Export diversification and output volatility: comparative firm-level evidence

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Abstract: The literature shows that openness to trade improves long-term growth but equally that it may increase exposure to high volatility. In this vein, our paper investigates whether diversification at the firm level lowers the output volatility of the firms, using data for Estonia, Hungary, Romania, Slovakia and Slovenia over the last boom-bust cycle. The instrumental variable technique is used to estimate the effect of endogenously treated diversification on the volatility of sales growth. The results show that the effect of export diversification on output volatility is statistically significant and economically large. Exporters that are more diversified by one standard deviation experience smaller output volatility of one fifth to four fifth of a standard deviation. The effect of the diversification in products is somewhat larger than the effect of diversification in destination markets, and the diversification effect decreased during the Great Recession. This decrease is related to the large and correlated negative shocks in all destination markets.

Keywords: export diversification, volatility of sales, business cycle, Europe
JEL codes: F14, F43, O57

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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. Indeed, 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 second assumption was called into question by several empirical studies (e.g. Koren and Tenreyro (2007)) showing 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 depends on the volatility of shocks in the trading partners and the correlation between those and the shock affecting the domestic economy. In particular, higher volatility arises when foreign markets are more volatile than the domestic market and when there is a high correlation between country-specific shocks.

While macro level studies are more abundant, empirical evidence on exporting and volatility at the firm level is scarce and inconclusive. In this paper we study the relationship between export diversification and output volatility at the firm level using comparative micro-data from five countries. Our contribution to the literature is threefold. First, unlike the previous studies we address the endogeneity of diversification in the volatility equation. Second, 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 have been 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. Third, we test whether the effect of diversification on volatility has changed over the business cycle. The time period analysed covers the last 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 diversification on volatility over the boom and bust period.

Our results show that export diversification has a strong negative effect on firm-level output volatility, meaning that exporting more types of products or serving more markets leads to higher stability for firm sales. Exporters that are more diversified by one standard deviation have lower volatility by one fifth to four fifth of a standard deviation. The diversification effects are the strongest in Romania and the weakest in Hungary. There is also evidence that the diversification of products has a stronger effect on volatility than the diversification of destination markets, and that the diversification effect is weaker for larger firms. Our results are robust to the different sets of instruments applied. The second result from our study is that the negative effect of diversification on volatility decreased during the recession that followed the global financial crisis. This result is most likely related to the common negative shock that occurred in all destination markets during the recession.

Our paper adds to the growing evidence on the granular nature of aggregate growth volatility, 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 the aggregate volatility. Similarly, firm-level co-movement of sales and the higher volatility of larger firms are factors in the higher contributions by firm-specific shocks to aggregate volatility. 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 the one hand, Buch et al. (2009) argue that exporters have lower output volatility and that this effect stems mostly from the extensive and not from the intensive margin. On the other hand, Vannoorenberghe (2012) finds that a large export share is related to lower export volatility. He also shows that the sales to domestic and foreign markets are negatively correlated, indicating the simultaneity of the diversification decision and volatility. Evidence also points to the importance of firm size. Vannoorenberghe et al. (2014) study the effect of export diversification on volatility and find the pattern to be different for small and large firms; export diversification is related to higher volatility in small firms and to lower volatility in large firms. The main channel behind high export volatility for small firms is that smaller firms occasionally export to new markets.

The paper is organised as follows. The next section provides a background for the study by presenting a theoretical model motivating the empirical specification and the characteristics of 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 firms' volatility of output. 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. The firm sells λ_i share of output domestically and exports the rest. The firm can sell to one or more foreign markets k and the sum of each foreign market share, $\sum_{k=1}^{K} \lambda_{ki}^{*}$, equals 1-λ_i. Firm profits are defined as:

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

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 condition from (2) and solving for labour yields:

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

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 $L_t^S = w_t^{\eta^S}$, 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. Given the state of equilibrium, summarised in equation (4), let us assume the firm faces random technology, demand and capital cost shocks, γ_A , γ_d and γ_K respectively. The time subscripts are suppressed from here on. Let us define these shocks as $A = \bar{A}e^{\gamma_A}$, $d = \bar{d}e^{\gamma_d} = \bar{d}e^{\gamma_p\lambda + \sum_k \gamma_{p_k^*} - c_k \lambda_k^*}$, and $K = \bar{K}e^{\gamma_K}$, where the demand shock depends on the domestic and foreign demand shocks. The 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:

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

and deriving the respective expressions of output with random shocks over the equilibrium output, we obtain the following results for output growth:

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

The variance of the output growth is then given by:

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

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 for more than one market, more than three components enter the output volatility equation, and this case adds variance to the demand shocks in all the markets and the covariance between the demand shocks for all the markets. Each additional market decreases output volatility because of the diversification effect in the covariance terms, but can increase volatility because of the high variance of demand shocks in additional markets.

The relationship between diversification of markets and volatility can be positive or negative, depending on the volatility of the markets served by a firm and the covariance of shocks between the 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, the smaller size of the domestic market and the structure of exports 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.

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 part of the communist world

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.[6]

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

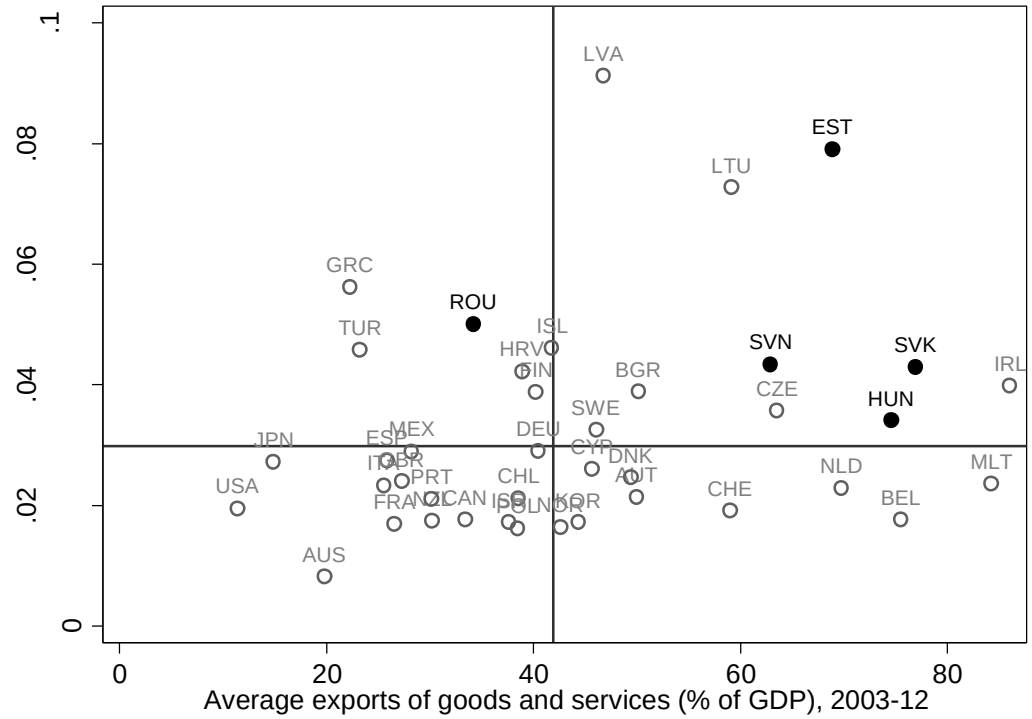


Figure 1. Openness and volatility, OECD and EU countries in 2003-2012.
Note: Hollow symbols: OECD and EU countries; filled symbols: sample countries. The vertical line denotes the average openness of 41.9% and the horizontal line the average volatility of 0.030. Luxembourg is omitted because of its very 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

[6] 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.

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 Slovakia 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 that takes one fifth to one quarter of their exports.

