LATVIJAS BANKA

ISBN 9984–676–33–1

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THE QUALITY AND VARIETY OF EXPORTS FROM NEW EU MEMBER STATES: EVIDENCE FROM VERY DISAGGREGATED DATA

WORKING PAPER

2 / 2010

CONTENTS

ABBREVIATIONS

CES	constant elasticity of substitution
CIF	cost, insurance and freight at the importer's boarder
CIS	Commonwealth of Independent States
EU	European Union
GDP	gross domestic product
HS	Harmonised Commodity Description and Coding System
HS2	HS two-digit category
n.i.d.	normally and independently distributed
NMS	new Member States (Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia)
SIC	Standard Industrial Classification
US	United States of America

ABSTRACT

According to trade theories, the average quantity of exported goods is not the only parameter of export performance – the variety and quality of exports also play an important role. The goal of this paper is to evaluate the variety and quality of exports from the new EU Member States Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia (NMS) in 1999–2009. The analysis is done on the basis of methodology proposed by R. C. Feenstra (7) and further developed by D. Hummels and P. Klenow (13), and Ch. Broda and D. E. Weinstein (4). Although unit values play an important role in defining export quality, the calculations herein take into account also market shares and the level of monopoly power of firms in a particular market. In addition, this study contributes to the existing literature by providing a different way of evaluating the variety assuming that the number of exported brands follows the Poisson distribution. The calculations show that exports from NMSs in 2009 were of lower quality in comparison with German exports: relative quality was ranging between 0.30 and 0.55. It was found that all NMSs significantly increased their average number of brands exported to the EU market; moreover, all NMSs were able to increase the average quality of their exports during the 10-year reference period. Finally, relative quality is much more stable than relative prices, providing evidence that the measure of relative quality developed herein is better than the traditional proxy, i.e. relative export prices, as it does not include relative costs of production but reflects structural factors.

Keywords: new EU Member States, exports, quality, variety

JEL classification: C43, F12, F14, O52

The views expressed in this publication are those of the authors, employees of the Monetary Policy Department of the Bank of Latvia. The authors assume responsibility for any errors and omissions.

The authors want to thank Viktors Ajevskis and Uldis Rutkaste (Bank of Latvia) for their valuable comments and recommendations.

INTRODUCTION

Trade theories suggest that there are different ways by which a country can increase its exports. Models that follow P. S. Armington (2) stress the intensive margin or exported quantity of a single product. Such models state that each country produces a single variety in each category of goods, so there are no changes in variety and no quality differences. Consequently, the only way to increase exports in such a theoretical model is to increase the average exported quantity of each product without altering the set of exported products or their quality. On the other hand, monopolistic competition models, like one developed by P. R. Krugman (14; 15; 16), assume that countries produce an endogenous number of varieties and put emphasis on the role of extensive margin and maintaining that in such a way exports can be boosted by higher export variety. In these models, however, exports are differentiated only horizontally, i.e. by various products. This gap is filled by models in the vein of H. Flam and E. Helpman (10), which are based on vertical product differentiation, i.e. differentiation according to quality. As a result, exports can be upgraded not only by using intensive or extensive margins, but also by exporting higher quality products.

While the theoretical models of horizontal and vertical differentiation in international trade have a long history, the empirical applications of these models are not so widespread, as investigating the role of variety and quality requires detailed trade data and intensive computations. This paper makes an attempt to fill the gap and evaluate variety and quality of exports from NMSs in 1999–2009.

Quality can be defined as any tangible or intangible attribute of a good that increases all consumers' valuation of it (12). Hence product quality encompasses physical attributes of a product (e.g. size, a set of available functions, durability, etc) as well as intangible attributes (e.g. product image, brand name, etc). There is less accordance in the definition of variety in empirical papers. Theoretically, variety is commonly defined as a brand produced by a firm, total output of a firm, output of a country, or output within an industry of a country (4). The former two definitions are closer to those in P. R. Krugman's monopolistic competition model, even though a problem of data availability arises; the latter two are more in accordance with P. S. Armington's framework and ignore a large part of variety. This paper defines variety as a brand produced by a firm.

For a long time, the usual way to assess unobserved export quality was to use observed export prices or unit values (value divided by quantity). Even though this proxy has a clear advantage of simplicity in calculations, it has always been argued that such a measure is unsatisfactory because export prices may vary for reasons other than quality, e.g. different production costs. Quite recently, several empirical works in the field of quality and variety based on a solid microeconomic background have appeared. The first to mention is a seminal paper by R. C. Feenstra (7) in which the effects of changes in variety on import prices in the US are studied. This methodology was further developed by Ch. Broda and D. E. Weinstein (4), and R. C. Feenstra and H. L. Kee (8; 9), while D. Hummels and P. J. Klenow (13) put quality into focus. Recent papers in this field worth to be mentioned are by J. C. Hallak and P. K. Schott (12) in which export prices are decomposed into quality and quality-adjusted price components, and by B. A. Bloningen and

A. Soderbery (3) using a detailed market-based data set on the US automobile market to assess the gains from increasing variety.

We evaluate the quality and variety of NMS exports on the basis of methodology proposed by R. C. Feenstra (7) and further developed by D. Hummels and P. J. Klenow (13), and Ch. Broda and D. E. Weinstein (4). Although unit values still play an important role in defining export quality, the calculations herein take into account also market shares and the level of monopoly power of firms in a particular market. In addition, this study contributes to the existing literature by providing a different way of evaluating variety, assuming that the number of exported brands follows the Poisson distribution.

For empirical analysis, the trade data available from *Eurostat Comext* database are used. As decomposition of nominal trade flows into prices and volumes is required, the analysis was done at the most detailed eight-digit HS classification level containing more than 17 000 categories of goods. Although focus herein is on NMS exports, statistics on EU imports limiting our analysis to NMS exports to the EU are used; this, however, is a good representation of export performance as the EU is the main trade partner of the NMSs.

The paper is structured as follows. Section 1 derives the theoretical framework of methodology, providing insight into household utility maximisation problem and import demand and supply equations. Section 2 describes the database, shows how the proxy for relative variety was obtained and how elasticities of substitutions were estimated. Section 3 discusses relative quality, prices and quality-adjusted prices of NMS exports. Final section concludes.

1 THEORETICAL MODEL

In this section, the role of quality and variety of products is analysed using a simple theoretical model. In this model, consumers' utility depends not only on the physical volume of consumption, but also on variety and quality of goods. The model is based on the models proposed and developed by R. C. Feenstra (7), D. Hummels and P. J. Klenow (13), and Ch. Broda and D. E. Weinstein (4).

1.1 Household Utility Maximisation Problem

The traditional way to specify how consumers value variety is a Dixit-Stiglitz framework where utility is given by CES function with a single elasticity of substitution. However, as argued by Ch. Broda and D. E. Weinstein (4), this creates several problems as obviously elasticities of substitution are not the same for varieties of different goods and it is difficult to interpret the meaning of a single elasticity.

To allow different elasticity of substitution for different categories of goods, we follow Ch. Broda and D. E. Weinstein (4) and denote preferences of a representative agent by a two-level utility function. Consumers buy from up to J countries[1] in each of I observable categories of goods. In each time period, consumers maximise utility U given by:

$$U = \left(\sum_{i=1}^{I} M_i^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \quad \gamma > 1 \qquad [1]^2$$

where M_i is sub-utility derived from consumption of imported good i, and γ denotes elasticity of substitution between imported goods.

Now, following D. Hummels and P. J. Klenow (13), it is defined that sub-utility from an individual good depends not only on the quantity of good but also on its variety and quality. Moreover, in the present model, elasticity of substitution between varieties differs across different goods:

$$M_i = \left(\sum_{j=1}^{J} Q_{ij} N_{ij} x_{ij}^{\frac{\sigma_i-1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i-1}}, \quad \sigma_i > 1 \qquad [2]$$

where x_{ij} is average quantity of a single brand of good i imported from country j, while Q_{ij} is average quality of a single brand ($Q_{ij} > 0$), N_{ij} denotes variety or the number of different brands of good i imported from country j, and σ_i is elasticity of substitution between varieties of good i.

Maximisation problem is subject to the budget constraint:

$$\sum_{i=1}^{I} \sum_{j=1}^{J} N_{ij} p_{ij} x_{ij} \le Y \qquad [3]$$

1 In this theoretical framework, the consumption of domestic products is also included into the utility function, so the set of *J* countries includes the domestic economy.

