demand elasticity. The labour supply is given by $L^S_t = (w/p)^{\eta^S}_t$, and then solving for equilibrium wages and equilibrium employment gives $L = (d\alpha A)^{\frac{\eta^D\eta^S}{\eta^D+\eta^S}}$. Substituting optimal demand for labour in the production function and taking logarithms gives:

$$ln\bar{Y} = \beta_0 + \beta_1 ln\bar{A} + \beta_2 ln\bar{d} + \beta_3 ln\bar{K} \quad (4)$$

where

$$\beta_0 = \alpha[\eta^D\eta^S/(\eta^D + \eta^S)]ln\alpha,$$
$$\beta_1 = 1 + \alpha[\eta^D\eta^S/(\eta^D + \eta^S)],$$
$$\beta_2 = \alpha[\eta^D\eta^S/(\eta^D + \eta^S)],$$
$$\beta_3 = 1 - \alpha.$$

Variables with bars denote equilibrium values. With a state of equilibrium, summarised in equation (4), the time subscripts are suppressed from here on. Let us assume the firm faces random technology, demand and capital cost shocks, γ_A, γ_d and γ_K respectively. The variables can be then defined as $= \bar{A}e^{\gamma_A}$, $d = \bar{d}e^{\gamma_d} = \bar{d}e^{\gamma_p\lambda + \sum_k \gamma_{p^*_k}\lambda^*_k}$, and $K = \bar{K}e^{\gamma_K}$, where the demand shock depends on the domestic and foreign demand shocks. In addition, we assume that firm-specific shocks to A and K are not correlated with each other or with the demand shock $\rho(\gamma_d, \gamma_A) = 0$, $\rho(\gamma_d, \gamma_K) = 0$, $\rho(\gamma_A, \gamma_K) = 0$, while the demand shocks of production markets can be correlated, but are not perfectly correlated $-1 < \left|\rho\left(\gamma_p, \gamma_{p^*_k}\right)\right| < 1$ for every foreign market k and $-1 < \left|\rho\left(\gamma_{p^*_j}, \gamma_{p^*_k}\right)\right| < 1$ for every foreign market $k \neq j$. The output with random shocks is given by:

$$Y = \exp(\beta_0 + \beta_1 (\ln(\bar{A}) + \gamma_A) + \beta_2(\ln(\bar{d}) + \gamma_d) + \beta_3(\ln(\bar{K}) + \gamma_K)) \quad (5)$$

After deriving the expressions of output with random shocks over the equilibrium output, we obtain the following percentage deviation from the equilibrium, which we consider as a proxy for output growth:

$$\ln\left(\frac{Y}{\bar{Y}}\right) = \beta_0 + \beta_1 (\ln(\bar{A}) + \gamma_A) + \beta_2(\ln(\bar{d}) + \gamma_d) + \beta_3(\ln(\bar{K}) + \gamma_K) - (\beta_0 + \beta_1 \ln(\bar{A}) + \beta_2 \ln(\bar{d}) + \beta_3 \ln(\bar{K})) = \beta_1\gamma_A + \beta_2\gamma_d + \beta_3\gamma_K \quad (6)$$

By substituting γ_d for $\left(\gamma_p\lambda + \sum_k \gamma_{p_k^*}\lambda_k^*\right)$, the variance of the output growth becomes:

$$Var\left(ln\left(\frac{\hat{Y}}{Y}\right)\right) = \beta_1^2 Var(\gamma_A) + \beta_2^2\left[\lambda^2 Var(\gamma_p) + \sum\nolimits_k {\lambda_k^*}^2 Var(\gamma_{p_k^*})\right] + \beta_3^2 Var(\gamma_k) + +2 \times \beta_2^2\left[\sum_k \lambda\lambda_k^* Cov(\gamma_p, \gamma_{p_k^*}) + \sum_{k\neq j} \lambda_k^*\lambda_j^* Cov(\gamma_{p_k^*}, \gamma_{p_j^*})\right] \quad (7)$$

If a firm is producing for one market only, be it domestic or foreign, the variance of output depends on three components: variance of productivity shocks, variance of demand shocks in the market, and variance of shocks to capital. If a firm is producing not for one but for n markets, then the output volatility equation is composed of $(n^2 + 2)$ components, which are two variances representing the technology and capital cost shocks, n variances to the demand shocks, and $\frac{n(n-1)}{2}$ double covariances between the demand shocks for all the markets. Due to the complexity of relations, entry to an additional market could either decrease output volatility because of the diversification effect in the covariance terms, or increase the output volatility because of the high variance or covariance of demand shocks of a firm in additional markets.

The relationship between diversification of markets and volatility can thus be positive or negative, depending on the volatility of the markets served by a firm and the covariance of shocks between those markets. We cannot disentangle the diversification and composition effects empirically, but these mechanisms help us to understand and explain the effect of diversification on volatility in the empirical section.

2.2. Volatility and openness at the country level

There are a large number of studies examining the link between openness and volatility using industry or country-level data. The main mechanism behind the positive relationship between openness and volatility is claimed to be more specialisation accompanied by openness. Rodrik (1998) argues that trade reduces aggregate risk for a country as the world market is less volatile than a single economy, but it also increases the specialisation that leads to concentration of products and increases aggregate risks. He shows that product concentration is positively correlated with growth volatility. Di Giovanni and Levchenko (2009) show that industries more open to trade have higher volatility, but weaker correlation between industry growth and aggregate growth. They show that the main mechanism behind the positive correlation of openness and volatility is the higher specialisation of more open countries. Haddad et al. (2013) demonstrate that trade diversification alters the relationship between openness and growth volatility. Very open economies have lower volatility when their exports are diversified and the diversification of products has a stronger effect on volatility than the diversification of markets.

In addition to the diversification effect, a smaller domestic market and a structure of exports biased towards less volatile markets can reduce the volatility from openness. Caselli et al. (2012) develop a model where the effect of openness on volatility depends on the size of the country, the variance of productivity shocks from other countries, and the covariance of domestic and foreign productivity shocks.

In this paper we use a sample of countries with comparable backgrounds in terms of openness and volatility. The following explanation provides a comparative background of the sample countries in terms of openness and volatility. All the countries are small, open economies from the upper middle and high-income group of countries according to the World Bank definition. The countries share common institutional features as they were all under a communist regime before the 1990s and switched to market economic reforms in the late 1980s or early 1990s. Although the speed and scope of the reforms have been different, their current level of institutional development is relatively similar. All these countries became WTO members in the 1990s and EU members in 2004 or 2007, and by 2015 three of them had joined the euro zone.[1]

Figure 1 shows the relationship between openness and volatility using data for OECD countries and EU members that have income levels comparable to

[1] Slovenia joined the euro zone in 2007, Slovakia in 2009 and Estonia in 2011; Hungary and Romania have a national currency with a floating exchange rate.

those of the sample countries. There is a weak and statistically insignificant positive correlation of 0.18 between export intensity and growth volatility within the ten years between 2003 and 2012. All the sample countries have had growth that is more volatile than the average in the OECD and the EU and most of the sample countries have also had higher openness. Three of the countries, Hungary, Slovakia and Slovenia, are very similar in their openness and growth volatility, while the largest country in the sample, Romania, is distinguished from the others by its much lower openness, and the smallest country in the sample, Estonia, stands out for its much higher growth volatility.