Given these findings it is suggested that the main factors behind higher volatility in the sample countries are high export concentration and strong correlation of shocks across the destination markets. The sample countries' trade is also concentrated in products such as transport equipment that are subject to high volatility from global sectoral shocks (see Koren and Tenreyro (2007) for the list of sectors with more volatility from global sectoral shocks). As a stabilising effect to 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. Data and empirical specification

3.1. Empirical specification

There are two major challenges in our empirical specification. First, it is difficult to measure volatility on firm-level data with yearly frequency. Given that firms in the sample countries are relatively young, the panel specification where one observation in the time dimension would be 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 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 endogeneity issue by introducing a specification that is strict in the chronological sequence of the diversification and volatility decision, and by applying the instrumental variable technique. 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. As the diversification decision in time t can still depend on the expected volatility, the diversification is instrumented by firm characteristics related to the potential for internationalisation such as firm size, age, export share and foreign ownership.

Given these concerns in the empirical specification, we cannot test the theoretical specification in equation (8) empirically one to one, but we aim to model the effect of the same variables as in equation (9) on output volatility. The following simultaneous system is estimated:

$$volatility_{i,t+1..t+4} = \beta_0 + \beta_1 \log(TFP_{i,t}) + \beta_2 \exp ort_concentration_{i,t} + \beta_3 \log(capital_intensity_{i,t}) + \gamma_{s,t} + \varepsilon_{i,t} \quad (8)$$

$$\exp ort_concentration_{i,t} = \alpha_0 + \alpha_1 \log(employment_{i,t}) + \alpha_2 \log(age_{i,t}) + \alpha_3 \exp ort_share_{i,t} + \alpha_4 foreign_{i,t} + \alpha_5 \log(TFP_{i,t}) + \alpha_6 \log(capital_intensity_{i,t}) + \gamma_{s,t} + u_{i,t} \quad (9)$$

The variable $volatility_{i,t+1...t+4}$ denotes the standard deviation of real turnover growth over four years and is dependent on total factor productivity, export concentration, capital per employee and NACE 2-digit industry dummies. The export concentration depends in turn on variables related to potential for internationalisation, firm employment, firm age, share of exports in turnover, and foreign ownership. The model is overidentified as one endogenous variable is instrumented by four instruments. All the explanatory variables are from period *t*, while the volatility is from period *t*+1 to *t*+4. Equations (8) and (9) are estimated simultaneously using 2SLS. Export concentration is measured by the Herfindahl index of export shares of products or markets; two separate models are estimated for the relationship between the concentration of products or destination markets and volatility. The estimations are run only for manufacturing firms as the trade data cover the export of products and not services. We expect the coefficient $\beta_2 > 0$ if firms with more concentrated exports have higher volatility. Equation (8) is also estimated by OLS and we expect $\beta_2^{2SLS} > \beta_2^{OLS}$ because export concentration and the potential to be more diversified are negatively correlated, contributing to downward bias in the OLS estimates. The intuition is that firms with high potential for internationalisation can also achieve more stable sales growth.

The empirical trade literature suggests that firm productivity, size and age are the important factors behind the export decision and trade diversification. More productive firms are more likely to enter export status and are able to cover their fixed costs by serving additional markets (Melitz (2003)). Larger firms are more likely to be more diversified in terms of trade because entry costs take a smaller part of their total sales, while older firms are more likely to be more diversified because they have more exporting experience. In addition, we add export share, as firms that are more dependent on foreign markets in their sales could also look more eagerly for options for diversification. The foreign ownership dummy controls for the tighter integration of multinationals into global value chains and their potentially better access to foreign markets. We also test for the role of a set of various additional instruments such as the share of high and medium-tech products in exports and firms' potential for diversification.

Appendix 1 presents the correlation coefficients of the variables analysed. These descriptive correlations support our specification. Size, age and export share are usually strongly correlated with export diversification and less strongly correlated with volatility. The total factor productivity is usually strongly negatively correlated with volatility and less strongly related to the diversification of trade. It is also notable that the correlation between the diversification of products and the diversification of destination markets is relatively weak.

This correlation is one of the strongest correlations presented, but it is still below 0.3, 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 still 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 firm-level balance sheet, profit/loss statement 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.[7],[8] In addition to variables covered by the CompNet project, our customs data enable us to disentangle yearly trade flows to a very detailed level, distinguishing between flows related to products at the 6-digit HS (Harmonised System by World Customs Organization) level 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. 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.

The diversification measure is calculated by the Herfindahl index for firm-level export flows in two categories of products at 6-digit HS and 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 2 reports the numbers of HS 6-digit products exported and the numbers of export destination markets served in 2008 and 2011. On average, cross-country differences in the numbers of products or markets resample the cross-country differences in the Herfindahl indices of concentration. 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.

It is also evident that the diversification of destination markets has generally decreased after the outbreak of the Great Recession, while the diversification of products has increased. There

[7] See Lopez-Garcia et al. (2014) for more details about the definition of variables and outlier treatment; and Benatti et al. (2014) for the validation of the data.

[8] 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.

are noticeable differences across the sample countries, as Estonian, Hungarian and Slovenian firms are diversified relatively little, with around one quarter to one third of firms exporting just one product or to one country, while Slovak firms are much more diversified, as only 10% of firms export one product or to one destination. The higher diversification in Slovakia is probably related to the characteristics of the sample, as only firms with 20 or more employees are covered. Exports by Romanian firms are more concentrated in destination markets, with up to half of firms exporting to only one country. Romania also has the highest concentration in the sample of destination markets at the aggregate level, see Section 2.2.

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 also cover small firms and use data that cover the whole population of firms or a large representative sample of the whole population of firms. The firms in our sample are relatively small[9] and young. At the same time they have high international openness, as the export share in the sales of firms is up to 50% on average and the share of foreign owned firms is as high as 50% on average in some of the sample countries (Table 1).

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=362)	Hungary (n=1740)	Romania (n=2799)	Slovakia[a] (n=913)	Slovenia (n=1393)
Standard deviation of sales growth: mean	0.259	0.237	0.230	0.251	0.218
standard deviation	0.131	0.130	0.129	0.159	0.120
Herfindahl index of HS6 products: mean	0.702	0.692	0.688	0.596	0.673
standard deviation	0.289	0.277	0.290	0.279	0.280
Herfindahl index of markets: mean	0.703	0.649	0.781	0.520	0.663
standard deviation	0.280	0.315	0.275	0.272	0.320
Employment: mean	54.4	4.498*	193.0	229.0	66.9
standard deviation	76.6	1.0627*	457.3	591.6	167.3
Age: mean	11.4	1.382*	12.9	11.4	2.571*
standard deviation	4.6	0.471*	5.2	5.1	0.547*
Export share in sales: mean	0.545	0.476	0.574	0.519	0.330
standard deviation	0.342	0.387	0.408	0.395	0.331
Share of foreign owned firms (base: domestic): mean	0.296	0.444	0.499	0.451	0.067
standard deviation	0.457	0.497	0.500	0.498	0.250
Log(TFP): mean	1.436		1.154	-0.019	1.359
standard deviation	0.656		0.707	1.446	0.540
Log(capital per employee): mean	1.187	1.7349	0.940	1.944	2.528
standard deviation	1.202	1.237	1.338	0.988	1.090

[a)] The Slovak sample covers only firms with 20 or more employees.

