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Heterogeneous firms and homogenising standards in agri-food trade – the Polish meat case

Marie-Luise Rau[1] and Frank van Tongeren[2]

[1] Agricultural Economics Research Institute (LEI), Division International Trade and Development, Den Hague, the Netherlands and Humboldt University of Berlin, Germany

[2] OECD, Trade and Agriculture Directorate, Paris, France

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Abstract

The paper develops a partial equilibrium trade model with heterogeneous firms. The model is applied to the issue of compliance with the EU food standards in the Polish meat sector. Estimates of the size and productivity distribution of Polish meat firms reflect firm heterogeneity. The model parameters are estimated using limited data and a full information least squares method to match observed patterns of trade. Kernel density estimates based on a Monte Carlo sample of parameter estimates show the asymmetric trade cost between Poland and the EU15. Simulation analysis finds that investment support programmes in the context of EU accession lower the firms' productivity threshold to meet standards and to qualify for exporting. This can slow down structural changes in the industry in the receiving country since existing smaller and less productive firms can continue to exist. However when considering productivity upgrades, the simulation analysis points out that a modest increase of the minimum productivity level in the industry would be more than sufficient to compensate for the export drops following an increase in fixed costs of compliance.

* The views expressed are those of the authors and do not reflect the official view of the OECD or of the governments of its member countries. Corresponding author: Frank van Tongeren, phone: +33 1 45 24 78 81, e-Mail: frank.vantongeren@oecd.org.

1. Introduction

Technical regulations and standards have gained great importance in international agri-food trade.[1] Governments of high-income countries have increasingly implemented tighter and mandatory standards for agri-food products and also demand that agri-food imports comply with them. Despite international coordination and harmonisation efforts, food standards differ across countries and, as import conditions, they potentially restrict market access of exporters that have to comply with domestic and foreign requirements. However, food standards may also facilitate trade because they solve information problems between buyers and sellers and make products more homogeneous.

Food standards can be characterised as non-tariff measures (NTMs). In traditional trade models NTMs are usually depicted by incorporating estimates of their tariff equivalents. Different methods are being used to arrive at such estimates, ranging from careful price comparisons along a given supply chain to cross-country econometric estimates. Ferrantino (2005) provides an overview of recent studies. One approach is to represent the effects of NTMs as price wedges for the respective product traded, and simulation models generate their usual comparative static effects via elasticities. Another approach is to introduce the trade cost of NTMs as so-called "iceberg tariffs" into simulation models. "Iceberg tariffs" melt away a fixed share of the export value on the way from the exporting to the importing country, thereby leading to efficiency losses. In both of the aforementioned representations NTMs are regarded as trade costs when products cross the borders between countries.

However, we argue that standards in general, and in particular food standards, are more than just border measures because they explicitly lead to fixed (through additional investments) and variable (through additional activities) compliance costs for exporting firms. As such, standards become an integral part of the export decision of firms. In recent advances of international trade theory heterogeneous firm models are applied (for example Melitz, 2003), and we consider them as most suitable for analysing standards. First, in heterogeneous firm models both the fixed and variable costs of complying with the standards can be reflected. Secondly, firms are considered to be heterogeneous in their productivity level. The most productive firms engage in exporting, while at the same time serving the domestic market. In the case of standards, only productive firms find it profitable to pay compliance costs so as to satisfy the specific requirements of importing countries and gain access to foreign markets.

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[1] Standards often refer to industry requirements that firms tend to meet on a voluntary basis, whereas technical regulations are always mandatory requirements imposed by governments. This paper uses the term "standard" in the sense of mandatory norms; industry standards are not considered.

The goal of this paper is to explore the market and trade effects of food standards by accounting for their fixed and variable compliance costs in an environment reflecting firm heterogeneity. For our analysis, we develop a partial equilibrium variant of a trade model with heterogeneous firms and apply it to the case of meat trade between Poland and the old member states (EU15). Food standards influence trade flows across the EU member states, specifically the old and new member states of Central and Eastern Europe (see for example, Chevassus-Lozza et al., 2007). While the principle of mutual recognition generally applies to intra-EU trade, harmonised EU standards particularly relating to food safety/hygiene matters have been pertinent in the agri-food sector (European Commission, 1985). Adopting the tight EU standards caused considerable difficulties for the new member states that had to take over the entire body of EU rules and regulations (*acquis commaunitaire*). This is true for Polish meat production and processing where the large number of small firms particularly struggled to meet the respective requirements and compliance continues to determine their access to the EU single market.

The paper is structured as follows: We first derive the heterogeneous firm model. This is followed by an introduction to the case study of Polish meat trade, with a focus on the EU standards and EU support programmes to assist firms in complying. Next comes a section on parameter estimation using full information least squares. This section also includes Monte Carlo simulation to obtain insights into the reliability of parameter estimates. Finally, we apply the heterogeneous firm model in a number of simulation scenarios to investigate the impact of the stricter EU standards on meat trade between Poland and the EU15. The simulations specifically explore the role of EU support programmes on lowering the market entry cost for Polish meat firms.