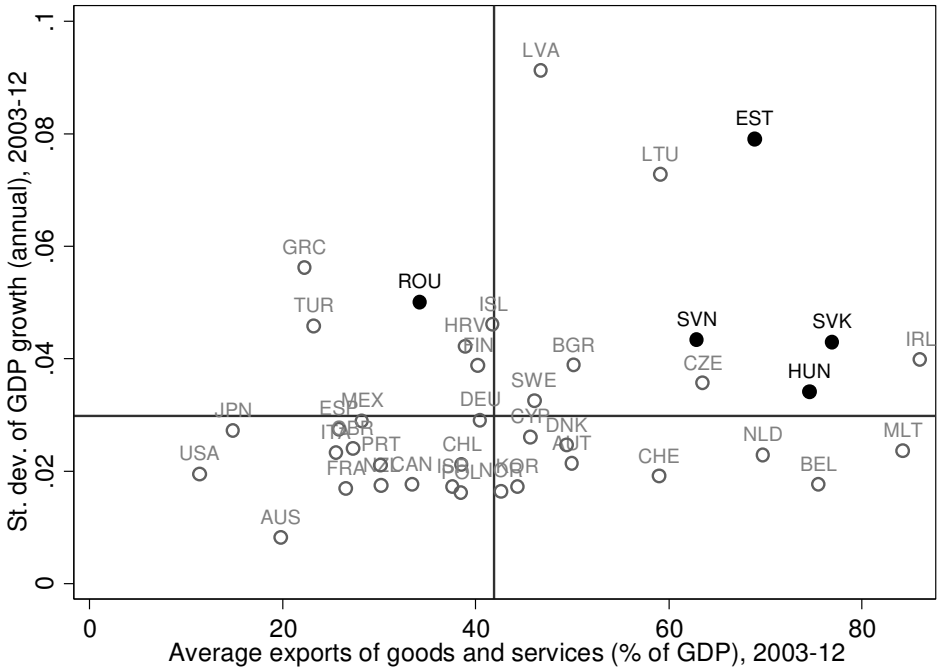

Figure 1: Openness and volatility, OECD and EU countries in 2003–2012

Note: Hollow symbols: OECD and EU countries; filled symbols: sample countries. The vertical line denotes the average openness of 41.9% and the horizontal line the average volatility of 0.030. Luxembourg is omitted because of its very high value for openness.

Source: World Bank, World Development Indicators.

The two largest countries in the sample, Romania and Hungary, export two thirds of their exports to the top ten destination markets, while the smaller countries in the sample have even more concentrated exports by destination. The most important products exported are electrical machinery, vehicles and machinery, and mechanical applications, which make up more than half of the exported products in Hungary and Slovakia and up to one third in Estonia and Slovenia. Aggregated country-level data show that Slo-

vakia and Estonia have the most concentrated exports geographically and are exposed to concentrated risks from neighbouring countries from Central Europe in Slovakia's case or from Scandinavia and Russia for Estonia. The covariance of shocks from destination markets is high as all the sample countries have a strong focus on trade within the EU internal market and within the euro area. There is also a strong common component of shocks from destination markets as the four Central European sample countries have Germany as the main export destination, taking one fifth to one quarter of their exports. (Statistics from UN Comtrade database)

Given these findings it is suggested that the main factors behind higher volatility in the sample countries are high openness, high export concentration and strong correlation of shocks across the destination markets. The trade of the sample countries is also concentrated in products such as transport equipment that are subject to high volatility from global sectoral shocks.[2] As a stabilising effect on foreign trade, the sample countries export mostly to high-income countries with less volatile growth. There is some cross-country variation in the diversification of exports in the sample countries, as the larger countries Romania and Hungary are less exposed to volatility risk from concentrated exports. Last but not least, the openness to trade is not necessarily the main factor behind high volatility as the domestic markets have also been highly volatile during recent decades. The sample countries have experienced a severe credit boom-bust cycle in asset prices (Bakker and Gulde (2010)).

3. Empirical specification and data

3.1. Empirical specification

There are two major challenges to empirical specification of the theoretical model presented in (7). First, it is difficult to measure volatility from firm-level data with yearly frequency. Given that the firms in the sample are relatively young, a panel specification where one observation in the time dimension is defined by a four or five-year interval would leave very many firms out of the panel. This attrition problem is not an issue in country-level or industry-level studies, but is of high relevance in firm-level studies. In order to keep as many firms as possible in the sample and keep the sample representative of the population, we propose a specification based on a cross-section where the volatility of output is computed over a four-year period. The volatility over a longer period of six years is shown as a robustness test.

[2] See Koren and Tenreyro (2007) for the list of sectors with more volatility from global sectoral shocks.

The second challenge is related to the endogeneity of the diversification decision in the output volatility equation. The endogeneity can originate from an omitted variable like an unobserved productivity shock that affects both volatility and diversification or from the simultaneity of volatility and diversification as firms can diversify their production in order to reduce the expected volatility of output. We address the first issue by introducing a specification that is strict in the chronological sequence of the diversification decision and volatility. The volatility in the period between time t+1 and time t+4 is dependent on the diversification decision in time t so that the unobserved productivity shock from the same period cannot affect both diversification and volatility.

The empirical specification aim to model the effect of the same variables as in equation (7) on output volatility. The parameters of the following equation (8) are estimated with the ordinary least squares methodology.

$$\begin{aligned} volatility_{i,t+1\ldots t+4} &= \beta_0 + \beta_1 \log(TFP_{i,t}) + \beta_2 \log(capital\_intensity_{i,t}) \\ &+ \beta_3 export\_concentration_{i,t} + \beta_4 export\_share_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{8}$$

The variable $volatility_{i,t+1\ldots t+4}$ denotes the standard deviation of real turnover growth over four years. In model (8) the sales volatility depends on total factor productivity (*TFP*), capital per employee (*capital intensity*), export concentration and the share of exports in sales (*export share*). All the explanatory variables are from period t, while the volatility is from period t+1 to t+4. The estimations are run only for manufacturing firms as the trade data cover exports of products and not services. We expect the coefficient $\beta_3 > 0$ if firms with more concentrated exports have higher volatility and $\beta_4 > 0$ if firms with higher export share have higher volatility.

An alternative specification is estimated with additional control variables in the volatility equation. Employment, firm age, and foreign ownership are added to equation (8). The introduction of additional variables is motivated by empirical evidence that small and young firms are more volatile (Fort et al. (2013)) and that subsidiaries of multinationals are more volatile (Barba Navaretti et al. (2003)).

Export concentration is measured by the Herfindahl index of export shares of products or markets. It is notable that the correlation between the diversification of products and the diversification of destination markets is relatively weak. This correlation is between 0.1 and 0.4 for all the sample countries, indicating that firms exporting many products do not necessarily export into many destination markets and firms exporting into many destination markets do not necessarily export many types of product. This result is in line with Amador and Opromolla (2013), who also find that the relationship between

diversification of products and destination markets is not one to one. Given that there is a weak positive correlation between the diversification of products and markets, two separate models are estimated for the diversification of products and the diversification of markets.

3.2. Data and descriptive statistics

This paper uses annual firm-level balance sheets, profit/loss statements and customs data. The balance sheet and profit/loss statement data were cleaned of outliers using an identical approach across countries. The datasets originate from the joint cross-country microdata project of CompNet.[3] To ensure better comparativeness across countries, we use a sample of firms that are larger, meaning they have 20 or more employees. Complementing the variables covered by the CompNet project, our customs data enable us to disentangle yearly trade flows at a very detailed level, distinguishing between flows related to products at the 6-digit HS level (the Harmonised System of the World Customs Organization) and also between destination markets. The paper focuses on the export volumes of manufacturing firms.