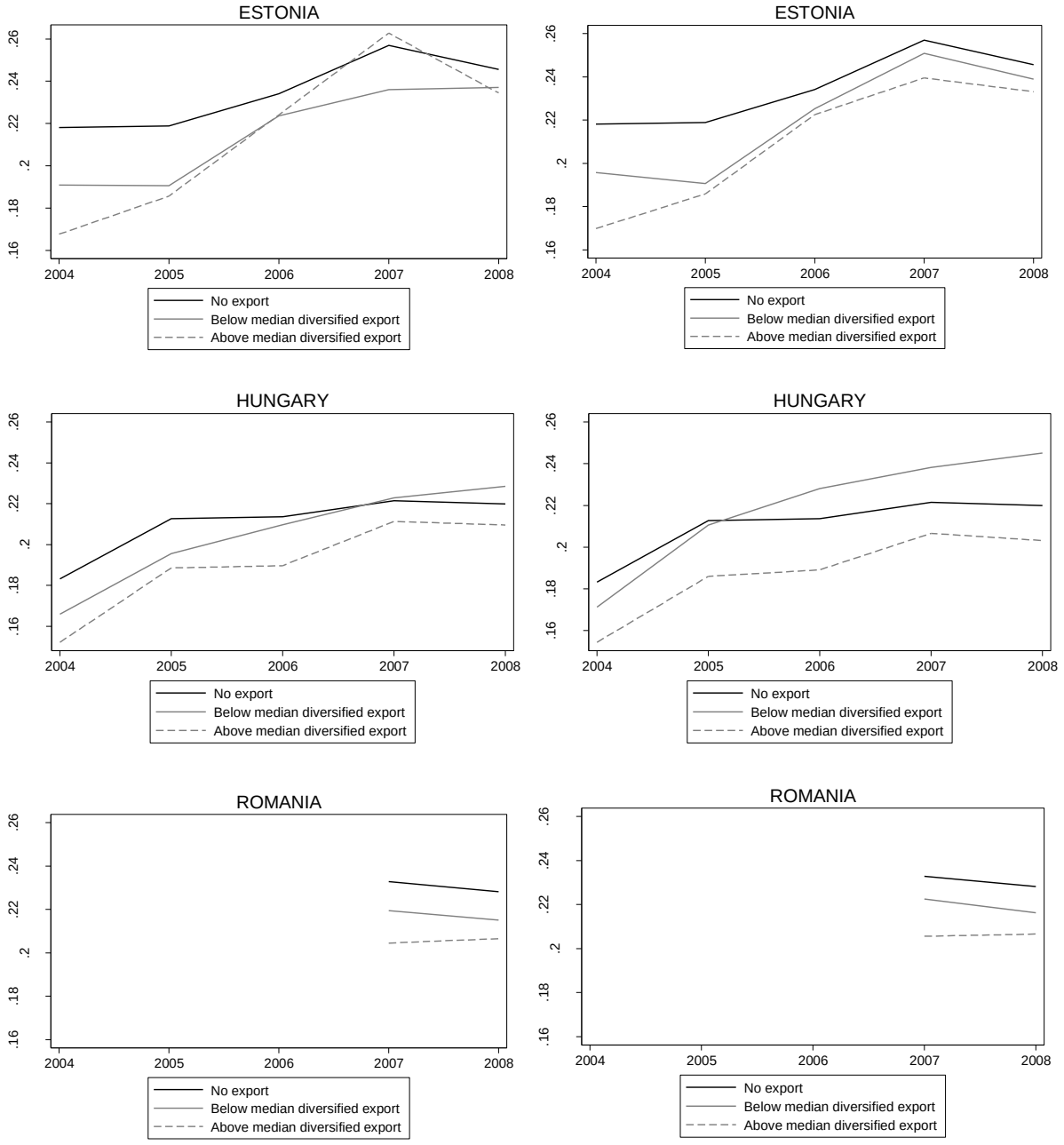
Notes: Foreign owned firms are defined as a binary variable where majority foreign owned firms take the value "1" and the rest "0". All the monetary variables are in thousands of euros and in prices of 2005. * Denotes variables in logarithms.

Source: authors' calculations from customs data.

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

[9] 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.

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 is more strongly correlated with the business cycle than the volatility of non-exporters is. The volatility of domestic firms is more stable over time and has different dynamics in different countries. For example, Estonian and Hungarian domestic firms faced increased volatility during the recession because of the large drop in domestic demand, while Slovakian domestic firms have had lower volatility during the recession as the drop in domestic demand was modest for them (see Bakker and Gulde (2010) for an overview of the dynamics of domestic demand in CEE countries).



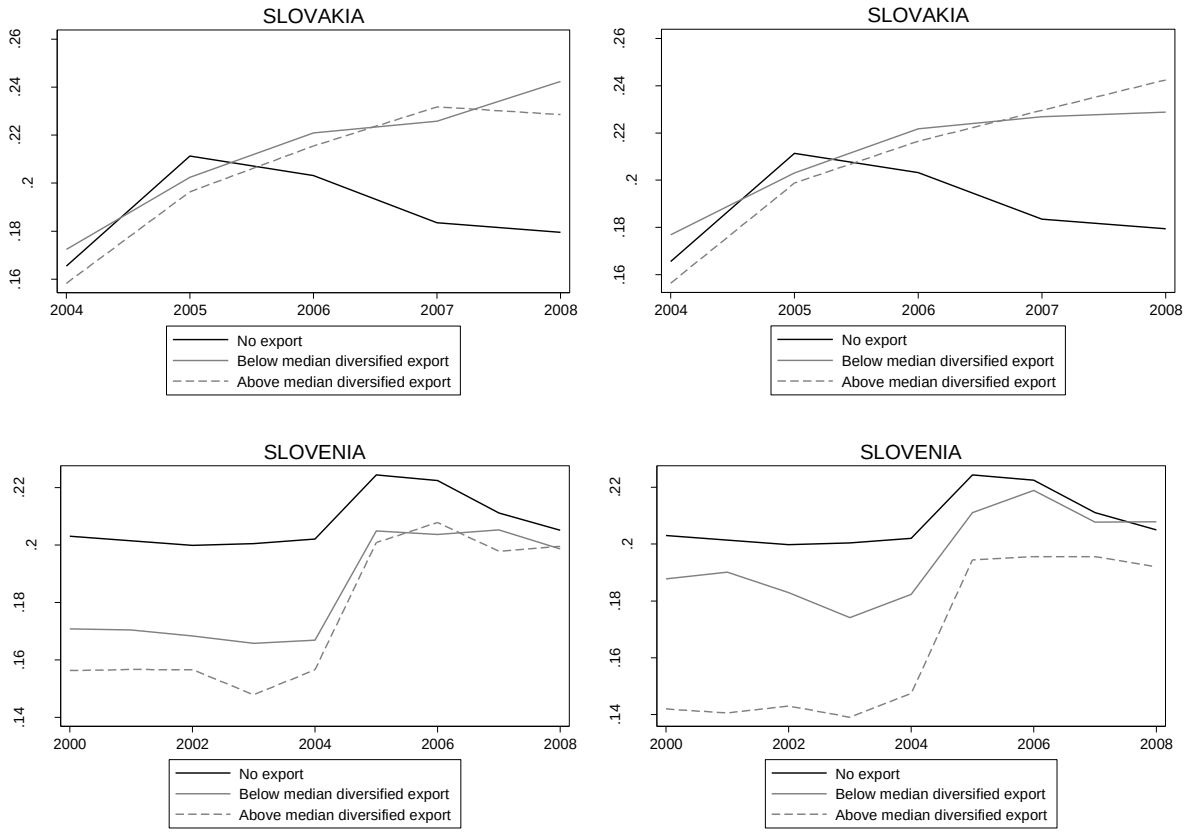


Figure 1. Unconditional real sales volatility over time: Left panel – firm diversification is classified over HS6 exported products; right panel – firm diversification is classified over destination markets.

[a)] The Slovak sample covers only firms with 20 or more employees.

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.

Source: authors' calculations from customs data.