2 For simplicity we skip the time subscript for all variables in Sections 1.1 and 1.2.

where p_{ij} is average price of good i imported from country j and Y is consumer's income.

1.2 Relative Quality Equation

The first order conditions from equations [1], [2] and [3] are the following:

$$U^{\frac{1}{\gamma}} M_i^{\left(\frac{1}{\sigma_i}-\frac{1}{\gamma}\right)} Q_{ij} x_{ij}^{-\frac{1}{\sigma_i}} = \lambda p_{ij} \qquad [4]$$

where λ is Lagrange multiplier. We can transform equation [4] into log-ratios to express relative quality in terms of relative prices, quantities and elasticity of substitution between varieties:

$$\ln\left(\frac{Q_{ij}}{Q_{ik}}\right) = \ln\left(\frac{p_{ij}}{p_{ik}}\right) + \frac{1}{\sigma_i}\ln\left(\frac{x_{ij}}{x_{ik}}\right) \qquad [5]$$

where k denotes benchmark country. It should be noted that relative quality depends only on elasticity of substitution between varieties, while elasticity of substitution between imported goods does not enter equation [5].

Equation [5] shows that relative quality is largely indicated by relative prices. If the price of specific good imported from country j is higher than the price of the same good imported from country k, this is an indication of a higher quality of the former. However, relative price is not the only indicator of relative quality. If the elasticity of substitution is not high, the relative consumed quantity of a single trademark is also an important factor. In case the different trademarks are not close substitutes, higher amount of consumption of one trademark is a clear sign of a better quality. On the other hand, in a situation close to perfect competition when different trademarks are close substitutes, the only reason for a higher price is higher quality, and relative prices have one-to-one connection to relative quality.

We can transform equation [5] by adding and subtracting relative varieties:

$$\ln\left(\frac{Q_{ij}}{Q_{ik}}\right) = \ln\left(\frac{p_{ij}}{p_{ik}}\right) + \frac{1}{\sigma_i}\ln\left(\frac{N_{ij}x_{ij}}{N_{ik}x_{ik}}\right) - \frac{1}{\sigma_i}\ln\left(\frac{N_{ij}}{N_{ik}}\right) \qquad [6].$$

The reason for transforming equation for relative quality into equation [6] is the fact that the consumed quantity of a single trademark is not an observable variable, while $N_{ij}x_{ij}$ is total quantity of good i imported from country j and is observed from trade statistics. Now relative quality could be derived from relative prices (observed from trade statistics on unit values), relative quantities of imports (observed from trade statistics on volumes), relative variety and elasticity of substitution between varieties of good. The two latter variables are not directly observable. For a moment, it should be assumed that there are data on relative variety and focus on the derivation of elasticity of substitution.

1.3 Import Demand and Supply Equations

To derive elasticity of substitution, import demand and supply equations need to be specified. The demand equation is determined in terms of market share $s_{ij,t}$, which denotes the share of country j in total imports of good i. By defining the minimum costs function and rearranging we obtain a demand equation (see Appendix 1 for technical details):

$$\ln s_{ij,t} = (\sigma_i - 1)\ln P_{i,t} - (\sigma_i - 1)\ln p_{ij,t} + \ln N_{ij,t} + \sigma_i \ln Q_{ij,t} \qquad [7]$$

$$s_{ij,t} = \frac{x_{ij,t} p_{ij,t} N_{ij,t}}{\sum_{j=1}^{J} x_{ij,t} p_{ij,t} N_{ij,t}}$$

$$P_{i,t} = \left(\sum_{j=1}^{J} N_{ij,t} Q_{ij,t}^{\sigma_i} p_{ij,t}^{1-\sigma_i} \right)^{\frac{1}{1-\sigma_i}}$$

where $P_{i,t}$ denotes minimum costs of obtaining one unit of services from imports of good i. As $P_{i,t}$ does not depend on j, it can be viewed as random effect. Equation [7] states that the market share of country j in total imports of a particular good is negatively related to relative price of imports from country j to average price of good. The higher elasticity of substitution is, the stronger the reaction of market share to the changes in relative price. Moreover, the market share is positively related to variety and quality of a product.

Making an assumption that log of quality is a random walk process

$$\ln Q_{ij,t} = \ln Q_{ij,t-1} + e_{ij,t} \qquad [8]$$

where $e_{ij,t}$ is stochastic n.i.d. process, the following demand equation in first differences is obtained:

$$\Delta \ln s_{ij,t} - \Delta \ln N_{ij,t} = \phi_{i,t} - (\sigma_i - 1)\Delta \ln p_{ij,t} + \varepsilon_{ij,t} \qquad [9]$$

$$\phi_{i,t} = (\sigma_i - 1)\Delta \ln P_{i,t}$$

$$\varepsilon_{ij,t} = \sigma_i e_{ij,t}$$

where $\varepsilon_{ij,t}$ appears as an error term in this demand equation.

Following R. C. Feenstra (7), the supply curve for imports from country j is specified in first differences as

$$\Delta \ln p_{ij,t} = \omega_i \Delta \ln x_{ij,t} + \xi_{ij,t}, \quad \omega_i \geq 0 \qquad [10]$$

where ω_i is inverse supply elasticity of good i, which is assumed to be the same for all producing countries, while $\xi_{ij,t}$ is random error that is assumed to be independent of $\varepsilon_{ij,t}$. This system of demand equation [9] and supply equation [10] will be used later to evaluate elasticity of substitution between varieties.

2 EMPIRICAL ESTIMATES

2.1 Description of Database

For empirical analysis, the trade data available from *Eurostat Comext* database is used. As we need to break down nominal trade flows into prices and volumes, the analysis was done at the most detailed eight-digit HS classification level containing more than 17 000 categories of goods.

Although the focus herein is on NMS exports, we use statistics on EU total imports from NMSs. First, our theoretical model is constructed from the import, not from the export side. Second, to estimate elasticities of substitution, data on EU imports from a large sample of countries both inside and outside the EU is needed. This limits the analysis herein to NMS exports to the EU, which, however, is a good representation of export performance as EU is the main trade partner of NMSs.[3]

The dataset contains annual data on EU imports from 50 different countries between 1999 and 2009[4]. The list of countries includes all 27 EU Member States, several CIS countries (Russia, Ukraine, Belarus, and Kazakhstan), other important EU trade partners (e.g. US, Japan, Canada, Australia, China, India, and Brazil). During the sample period, EU imports are nonzero in 14 520 categories of goods. Unit value indices (euro per kg)[5] are used as proxy for the prices and trade volumes (mainly in kg) as proxy for quantities. This means that all varieties of a particular good are aggregated within each country.

The dataset has undergone two adjustments. First, in many cases there are data either for values or for volumes but not for both; therefore, it was not possible to calculate the unit value indices. Such incomplete observations were ignored and removed from the database. The second adjustment is connected with structural changes within the categories of goods. Although the most detailed classification available has been used, it is still possible that sometimes apples and oranges are compared within one particular category. One indication of such a problem is the large price level differences. Consequently, all observations with outlying unit value indices were excluded from the database.[6]

[3] The share of NMS exports to the EU in total exports is reasonably high, ranging between 64% and 86% in 2009 (64.3% for Bulgaria, 84.6% for Czech Republic, 69.5% for Estonia, 78.8% for Hungary, 67.6% for Latvia, 64.3% for Lithuania, 79.3% for Poland, 74.3% for Romania, 85.8% for Slovakia and 68.9% for Slovenia).

[4] In the theoretical model, it was assumed that consumers maximise their utility taking into account both foreign and domestic production. However, the empirical analysis faces serious constraints as data on domestic consumption are not as detailed and disaggregated as for international trade flows. Therefore, there are no data on domestic consumption of individual EU Member States, e.g. EU imports from Germany are missing the German consumption of domestic products, EU imports from Italy do not contain Italian consumption of domestic products, etc. This data problem biases empirical calculations herein from the theoretical model and can affect the final results. The solution of this problem could be the subject for further research.

[5] Import values in the database are in CIF prices, which is the price of a good delivered at the frontier of the importing country, including any insurance, and freight charges incurred to that point.

[6] The observation was treated as an outlier if the absolute difference of unit value index with the mean unit value of the category exceeded three standard errors.

2.2 Proxy for Relative Variety

Although data describing prices and total quantity of a particular good imported from a particular country are available, any data about the varieties or numbers of different brands for one product are missing. It is possible to find such data for some albeit a very limited set of goods, which is, however, not enough to make a systematic analysis.