The output volatility is measured as the standard deviation of the firm-level real sales growth rate over a period of four years. The choice of four years is chosen as a trade-off between more information about volatility captured by a longer time span and a larger number of firms covered by a shorter time span. A longer timespan of six years is also used as a robustness test. The turnover is converted into real terms using NACE 2-digit industry level deflators. As we cannot control for mergers or acquisitions, observations with a decline of more than 50% in yearly sales or an increase of more than 100% in yearly sales are excluded, and only firms that have sales growth data for at least three years within a four year time span are taken into the analysis. Table 1 presents the descriptive statistics of the variables analysed.

[3] See Lopez-Garcia and di Mauro (2015) for more details about the definition of variables and outlier treatment; Benatti et al. (2014) for the validation of the data; and the following webpage for the data governance rules http://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_compnet.en.html. The databases from Estonia, Hungary and Romania cover the whole population of firms according to customs and Business Register data, while databases from Slovakia and Slovenia are based on a large representative sample of firms.

Table 1: Descriptive statistics of the variables analysed; volatility of real sales growth rate covers the period 2009–2012 and other variables cover 2008

	Estonia (n=187)	**Hungary[a] (n=1084)**	**Romania (n=1961)**	**Slovakia (n=886)**	**Slovenia (n=560)**
Standard deviation of sales growth:					
mean	0.241	0.230	0.220	0.235	0.206
standard deviation	0.126	0.128	0.124	0.132	0.110
Herfindahl index of HS6 products:					
mean	0.648	0.649	0.651	0.606	0.570
standard deviation	0.290	0.271	0.291	0.280	0.278
Herfindahl index of markets:					
mean	0.608	0.588	0.740	0.522	0.444
standard deviation	0.271	0.316	0.289	0.273	0.297
Export share in sales:					
mean	0.593	0.579	0.668	0.595	0.515
standard deviation	0.326	0.364	0.375	0.369	0.336
Log(TFP):					
mean	–0.054	0.779	1.180	–0.033	0.268
standard deviation	1.079	0.909	0.694	1.686	1.098
Log(capital per employee):					
mean	1.394	1.846	0.889	1.963	2.660
standard deviation	1.045	1.149	1.378	0.954	0.890
Employment:					
mean	88.8	254.5	248.0	243.0	189.4
standard deviation	93.4	506.8	530.6	471.0	346.4
Age:					
mean	12.7	4.7	12.9	11.3	16.8
standard deviation	4.0	0.8	5.3	4.9	7.2
Share of foreign owned firms[b] (base: domestic):					
mean	0.326	0.577	0.562	0.497	0.264
standard deviation	0.470	0.494	0.496	0.500	0.441

Notes:
[a] Firm age in the Hungarian sample is calculated as the years spent in the sample since 2004.
[b] Foreign owned firms are defined as a binary variable where majority foreign owned firms take the value "1" and the rest "0". All the monetary variables are in thousands of euros and in prices of 2005.

Source: authors' calculations from CompNet and customs data.

The diversification measure is calculated by the Herfindahl index for firm-level export flows in two categories, for products at 6-digit HS and for destination markets. The Herfindahl index is calculated as the sum of squared market shares in the two categories; the index varies between 0 and 1, and

has larger values for more concentrated exports and lower values for more diversified exports. There are various ways to measure the diversification of exports. Appendix 1 reports the count of products exported and destination markets served in 2008 and 2012. The level of diversification of products and markets varies somewhat across the countries; the median firms export around five to ten products, to around two to ten countries. Estonian, Hungarian and Romanian firms are diversified relatively little, with around 10–20% of firms exporting just one product in terms of the HS 6-digit classification, while Slovak and Slovenian firms are much more diversified, as less than 10% of firms export one product. Exports by Romanian firms are more concentrated in destination markets, with up to 40% of firms exporting to only one country. Sample countries with high concentration at the aggregate level do not necessarily have firms with concentrated exports, so Slovenian firms have relatively concentrated exports at the aggregate level (see Section 2.2), but Slovenian firms are well diversified.

On average, cross-country differences in the numbers of products or markets resemble the cross-country differences in the Herfindahl indices of concentration; see Appendix 1 and Table 1. However, the Herfindahl index is used as the default measure of diversification in estimations in the following sections, because it reflects the relative firm-level diversification more accurately. The different measure of diversification at 4-digit HS codes and at groups of countries is presented as a robustness test.

The sample firms are more volatile and more concentrated in terms of exports than the data in previous studies show (Buch et al. (2009) and Vannoorenberghe et al. (2014)). The main advantage of our database is that unlike previous studies we provide cross-country comparative evidence from comparable and well validated databases that also cover smaller firms. The firms in our sample are relatively small[4] and young. At the same time they have high international openness, as the export share in the sales of firms is higher than 50% and the share of foreign owned firms is as high as 50% in some of the sample countries (Table 1).

Figure 2 presents the firm-level unconditional sales volatility over the business cycle. The reported year in the figure indicates volatility between t+1 and t+4, for example the year 2004 shows the growth volatility between 2005 and 2008. The firm-level volatility correlates well with the business cycle; the volatility was low during the years of fast growth between 2005 and 2008 and increased substantially during the Great Recession in 2009. These dynamics are captured by low volatility in 2004 and by increased volatility since 2005 in the figure. The unconditional volatility of exporting firms

[4] The average firm in the sample is in the medium size category following the European definition where a medium sized firm has between 50 and 250 employees.

is more strongly correlated with the business cycle and exceeds the volatility of non-exporters during the crisis in most of the sample countries. The volatility of non-exporting firms is more stable over time in all the countries.