The unconditional relationship between diversification and volatility is negative during the boom years identified by 2004 in the figure. More diversified exporters have lower sales volatility than less diversified exporters during the years of fast growth. However, the Great Recession in 2009 raised the volatility to similarly high levels for all the exporters. Given our 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 joint increase in volatility. Appendix 2 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.

4. Results

4.1. The results of baseline specification

This section presents the estimation results of specifications (8) and (9). Table 2 presents the results for the concentration of products and Table 3 presents those for the concentration of destination markets. The model specification tests indicate that given the set of instruments,

the exogeneity of diversification is rejected for most of the regressions. This test relies heavily on the validity of the instruments, but the tests of overidentifying restrictions are less encouraging and the validity of the instruments is rejected for Hungary, Romania and Slovenia. The results of the specification tests differ across timespans and countries (see Appendix 3), for example estimations from around 2005 show the validity of instruments for all the sample countries. Given that the coefficients are also rather similar for all the countries, we maintain an identical specification across countries.

The instruments applied are usually strongly correlated with the concentration in the first stage, indicating that the weak instrument problem is not substantial. The first-stage equation for concentration shows that larger and older firms and firms with higher export intensity have more diversified exports of products, while the total factor productivity and capital intensity that enter the volatility equation usually have a weaker correlation with diversification. Foreign-owned firms have more concentrated exports than domestic firms in terms of destination markets, but not in terms of products exported. It can be speculated that foreign-owned firms are integrated with business groups by specialisation in destination markets and not by specialisation in products.

The output equation demonstrates that the concentrations of products and destination markets have a strong positive effect on volatility. The size of the effect is large, as higher concentration of one standard deviation is related to higher volatility of 0.2 to 0.8 of a standard deviation. Romanian firms benefit more from higher diversification, while the Hungarian firms benefit less. 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 can be related to lower adjustment costs for capital than for labour.

As expected, the 2SLS coefficient for concentration is much larger than the coefficient from OLS. We proposed in the section on the empirical specification that an inability to control for the potential for internationalisation in OLS biases the effect of concentration on volatility downwards (see Appendix 3 for OLS results).

It is also evident that the diversification of products has a stronger effect on volatility than the diversification of destination markets. Appendix 4 demonstrates that this regularity holds throughout the business cycle and is not related to the time period over the Great Recession presented in Tables 2 and 3. However, the effect of diversification on volatility decreased during the recession in all the sample countries (see Appendix 4). This finding is in line with our theoretical specification in Section 2.1. The covariance of shocks in all the markets increased due to the joint global shock in all the markets, and the contribution of the diversification component to volatility weakened. In other words, both the unconditional and conditional effects of diversification on volatility decreased during the recession.

Appendix 5 tests whether the diversification effect is different for larger firms. The negative relationship between diversification and volatility also holds for larger firms, but is smaller in size and less frequently statistically significant.

Table 2. The effect of product concentration on volatility, 2SLS estimation of concentration in 2008 and volatility in 2009-2012

	Estonia	Hungary	Romania	Slovakia[a]	Slovenia
Output equation: volatility of sales growth					
Concentration of products	0.212***	0.097*	0.355***	0.226***	0.127**
	(0.080)	(0.050)	(0.050)	(0.081)	(0.055)
Log(TFP)	-0.035***	-0.021***	-0.001	-0.013	-0.005
	(0.013)	(0.008)	(0.006)	(0.009)	(0.009)
Log(capital per employee)	0.009	0.007**	0.007***	0.012*	0.002
	(0.007)	(0.003)	(0.003)	(0.006)	(0.003)
Sectors (2-digit NACE2008)	Yes	Yes	Yes	Yes	Yes
First stage equation: concentration of products					
Log(employment)	-0.049***	-0.050***	-0.042***	-0.033***	-0.042***
	(0.014)	(0.006)	(0.004)	(0.011)	(0.006)
Log(age)	-0.078***	-0.033*	-0.038***	-0.033*	-0.013
	(0.025)	(0.018)	(0.012)	(0.018)	(0.013)
Share of export in sales	-0.128***	0.043**	-0.052***	0.168***	-0.017
	(0.044)	(0.021)	(0.016)	(0.028)	(0.027)
Foreign owned (base: domestic)	-0.026	-0.027*	-0.011	0.012	0.026
	(0.036)	(0.015)	(0.012)	(0.022)	(0.032)
Log(TFP)	0.040	-0.029**	-0.025***	0.003	-0.048***
	(0.026)	(0.013)	(0.009)	(0.015)	(0.018)
Log(capital per employee)	-0.023*	0.004	-0.018***	-0.013	-0.010
	(0.013)	(0.006)	(0.004)	(0.011)	(0.007)
Sectors (2-digit NACE2008)	Yes	Yes	Yes	Yes	Yes
The effect of increase in concentration by one std. dev. on volatility in std. dev.	0.468	0.207	0.798	0.397	0.296
No of obs	362	1740	2799	913	1393
R^2 first stage equation	0.246	0.118	0.190	0.136	0.143
DWH test of endogeneity (p-value)	0.001	0.101	0.000	0.002	0.052
Hansen test of overidentifying restrictions (p-value)	0.438	0.012	0.015	0.911	0.014

[a)] The Slovak sample covers only firms with 20 or more employees.

Notes: The DWH test is the Durbin-Wu-Hausman test of endogeneity. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from customs data.

Table 3. The effect of market concentration on volatility, 2SLS estimation of concentration in 2008 and volatility in 2009-2012

	Estonia	Hungary	Romania	Slovakia[a]	Slovenia
Output equation: volatility of sales growth					
Concentration of markets	0.161**	0.083***	0.191***	0.223*	0.013
	(0.070)	(0.030)	(0.023)	(0.115)	(0.019)
Log(TFP)	-0.027**	-0.018**	-0.001	-0.009	-0.015*
	(0.013)	(0.007)	(0.005)	(0.010)	(0.008)
Log(capital per employee)	0.010	0.010***	0.007***	0.019**	0.000
	(0.007)	(0.003)	(0.002)	(0.009)	(0.003)
Sectors (2-digit NACE2008)	Yes		Yes	Yes	Yes
First stage equation: concentration of markets					
Log(employment)	-0.075***	-0.078***	-0.081***	-0.027***	-0.082***
	(0.014)	(0.006)	(0.004)	(0.010)	(0.006)
Log(age)	-0.051*	-0.078***	-0.038***	-0.006	-0.003
	(0.026)	(0.017)	(0.011)	(0.018)	(0.013)
Share of export in sales	-0.066	-0.024	-0.059***	0.062**	-0.297***
	(0.044)	(0.021)	(0.014)	(0.029)	(0.028)
Foreign owned (base: domestic)	0.044	0.090***	0.068***	0.066***	0.125***
	(0.034)	(0.015)	(0.011)	(0.021)	(0.037)
Log(TFP)	0.000	-0.063***	-0.052***	-0.025*	-0.076***
	(0.028)	(0.015)	(0.008)	(0.015)	(0.017)
Log(capital per employee)	-0.035***	-0.039***	-0.031***	-0.053***	-0.012*

	(0.013)	(0.006)	(0.004)	(0.010)	(0.006)
Sectors (2-digit NACE2008)	Yes	Yes	Yes	Yes	Yes
The effect of increase in concentration by one std. dev. on volatility in std. dev.	0.355	0.201	0.407	0.391	0.035
No of obs	362	1740	2799	913	1393
R^2 first stage equation	0.266	0.238	0.241	0.122	0.422
DWH test of endogeneity (p-value)	0.034	0.233	0.000	0.0435	0.220
Hansen test of overidentifying restrictions (p-value)	0.092	0.063	0.001	0.194	0.001

[a)] The Slovak sample covers only firms with 20 or more employees.
Notes: The DWH test is the Durbin-Wu-Hausman test of endogeneity. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.
Source: authors' calculations from customs data.