As was discussed above, the definition of variety differs significantly in various empirical papers. R. C. Feenstra (7) defined the variety of US imports as eight-digit SIC good produced in a particular country, acknowledging that by this all varieties of a particular good are aggregated within each country, which leads to several sources of error. R. C. Feenstra and H. L. Kee (8; 9) defined the variety of country's exports to the US as a share of total US imports of products that are exported by this country. This is done using 10-digit HS classification of US imports. Ch. Broda and D. E. Weinstein (4) have opted to use the same definition of variety, indicating at the same time that the reliance on Krugman's theory might suggest the adoption of such a definition of variety that is based on firm-level exports. D. Hummels and P. J. Klenow (13) argue that it is not possible to disentangle quality from within-category variety unless there are detailed data on precise numbers of variety per good from another source. The only empirical research using such data to our knowledge is by B. A. Bloningen and A. Soderbery (3). They use a data set of automobile varieties for the US market and conclude that HS codes often lumped quite dissimilar products into the same good classification, in such a way biasing elasticities of substitution downward.

Another way of dealing with the problem of unobserved variety is to link it to several observable macroeconomic variables. A. Dennis and B. Shepherd (5) tried to explain diversification of exports to the EU by various variables and found that it is linked to the nominal GDP, both positively and statistically significantly, while the distance from the exporting country, entry costs and export costs in the country of origin affect diversification negatively and statistically significantly. Diversification is defined as the number of eight-digit product lines in a two-digit sector for which a country has strictly positive export to the EU, so it is still subject to the problems indicated above. However, there is one interesting property in the methodology proposed by A. Dennis and B. Shepherd that we can use: since the diversification measure takes the form of count data, it is assumed that it follows a Poisson distribution.

The number of eight-digit products in a two-digit sector for which a country has strictly positive export to the EU is observed. The ratio of the number of such products to the total number of products in a two-digit sector alone can serve as an indicator of average export variety in this sector. By this it is implicitly assumed that a country exports either zero or one brand of each product. However, the fact that a country has positive exports of a particular product means that the number of brands is a positive integer, which is unobserved. As a result, the number of export varieties will be underestimated. This problem can be solved by assuming that the number of brands in each two-digit sector follows a Poisson distribution.

Denoting the probability mass function of Poisson distribution by $f(\cdot)$, it can be argued that from the trade data e only $f(0)$, which is the ratio of products in which a country has no exports to the total number of products in a two-digit sector, can be observed. From this it could be easily proven that (see Appendix 2 for more details):

$$\mu_s = -\ln(f(0)) \qquad [11]$$

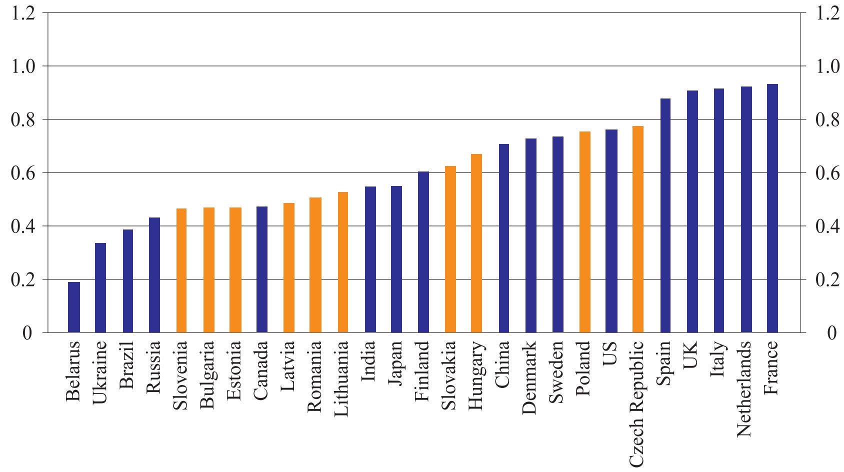
where μ_s is the mean amount of brands per product exported in a two-digit sector s. Hence it is assumed that (see Appendix 2 for more details)

$$N_{ij,t} = \begin{cases} 0 & if \quad I_{ijs,t} = 0 \\ \dfrac{\mu_s}{1-f(0)} & if \quad I_{ijs,t} = 1 \end{cases} \qquad [12]$$

where $I_{ijs,t}$ is binary variable, which is equal to 1 if country j is exporting good i classified within sector s, and equal to 0 otherwise.

Chart 1 shows the estimates for mean relative variety in 2009 using equation [11] with Germany as a benchmark country. The smallest amount of brands among NMSs is coming from Slovenia, Bulgaria, Romania and the Baltic States (45%–50% of German amount of brands). Slovakia's and Hungary's variety is estimated to be around 65% of German variety, while the highest export variety in NMSs is found in Poland and the Czech Republic (around 75%). In addition, relative variety is also quite heterogeneous across different product categories (see Appendix 3).

Chart 1
Mean relative variety of total exports to EU in 2009 (compared with Germany)



Source: authors' calculations.

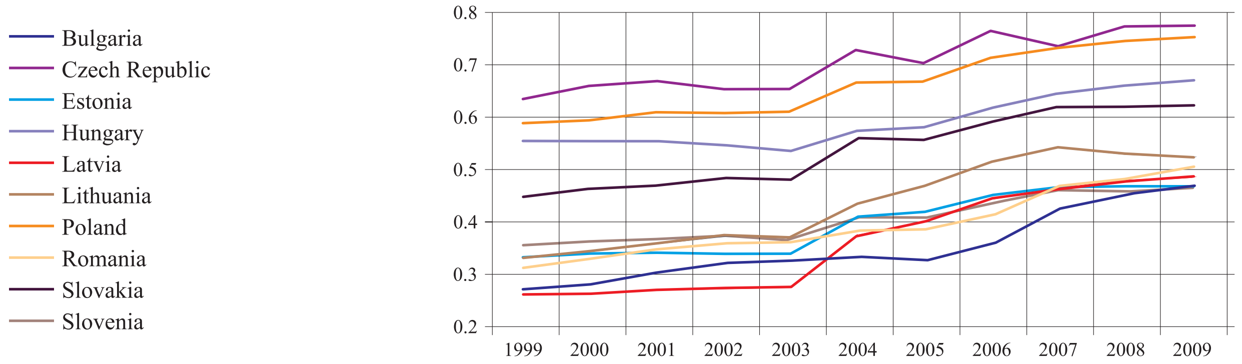
As regards other exporters, the highest estimated variety is for Germany, although other big EU countries (France, the Netherlands, Italy, UK and Spain) have quite similar amounts of exported brands (90%–95%). Although the size of the US and China economies is bigger than that of Germany, relative variety is estimated to be relatively low (70%–75%) due to much larger distance to the EU market. A similar reason could explain low varieties for Japan (55%) and Brazil (40%), while relatively low variety of Russia's exports (40%) could be also driven by poor business climate.

Overall, although the obtained ranking of countries is plausible, the absolute value of relative varieties seems to be too high for small countries like Slovenia, Bulgaria, the Baltic States, etc. First, it could be connected with the fact that the assumption herein about the number of varieties following Poisson distribution is not valid. Second, despite the most detailed available classification used, it is still possible that the number of individual products in international trade is significantly higher; hence the usage of eight-digit HS classification is overestimating relative variety.

The dynamics of relative variety during the last 11 years in NMSs is shown in Chart 2. It is clear that all NMSs increased significantly the average number of brands exported to the EU market; moreover, the most rapid increase is observed for 2004, the year of the EU accession for the most countries in the analysis herein[7]. This shows that integration into the EU market goes not only in the intensive but also in the extensive dimension. The result of growing export variety is also in line with the analysis made by M. Funke and R. Ruhwedel (11) who reported increasing export variety for NMSs in 1993–2000.

Chart 2

Mean relative variety of NMS total exports to EU in 1999–2009 (compared with Germany)



Source: authors' calculations.

The most significant progress in extensive margin is estimated for Latvia, which compared with German variety increased its export variety from 25% in 1999 to almost 50% in 2009. A similar increase was observed for the other Baltic States, Bulgaria, and Romania.