2. The model

The heterogeneous firm model we derive is a partial equilibrium variant close to the general equilibrium model by Balistreri et al. (2007). There is a set of countries/regions R with each region $r = 1,2...n_r$ exporting and importing. For pairs of trading regions, *s* denotes the exporting or source region, and *r* denotes the importing or destination region; $s, r \in R$. If $s = r$ products are sold domestically, whereas $s \neq r$ implies sales on foreign markets.

Assuming Dixit-Stiglitz monopolistic competition, firms in each region produce one specific variety of the differentiated product, and consumers demand a standard CES composite bundle of the product varieties with the substitution elasticity σ. Note that σ measures the constant substitutability among the product varieties and consumers are assumed to equally prefer respective varieties, no matter where they come from. The total demand for the differentiated product in each region is given by

$$Q_r = \mu_r * \frac{Y_r}{P_r} \tag{I}$$

where $\mathrm{Y_r}$ denotes the national income in region *r,* and μ_r denotes the expenditure share. P_r refers to a (dual) price index that is defined over the prices of each supplying firm.

In the profit maximisation problem, firms consider the variable costs of supply to the domestic and foreign markets, next to tariffs. Focusing on foreign markets, the variable costs of exporting not only include transport costs but also contain the variable compliance costs that firms incur to gain market access. As firms use resources to cover the variable export costs, they increase firms' marginal unit costs, and the model captures them in the standard fashion of "iceberg trade costs".

Each firm sets an optimal price p_{sr} to maximize profits $p_{sr} q_{sr} - \frac{c_s * \tau_{sr}}{\theta_{sr}} * (1 + t_{sr}) \cdot q_{sr}$ on each of its potential markets, where t_{sr} refers to the ad-valorem tariff rate and τ_{sr} refers to the "iceberg trade costs". Note that for exporting firms $\tau_{sr} \geq 1$ and $(1 + t_{sr}) \geq 1$, whereas for firms selling on the domestic market only $\tau_{rr} = \tau_{ss} = 1$ and $t_{rr} = t_{ss} = 0$. The marginal unit costs are denoted c_s, and θ_{sr} is the firms' productivity, which will be greater than some minimum productivity level θ^*_{sr} whose function will become apparent below.

It is convenient to express all firm level variables in terms of the variety with average productivity $\theta_{sr} = \bar{\theta}_{sr}$. The profit-maximizing price of this average variety is given by:

$$\bar{p}_{sr} = \frac{c_s * \tau_{sr}}{\bar{\theta}_{sr}} * (1 + t_{sr}) * \frac{\sigma}{\sigma - 1} \tag{II}$$

The corresponding CES demand of the average variety is determined by:

$$\bar{q}_{sr} = Q_r * \left[\frac{\bar{p}_{sr}}{P_r} \right]^{-\sigma} \tag{III}$$

The price index P_r can also be expressed in terms of average variety, see Balistreri et al (2007). Defining the average price as $P_r = \left[\sum_s \int_{\theta^*}^{\infty} p_s(\theta_s)^{1-\sigma} d\theta_s \right]^{\frac{1}{1-\sigma}}$ and, using a CES weighted average of productivity, the price index in each region can be approximated by:

$$P_r = \left[\sum_s N_{sr} * \bar{p}_{sr}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{IV}$$

where N_{sr} is the number of supplying firms, equal to the number of varieties, and $\bar{p}_{sr}$ denotes the price in region *r* for the variety sourced from s produced at average productivity.

The equation for bilateral trade is derived by multiplying equation (III) with $\overline{p}_{rs}$ and substituting total demand Q_r (equation I):

$$\overline{q}_{sr} * \overline{p}_{sr} = \mu_s * Y_s * N_{sr} * \left[\frac{\overline{p}_{sr}}{P_s}\right]^{1-\sigma} \tag{V}$$

Firms also face fixed costs and, like the variable costs, they are assumed to be equal across firms within each region. The model distinguishes between the firms' fixed costs to set-up in the domestic market ($s = r$) and those to export ($s \neq r$). We consider the fixed export costs to include the compliance costs of standards that exporting firms have to meet in order to supply foreign markets. Each firm's market entry decision crucially depends on its distinct productivity level, and there are cut-off productivity thresholds that determine which markets firms supply. Let θ_{sr} denote the firm's productivity and θ^*_{sr} refer to the productivity threshold. Firms with $\theta_{rr} > \theta^*_{rr}$ serve the domestic market and those with $\theta_{sr} > \theta^*_{sr}$ serve foreign markets. The condition $\theta^*_{sr} > \theta^*_{rr}$ holds in order to ensure the partitioning of firms by the markets they supply.

Firm productivity is assumed to be distributed according to the Pareto distribution with the shape parameter α and the location parameter β: The probability distribution function is $g(\theta) = \frac{\alpha}{\beta}\left(\frac{\beta}{\theta}\right)^{\alpha+1}$ and the cumulative density $G(\theta) = 1 - \left(\frac{\beta}{\theta}\right)^{\alpha}$.