Our results support the idea that diversification of exports reduces output volatility, which has not always been confirmed by previous studies. Vannoorenberghe et al. (2014) find export diversification and volatility to be negatively related only in large firms, whereas we find that the negative relationship holds for the majority of countries and subgroups in the sample. We have also observed that it is important to control for the endogeneity of diversification in the volatility equation, as our results from the naive OLS specification are much less encouraging for the idea that diversification has any effect on volatility, and various specification tests note the endogeneity of diversification.

4.2. The results with a different set of instruments

The result that more diversified exporters have lower output volatility is only evident after the endogeneity of diversification in the volatility equation has been controlled for. Estimating the volatility equation without instrumenting diversification usually shows a small positive and statistically insignificant relationship between concentration and volatility. The OLS estimations are presented in Appendix 3. Our specification tests clearly indicate endogeneity of diversification. However, the identification of valid instruments is not so straightforward.

The failure to reject the overidentifying restrictions test suggests that at least one of the instruments is valid and rejection suggests that at least one instrument is not valid (Cameron and Trivedi (2009)). As a robustness test we estimate the specification in equations (8) and (9) adding two additional instruments one by one. We aim to improve the validity of the instruments and test whether the results hold after additional controls are included in the first stage[10].

First, we introduce high and medium-tech content of exports. This step is motivated by country-level findings showing that the concentration of exports is higher for countries focusing on high and medium-tech exports (Amador et al. (2011)). We construct the instrument using the OECD definition of high and medium-tech products by HS 6-digit

[10] Another robustness test is done by excluding the instruments one by one from the original specification in section 3.1 and adding these to the output equation. The results remain qualitatively unchanged, while the most important instrument behind the diversification effect tends to be employment. The exclusion of employment usually renders the diversification effect insignificant, while employment usually remains insignificant in the output equation, suggesting that the effect of employment on volatility takes place through the diversification.

classification.[11] We calculate the instrument at the firm level as the share of high and medium-tech products in total exports.

Second, we introduce an instrument capturing potential for diversification. The instrument is calculated by multiplying the firm's share of exports in the total exports of the sample country to a particular destination market by the difference between total imports to that destination market and the imports from the sample country. The results of this multiplication are summed for all the destination markets where the firm is exporting. The export structure is taken from 2006, while the import structure comes from 2008[12]. The idea of the instrument is to capture firms that are capable of exporting a larger share to large markets, because in these cases exports are expected to be less concentrated as large markets are served by many firms (Arkolakis and Muendler (2013)), and having a larger share in these markets shows the firm's potential ability to exceed entry costs to other markets or with other products.

Tables 4 and 5 present the results with these two new instruments. The high and medium-tech content of exports is more suitable for instrumenting the diversification of products; it is usually positively correlated with diversification as expected, while the potential for diversification by market size is more weakly correlated with the diversification of products. The first instrument lowers the effect of diversification on volatility somewhat, but the results remain qualitatively unchanged. The instrument for the potential for diversification is more suitable for instrumenting diversification of markets, as expected, as it is negatively correlated with the concentration of markets. The results change more noticeably than for diversification of products, but the diversification effect is still sizeable and statistically significant for Hungary, Romania and Slovakia. We conclude that the results are robust to the effect of the diversification of products, while the diversification of destination markets is more sensitive to the choice of instruments.

Table 4. The effect of product concentration on volatility; additional instruments in the 2SLS estimation of concentration in 2008 and volatility in 2009-2012

	Estonia	Hungary	Romania	Slovakia[a]	Slovenia
Additional instrument: high and medium-tech content of exports					
Output equation, dependent: volatility of sales growth					
Concentration of products	0.195**	0.139***	0.335***	0.221***	0.145***
	(0.081)	(0.048)	(0.049)	(0.076)	(0.048)
First stage equation, dependent: concentration of products					
Share of high-tech in exports	0.052	0.090***	-0.036	0.042	0.117***
	(0.071)	(0.022)	(0.024)	(0.039)	(0.023)
The effect of an increase in concentration by one std. dev. on volatility in std. dev	0.430	0.296	0.753	0.388	0.338
No of obs	351	1719	2778	900	1391
R^2 first stage equation	0.239	0.125	0.190	0.150	0.158
DWH test of endogeneity (p-value)	0.002	0.008	0.000	0.001	0.008
Hansen test of overidentifying restrictions (p-value)	0.565	0.006	0.000	0.888	0.029
Additional instrument: diversification					

[11] These products are aerospace; computers, office machinery; electronics-communications; pharmaceuticals; scientific instruments; motor vehicles; electrical machinery; chemicals; other transport equipment and non-electrical (http://www.oecd.org/sti/ind/48350231.pdf).

[12] We thank Luca David Opromolla for suggesting this idea; the authors are responsible for any misinterpretation.

potential					
Output equation, dependent: volatility of sales growth					
Concentration of products	0.279**	0.089*	0.343***	0.202**	0.091
	(0.128)	(0.052)	(0.064)	(0.081)	(0.068)
First stage equation, dependent: concentration of products					
Diversification potential	-0.001	-0.008***	0.000	0.003	-0.000
	(0.004)	(0.002)	(0.002)	(0.003)	(0.002)
The effect of an increase in concentration by one std. dev. on volatility in std. dev	0.616	0.190	0.771	0.354	0.212
No of obs	303	1441	1622	855	1070
R^2 first stage equation	0.248	0.116	0.194	0.147	0.127
DWH test of endogeneity (p-value)	0.003	0.183	0.000	0.006	0.229
Hansen test of overidentifying restrictions (p-value)	0.568	0.135	0.612	0.662	0.079

[a)] The Slovak sample covers only firms with 20 or more employees.

Notes: Only the coefficient of concentration from the output equation and the coefficient of the new instrument from the first stage are presented. The DWH test is the Durbin-Wu-Hausman test of endogeneity. The high-tech content of exports is calculated as the share of high and medium-tech products according to the OECD classification in total exports. Export demand is calculated as the firm's export share to a destination market in 2006 multiplied by total imports minus the sample country's imports by destination country in 2008. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from customs data.

Table 5. The effect of market concentration on volatility; additional instruments in the 2SLS estimation of concentration in 2008 and volatility in 2009-2012

	Estonia	Hungary	Romania	Slovakia[a]	Slovenia
Additional instrument: high and medium-tech content of exports					
Output equation, dependent: volatility of sales growth					
Concentration of markets	0.139**	0.092***	0.185***	0.215*	0.017
	(0.069)	(0.030)	(0.023)	(0.110)	(0.019)
First stage equation, dependent: concentration of markets					
Share of high-tech in exports	0.047	0.037	-0.021	-0.009	0.047**
	(0.062)	(0.025)	(0.024)	(0.043)	(0.022)
The effect of an increase in concentration by one std. dev. on volatility in std. dev	0.307	0.223	0.394	0.377	0.045
No of obs	351	1719	2778	900	1391
R^2 first stage equation	0.261	0.241	0.243	0.122	0.423
DWH F-test (p-value)	0.066	0.141	0.000	0.046	0.307
Hansen test (p-value)	0.181	0.006	0.000	0.212	0.0004
Additional instrument: diversification potential					
Output equation, dependent: volatility of sales growth					
Concentration of markets	0.008	0.068**	0.135***	0.201**	-0.021
	(0.063)	(0.030)	(0.026)	(0.085)	(0.021)
First stage equation, dependent: concentration of markets					
Diversification potential	-0.021***	-0.014***	-0.013***	-0.009***	-0.013***
	(0.004)	(0.003)	(0.001)	(0.003)	(0.002)
The effect of an increase in concentration by one std. dev. on volatility in std. dev	0.017	0.165	0.288	0.344	-0.056
No of obs	303	1441	967	855	1070
R^2 first stage equation	0.344	0.264	0.258	0.140	0.411

DWH test (p-value)	0.916	0.540	0.000	0.016	0.004
Hansen test (p-value)	0.019	0.216	0.004	0.411	0.065

[a)] The Slovak sample covers only firms with 20 or more employees.