2.3 Empirical Estimates of Elasticity of Substitution

Now when evaluation for relative variety is obtained, we can return to the system of demand ([9]) and supply ([10]) equations to estimate elasticities of substitution. First, the demand equation [9] is transformed into ratios to a reference country k to eliminate $\phi_{i,t}$ and expressed in the following way:

$$\Delta \ln\left(\frac{s_{ij,t}}{s_{ik,t}}\right) - \Delta \ln\left(\frac{N_{ij,t}}{N_{ik,t}}\right) + (\sigma_i - 1)\Delta \ln\left(\frac{p_{ij,t}}{p_{ik,t}}\right) = \tilde{\varepsilon}_{ij,t} \qquad [13]$$

[7] Although the EU import, not NMS export data are analysed, it is still possible that a part of the increase in variety was due to methodological changes, as EU imports include also EU NMS imports.

$\tilde{\varepsilon}_{ij,t} = \varepsilon_{ij,t} - \varepsilon_{ik,t}$.

Afterwards, the supply equation [10] is determined in terms of market shares and rearranged in the following form (see Appendix 4 for technical details):

$$(1-\rho_i)\Delta\ln\left(\frac{p_{ij,t}}{p_{ik,t}}\right) - \frac{\rho_i}{\sigma_i - 1}\left(\Delta\ln\left(\frac{s_{ij,t}}{s_{ik,t}}\right) - \Delta\ln\left(\frac{N_{ij,t}}{N_{ik,t}}\right)\right) = \tilde{\delta}_{ij,t} \qquad [14]$$

$$\tilde{\delta}_{ij,t} = \delta_{ij,t} - \delta_{ik,t}$$

$$\delta_{ij,t} = \frac{\xi_{ij,t}}{1+\omega_i\sigma_i}$$

$$0 \le \rho_i = \frac{\omega_i(\sigma_i - 1)}{1+\omega_i\sigma_i} < 1$$

where error terms $\tilde{\varepsilon}_{ij,t}$ and $\tilde{\delta}_{ij,t}$ are mutually independent.

There is a system of two variables (changes in relative market shares of one brand and changes in relative prices), two equations and two coefficients to estimate. The unusual feature of the system of equations [13] and [14] is the absence of exogenous variables which would normally be needed to identify and estimate elasticities.

Following R. C. Feenstra (7), estimation of the system in the absence of instruments is considered, exploiting the panel nature of the data set. To obtain the estimates there is a need to transform the system of the two equations into a single equation by exploiting E. E. Leamer's (17) insight and independence of errors $\tilde{\varepsilon}_{ij,t}$ and $\tilde{\delta}_{ij,t}$. It is done by multiplying both sides of equations [13] and [14]. After such transformations, the following equation is obtained:

$$Y_{ij,t} = \theta_{1,i}X_{ij,t} + \theta_{2,i}Z_{ij,t} + u_{ij,t} \qquad [15].$$

$$Y_{ij,t} = \left(\Delta\ln\left(\frac{p_{ij,t}}{p_{ik,t}}\right)\right)^2, \quad X_{ij,t} = \left(\Delta\ln\left(\frac{s_{ij,t}}{s_{ik,t}}\right) - \Delta\ln\left(\frac{N_{ij,t}}{N_{ik,t}}\right)\right)^2,$$

$$u_{ij,t} = \frac{\tilde{\varepsilon}_{ij,t}\tilde{\delta}_{ij,t}}{(1-\rho_i)(\sigma_i - 1)}, \quad Z_{ij,t} = \left(\Delta\ln\left(\frac{s_{ij,t}}{s_{ik,t}}\right) - \Delta\ln\left(\frac{N_{ij,t}}{N_{ik,t}}\right)\right)\left(\Delta\ln\left(\frac{p_{ij,t}}{p_{ik,t}}\right)\right),$$

$$\theta_{1,i} = \frac{\rho_i}{(\sigma_i - 1)^2(1-\rho_i)}, \quad \theta_{2,i} = \frac{2\rho_i - 1}{(\sigma_i - 1)(1-\rho_i)}$$

It should be noted that the estimating of $\theta_{1,i}$ and $\theta_{2,i}$ leads to inconsistent estimates, as relative prices and relative market shares are correlated with the error $u_{ij,t}$ and, therefore, also $X_{ij,t}$ and $Z_{ij,t}$ are correlated with the error. However, R. C. Feenstra (7) provides a transformation that allows for consistent estimation of $\theta_{1,i}$ and $\theta_{2,i}$ by averaging all variables over all t. By doing it, the following asymptotic conditions are met:

$$E\left(\bar{X}_{ji}\bar{u}_{ji}\right) = 0, \quad E\left(\bar{Z}_{ji}\bar{u}_{ji}\right) = 0$$

where upper bars on variables denote sample means. These conditions, combined with the assumption that the mean of the errors is independent, imply that the estimator delivers consistent estimates of $\theta_{1,i}$ and $\theta_{2,i}$. R. C. Feenstra (7) also shows that the estimates are consistent even in the presence of measurement errors in unit values provided that a constant term is included in the equation. Therefore, a weighted least square (WLS) regression is run on the following equation:

$$\overline{Y}_{ij} = \theta_{0,i} + \theta_{1,i}\overline{X}_{ij} + \theta_{2,i}\overline{Z}_{ij} + \overline{u}_{ij} \qquad [16]$$

After obtaining the estimates of the coefficients in equation [16], demand and supply elasticities can be calculated.

If $\theta_{1,i} > 0$, there are two solutions for σ_i, one larger and the other smaller than unity. According to sign restrictions on σ_i, the attention is restricted to the solution that exceeds unity:

$$\hat{\sigma}_i = 1 + \left(\frac{2\hat{\rho}_i - 1}{1 - \hat{\rho}_i}\right)\frac{1}{\hat{\theta}_{2,i}}$$

if $\theta_{2,i} \geq 0$, then

$$\hat{\rho}_i = \frac{1}{2} + \left(\frac{1}{4} - \frac{1}{4 + \left(\hat{\theta}_{2,i}^2 / \hat{\theta}_{1,i}\right)}\right)^{\frac{1}{2}}$$

if $\theta_{2,i} < 0$, then

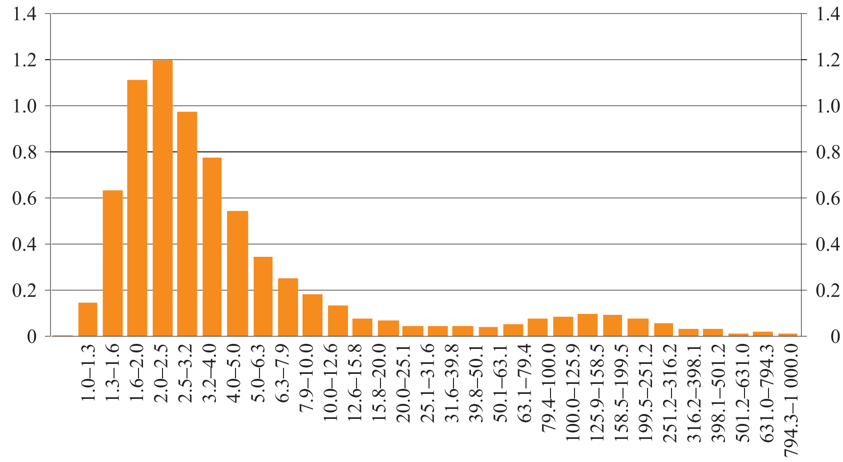
$$\hat{\rho}_i = \frac{1}{2} - \left(\frac{1}{4} - \frac{1}{4 + \left(\hat{\theta}_{2,i}^2 / \hat{\theta}_{1,i}\right)}\right)^{\frac{1}{2}}.$$

As was noted by Ch. Broda and D. E. Weinstein (4), R. C. Feenstra's methodology tends to generate a large number of elasticities that take on imaginary values which are difficult to interpret. They propose to deal with this problem by conducting a grid search in cases where $\theta_{1,i} \leq 0$. Grid search finds the minimum sum of weighted least squares of residuals over the value of elasticities in the specified ranges. We make a grid search for values of $\sigma_i \in (\exp(0), \exp(20)]$ at 200 intervals and $\rho_i \in [0,1)$ at 100 intervals.

Elasticity of substitution between varieties is estimated for all i where data on at least 15 importing countries were available. Overall, elasticities for 7 278 different goods were evaluated. Chart 3 shows the distribution of estimated elasticities.