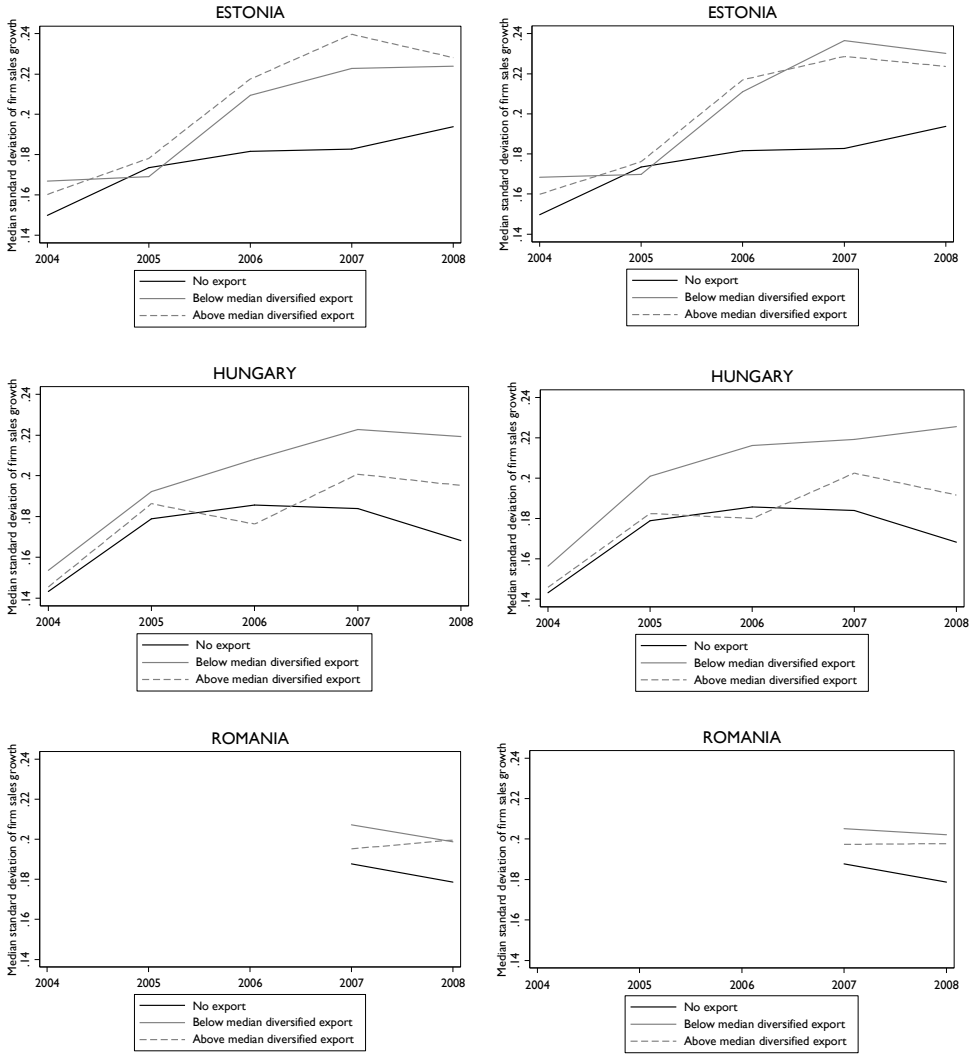

Figure 2: Unconditional real sales volatility over time: Left panel – firm diversification is classified over HS6 exported products; right panel – firm diversification is classified over destination markets

Note: Standard deviation of firm real sales growth is calculated over a four-year rolling window and reported for the year before the four-year period, for example 2004 refers to the volatility in 2005–2008. Data available on Romania only starts from 2007.

Source: authors' calculations from CompNet and customs data.

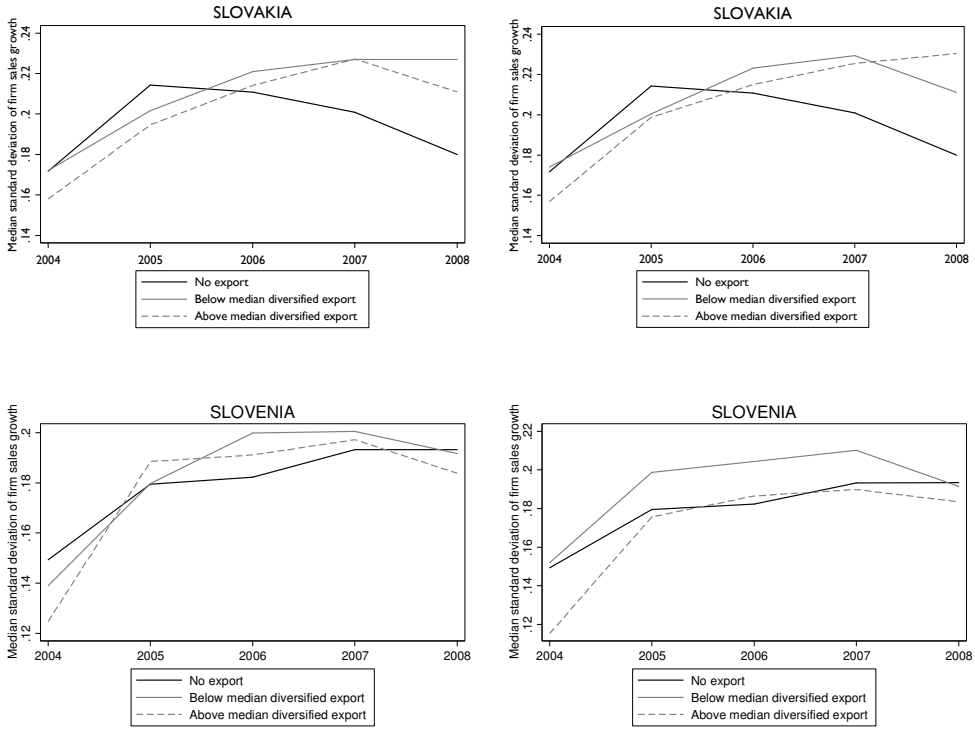

Figure 2. Unconditional real sales volatility over time: Left panel – firm diversification is classified over HS6 exported products; right panel – firm diversification is classified over destination markets (cont.)

Note: Standard deviation of firm real sales growth is calculated over a four-year rolling window and reported for the year before the four-year period, for example 2004 refers to the volatility in 2005–2008. Data available on Romania only starts from 2007.

Source: authors' calculations from CompNet and customs data.

According to Figure 2, the unconditional relationship between diversification and volatility of firm sales is rather ambiguous for exporting firms. Above and below median diversified exporters have similar levels and dynamics in volatility. Appendix 1 demonstrates that the diversification of exports did not change substantially over the Great Recession and it is likely that it was not the change in concentration, but the large and correlated negative shock in all the markets that was behind the increased volatility. Given the theoretical specification in section 2, it can be speculated that it is the higher variance of shocks and the stronger covariance between shocks in foreign markets that is behind the simultaneous increases in volatility. With the diversification of destination markets however, there is evidence that firms have become less diversified after the Great Recession in some countries.

4. Results

4.1. The baseline and alternative specification

This section presents the estimation results of equation (8); we start out with a baseline specification with fewer control variables and continue with an alternative specification that adds firm size, age and ownership as additional controls. Table 2 presents the results for the concentration of products and Table 3 presents those for the concentration of destination markets.

The volatility equation demonstrates that the concentrations of products and destination markets are usually positively correlated with volatility, demonstrating that a higher concentration of production is related to higher volatility. The relationship is seldom statistically significant and once it is even negative for the diversification of products. However, the concentration of destination markets is positively and statistically significantly related to output volatility in Hungary, Slovakia and Slovenia. Like the studies by Kurz and Senses (2015) and Vannoorenberghe et al. (2014) for large firms, we find that more diversified exporters have lower output volatility, but we find this relationship to hold only for the diversification of destination markets and even there it does not hold for all the sample countries.

The relationship between export intensity and sales volatility is less ambiguous, as firms with higher export share usually also have higher volatility, which is in line with the unconditional regularity that non-exporting firms are less volatile (see Figure 1) and with the findings of Vannoorenberghe (2012) and Nguyen and Schaur (2010). There are also differences across countries as firms with a higher export share have higher volatility in Hungary, Slovakia and Slovenia, while the relationship is insignificant in Estonia and Romania.

The coefficients for the remaining explanatory variables also have the expected signs in the output equation; more productive firms have lower volatility and more capital intensive firms have higher volatility. In line with the theory, more productive firms enjoy a larger scope for internal adjustments. The positive relationship between capital intensity and volatility may be related to adjustment costs being lower for capital than for labour.

Table 2: Product concentration and sales volatility, concentration in 2008 and volatility in 2009–2012

	Estonia	**Hungary**	**Romania**	**Slovakia**	**Slovenia**
Concentration of products	–0.052*	0.015	0.008	0.002	0.008
	(0.030)	(0.014)	(0.009)	(0.015)	(0.017)
Export share	–0.000	0.075***	0.006	0.057***	0.064***
	(0.029)	(0.011)	(0.009)	(0.013)	(0.014)
Log(TFP)	–0.024***	–0.007*	–0.020***	–0.002	0.001
	(0.008)	(0.004)	(0.004)	(0.003)	(0.004)
Log(capital per employee)	0.009	0.009***	0.007***	0.000	–0.008
	(0.008)	(0.003)	(0.002)	(0.005)	(0.005)
No of obs	187	1084	1961	888	576
R^2	0.052	0.042	0.013	0.028	0.045

Note: Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from CompNet and customs data.