Notes: Only the coefficient of concentration from the output equation and the coefficient of the new instrument from the first stage are presented. The DWH test is the Durbin-Wu-Hausman test of endogeneity. The high-tech content of exports is calculated as the share of high and medium-tech products according to the OECD classification in total exports. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from customs data.

5. Summary

The paper investigates whether diversification in exporting products and destination markets at the firm level lowers the 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 volatility of the markets served by the firm and the covariance between shocks in the markets.

We test the diversification and volatility link using a large representative sample of firms from Estonia, Hungary, Romania, Slovakia and Slovenia. Our empirical results confirm that export diversification has a strong negative effect on firm-level output volatility, i.e. exporting more products or serving more markets leads to higher stability for firm sales. Firms with higher diversification by one standard deviation have lower volatility of one fifth to four fifth of a standard deviation. Unlike the study by Vannoorenberghe et al. (2014) we find export diversification and volatility to be negatively related for the majority of countries and subgroups in the sample. The diversification effects are the strongest in Romania and the weakest in Slovenia. There is also evidence that the diversification of products has a stronger effect on volatility than the diversification of destination markets does and that the diversification effect is weaker for larger firms. Our results are robust to the different sets of instruments applied.

We also find that the negative effect of diversification on volatility decreased during the Great Recession. This result is likely to be related to the common negative shock present across all the destination markets during the Great Recession, when the covariance of shocks increased and the effect of the diversification component on volatility weakened.

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Appendix 1. Correlation coefficients between the variables analysed, 2008.

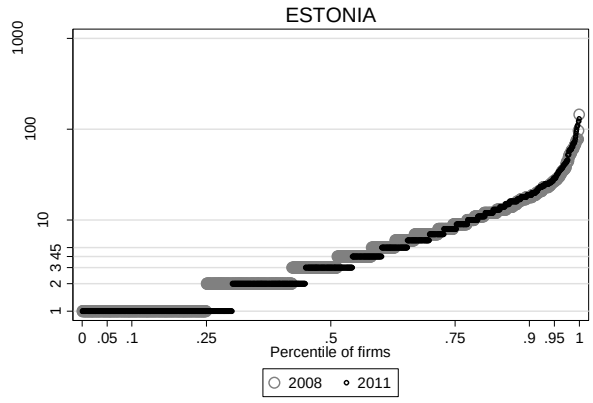
Table 1. Pearson correlation coefficients, 2008

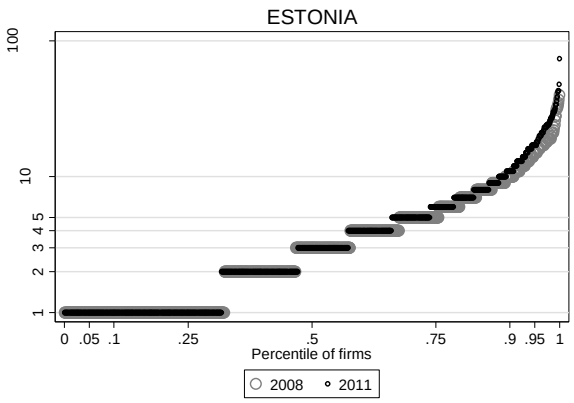
	Standard deviation of sales growth 2009-2012 (1)	Concentration of products, Herfindahl 2008 (2)	Concentration of markets, Herfindahl 2008 (3)	Log(employment) 2008 (4)	Log(age) 2008 (5)	Share of export in sales 2008 (6)	Foreign owned 2008 (7)	Log(TFP) 2008 (8)	Log(capital per employee) 2008 (9)
Estonia (n=362)									
(2)	-0.0319	1							
(3)	0.0887	0.1790*	1						
(4)	-0.1310*	-0.2418*	-0.3541*	1					
(5)	-0.0307	-0.2026*	-0.2220*	0.3387*	1				
(6)	-0.0623	-0.2031*	-0.0456	0.1520*	-0.0184	1			
(7)	-0.1040*	-0.0921	0.0417	0.1141*	-0.0840	0.2668*	1		
(8)	-0.1416*	0.0186	-0.1310*	0.1888*	-0.0076	-0.0147	0.0679	1	
(9)	-0.0056	-0.0124	-0.2480*	0.1508*	0.0946	-0.1653*	-0.0431	0.0776	1
Hungary (n=1740)									
(2)	0.0322	1							
(3)	0.1375*	0.2709*	1						
(4)	-0.0477	-0.1231*	-0.1883*	1					
(5)	-0.0288	-0.2572*	-0.3898*	0.2687*	1				
(6)	-0.0392	-0.0627*	-0.3528*	0.0032	0.1928*	1			
(7)	0.1715*	-0.0952*	-0.0644*	0.1514*	0.1893*	-0.1945*	1		
(8)	0.0566*	-0.0908*	-0.0383	0.0486*	0.2095*	0.1428*	0.3466*	1	
(9)	-0.0085	0.0018	-0.2437*	0.0150	0.1440*	0.5833*	-0.2048*	0.1062*	1
Romania (n=2799)									
(2)	0.0326	1							
(3)	0.0579*	0.1957*	1						
(4)	-0.1833*	-0.2472*	-0.3770*	1					
(5)	-0.0799*	-0.0694*	-0.1714*	0.2088*	1				
(6)	0.0032	-0.1521*	0.0527*	0.1073*	-0.2165*	1			
(7)	-0.0047	-0.0286	0.0976*	0.0224	-0.3611*	0.3563*	1		
(8)	-0.0960*	0.0445*	-0.1668*	-0.0393*	-0.0444*	-0.2123*	0.0846*	1	
(9)	0.0174	0.0449*	-0.2176*	-0.0194*	0.0796*	-0.3597*	-0.0091	0.2676*	1
Slovakia[a] (n=913)									
(2)	0.0366	1							
(3)	-0.0155	0.2165*	1						
(4)	0.0114	-0.0573	-0.1032*	1					
(5)	-0.0601	-0.1097*	-0.0542	0.0252	1				
(6)	0.1840*	0.1622*	0.0790*	0.2290*	-0.0644	1			
(7)	0.0823*	0.0838*	0.0667*	0.2836*	-0.2136*	0.3979*	1		
(8)	-0.0792*	-0.014	0.0406	0.1580*	-0.0098	-0.1496*	0.0075 1	1	
(9)	-0.0401	0.0069	-0.2152*	0.2155*	0.1793*	-0.1194*	0.0876*	0.0744*	1
Slovenia (n=1393)									
(2)	0.0389	1							
(3)	0.0898*	0.3591*	1						
(4)	-0.0912*	-0.2681*	-0.5398*	1					
(5)	-0.0524*	-0.0995*	-0.1427*	0.2400*	1				
(6)	0.0857*	-0.1514*	-0.4231*	0.4246*	0.0772*	1			
(7)	-0.0052	-0.0487	0.0747*	0.2257*	-0.0291	0.2505*	1		