The median elasticity of substitution between varieties is 3.58. This, according to Krugman's model where a firm mark-up equals $\sigma_i / (\sigma_i - 1)$, gives a median mark-up of 38.5%, which seems to be a plausible result. Also, Chart 3 testifies to a very high degree of heterogeneity in elasticity of substitution for individual products. Some markets could be characterised as markets with monopolistic competition, while a significant proportion of markets is close to perfect competition.

Chart 3
The distribution of estimated elasticities of substitution between varieties



Source: authors' calculations.

Table
The distribution of estimated elasticities of substitution between varieties for selected two-digit HS categories of goods

Two-digit HS category of goods	Number of observations	Median elasticity	Median mark-up (%)
Pharmaceutical products	37	5.30	23.3
Plastics and articles thereof	220	3.50	40.0
Rubber and articles thereof	132	3.20	45.5
Wood and articles of wood	184	3.67	37.5
Paper and paperboard	255	3.39	41.8
Articles of apparel and clothing accessories	165	3.39	41.8
Iron and steel	349	4.56	28.1
Articles of iron and steel	302	3.16	46.3
Miscellaneous articles of base metal	48	3.54	39.4
Machinery and mechanical appliances	890	3.73	36.6
Railway or tramway locomotives	18	3.45	40.8

Source: authors' calculations.

The analysis of elasticity of substitution between varieties for selected two-digit categories of goods shows that, although there is significant heterogeneity in elasticities of substitution, it does not come from between-categories difference, as median elasticities of several important import categories are quite similar (see Table 1). Therefore, these results suggest that heterogeneity mostly comes from within-categories difference, in other words, different product markets have different levels of competition even within the same category of trade.

2.4 Aggregation of Relative Quality and Prices

The use of very disaggregated data creates the problem for the interpretation of results, as it is not possible to describe the outcome for several thousands of different products. Therefore, aggregation is needed. For the aggregation of relative prices and quality the Sato-Vartia index was used (see K. Sato (18) for more details):

$$\ln P_{jk,t} = \sum_{i \in I_{jk}} W_{i,t} \ln \frac{P_{ij,t}}{P_{ik,t}} \qquad [17],$$

$$\ln Q_{jk,t} = \sum_{i \in I_{jk}} W_{i,t} \ln \frac{Q_{ij,t}}{Q_{ik,t}} \qquad [18]$$

$$S_{ij,t} = \frac{N_{ij,t} p_{ij,t} x_{ij,t}}{\sum_{i \in I_{jk}} N_{ij,t} p_{ij,t} x_{ij,t}}$$

$$W_{i,t} = \frac{\left(\frac{S_{ij,t} - S_{ik,t}}{\ln S_{ij,t} - \ln S_{ik,t}} \right)}{\sum_{i \in I_{jk}} \left(\frac{S_{ij,t} - S_{ik,t}}{\ln S_{ij,t} - \ln S_{ik,t}} \right)}$$

where $P_{jk,t}$ is aggregated relative export prices of countries j and k at time period t, $Q_{jk,t}$ is aggregated relative quality, $S_{ij,t}$ denotes cost shares, while $W_{i,t}$ is weights of the Sato-Vartia index. Finally, I_{jk} denotes the set of products which are exported both by countries j and k.

Equations [17] and [18] could be used to report relative price or quality in some particular period of time, while it cannot be used for the analysis of dynamics, as it does not take into account structural changes in country's exports. Therefore, a different Sato-Vartia index should be used to calculate changes in relative prices:

$$\ln \pi_{jk,t} = \sum_{i \in I_{jk}} w_{ij,t} \Delta \ln p_{ij,t} - \sum_{i \in I_{jk}} w_{ik,t} \Delta \ln p_{ik,t} \qquad [19]$$

$$w_{ij,t} = \frac{\left(\frac{S_{ij,t} - S_{ij,t-1}}{\ln S_{ij,t} - \ln S_{ij,t-1}} \right)}{\sum_{i \in I_{jk}} \left(\frac{S_{ij,t} - S_{ij,t-1}}{\ln S_{ij,t} - \ln S_{ij,t-1}} \right)}$$

where $\pi_{jk,t}$ denotes changes in relative aggregated prices and $w_{ij,t}$ is weights.

A problem arises for the calculation of changes in relative quality as there are no data or estimates of absolute quality of exports from countries j and k. This problem is tackled by assuming that quality of exports from the benchmark country ($Q_{ik,t}$) is always unchanged, thus the changes in aggregate relative quality are calculated in the following way:

$$\ln q_{jk,t} = \sum_{i \in I_{jk}} w_{ij,t} \Delta \ln \frac{Q_{ij,t}}{Q_{ik,t}} \qquad [20]$$

where $q_{jk,t}$ denotes changes in relative aggregated quality.

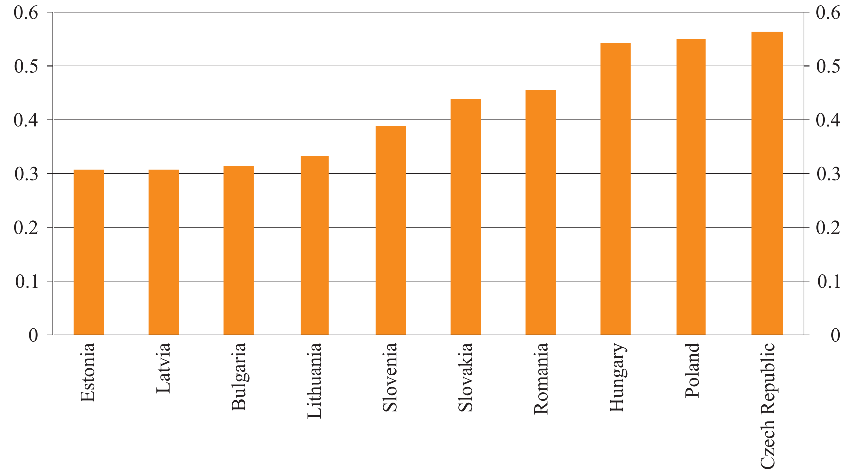
3 RESULTS

Finally, as relative market shares, unit value indices, proxy for relative variety and estimated elasticities of substitutions between varieties have been obtained, all ingredients for equation [6] are available and it is possible to evaluate relative quality of NMS exports.

3.1 Relative Quality Levels of NMS Exports

First, let the focus be on the analysis of relative quality levels, which were obtained by aggregating relative quality for individual products using equation [18]. Chart 4 reports the results for NMS total exports to the EU in 2009.

Chart 4
Relative quality of NMS total exports to EU in 2009 (compared with Germany)



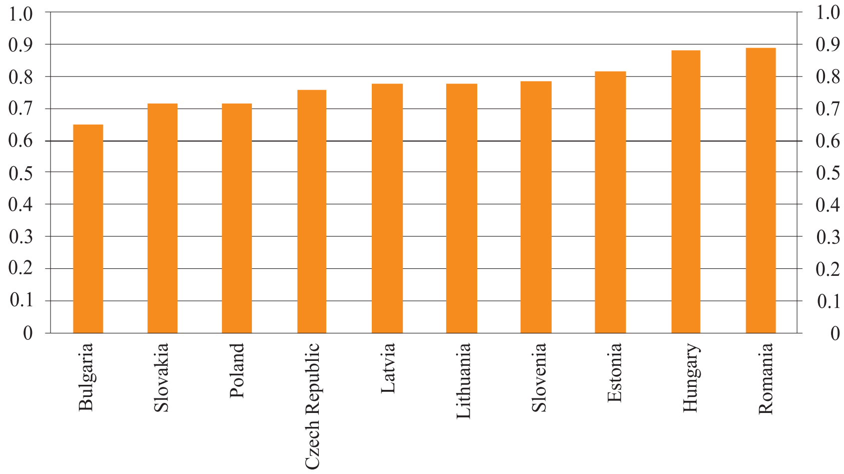
Source: authors' calculations.

Two immediate conclusions could be drawn from these results. First, according to authors' estimations, the NMS exports compared with German exports were of lower quality in 2009: relative quality was ranging around between 0.30 and 0.55. Second, there is a significant difference in total export quality for NMSs. The Baltic countries and Bulgaria appear at the low end of the range, with relative quality of around 30% of German quality, while the highest export quality was observed for Hungary, Poland and the Czech Republic (around 55% of German quality).