Given the number of active firms, we can derive the productivity level of the marginal firm, i.e. the firm that just finds it profitable to operate. The proportion of firms trading from s to r equals the ratio $\frac{N_{sr}}{M_s}$ where M_s refers to the mass of firms potentially operating in the respective region. M_s is assumed to be constant.[2]

In each region, the probability of finding a firm with productivity level greater than the threshold is $Prob(\theta_{sr} \geq \theta^*_{sr}) = 1 - G(\theta^*_{sr}) = \frac{N_{sr}}{M_s}$. With the Pareto distribution for firm productivity, the cut-off productivity threshold θ^*_{sr} is thus given by

$$\theta^*_{sr} = \beta_s * \left[\frac{N_{sr}}{M_s}\right]^{-\frac{1}{\alpha_s}} \tag{VI}$$

[2] Focusing on the medium term, we assume M_s to be given. However, the model could also endogenously determine M_s by defining an equation for the firms general decision to produce or not. Such an equation would involve specifying the firms expected profits, see Balistreri et al. (2007).

To determine the number of firms (varieties), we need a zero-profit condition. Only sufficiently productive firms find it profitable to pay the respective fixed entry costs and engage in trading from s to r. At the cut-off productivity level θ_{sr}^{*}, the firms' variable profit (gross of tariff) equals the fixed costs f_{sr} which firms face when supplying the respective market, and we derive the zero profit cut-off productivity accordingly:

$q_{sr}(\theta_{sr}^{*}) * \left[p_{sr}(\theta_{\mathrm{sr}}^{*}) - \frac{c_{\mathrm{s}} * \tau_{\mathrm{sr}}}{\theta_{\mathrm{sr}}^{*} * (1 + t_{\mathrm{sr}})} \right] - f_{\mathrm{sr}} = 0$. Note, once a firm overcomes the entry costs to the domestic market, they are sunk and hence do not matter in the firm's decision to supply foreign markets.

A salient feature of the monopolistic competition framework is that the ratio of revenues between any two firms only depends on the ratio of productivities. We exploit this feature to retrieve the zero profit cut-off productivity in terms of averages. Using equations (II) and (III), we obtain

$\frac{r(\bar{\theta}_{sr})}{r(\theta_{sr}^{*})} = \left[\frac{\bar{\theta}_{sr}}{\theta_{sr}^{*}} \right]^{\sigma-1}$ where $r(\bar{\theta}_{sr})$ refers to the revenue of firms producing the average differentiated product with average productivity and $r(\theta_{sr}^{*})$ denotes revenue at the respective productivity thresholds.

The relation between $\bar{\theta}_{sr}$ and θ_{sr}^{*} can be established by using a CES weighted average productivity. Define the average productivity as

$\bar{\theta}_{sr} = \left[\frac{1}{1 - G(\theta_{sr}^{*})} * \int_{\theta_{sr}^{*}}^{\infty} \theta_{sr}^{\sigma-1} g(\theta_{sr}) d\theta_{sr} \right]^{\frac{1}{\sigma-1}}$. With the Pareto distribution, this yields a constant ratio between the cut-off level and the average productivity:

$$\bar{\theta}_{sr} = \theta_{sr}^{*} * \left[\frac{\alpha_s}{(\alpha_s + 1 - \sigma)} \right]^{\frac{1}{\sigma-1}} \qquad \text{(VII)}$$

Using this relation, the revenue at the productivity thresholds $r(\theta_{sr}^{*})$ can be expressed in terms of $r(\bar{\theta}_{sr})$ and yields the zero profit cut-off productivity in terms of averages as follows:

$$\frac{\bar{p}_{sr} * \bar{q}_{sr}}{\sigma * (1 + t_{sr})} * \left(\frac{\alpha_s + 1 - \sigma}{\alpha_s} \right) - f_{sr} = 0 \qquad \text{(VIII)}$$

where f_{sr} denotes the fixed entry cost into each market.

3. Application of the model

3.1. The Polish meat case

The integration of Poland into the EU started long before its accession in May 2004. Under the European Agreement in 1999 and subsequent amendments, agri-food trade between Poland and the EU15 was gradually liberalised in order to establish a free trade area with common border protection (custom union). While offering improved trading opportunities, EU membership was conditional on taking over the entirety of the EU legal rules and regulations (*aquis communautaire)*. As such, Poland had to adopt the EU food standards, just like the other new member states, but transitional periods for the time after accession and special safeguard clauses to ensure the functioning of the EU common market were agreed upon; for details see Inglis (2004).[3] Since food of animal origin can present serious hazards to human health, the EU meat standards are particularly strict and thus meat production and processing seems to be considerably affected.