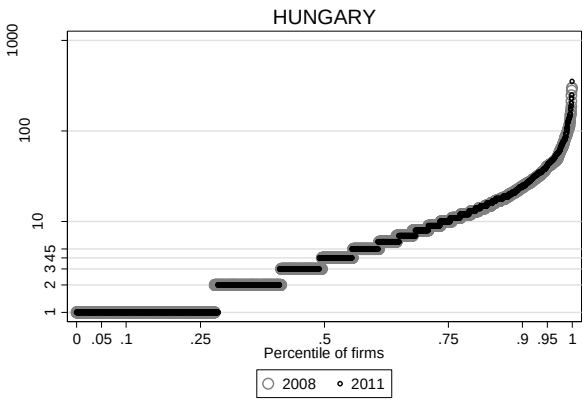
(8)	-0.1001*	-0.1411*	-0.2796*	0.3480*	0.0306	0.0861*	0.1494*	1	
(9)	-0.0204	-0.0200	-0.0696*	0.0481	0.1649*	0.0245	-0.0195	0.0734*	1

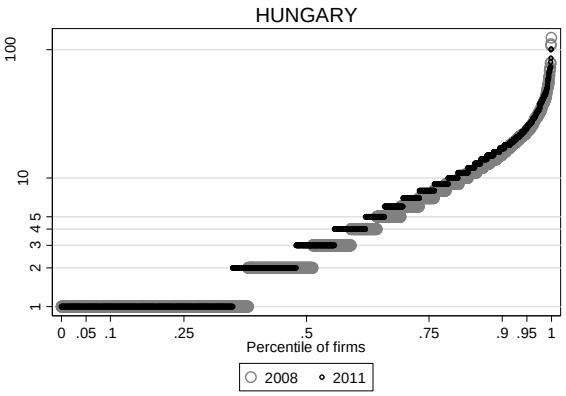
[a)] The Slovak sample covers only firms with 20 or more employees.
Note: * denotes statistical significance at the 5% level.

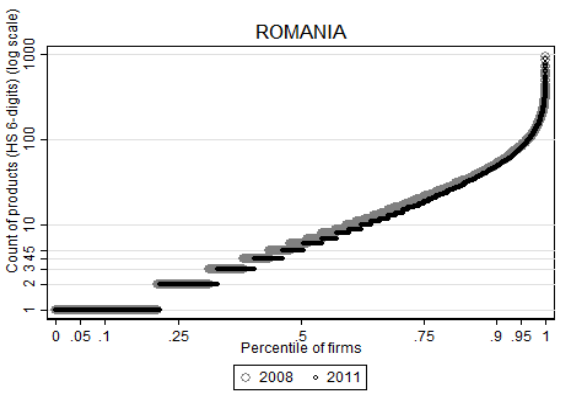
Appendix 2. Diversification of products and markets in 2007 and 2011

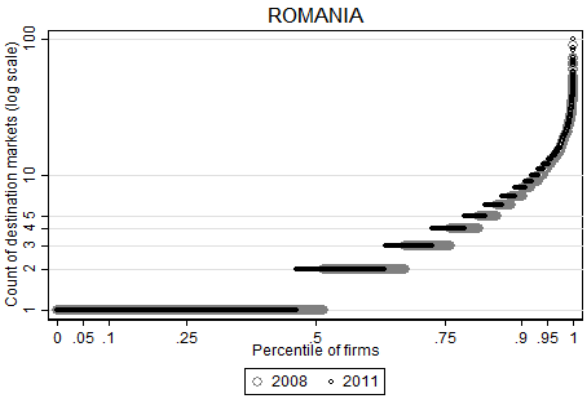


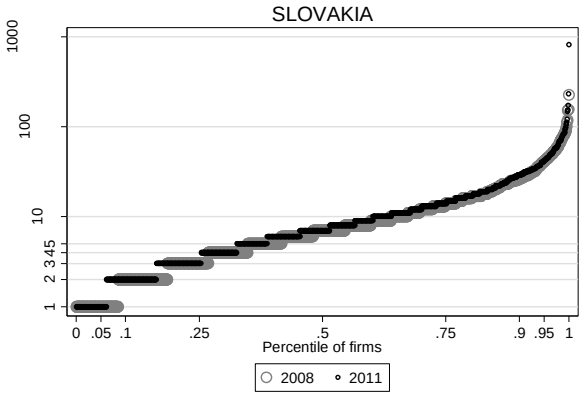


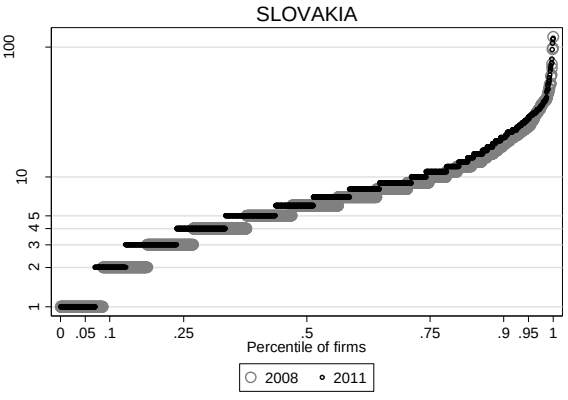












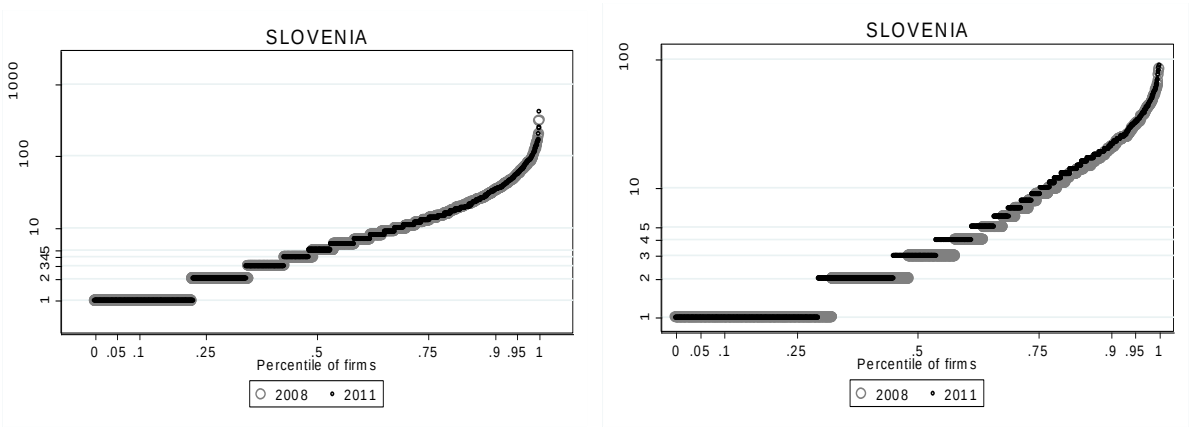


Figure 1. Diversification of exported products and destination markets, manufacturing, 2008 and 2011.

[a)] The Slovak sample covers only firms with 20 or more employees.

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

Source: authors' calculations from customs data.

Appendix 3. Concentration and volatility by OLS estimation.

Table 1. The effect of product concentration on volatility, OLS estimation of concentration in 2008 and volatility in 2009-2012

	Estonia	Hungary	Romania	Slovakia[a]	Slovenia
Output equation: volatility of sales growth					
Concentration of products	-0.014	0.018	0.010	-0.001	0.026**
	(0.025)	(0.011)	(0.009)	(0.017)	(0.011)
Log(TFP)	-0.031**	-0.027***	-0.012**	-0.015*	-0.016**
	(0.012)	(0.007)	(0.005)	(0.008)	(0.007)
Log(capital per employee)	0.002	0.007**	0.000	0.007	0.000
	(0.007)	(0.003)	(0.002)	(0.006)	(0.003)
Secors (2-digit NACE2008)	Yes	Yes	Yes	Yes	Yes
No of obs	362	1740	2799	913	1393
R^2 first stage equation	0.154	0.138	0.050	0.195	0.094

[a)] The Slovak sample covers only firms with 20 or more employees.
Note: Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.
Source: authors' calculations from customs data.