Although these results are already quite informative, it is even more useful to look at relative quality for the most important export sectors (see Appendix 5). The two abovementioned conclusions are still valid here. In almost all of the reported industries, export quality is relatively small compared with Germany. Also, the country ranking remains broadly unchanged. However, export quality is not homogenous across different industries within one country and the ranking of industries can significantly vary. For example, the Baltic States show the best performance in exports of wood as well as iron and steel; Bulgaria, Poland and Romania excel in exports of clothing and railway vehicles, while the Czech Republic has the most qualitative exports of miscellaneous articles of base metals.

It is interesting to compare the results from Chart 4 with what would be obtained if relative quality was proxied just by relative export prices or unit values. The results for relative price of NMS total exports to the EU are obtained using equation [17] and reported in Chart 5.

Chart 5
Relative price of NMS total exports to EU in 2009 (compared with Germany)



Source: authors' calculations.

For all NMSs, relative prices are higher than relative quality (despite Chart 5 indicating that the NMS export prices are still lower than the German export prices). Moreover, the difference in relative prices is not as pronounced and the country ranking looks different: the lowest prices are in Bulgaria, Slovakia and Poland, while the highest in Hungary and Romania.

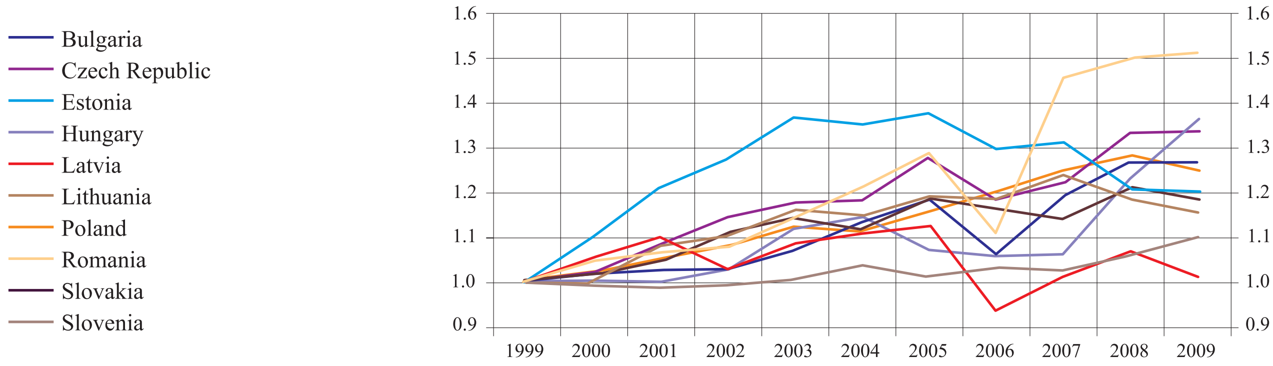
What conclusions can be drawn from the fact that relative export quality is lower than relative prices? From equation [5] it can be easily seen that it indicates a lower market share of one exported NMS brand compared with the share of one German brand. This difference in market shares is larger if the gap between relative quality and relative price is more pronounced, and it is increasing in elasticity of substitution between varieties.

3.2 Changes in Relative Quality of NMS Exports

Previous subsection provides useful information about relative quality in a particular year; further dynamics of relative quality can be discussed. Changes in relative quality of NMS total exports during the last 10 years were calculated using equation [20] and are shown in Chart 6.

Chart 6

Dynamics of relative quality of NMS total exports to the EU, 1999–2009 (compared with Germany; 1999 = 1)



Source: authors' calculations.

Although the quality is a structural factor and is not expected to be volatile, Chart 6 shows that by using this particular methodology it was impossible to exclude sharp changes in the quality estimate in some years (e.g. a sharp decrease for Latvia, Bulgaria and Romania in 2006, an increase for Romania and Bulgaria in 2007 and for Hungary in 2008–2009). This could be due to outliers, changes in classification, statistical errors, etc.; hence the results are interpreted with some caution.

Overall, it was found that all NMSs were able to increase the average quality of their exports during the sample 10-year period, despite, as in the previous subsection, the presence of evidence about differences across countries. The highest cumulative increase in quality is observed in Romania (50%), whereas in Hungary and the Czech Republic quality increased by 35%. The lowest performance was showed by Latvia (almost no changes in the given 10-year period, which, however, to a large extent was driven by outlying results of 2006) and Slovenia (10%). It could also be noted that a relatively weak increase in Baltic States' export quality was driven by the fall in the second half of the sample period.

Another interesting exercise is to compare the dynamics of relative quality to that of relative prices and to calculate changes in prices adjusted by quality (or "pure prices" as defined by J. C. Hallak and P. K Schott (12)). Quality is mostly a structural characteristic of a product; therefore, relative quality could be expected to be less volatile than the relative price index.

Appendix 6 shows that it is really so: relative quality is much more stable than relative prices, providing evidence that the measure of relative quality herein is better than the traditional proxy of relative export prices. Smaller volatility of relative quality could be observed in the case of Slovenia and Latvia. Moreover, the advantage of this relative quality measure is even clearer while analysing the changes in 2009. Observed is a significant decrease in relative export prices in the Czech Republic and Poland due to nominal depreciation of the exchange rate, which, however, is not mirrored in relative quality – it remains quite stable despite the economic crisis. This means that the employed quality measure does not include changes in relative costs of production and reflects structural factors.

CONCLUSIONS

The goal of this paper was to evaluate variety and quality of NMS exports in 1999–2009. To achieve the goal, methodology proposed by R. C. Feenstra (7) and further developed by D. Hummels and P. J. Klenow (13), and Ch. Broda and D. E. Weinstein (4), which takes into account not only unit values but also market shares and elasticities of substitution, was used.

The proxy for unobserved relative variety was obtained assuming that the number of brands in each two-digit sector follows a Poisson distribution. According to the calculations herein, the smallest amount of brands among NMSs is coming from Slovenia, Bulgaria, Romania and the Baltic States (45%–50% of German amount of brands), while the highest export variety among NMSs is characteristic for Poland and the Czech Republic (around 75%). All NMSs increased significantly the average number of brands exported to the EU market; moreover, the most rapid increase was observed in 2004, the year of the EU accession for most countries in this analysis. It shows that integration into the EU market goes not only in the intensive but also in the extensive dimension.

The median elasticity of substitution between varieties for EU imports is estimated to be 3.58, which gives a median mark-up of 38.5%. Elasticity of substitution is highly heterogeneous across individual products. The analysis of elasticities in different sectors suggests that heterogeneity mostly comes from within-categories differences. In other words, different product markets have different levels of competition even within the same category of trade.

Calculations show that NMS exports compared with German exports were of lower quality in 2009. The Baltic States and Bulgaria appear at the lower end of the range, with relative quality of around 30% of German quality, while the highest export quality was observed in Hungary, Poland and the Czech Republic (around 55% of German quality). Export quality is not homogenous across different industries within one country either. For all NMSs, relative prices are higher than relative quality. This means that one exported brand from an NMS has a lower market share in the common EU market than the one from Germany.

It was found that all NMSs were able to increase average quality of their exports during the sample 10-year period, although there is evidence of differences across countries. The highest cumulative increase in quality is observed in Romania (50%), whereas in Hungary and the Czech Republic quality increased by 35%. The lowest increase was showed by Latvia (almost no changes, which, however, to a large extent was driven by outlying results of 2006) and Slovenia (10%). It could also be noted that a relatively weak quality increase of the Baltic States' exports was driven by the fall in the second half of the sample period.

Finally, relative quality is much more stable than relative prices, providing evidence that the developed measure of relative quality is better than the traditional proxy of relative export prices, as it does not include relative costs of production but reflects structural factors.