Table 3: Market concentration and sales volatility, concentration in 2008 and volatility in 2009–2012

	Estonia	**Hungary**	**Romania**	**Slovakia**	**Slovenia**
Concentration of markets	0.001	0.057***	0.019*	0.004	0.037**
	(0.034)	(0.013)	(0.010)	(0.017)	(0.017)
Export share	0.009	0.073***	0.005	0.057***	0.075***
	(0.028)	(0.011)	(0.009)	(0.013)	(0.015)
Log(TFP)	–0.021***	–0.005	–0.019***	–0.002	0.002
	(0.008)	(0.004)	(0.004)	(0.003)	(0.004)
Log(capital per employee)	0.008	0.013***	0.008***	0.001	–0.005
	(0.009)	(0.004)	(0.002)	(0.005)	(0.005)
No of obs	187	1084	1961	888	576
R^2	0.039	0.059	0.015	0.028	0.053

Note: Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from CompNet and customs data.

Tables 4 and 5 present the results where additional control variables are added to the volatility equation. The relationship between export concentration and volatility becomes weaker and often negative, while the results for export intensity remain unchanged. Like in findings from previous studies, larger and older firms have lower volatility (Fort et al. (2013)), but unlike in previous studies the subsidiaries of multinationals are less volatile (Barba Navaretti et al. (2003)).

Table 4: Product concentration and sales volatility with additional controls, concentration in 2008 and volatility in 2009–2012

	Estonia	**Hungary**	**Romania**	**Slovakia**	**Slovenia**
Concentration of products	–0.045	0.015	–0.006	–0.006	–0.004
	(0.030)	(0.015)	(0.010)	(0.016)	(0.017)
Export share	0.018	0.069***	0.000	0.061***	0.080***
	(0.030)	(0.012)	(0.009)	(0.014)	(0.014)
Log(TFP)	–0.023***	–0.007*	–0.020***	–0.002	0.003
	(0.008)	(0.004)	(0.004)	(0.003)	(0.004)
Log(capital per employee)	0.009	0.008**	0.008***	0.003	–0.005
	(0.008)	(0.004)	(0.002)	(0.005)	(0.005)
Log(employment)	0.027**	0.000	–0.012***	–0.008*	–0.013**
	(0.012)	(0.004)	(0.003)	(0.005)	(0.005)
Log(age)	–0.027	0.014*	–0.022***	–0.019**	–0.012
	(0.020)	(0.008)	(0.007)	(0.008)	(0.010)
Foreign owned (base: domestic)	–0.053***	0.015	–0.001	0.000	–0.014
	(0.020)	(0.015)	(0.006)	(0.010)	(0.010)
No of obs	187	1081	1961	888	576
R^2	0.099	0.047	0.033	0.037	0.065

Note: Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from CompNet and customs data.

The sensitivity of the results over the business cycle is tested by estimating specifications in a rolling window over the period 2004–2007 as in Tables 4 and 5. The results are presented in Appendix 2. There is no evidence that the diversification of exports has an effect on volatility throughout the business cycle and the effects of diversification in products and destination markets do not differ in this respect. The diversification of destination markets contributes to lower volatility of sales with statistical significance only in Hungary and Slovakia, and there too the effect is only occasionally significant. The weak diversification effect may be related to the high covariance of shocks in export markets, and this could be due to the homogeneity of export markets or to the Great Recession, which had an adverse effect on all the markets and increased the covariance of shocks. This finding is in line with our theoretical specification in Section 2.1, which implies that as the covariance of shocks increases, for example due to a common global shock, the contribution of the diversification component to volatility weakens.

Table 5: Market concentration and sales volatility with additional controls, concentration in 2008 and volatility in 2009–2012

	Estonia	**Hungary**	**Romania**	**Slovakia**	**Slovenia**
Concentration of markets	0.024	0.057***	–0.004	–0.001	0.027
	(0.034)	(0.013)	(0.011)	(0.017)	(0.018)
Export share	0.024	0.070***	0.001	0.060***	0.086***
	(0.029)	(0.012)	(0.009)	(0.014)	(0.015)
Log(TFP)	–0.021***	–0.006	–0.020***	–0.002	0.003
	(0.008)	(0.005)	(0.004)	(0.003)	(0.004)
Log(capital per employee)	0.010	0.012***	0.007***	0.003	–0.003
	(0.008)	(0.004)	(0.003)	(0.005)	(0.005)
Log(employment)	0.033***	0.003	–0.012***	–0.008*	–0.011*
	(0.012)	(0.004)	(0.003)	(0.005)	(0.006)
Log(age)	–0.024	0.008	–0.022***	–0.019**	–0.011
	(0.020)	(0.008)	(0.007)	(0.008)	(0.010)
Foreign owned (base: domestic)	–0.055***	0.057***	–0.000	0.000	–0.015
	(0.020)	(0.013)	(0.006)	(0.010)	(0.010)
No of obs	187	1081	1961	888	576
R^2	0.091	0.063	0.032	0.037	0.069

Note: Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from CompNet and customs data.

However, export intensity is positively related to volatility and the effect increased during the Great Recession. This effect is in line with the unconditional findings of Figure 2 and suggests that the volatility became higher in export markets than in domestic markets during the recession, and this contributed to higher volatility because of the composition effect. This result holds for Hungary, Slovakia and Slovenia. The size of the effect is also economically large in these countries, as the one standard deviation, or around 0.33, higher export share is related to higher volatility of 0.02 and 0.03, which corresponds to one fifth and one quarter of a standard deviation in volatility.

4.2. Robustness tests: alternative measure of concentration

The role of the homogeneity of destination markets or products was identified as one possible explanation for the limited role of export diversification in output volatility in the previous section. This subsection tests for the robustness of our findings by introducing an alternative measure of diversification across less homogenous products and markets.

As was already discussed in Section 2.2, our sample countries export mostly to the European Union and their exports are concentrated in their neighbouring countries in Central Europe. Given that these countries have correlated business cycles and several are part of the common currency area, our destination country based measure of diversification may not capture the diversification of volatility risk. Instead of calculating the Herfindahl index of export shares by destination countries, we calculate an alternative Herfindahl index of export shares by geographical regions. The countries are divided into 17 geographical regions based on the United Nations country classification of 2014 (United Nations (2014)) and an alternative measure of diversification is derived from geographical regions rather than countries.[5]

Similarly, the alternative measure for product diversification is derived using more aggregated product categories at the 4-digit HS level. Products in these categories are more dissimilar to each other and, like the country groups, form a stronger measure of diversification than the default measure.

Tables 6 and 7 present the results for concentration in 2008 and Appendix 3 shows those for the rolling window of concentration over 2004–2007. It is surprising that the effect of diversification often reverses to negative, and for market concentration it remains occasionally positive and statistically significant in only two countries, Hungary and Slovenia. The positive relationship between export share and volatility remains unchanged.

The often negative and sometimes statistically significant relationship between export concentration and volatility could be related to the compositional effect, as more distant markets outside Europe can be more volatile. Another explanation for this is that sales to more distant markets are occasional and last for a shorter duration, which results in more volatile total sales in the model of Vannoorenberghe et al. (2014). An explanation for the negative relationship between the concentration of more aggregated products and volatility may lie in risky experimentation with products that are new not incrementally, but through more substantial innovations. At the same time, we should bear in mind other factors that are even more difficult to prove and that relate to the high levels of involvement in global value chains of the exporting firms being analysed (see e.g. De Backer and Miroudot (2014)). Given their relatively low position, it may be difficult for them to manage their product or market portfolios actively and their economic results may in some cases be significantly skewed by factors like transfer pricing.