Table 2. The effect of market concentration on volatility, OLS estimation of concentration in 2008 and volatility in 2009-2012

	Estonia	Hungary	Romania	Slovakia[a]	Slovenia
Output equation: volatility of sales growth					
Concentration of markets	0.028	0.049***	0.029***	0.004	0.034***
	(0.025)	(0.010)	(0.009)	(0.018)	(0.010)
Log(TFP)	-0.030**	-0.022***	-0.010**	-0.015*	-0.011
	(0.012)	(0.007)	(0.005)	(0.008)	(0.007)
Log(capital per employee)	0.004	0.009***	0.001	0.007	0.001
	(0.006)	(0.003)	(0.002)	(0.006)	(0.003)
Secors (2-digit NACE2008)	Yes	Yes	Yes	Yes	Yes
No of obs	362	1740	2799	913	1393
R^2 first stage equation	0.157	0.148	0.053	0.195	0.097

[a)] The Slovak sample covers only firms with 20 or more employees.
Note: Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.
Source: authors' calculations from customs data.

Appendix 4. Robustness of estimates over different timespans of concentration and volatility.

Table 1. The effect of product concentration on volatility, 2SLS estimation of rolling window between 2004 and 2011

Output equation: standard deviation of sales growth	Estonia	Hungary	Romania	Slovakia[a]	Slovenia
Concentration of products, 2004	0.203***			0.228***	0.454***
	(0.059)			(0.070)	(0.075)
DWH test (p-value), 2004	0.001			0.0005	0.000
Hansen test (p-value), 2004	0.000			0.385	0.844
Concentration of products, 2005	0.331***			0.221***	0.333***
	(0.091)			(0.063)	(0.068)
DWH test (p-value), 2005	0.000			0.000	0.000
Hansen test (p-value), 2005	0.174			0.748	0.857
Concentration of products, 2006	0.179**			0.097	0.216***
	(0.087)			(0.066)	(0.062)
DWH test (p-value), 2006	0.008			0.102	0.000
Hansen test (p-value), 2006	0.431			0.629	0.871
Concentration of products, 2007	0.256**		0.265***	0.141**	0.137**
	(0.103)		(0.043)	(0.068)	(0.057)
DWH test (p-value), 2007	0.004		0.000	0.030	0.013
Hansen test (p-value), 2007	0.969		0.000	0.078	0.027
Concentration of markets, 2004	0.208***			0.095***	0.145***
	(0.044)			(0.034)	(0.019)
DWH test (p-value), 2004	0.000			0.011	0.000
Hansen test (p-value), 2004	0.0003			0.050	0.0007
Concentration of markets, 2005	0.221***			0.134***	0.099***
	(0.051)			(0.037)	(0.018)
DWH test (p-value), 2005	0.000			0.0001	0.000
Hansen test (p-value), 2005	0.154			0.419	0.030
Concentration of markets, 2006	0.157**			0.060	0.060***
	(0.067)			(0.050)	(0.018)
DWH test (p-value), 2006	0.003			0.189	0.149
Hansen test (p-value), 2006	0.527			0.386	0.097
Concentration of markets, 2007	0.143**		0.142***	0.046	0.019
	(0.070)		(0.021)	(0.055)	(0.018)
DWH test (p-value), 2007	0.0141		0.000	0.360	0.846
Hansen test (p-value), 2007	0.294		0.000	0.011	0.003
No of obs, 2004	737			938	1509
No of obs, 2005	562			891	1359
No of obs, 2006	367			1010	1365
No of obs, 2007	365		2766	983	1356

[a)] The Slovak sample covers only firms with 20 or more employees.

Notes: The DWH test is the Durbin-Wu-Hausman test of endogeneity. Only the coefficient of concentration from the output equation is presented. The standard deviation of sales growth in 2005-2008 is regressed with the concentration in 2004; the standard deviation of sales growth in 2006-2009 is regressed with the concentration in 2005 and so on. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from customs data.

Appendix 5. Robustness of estimates: large firms over different timespans of concentration and volatility.

Table 1. The effect of product concentration on volatility, 2SLS estimation of rolling window between 2004 and 2012 and firms with 20 or more employees

Output equation: standard deviation of sales growth	Estonia	Hungary	Romania	Slovakia	Slovenia
Concentration of products, 2004	-0.001			0.228***	0.223***
	(0.100)			(0.070)	(0.086)
DWH test (p-value), 2004	0.793			0.0005	0.011
Hansen test (p-value), 2004	0.009			0.385	0.873
Concentration of products, 2005	0.243**	0.105**		0.221***	0.233***
	(0.120)	(0.049)		(0.063)	(0.072)
DWH test (p-value), 2005	0.005	0.041		0.000	0.000
Hansen test (p-value), 2005	0.755	0.770		0.748	0.830
Concentration of products, 2006	0.015	0.192***		0.097	0.192**
	(0.111)	(0.064)		(0.066)	(0.089)
DWH test (p-value), 2006	0.560	0.005		0.102	0.004
Hansen test (p-value), 2006	0.977	0.033		0.629	0.658
Concentration of products, 2007	0.074	0.091	0.168***	0.141**	0.154**
	(0.088)	(0.057)	(0.042)	(0.068)	(0.075)
DWH test (p-value), 2007	0.259	0.190	0.000	0.030	0.007
Hansen test (p-value), 2007	0.079	0.0004	0.008	0.078	0.693
Concentration of products, 2008	-0.080	0.037	0.236***	0.226***	0.095
	(0.126)	(0.054)	(0.048)	(0.081)	(0.076)
DWH test (p-value), 2008	0.685	0.797	0.000	0.002	0.150
Hansen test (p-value), 2008	0.075	0.0006	0.071	0.911	0.167
Concentration of markets, 2004	0.037			0.095***	0.073**
	(0.061)			(0.034)	(0.034)
DWH test (p-value), 2004	0.523			0.011	0.305
Hansen test (p-value), 2004	0.008			0.050	0.278
Concentration of markets, 2005	0.105*	0.057		0.134***	0.105***
	(0.063)	(0.035)		(0.037)	(0.030)
DWH test (p-value), 2005	0.038	0.319		0.0001	0.005
Hansen test (p-value), 2005	0.178	0.328		0.419	0.401
Concentration of markets, 2006	0.017	0.158***		0.060	0.081**
	(0.086)	(0.040)		(0.050)	(0.037)
DWH test (p-value), 2006	0.504	0.004		0.189	0.178
Hansen test (p-value), 2006	0.980	0.204		0.386	0.351
Concentration of markets, 2007	-0.130	0.121***	0.081***	0.046	0.055*
	(0.098)	(0.042)	(0.021)	(0.055)	(0.031)
DWH test (p-value), 2007	0.459	0.0205	0.002	0.360	0.456
Hansen test (p-value), 2007	0.095	0.010	0.001	0.0111	0.318
Concentration of markets, 2008	-0.216*	0.062	0.123***	0.223*	-0.028
	(0.120)	(0.038)	(0.024)	(0.115)	(0.035)
DWH test (p-value), 2008	0.092	0.714	0.000	0.044	0.116
Hansen test (p-value), 2008	0.383	0.001	0.024	0.194	0.133
No of obs, 2004	341			938	575
No of obs, 2005	284	1427		891	562
No of obs, 2006	178	1343		1010	532
No of obs, 2007	188	1338	2196	983	523
No of obs, 2008	187	1369	2260	913	495

Notes: The DWH test is the Durbin-Wu-Hausman test of endogeneity. Only the coefficient of concentration from the output equation is presented. The standard deviation of sales growth in 2005-2008 is regressed with the concentration in 2004; the standard deviation of sales growth in 2006-2009 is regressed with the concentration in 2005 and so on. Robust standard errors in parenthesis. ***, **, * show statistical significance at the 1, 5 and 10% level.

Source: authors' calculations from customs data.