In order to place meat products on the EU single market, slaughterhouses, cutting plants and possessing firms have to comply with Directive 77/99/EEC and 64/433/EEC that include the EU meat standards and specify some additional provisions regarding product testing, transportation and administrative matters.[4] For meeting the respective EU requirements, both product and process standards, Polish meat firms had to substantially modernise production facilities and processes, leading to fixed costs of compliance. While potentially promoting the productivity of Polish meat firms, the necessary changes in processing methods and control systems for food safety/hygiene also increased variable production costs, mainly due to the employment of more skilled workers, more frequent checks as well as documentation requirements (Preidl and Rau, 2006). Representative information about the fixed and variable compliance costs in the Polish meat sector is not available. However, the investments undertaken in the sector are reported, and they most likely contain the fixed costs of compliance.

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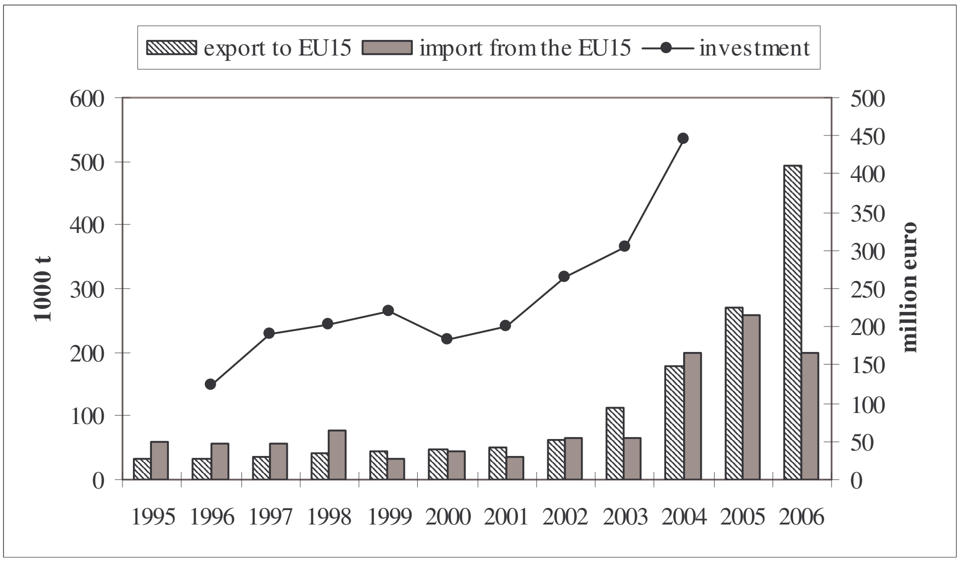
[3] Under the safeguard clauses, the very small meat firms in Poland that had tremendous difficulties to adjust to the EU standards have been granted special provisions allowing them to continue their production for the domestic market without fully meeting the EU requirements. The exemptions mainly relate to the detailed documentation requirements and record keeping.

[4] Directive 77/99/EEC on health problems affecting intra-Community trade in meat products (OJ L26, 31.1.1977). Directive 64/433/EEC on health problems affecting intra-Community trade in fresh meat (OJ P121, 29.7.1964). Note that minced meat is covered in a separate directive, 94/65/EC (OJ L368, 31.12.1994), and not considered here. The directives apply to all meat firms in the member states and third countries that wish to sell their products on the single EU market.

Figure 1 plots the development of meat trade between Poland and the EU15 against the investments in the Polish meat sector. The volume of Polish meat exports steadily grew in the pre-accession period, and the largest increase is observed after Poland became EU member country in 2004. While obviously reflecting the liberalisation of meat trade between Poland and the EU15, trade growth shows a rather strong correlation with the investments undertaken.

Figure 1: Development of meat trade and investment in the Polish meat sector



Source: Eurostat.

In the years shortly before accession, investments in the Polish meat firms extremely increased, and this influx coincides with the implementation of the EU's Special Accession Programme for Agriculture and Rural Development (SAPARD) in Poland. While the SAPARD programme was scheduled for the time period 2000-2006, the effective start of the programme was delayed, and the first payments were only made in 2002. Almost 40% of the total SAPARD funds in Poland were earmarked for supporting agri-food processing firms in their adjustment to the EU standards (Measure 1 "Improvement in processing and marketing of agri-food products"). According to the ex-ante evaluation of the Polish SAPARD programme, the meat sector absorbed 48.6% of the financial assistance paid under measure 1, equalling about 266.2 million euro (IERiGZ-PIB, 2007).

With regard to the aforementioned directives, Rau and van Tongeren (2007) elaborate on the state of compliance in Polish meat sector and the resulting market opportunities for firms in the accession year 2004. Polish meat firms that comply are approved to export to the other EU member states and receive a EU export licence, whereas non-complying firms can sell their produce on the domestic market only. The production capacity marks the dividing line between complying and non-complying Polish meat firms. In 2004, almost 70% of the Polish meat firms did not meet the EU requirements, and they were mainly small and medium enterprises with considerably lower production capacities than large Polish meat firms.