APPENDICES

Appendix 1
Derivation of import demand equation

The minimum costs of obtaining one unit of services from imports of good i are defined as total expenditure on good i (denoted by Y_i) divided by sub-utility from the consumption of good i. Using equation [4], x_{ij} can be replaced and the expression for minimum costs obtained:

$$P_i = \frac{Y_i}{M_i} = \frac{\sum_{j=1}^{J} N_{ij}\, p_{ij}\, x_{ij}}{\left(\sum_{j=1}^{J} Q_{ij} N_{ij}\, x_{ij}^{\frac{\sigma_i - 1}{\sigma_i}}\right)^{\frac{\sigma_i}{\sigma_i - 1}}} = \frac{\sum_{j=1}^{J} N_{ij}\, p_{ij}^{1-\sigma_i} Q_{ij}^{\sigma_i}}{\left(\sum_{j=1}^{J} N_{ij}\, p_{ij}^{1-\sigma_i} Q_{ij}^{\sigma_i}\right)^{\frac{\sigma_i}{\sigma_i - 1}}} = \left(\sum_{j=1}^{J} N_{ij}\, p_{ij}^{1-\sigma_i} Q_{ij}^{\sigma_i}\right)^{\frac{1}{1-\sigma_i}} \quad \text{[A1.1].}$$

Further, taking into account the definition of market share of a country j in total imports of good i and using equations [4] and [A1.1], the demand function in terms of market shares is obtained:

$$s_{ij,t} = \frac{x_{ij,t}\, p_{ij,t}\, N_{ij,t}}{\sum_{j=1}^{J} x_{ij,t}\, p_{ij,t}\, N_{ij,t}} = \frac{N_{ij,t}\, p_{ij,t}^{1-\sigma_i} Q_{ij,t}^{\sigma_i}}{\sum_{j=1}^{J} N_{ij,t}\, p_{ij,t}^{1-\sigma_i} Q_{ij,t}^{\sigma_i}} = \frac{p_{ij,t}^{1-\sigma_i}}{P_{i,t}^{1-\sigma_i}} N_{ij,t}\, Q_{ij,t}^{\sigma_i} \quad \text{[A1.2],}$$

which transforms into equation [7] after log transformation.

Appendix 2
Poisson distribution of variety

It is assumed that the number of brands in each two-digit sector follows a Poisson distribution:

$$f(n_s) = \frac{\mu_s^{n_s} e^{-\mu_s}}{n_s!} \qquad \text{[A2.1]}$$

where n_s is number of brands of eight-digit product in two-digit sector s, μ_s is a positive real number equal to the expected number of brands of eight-digit product in two-digit sector s.

$f(0)$, which is the ratio of products, in which country has no exports, to the total number of products in two-digit sector, is observed. As

$$f(0) = \frac{\mu_s^0 e^{-\mu_s}}{0!} = e^{-\mu_s}$$

then

$$\mu_s = -\ln(f(0)) \qquad \text{[11]},$$

which produces the average amount of brands exported in two-digit sector s.

Equation [11] gives the average amount of brands in the sector; however, this formula for the estimates of relative quality in equation [6] can be improved and $N_{ij,t}$ to be zero defined, if the product is not exported; likewise, the average amount of brands in case the product is exported can be estimated. The latter is calculated as a weighted average of a strictly positive amount of brands:

$$\sum_{n_s=1}^{\infty} \frac{f(n_s)}{1-f(0)} n_s = \frac{1}{1-f(0)} \sum_{n_s=1}^{\infty} f(n_s) n_s = \frac{1}{1-f(0)} \sum_{n_s=0}^{\infty} f(n_s) n_s = \frac{\mu_s}{1-f(0)},$$

therefore,

$$N_{ij,t} = \begin{cases} 0 & if \quad I_{ijs,t} = 0 \\ \dfrac{\mu_s}{1-f(0)} & if \quad I_{ijs,t} = 1 \end{cases} \qquad \text{[12]}$$

where $I_{ijs,t}$ is a binary variable, which is equal to 1 if country j is exporting good i classified within sector s, and equal to 0 otherwise.

Appendix 3

Relative variety of NMS exports of selected two-digit HS categories of goods to the EU in 2009 (compared with Germany)

HS2 category of goods	Bulgaria	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Romania	Slovakia	Slovenia
Pharmaceutical products	0.456	0.813	0.440	0.699	0.507	0.507	0.699	0.409	0.627	0.424
Plastics and articles thereof	0.504	0.800	0.563	0.765	0.535	0.613	0.779	0.645	0.714	0.634
Rubber and articles thereof	0.702	0.911	0.702	0.882	0.690	0.690	0.911	0.855	0.868	0.750
Wood and articles of wood	0.484	0.728	0.612	0.714	0.612	0.655	0.812	0.694	0.662	0.668
Paper and paperboard	0.639	0.941	0.728	0.822	0.707	0.728	0.884	0.721	0.830	0.714
Articles of apparel and clothing accessories	0.789	0.934	0.746	0.849	0.812	0.756	0.934	0.812	0.890	0.688
Iron and steel	0.450	0.907	0.406	0.746	0.489	0.489	0.878	0.492	0.802	0.692
Articles of iron and steel	0.694	0.954	0.728	0.886	0.723	0.738	0.922	0.795	0.874	0.694
Miscellaneous articles of base metal	0.884	0.921	0.884	0.884	0.921	0.848	0.921	0.884	0.921	0.884
Machinery and mechanical appliances	0.539	0.869	0.510	0.747	0.554	0.543	0.815	0.623	0.727	0.573
Railway or tramway locomotives	0.711	0.928	0.754	0.889	0.780	0.783	0.909	0.752	0.853	0.750

Source: authors' calculations.

Appendix 4
Derivation of equation [14]

The supply curve for imports from country j is specified in first differences as:

$$\Delta \ln p_{ij,t} = \omega_i \Delta \ln x_{ij,t} + \xi_{ij,t}, \quad \omega_i \geq 0 \qquad [10]$$

where ω_i is inverse supply elasticity of good i, which is assumed to be the same for all producing countries, while $\xi_{ij,t}$ is a random error.

Using the definition of market share:

$$s_{ij,t} = \frac{x_{ij,t} p_{ij,t} N_{ij,t}}{\sum_{j=1}^{J} x_{ij,t} p_{ij,t} N_{ij,t}} = \frac{x_{ij,t} p_{ij,t} N_{ij,t}}{Y_t}$$

we can rearrange equation [10] into

$$\Delta \ln p_{ij,t} = \omega_i \Delta \ln s_{ij,t} + \omega_i \Delta \ln Y_t - \omega_i \Delta \ln p_{ij,t} - \omega_i \Delta \ln N_{ij,t} + \xi_{ij,t}.$$

Using equation [9], we obtain:

$$\Delta \ln p_{ij,t} = \frac{\omega_i \phi_{i,t}}{1+\omega_i \sigma_i} + \frac{\omega_i}{1+\omega_i \sigma_i} Y_t + \frac{\omega_i}{1+\omega_i \sigma_i} \varepsilon_{ij,t} + \frac{\xi_{ij,t}}{1+\omega_i \sigma_i} \qquad [A4.1]$$

and by replacing $\varepsilon_{ij,t}$ one can easily get:

$$\left(1 - \frac{\omega_i(\sigma_i - 1)}{1+\omega_i \sigma_i}\right) \Delta \ln\left(p_{ij,t}\right) = \frac{\omega_i(\sigma_i - 1)}{(1+\omega_i \sigma_i)(\sigma_i - 1)} \left(\Delta \ln\left(s_{ij,t}\right) - \Delta \ln\left(N_{ij,t}\right)\right) + \\ + \frac{\omega_i(\sigma_i - 1)}{(1+\omega_i \sigma_i)(\sigma_i - 1)} Y_t + \frac{\xi_{ij,t}}{1+\omega_i \sigma_i} \qquad [A4.2]$$

which, after taking ratio to a reference country k, transforms into equation [14].

Appendix 5
Relative quality of NMS exports of selected two-digit HS categories of goods to the EU in 2009 (compared with Germany)

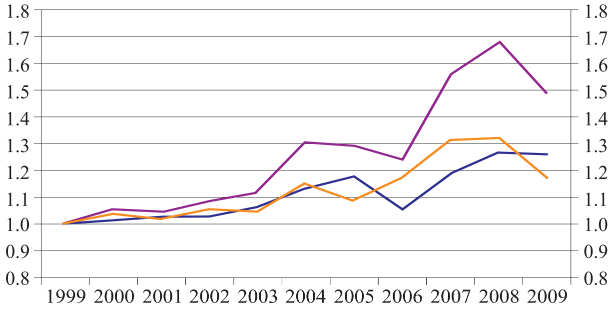
HS2 category of goods	Bulgaria	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Romania	Slovakia	Slovenia
Pharmaceutical products	0.058	0.185	0.072	0.385	0.151	0.221	0.254	0.280	0.113	0.336
Plastics and articles thereof	0.223	0.505	0.222	0.439	0.216	0.302	0.476	0.295	0.379	0.277
Rubber and articles thereof	0.223	0.650	0.325	0.624	0.289	0.326	0.569	0.495	0.472	0.377
Wood and articles of wood	0.282	0.551	0.549	0.514	0.506	0.418	0.669	0.517	0.517	0.567
Paper and paperboard	0.177	0.555	0.213	0.471	0.215	0.253	0.601	0.256	0.488	0.384
Articles of apparel and clothing accessories	0.584	0.718	0.377	0.598	0.315	0.376	0.671	0.928	0.392	0.395
Iron and steel	0.428	0.652	0.462	0.555	0.451	0.432	0.616	0.492	0.640	0.543
Articles of iron and steel	0.252	0.630	0.315	0.456	0.270	0.234	0.581	0.398	0.463	0.363
Miscellaneous articles of base metal	0.400	0.725	0.276	0.626	0.265	0.307	0.651	0.331	0.468	0.465
Machinery and mechanical appliances	0.230	0.567	0.184	0.498	0.190	0.183	0.453	0.293	0.347	0.262
Railway or tramway locomotives	0.496	0.712	0.420	1.097	0.149	0.509	0.701	0.568	0.534	0.517

Source: authors' calculations.