[5] The following country groups have been applied: EU15, New EU member states, North America, South-Eastern European economies in transition, Commonwealth of Independent States and Georgia, North Africa, Central Africa, East Africa, Southern Africa, West Africa, East Asia, South Asia, Western Asia, Caribbean, Mexico and Central America, South America, Oceania, and Japan.

Table 6: 4-digit HS product concentration and output volatility with additional controls, concentration in 2008 and volatility in 2009–2012

	Estonia	**Hungary**	**Romania**	**Slovakia**	**Slovenia**
Concentration of products	–0.040	0.002	–0.025**	–0.035**	–0.019
	(0.033)	(0.016)	(0.011)	(0.016)	(0.018)
Export share	0.020	0.070***	0.001	0.059***	0.080***
	(0.029)	(0.012)	(0.009)	(0.014)	(0.014)
Log(TFP)	–0.022***	–0.007	–0.020***	–0.002	0.003
	(0.008)	(0.004)	(0.004)	(0.003)	(0.004)
Log(capital per employee)	0.009	0.008**	0.008***	0.004	–0.005
	(0.008)	(0.004)	(0.002)	(0.005)	(0.005)
Log(employment)	0.028**	–0.001	–0.012***	–0.010**	–0.014***
	(0.012)	(0.004)	(0.003)	(0.005)	(0.005)
Log(age)	–0.026	0.014*	–0.022***	–0.019**	–0.012
	(0.020)	(0.008)	(0.007)	(0.008)	(0.010)
Foreign owned (base: domestic)	–0.053***	0.002	–0.001	0.000	–0.014
	(0.020)	(0.016)	(0.006)	(0.010)	(0.010)
No of obs	187	1081	1961	891	576
R^2	0.096	0.046	0.035	0.042	0.067

Note: Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from CompNet and customs data.

4.3. Robustness tests: a longer time span for volatility

As another robustness test we estimate the specification in Tables 4 and 5 with an alternative measure of volatility over a longer time span of six years. This is complementary to the previous subsection, which tested the robustness of the measure of the explanatory variable for diversification, and it tests the robustness of the measure of the dependent variable for volatility.

The results are presented in Appendix 4 and confirm our findings for the default specification. The relationship between export concentration and volatility is ambiguous, as it is statistically significant and positive only in Hungary and Slovenia, while the relationship between export share and volatility is positive and mostly statistically significant. There is no clear pattern showing export share to be more important for volatility during the later years, as was observed in the baseline specification. This is related to the longer time span for the volatility measure, which contains the crisis years and covers all the observation points in the rolling window. This result confirms our findings from the default specification that including the crisis years matters as the volatility of export markets became substantially higher than that of domestic markets during the crisis.

Table 7: Geographical regions concentration and output volatility with additional controls, concentration in 2008 and volatility in 2009–2012

	Estonia	**Hungary**	**Romania**	**Slovakia**	**Slovenia**
Concentration of markets	–0.014	0.065***	–0.006	–0.052**	0.039*
	(0.056)	(0.018)	(0.015)	(0.025)	(0.020)
Export share	0.027	0.067***	0.001	0.059***	0.082***
	(0.030)	(0.012)	(0.009)	(0.014)	(0.014)
Log(TFP)	–0.021**	-0.006	–0.020***	–0.002	0.004
	(0.008)	(0.005)	(0.004)	(0.003)	(0.004)
Log(capital per employee)	0.008	0.011***	0.007***	0.004	–0.004
	(0.008)	(0.004)	(0.003)	(0.005)	(0.005)
Log(employment)	0.030**	0.001	-0.012***	–0.008*	–0.010*
	(0.012)	(0.004)	(0.003)	(0.005)	(0.005)
Log(age)	–0.026	0.011	–0.022***	–0.020**	-0.011
	(0.020)	(0.008)	(0.007)	(0.008)	(0.010)
Foreign owned (base: domestic)	–0.053***	0.065***	–0.001	0.001	–0.014
	(0.020)	(0.018)	(0.006)	(0.010)	(0.010)
No of obs	187	1081	1961	891	576
R^2	0.089	0.058	0.033	0.043	0.071

Note: Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from CompNet and customs data.

5. Conclusions

The paper investigates whether exporting and diversification in exporting at the firm level are related to output volatility for a firm. Whereas there is a vast macroeconomic literature describing the relations between openness to trade, volatility, and country growth, the firm-level evidence on exporting and volatility is scarce and inconclusive.

The empirical specification is motivated by a simple model where firms maximise profits given their diversification pattern. The model demonstrates that the relationship between diversification of markets and volatility can be positive or negative, depending on the composition effect, which is the volatility of the markets served by the firm, and the diversification effect, which is the covariance between shocks in the markets.

We test the exporting, diversification and volatility link using a large representative sample of firms from Estonia, Hungary, Romania, Slovakia and

Slovenia. Our results support the findings that the share of exports in sales is positively related to output volatility. The existing literature has found this relationship to be positive and negative, and our findings overlap with the findings of Vannoorenberghe (2012) and Nguyen and Schaur (2010). There is also evidence that export markets became more volatile than domestic markets during the Great Recession, which increased the effect of export share on volatility during that crisis. The size of the effect is economically large in Hungary, Slovakia and Slovenia, where firms with higher export share by one standard deviation have higher volatility by one fifth to one quarter of a standard deviation. The strong effects in Hungary, Slovakia and Slovenia may arise because these countries export products like transport equipment and electronics that are subject to high volatility (see Koren and Tenreyro (2007)), while in Estonia and Romania the correlation between export specialisation and volatility is less clear.

We find that diversification has a negative effect on volatility only occasionally in Hungary and Slovenia, where it is negative mostly because of the diversification of destination markets. Factors like firm productivity, size and age are more strongly negatively correlated with volatility than export diversification is. Our results support the idea that diversification of exports has an ambiguous effect on output volatility, meaning that exporting more products or serving more markets is not necessarily related to higher stability for firm sales.

There is evidence that the relationship between diversification and volatility can even become positive for the stricter measure of volatility based on diversification of exports across geographic regions rather than countries. A positive relation between export diversification and sales volatility can be theoretically explained by the positive covariance of shocks, due for example to a common global shock, exceeding the negative contribution of export diversification. Another possible explanation for this finding is the composition effect, which is that more distant export markets are also more volatile. The model of Vannoorenberghe et al. (2014) may provide an alternative explanation, as exporting to more distant markets can be more volatile because there is more active experimentation and a shorter duration of exports to more distant regions. Alternatively, the relatively low position of firms from our sample countries in global value chains implies that it is difficult for them to manage their product or market portfolios actively.

A possible avenue for further research is to extend the analysis to measure the volatility of demand in foreign markets and the volatility of demand in product sectors.