In general, the Polish meat sector has been characterised by its very asymmetric structure. There are many small firms and only a few large firms, and the size distribution of Polish meat firms is thus extremely skewed. Of the 4271 firms in the Polish meat industry[5] registered by EUROSTAT in 2002, 72% had between 1 and 9 employees, and10% had more than 50 persons employed. By 2004, the number of firms has declined to 3881, with most of the industry exit occurring in the smallest size class, reducing their share to 69%.The asymmetric structure is also reflected by the indicators of inequality that are estimated based on Eurostat data for the time period 2000-2004 and presented in table 1. Table 1 also includes the respective indicators for the EU15 for comparison. With regard to employment, turnover and value-added, the value of the Gini-coefficient shows that the meat sector in Poland is more unequal than in the EU15. Similarly, the concentration ratios are slightly higher for Poland, indicating the relative economic dominance of large firms in the sector.

Table 1: Indicators of inequality in the meat sector in Poland and the EU15, 2000-2004

		Gini-coefficient	C5-ratio	C10-ratio
Poland				
	employment	0.62	0.21	0.24
	turnover	0.64	0.23	0.27
	value-added	0.59	0.19	0.22
EU15				
	employment	0.65	0.14	0.17
	turnover	0.68	0.18	0.22
	value-added	0.69	0.18	0.21

Source: own calculation based on Eurostat. Note: inequality indicators are calculated on the basis of estimated size distributions, see Appendix 1.

3.2. Parameter estimation using full information least squares

In our application to meat trade between Poland and the EU15 (two countries/regions case), the model features a total of 15 parameters that have to be determined. The $2*2$ Pareto shape and location parameters (α_s, β_s) are estimated outside the model (see appendix A1). This leaves 11 parameters to be determined: c_s, f_{sr}, τ_{sr} and σ. Since τ_{ss}= 1, the number of parameters to be estimated reduces to $n_r * (1+2n_r) - 1 = 9$. The estimation method is inspired by Balistreri et al. (2007) who propose a full information least squares method to estimate the unobservable trade cost parameters by using cross section data on bilateral trade

[5] The meat industry includes Production, processing, preserving of meat, meat products.

and imposing exogenous estimates of the variety substitution elasticity, the Pareto location parameter and the domestic set-up costs. Our estimation however relies on (short) time series and estimates all parameters consistently with the model equations.

Let $\boldsymbol{\gamma}$ denote the vector of parameters, $\boldsymbol{x}$ the vector of endogenous variables generated by the model, $\hat{\boldsymbol{x}}$ a vector of a subset of endogenous variables and $\boldsymbol{x^0}$ the corresponding observations of these variables. Writing the equations of the model as $F(\boldsymbol{x},\gamma)$, the estimation method finds the values of the subset of parameters $\hat{\gamma}$ that minimizes the sum of squares:

$$\min_{\hat{\gamma},\hat{x}} (\,\hat{\boldsymbol{x}} - \boldsymbol{x^0}\,)^T (\,\hat{\boldsymbol{x}} - \boldsymbol{x^0}\,)$$

subject to: $\hat{\boldsymbol{x}} = F(\boldsymbol{x},\gamma)$

$$\bar{\gamma} = \mathbf{k}$$

$$\hat{\gamma} \leq \mathbf{a}$$

where $\bar{\gamma} = \mathbf{k}$ is the value of Pareto parameters estimated outside the model, and the last inequality represents possible restrictions on the parameters. The theory of the model puts one important restriction on the variety elasticity of substitution: $\sigma < \alpha + 1$. The data $\boldsymbol{x^0}$ are time series of bilateral trade in meat products between PL and the EU15 for the years 2002, 2003 and 2004, yielding 12 observations. In addition, we use six observations on the total number of firms (M_s) for each year.

Table 2 presents the estimates obtained by this method as well as those of the Pareto parameters of the Pareto productivity distribution that have been obtained through OLS outside the model (see appendix A1). A remarkable feature of the estimates is that they imply that the variable and fixed trade costs are higher for firms in the EU15 than for their Polish counterparts. It appears to be far less costly for Polish firms to enter the EU market, and once they have entered, the variable trade costs are also smaller. Our estimates of fixed costs implicitly take the effects of standards and compliance subsidies into account. By 'backcasting' the model to a situation without subsidies, we shall explore the effects of subsidies on trade and markets. As shown in table 2, the domestic set-up cost are also much smaller in Poland, which is consistent with the size distribution of firms in Poland being dominated by many small firms with low productivity. On average, EU15 firms are larger and even the smallest have a productivity that is 4.5 times greater than that of the smallest Polish firm. The estimated unit price for variable inputs (c_s) is slightly smaller in Poland, but the difference is far less pronounced than the extraordinary difference in the other parameter estimates. Finally, the estimate of the elasticity of substitution between varieties (σ) is found to be on its upper bound, dictated by the value of the Pareto shape parameter for Poland.

Table 2: Parameter estimates used in the model.