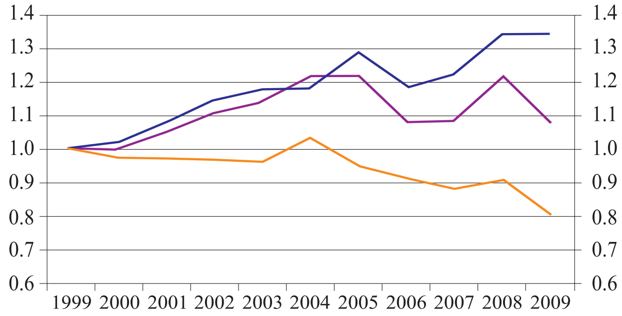
Appendix 6

Dynamics of relative quality, price and quality adjusted price of NMS total exports to the EU in 1999–2009 (compared with Germany; 1999 = 1)

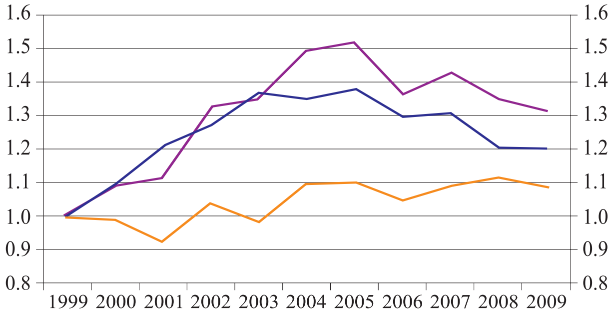
Bulgaria



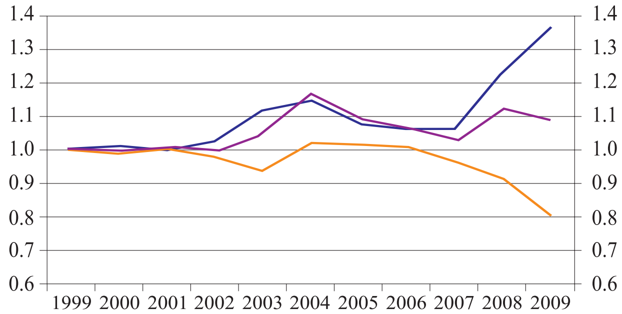
Czech Republic



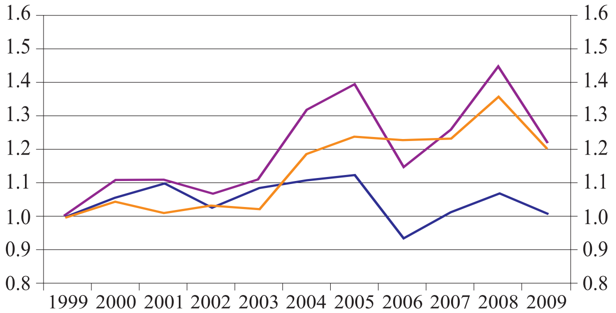
Estonia



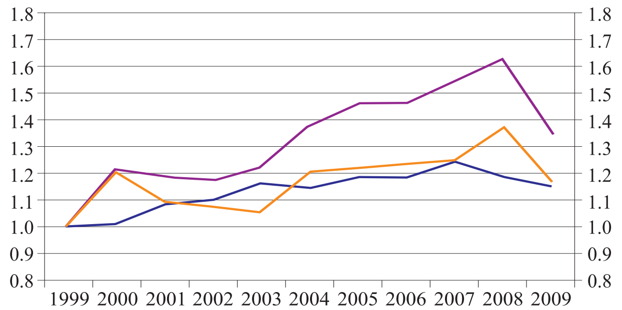
Hungary



Latvia



Lithuania

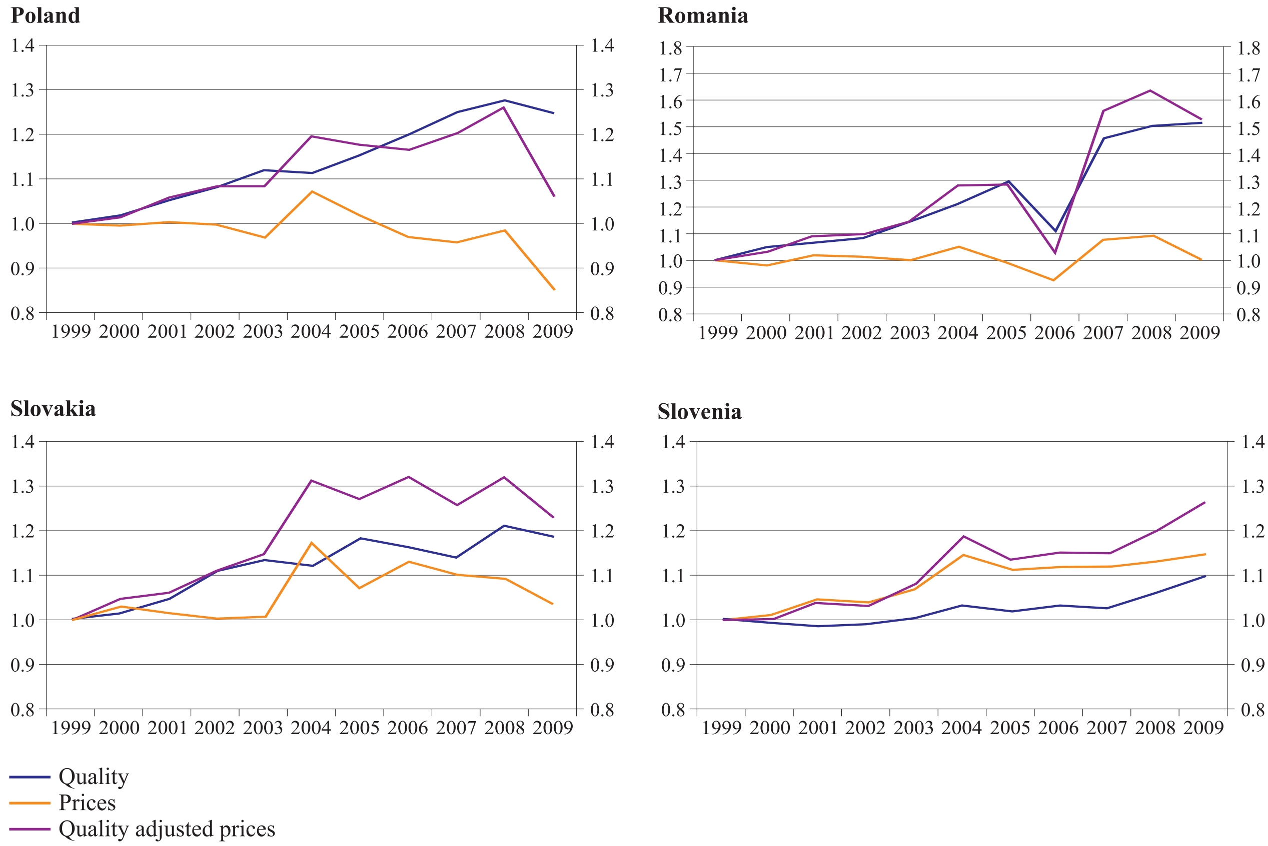


Quality
Prices
Quality adjusted prices

Source: authors' calculations.

Appendix 6 (cont).

Dynamics of relative quality, price and quality adjusted price of NMS total exports to the EU in 1999–2009 (compared with Germany; 1999 = 1)



Source: authors' calculations.

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