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Appendix 1. Diversification of products exported and destination markets in 2008 and 2012

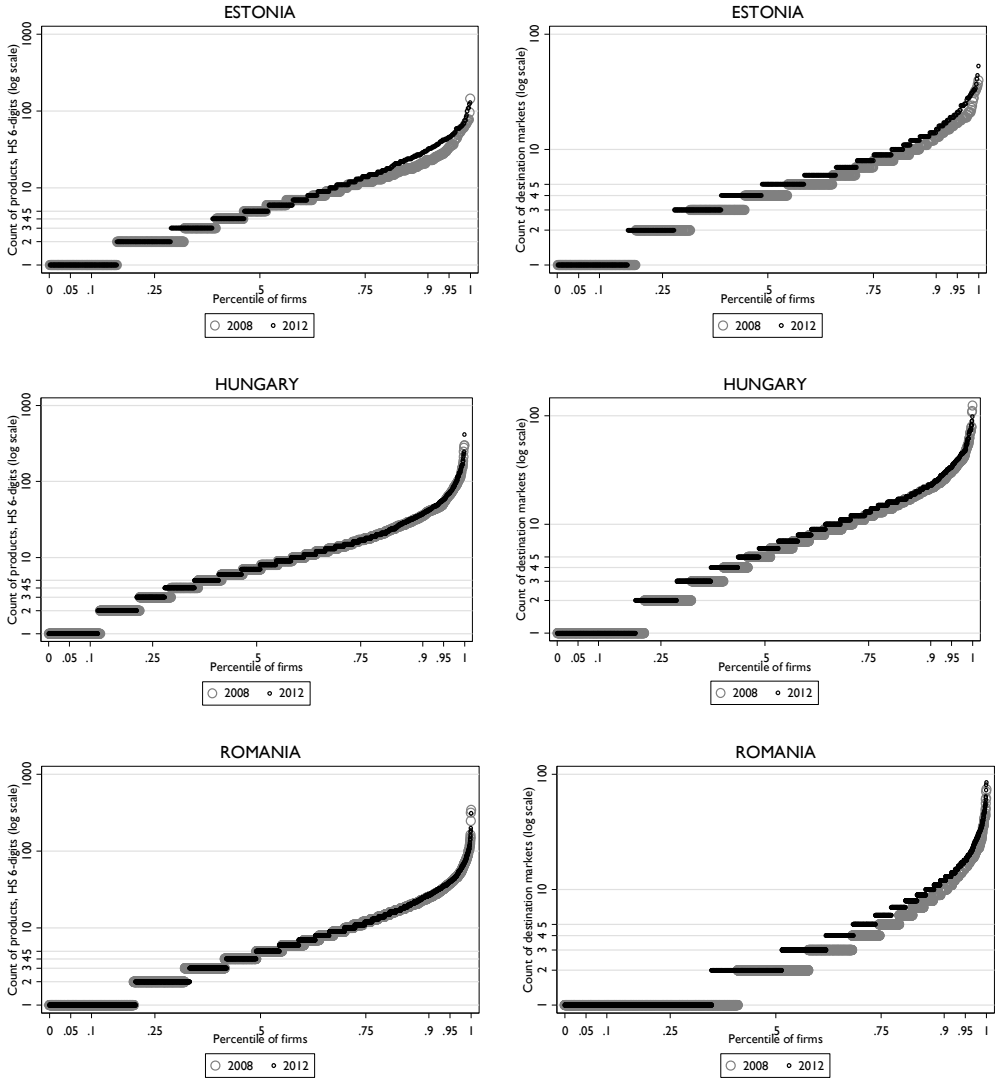

Figure 1: Diversification of products exported and destination markets, manufacturing, 2008 and 2012

Note: The figures are inspired by the presentation by Arkolakis and Muendler (2013) of exporter scope distribution.

Source: authors' calculations from CompNet and customs data.

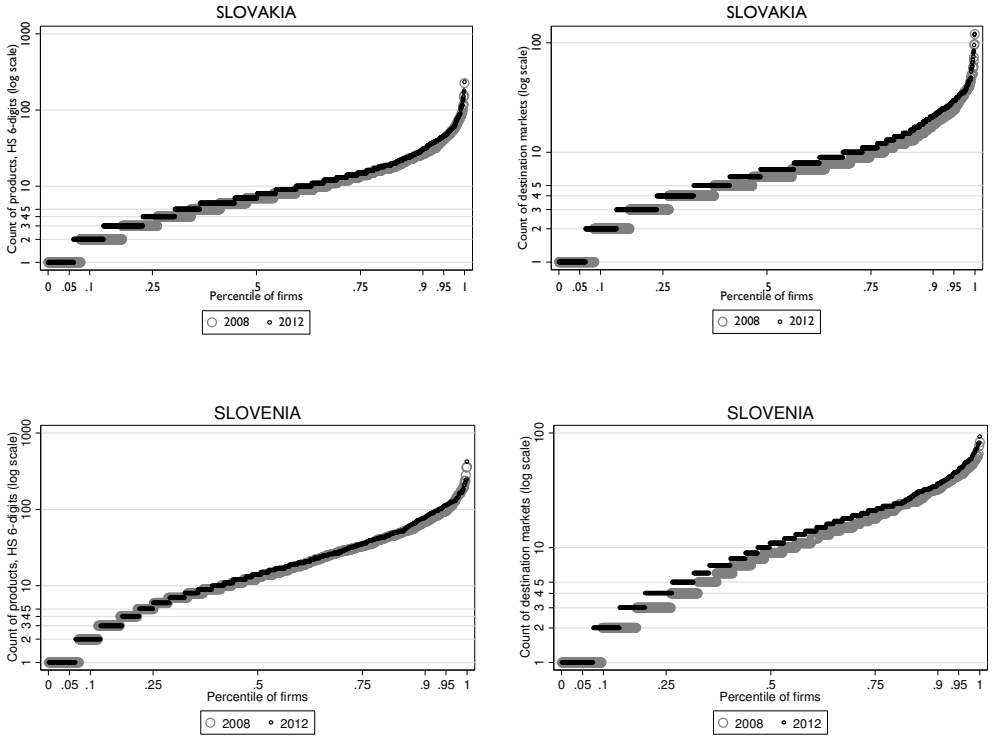

Figure 1: Diversification of products exported and destination markets, manufacturing, 2008 and 2012 (cont.)

Note: The figures are inspired by the presentation by Arkolakis and Muendler (2013) of exporter scope distribution.

Source: authors' calculations from CompNet and customs data.

Appendix 2. Estimates of concentration and volatility over different time spans, 2004–2012

Table 1: Export concentration and output volatility with additional controls, rolling window between 2004 and 2012

Dependent variable: standard deviation of sales growth	**Estonia**	**Hungary**	**Romania**	**Slovakia**	**Slovenia**
Concentration of products, 2004	0.026	0.016		–0.008	0.020
	(0.020)	(0.012)		(0.015)	(0.015)
Export share	0.014	0.018*		0.006	0.015
	(0.015)	(0.010)		(0.012)	(0.013)
Concentration of products, 2005	–0.023	0.014		–0.013	–0.015
	(0.021)	(0.012)		(0.014)	(0.015)
Export share	0.025	0.030***		-0.014	0.010
	(0.016)	(0.010)		(0.012)	(0.013)
Concentration of products, 2006	–0.038	0.034**		-0.001	-0.024
	(0.030)	(0.014)		(0.014)	(0.017)
Export share	0.029	0.049***		0.022*	0.043***
	(0.026)	(0.012)		(0.011)	(0.014)
Concentration of products, 2007	–0.049	0.025*	0.002	–0.000	–0.026
	(0.032)	(0.014)	(0.010)	(0.017)	(0.017)
Export share	0.024	0.063***	0.004	0.039***	0.058***
	(0.028)	(0.011)	(0.009)	(0.014)	(0.014)
Concentration of markets, 2004	0.002	0.017		–0.007	0.027*
	(0.022)	(0.012)		(0.014)	(0.016)
Export share	0.011	0.017*		0.006	0.021
	(0.015)	(0.010)		(0.012)	(0.013)
Concentration of markets, 2005	–0.028	0.035***		–0.009	0.009
	(0.023)	(0.012)		(0.014)	(0.016)
Export share	0.027	0.029***		–0.014	0.013
	(0.016)	(0.010)		(0.012)	(0.014)
Concentration of markets, 2006	–0.052	0.059***		–0.021	0.028
	(0.036)	(0.013)		(0.016)	(0.017)
Export share	0.031	0.047***		0.022**	0.048***
	(0.025)	(0.011)		(0.011)	(0.015)
Concentration of markets, 2007	–0.036	0.029**	0.003	–0.011	0.021
	(0.031)	(0.013)	(0.011)	(0.018)	(0.016)
Export share	0.032	0.063***	0.004	0.039***	0.063***
	(0.028)	(0.011)	(0.009)	(0.014)	(0.015)
No of obs, 2004	341	1222		825	656
No of obs, 2005	284	1155		869	644