		Poland	EU15
Parameter estimates full information least squares			
Iceberg trade cost τ_{rs}:		Poland	EU15
	Poland	1.000	3.608
	EU15	4.553	1.000
Fixed market entry cost f_{sr} (1000 euro):			
	Poland	22.553	14.891
	EU15	2031.772	585.307
		Poland	EU15
Unit price of variable inputs c_s:		0.731	0.759
Substitution elasticity of varieties σ:		3.237	3.237
Estimates Pareto productivity distribution			
		Poland	EU15
Pareto shape parameter α_s:		2.337	3.993
	standard error	0.099	0.193
Pareto location parameter β_s (minimum productivity):		0.0263	0.117
	standard error	n/a	n/a
	R^2	0.963	0.953

Source: own estimations.

Unfortunately the reliability of the parameter estimates cannot be judged on the basis of standard test statistics. First, it is not obvious how to obtain covariance matrices of the parameters, and second we do not know the distributions that govern the parameters. The latter implies that we cannot rely on test statistics that assume normality. Some insights into the distribution of the parameters can be gained by Monte Carlo simulation.

Monte Carlo simulation:

Given the parameter estimates and observations on exogenous variables, we generate a new dataset of trade values $\hat{\mathbf{x}}^{\mathbf{s}}$ by adding random disturbances, assumed to be iid N(0,s), to the model simulated trade values: $\hat{\boldsymbol{x}}^{\boldsymbol{S}} = F(\boldsymbol{x}, \hat{\boldsymbol{\gamma}}) + \boldsymbol{e}$. Subsequently, the least-squares estimation is repeated with $\hat{\mathbf{x}}^{\mathbf{s}}$ assuming the role of $\mathbf{x}^{\mathbf{0}}$**.** After repeating this process 100 times a reasonably large sample of parameter estimates is obtained.[6] This sample of estimates reveals that the parameters are certainly not normally distributed, as seen for example by comparing the mean and median values presented in table 3, and hence the usual normality-based test statistics do not apply.

[6] In practice some of the Monte Carlo simulated bilateral trade values do not yield feasible solutions to the estimation problem and those observations were discarded. The optimal sample size is not a priori known, but could be approximated by using a non-parametric test statistic on the moments of key parameters.

Table 3: Summary statistics of Monte Carlo simulated estimations, n=100.

	σ	Unit price c		Variable trade costs τ		Fixed costs f			
						Domestic market		Foreign market	
		PL	EU15	PL-EU15	EU15-PL	PL	EU15	PL	EU15
Mean	2.97	0.61	0.71	4.63	4.60	117.61	28.07	2813.32	832.32
Standard deviation	0.42	0.32	0.33	2.40	1.44	165.20	43.91	2572.58	392.65
Standard error (mean)	0.04	0.03	0.03	0.24	0.15	16.60	4.413	258.55	39.46
Skewedness	-1.43	1.06	1.21	4.34	3.81	2.13	2.41	2.93	2.24
Median	3.24	0.55	0.67	3.73	4.62	23.94	8.25	1994.76	643.79
96% confidence interval of median*	3.15 3.24	0.46 0.65	0.56 0.72	3.71 3.83	4.42 4.7	22.6 36.45	5.78 11.23	1774.94 2214.87	615.70 724.13

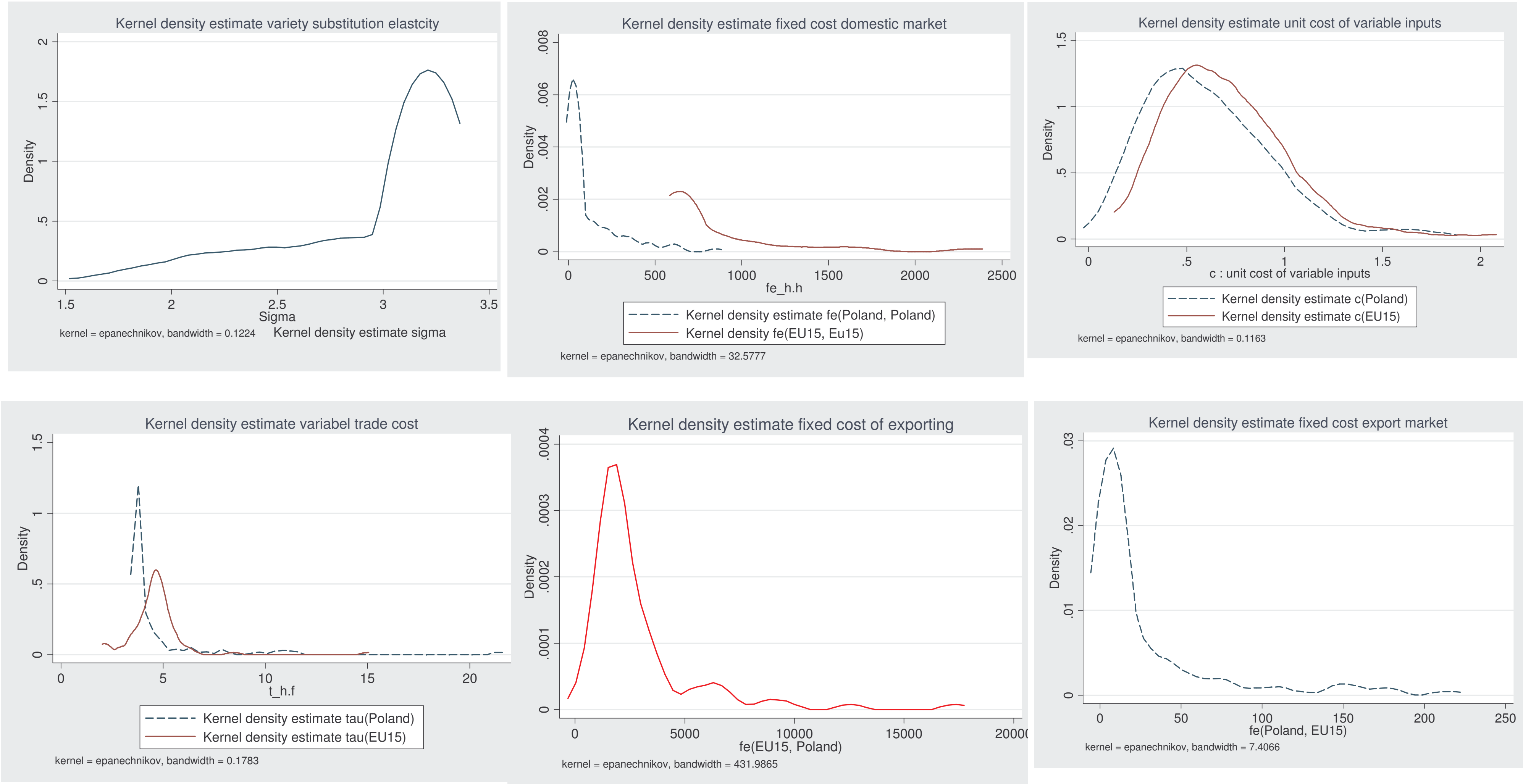
Source: own estimations.

* Calculated by using the binominal distribution to determine the 96% probability of observations falling in the interval around the median: $\text{Prob}[x_i < \text{median} < x_j] = \sum_{l=i}^{j-1} \binom{n}{l} \left(\frac{1}{2}\right)^N$.

Kernel density estimation

The non-parametric kernel density estimation allows us to empirically construct a density function on the basis of the sample of observations generated through the Monte Carlo simulations (Silverman, 1986). The results of the kernel density estimates are presented in figure 2. As shown, the estimates of the substitution elasticity (σ) are very much clustered near its theoretical upper bound, while some estimates also yield lower values. In comparison to other estimates, the unit price of variable inputs (c) is most symmetric around the mean. The kernel density estimates suggest that there is indeed a difference in c , with both the median and mean values for the EU15 being larger than for Poland. In contrast, the estimated distributions for trade cost are all extremely left-skewed. The median value of "iceberg trade costs" (τ) for Poland is below the EU 15 median, and this appears to indicate a consistent difference in variable trade cost. The densities of fixed cost of domestic market entry are sufficiently far apart to be able to conclude that there is a significant difference between the two markets. Likewise, the fixed costs of entry into the export market are orders of magnitudes apart, although the density estimates reveal a similar shape.

Figure 2: Kernel density estimates of model parameters, Poland and EU15.



Source: own simulations

The results presented in this section indicate that consistent estimation of the parameters for the heterogeneous firm model is possible with limited information, but the estimates cannot be assumed to be normally distributed. We have been able to estimate the unobservable trade cost by imposing a huge theoretical structure on the estimation problem. The highly non-linear characteristics of the model in combination with theoretical bounds on parameters and a very pronounced size asymmetry between the two markets makes parameter estimation a perilous task.

4. Scenarios and Simulation Results

In our simulations, we explore the effects of subsidizing compliance costs, like the EU SAPARD programme did in the Polish meat sector. With the calibration the simulations take the accession year 2004 as the base, and our parameter estimates implicitly include the effects of both stricter standards and SAPARD funds. We therefore "backcast" the model in the first set of simulations that consequently reflect scenarios where standards are in place but the subsidies to comply with them are reduced. This allows us to investigate the effects of supporting firms in their compliance with standards.

More specifically, we increase the fixed entry costs for both the domestic and the EU15 market in the first simulation experiment (S1) in order to reflect the fact that the SAPARD programme was not specifically targeted at exporting firms. Given the information about the SAPARD programme, the size of the shock amounts to 25% and approximates the full removal of the subsidy paid to Polish meat firms. In the second simulation (S2), we refer to the considerable test and documentation requirements for exporting to the EU market, and thus increase the variable "iceberg trade costs" for Polish meat firms. Without representative information, we also apply a 25% shock. The third simulation is a combination of S1 and S2.

The forth simulation (S4) relates to the upgrading of the Polish meat sector to the EU standards that may lead to more dynamic productivity gains. Whether standards bring about an overall increase in productivity is first and foremost an empirical question. However, since the Polish meat sector can generally be considered as rather traditional we assume that the investments undertaken to meet the EU requirements had a positive effect on the productivity of Polish meat firms. In the simulation, we mimic this by raising the minimum productivity level determined by the Pareto location parameter β .