Output equation: standard deviation of sales growth	Estonia	Hungary	Romania	Slovakia	Slovenia
No of obs, 2006	178	1069		936	609
No of obs, 2007	188	1057	1860	834	601

Notes: Only the coefficient of concentration and export share are presented, the rest of the explanatory variables for productivity, capital intensity, employment, age and FDI are not shown. The standard deviation of sales growth in 2005–2008 is regressed with explanatory variables for 2004; the standard deviation of sales growth in 2006–2009 is regressed with explanatory variables for 2005 and so on. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from CompNet and customs data.

Appendix 3. Estimates of concentration and volatility over different time spans, alternative measure of concentration, 2004–2012

Table 1: Export concentration and output volatility with additional controls, alternative measure of concentration, rolling window between 2004 and 2012

Dependent variable: standard deviation of sales growth	**Estonia**	**Hungary**	**Romania**	**Slovakia**	**Slovenia**
Concentration of products, 2004	0.026	0.014		–0.008	0.019
	(0.020)	(0.013)		(0.016)	(0.015)
Export share	0.014	0.018*		0.006	0.014
	(0.015)	(0.010)		(0.012)	(0.013)
Concentration of products, 2005	–0.020	–0.011		–0.018	–0.023
	(0.023)	(0.013)		(0.015)	(0.016)
Export share	0.026	0.030***		–0.013	0.011
	(0.016)	(0.010)		(0.012)	(0.013)
Concentration of products, 2006	–0.030	0.011		–0.026*	–0.040**
	(0.032)	(0.014)		(0.015)	(0.014)
Export share	0.032	0.049***		0.021*	0.044***
	(0.026)	(0.012)		(0.011)	(0.014)
Concentration of products, 2007	–0.048	0.016	–0.019*	–0.038**	–0.038**
	(0.034)	(0.015)	(0.011)	(0.017)	(0.018)
Export share	0.026	0.063***	0.004	0.037***	0.059***
	(0.028)	(0.011)	(0.009)	(0.014)	(0.014)
Concentration of markets, 2004	–0.034	0.020		–0.027	0.025
	(0.031)	(0.017)		(0.020)	(0.019)
Export share	0.013	0.016		0.005	0.015
	(0.015)	(0.010)		(0.012)	(0.013)
Concentration of markets, 2005	–0.023	0.040**		–0.032*	0.022
	(0.034)	(0.016)		(0.018)	(0.018)
Export share	0.029*	0.026**		–0.015	0.011
	(0.017)	(0.010)		(0.012)	(0.013)
Concentration of markets, 2006	–0.024	0.041		–0.054**	0.039**
	(0.050)	(0.029)		(0.022)	(0.018)
Export share	0.038	0.003		0.020*	0.043***
	(0.026)	(0.039)		(0.011)	(0.014)
Concentration of markets, 2007	–0.017	0.032*	–0.001	–0.059**	0.039**
	(0.048)	(0.017)	(0.015)	(0.024)	(0.018)
Export share	0.036	0.061***	0.004	0.038***	0.060***
	(0.028)	(0.011)	(0.009)	(0.014)	(0.014)

Output equation: standard deviation of sales growth	Estonia	Hungary	Romania	Slovakia	Slovenia
No of obs, 2004	341	1222		825	656
No of obs, 2005	284	1155		869	644
No of obs, 2006	178	1069		941	609
No of obs, 2007	188	1057	1860	836	601

Notes: Only the coefficient of concentration and export share are presented, the rest of the explanatory variables for productivity, capital intensity, employment, age and FDI are not shown. The standard deviation of sales growth in 2005–2008 is regressed with explanatory variables for 2004; the standard deviation of sales growth in 2006–2009 is regressed with explanatory variables for 2005 and so on. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from CompNet and customs data.

Appendix 4. Estimates of concentration and volatility over different time spans, volatility over six years, 2004–2012

Table 1: Export concentration and output volatility with additional controls, volatility over six years, rolling window between 2004 and 2012

Dependent variable: standard deviation of sales growth	**Estonia**	**Hungary**	**Romania[a)]**	**Slovakia**	**Slovenia**
Concentration of products, 2004	0.038**	0.023**		–0.014	0.009
	(0.019)	(0.011)		(0.014)	(0.013)
Export share	0.033**	0.048***		0.022**	0.030**
	(0.015)	(0.009)		(0.011)	(0.012)
Concentration of products, 2005	–0.010	0.020*		–0.003	–0.004
	(0.020)	(0.011)		(0.013)	(0.014)
Export share	0.020	0.048***		0.007	0.023*
	(0.016)	(0.009)		(0.011)	(0.013)
Concentration of products, 2006	–0.039*	0.023**	0.000	–0.007	–0.010
	(0.022)	(0.011)	(0.009)	(0.012)	(0.014)
Export share	0.009	0.053***	0.010	0.021**	0.026**
	(0.019)	(0.010)	(0.008)	(0.010)	(0.012)
Concentration of markets, 2004	–0.033	0.029**		–0.022	0.020
	(0.022)	(0.011)		(0.014)	(0.015)
Export share	0.026*	0.045***		0.020*	0.034***
	(0.015)	(0.009)		(0.011)	(0.012)
Concentration of markets, 2005	–0.028	0.037***		–0.006	0.025*
	(0.022)	(0.011)		(0.014)	(0.015)
Export share	0.020	0.047***		0.006	0.029**
	(0.016)	(0.009)		(0.011)	(0.013)
Concentration of markets, 2006	–0.044*	0.039***	–0.001	–0.015	0.024*
	(0.025)	(0.011)	(0.009)	(0.013)	(0.014)
Export share	0.013	0.053***	0.010	0.021**	0.032**
	(0.019)	(0.010)	(0.008)	(0.010)	(0.012)
No of obs, 2004	357	1312		884	664
No of obs, 2005	315	1238		889	657
No of obs, 2006	266	1179	2062	984	628

Notes: Only the coefficient of concentration and export share are presented, the rest of the explanatory variables for productivity, capital intensity, employment, age and FDI are not shown. The standard deviation of sales growth in 2005–2010 is regressed with explanatory variables for 2004; the standard deviation of sales growth in 2006–2011 is regressed with explanatory variables for 2005 and so on. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

[a)] Romanian estimates are from 2007–2012, explanatory variables from 2007 and volatility from 2008–2012.

Source: authors' calculations from CompNet and customs data.

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