Table 4 summarizes key simulation results. The 25% rise in fixed entry costs following an assumed withdrawal of the SAPARD programme leads to an increase of the average productivity of Polish meat exporters (10.6%). Less productive firms are driven out of the market. In other words, without the financial assistance they cannot bear the higher market entry cost. Only those firms that have at least a 10.1% higher productivity enter the EU15 market without the subsidy. Consequently, the number of exporters falls, and the average output is also lower without the subsidy. Despite fewer exporting firms, the total export value is however hardly affected.

Table 4: Simulation results

	BASE	S1	S2	S3	S4
Shocks	n/a	Increase fixed entry cost PL	Increase variable trade cost PL	Increase fixed entry and variable trade cost PL	Increase of minimum productivity level PL
Simulation results		% change	% change	% change	% change
Fixed trade cost, $f_{PL,EU15}$	14.891	25.0	0.0	25.0	0
Variable trade cost, $\tau_{PL,EU15}$	3.608	0.0	25.0	25.0	0
Average productivity exporters, $\bar{\theta}_{PL,EU15}$	0.322	10.6	25.2	38.2	0
Cut-off productivity exporters, $\theta^{*}_{PL,EU15}$	0.079	10.1	24.1	38.0	0
Number of exporters, $N_{PL,EU15}$	291	-21.0	-40.5	-52.9	24.7
Export value, (million EUR)	331.904	-0.1	-40.6	-40.7	2.0
Volume average firm supply/ demand, $\bar{q}_{PL,PL}$	172.458	37.6	0.0	37.6	9.5
Volume average firm supply/ demand, $\bar{q}_{PL,EU15}$	95.120	38.1	0.0	38.1	0
Consumer utility index					
Poland	-	-5.1	0.0	-5.1	120.4
EU15	-	-0.6	-26.3	-26.6	16.1

Source: own calculations.

The results are different in case where the variable "iceberg trade cost" are increased (S2). Although the productivity of exporters increases, the number of exporters falls and export values decline. The reason for the different effects between fixed and variable trade costs is that the former are sunk and are not taken into account once the firm has entered the market. In contrast, the variable trade costs play a role in the firm's pricing decisions. At any given level of market entry costs, higher variable trade costs lead to higher prices, reducing export demand and driving firms out of the market. Note also that EU15 consumers' welfare is negatively affected by higher variable trade cost since higher prices and less variety reduce welfare. In the case of higher market entry cost, the Polish consumers are affected by higher prices, but this does not significantly spill over to EU15 consumers. Polish meat has a very small market share on the EU15 market, and consequently the supply changes do not have big market effects in the EU15. Combining higher fixed costs with higher variable trade cost reinforces the previous effects: drop in the number of exporting firms and a higher average productivity to cover market entry cost and variable trade costs.

These sets of simulation experiments (S1, S2 and S3) indicate that the subsidy to support Polish firms to meet the fixed and variable costs of compliance with the EU standards may have slowed down the exit of smaller and less productive firms.

Compliance to standards can be expected to lead to productivity upgrades, which will be reinforced if compliance costs are subsidized. To capture this more dynamic effect, the last column in table 3 shows the effects of a 10% increase in the minimum productivity level (β) in the Polish meat sector. This is a very modest increase in view of the fact the economy wide labour productivity growth in Poland between 2002-2004 amounted to about 4% per year. The change in minimum productivity shifts the lower end of the productivity distribution to the right, but it does not affect the export market entry decisions. Those Polish meat firms that were able to export before continue to do so. It is evident from the simulation results that this productivity increase would have been sufficient to compensate the export drop that results from increased fixed cost of compliance without the subsidy.

5. Conclusion

The heterogeneous firm model we develop recognizes the asymmetric situation in the Polish meat sector, where complying and non-complying firms co-exist but supply different markets. The model features are characterised by firm-level monopolistic competition, and we estimate the model parameters by using limited data and full information least squares method to match observed patterns of trade. Our estimates of the size and productivity distribution of Polish meat firms and our approximated compliance costs reflect the heterogeneity in the sector.

Our analysis examines the effects of standards on indicators of market performance as well as trade patterns. While this paper investigates the case of Polish meat trade in the context of the EU SAPARD programme to help firms in the new member states adopt the EU standards, some more general conclusions can be drawn. Our analysis shows that such financial assistance lowers the firms' productivity threshold to meet standards and to qualify for exporting. As such, structural changes in the industry of the exporting country tend to be dampened since smaller and less productive firms that already operate in the industry can continue to exist. In order to present a more complete picture, the analysis combines the direct cost-increasing effects of standards with productivity upgrades. Although the data do not allow us to exactly pin down the size of the productivity gains, the simulation analysis shows that a modest 10% increase of the minimum productivity level in the industry would be more than sufficient to compensate for the export drops following a 25% increase in fixed costs of compliance.

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Appendix

A1: Estimating the Pareto distribution of firm productivity with grouped data.

To be completed

This Appendix describes the estimation of size- and productivity distribution using grouped data.