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Trade Integration in an Enlarged European Union – Poland's Road to Success?

Claus-Friedrich Laaser, Klaus Schrader and Benedikt Heid

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WARSAW SCHOOL OF ECONOMIC
WORLD ECONOMY FACULTY
WORLD ECONOMY RESEARCH INSTITUTE
24, Rakowiecka 02-521 Warsaw, Poland
Phone (48 22) 564 93 70
Fax (48 22) 564 86 74
e-mail weri@sgh.waw.pl

Abstract[*]

The paper focuses on Poland's distinctly changing foreign trade patterns in the course of economic transformation and EU accession. In order to shed more light on the structure of Poland's integration into the European division of labour the Polish trade flows are analysed by applying a filtered gravity approach. This model combines a trade-type-decomposition of trade—distinguishing between inter-industry trade as well as vertical and horizontal intra-industry trade—with a gravity approach of the count model type.

The estimates show that the rapidly growing exports to Western Europe go in line with a significantly higher share of both types of intra-trade with these countries, in particular with Poland's main partner Germany, indicating a growing exchange of technology intensive goods. Apparently, Poland's economy has been integrated into Western European networks of production. In addition, the estimates show a regional integration with the Visegrad partners characterized by a perceptible level of intra-industry trade as well. It is concluded that Poland's extensive participation in the Western and Central European division of labour contributes significantly to the modernization of the Polish economy.

Keywords: Polish trade structure, Eastern enlargement, specialization patterns, gravity model, trade-type approach

JEL Classification: F 14, F 15

Contact:

Dr. Claus-Friedrich Laaser
The Kiel Institute for the World Economy
24100 Kiel, Germany
Phone: (+49) 431 8814–463
Fax: (+49) 431 85853
e-mail: claus-friedrich.laaser@ifw-kiel.de

Dr. Klaus Schrader
The Kiel Institute for the World Economy
24100 Kiel, Germany
Phone: (+49) 431 8814–280
Fax: (+49) 431 85853
e-mail: klaus.schrader@ifw-kiel.de

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1. Introduction

The Eastern Enlargement of the European Union (EU) ran parallel with the development of a new European division of labour. The stepwise institutional integration of transformation countries beginning in the early nineties promoted the formation of European networks of production. It can be assumed that these networks determined for a large part the change in trade patterns and employment structures in the enlarged EU as a whole. Especially Germany and its neighbour country Poland, the largest EU-15 country and the largest accession country, contributed crucially to the process of European trade integration.

Poland realigned its trade patterns in favour of EU markets in the course of substantial trade concessions by the EU first granted in 1991 and complemented in subsequent steps until full membership in 2004. Being endowed with an abundant labour force, the country's role in the European division of labour could initially be expected to be that of a mere workbench, providing largely labour-intensive standardized products. This particular role would entail only limited prospects of income growth and economic catching-up if extrapolated into the foreseeable future. Although the Polish catching-up process indeed stagnated for a longer time span, it has got momentum recently. Hence, the question arises, whether the Polish economy really is still playing the role of a workbench for its European partners or whether the quality of its trade integration into the Common Market has been significantly upgraded. This entails the question, in how far the Polish trade structures already indicate that Poland can compete for technology intensive productions within multinational networks.

Accordingly, the paper is organised as follows: In section 2, we introduce a trade type approach as an analytical tool to explain the changing composition of Poland's regional trade patterns in the course of transformation and EU accession. Types of monopolistic intra-industrial trade are separated from Heckscher-Ohlin inter-industrial trade to generate respective trade-type indicators providing the basis for an analysis of structural change in Polish bilateral trade. In section 3, we deploy a gravity model to identify Poland's regional integration in the international division of labour, with a special focus on the country's role in European trade. This gravity approach is modified by estimating gravitational forces on Poland's inter- and intra-trade flows in order to disentangle Poland's multifaceted trade relations with its neighbours. This variant of a filtered gravity model combines the regional dimension with the sectoral dimension as provided by the trade-type approach. In section 4, we draw some conclusions on Poland's trade integration in European markets and its new role in European networks of production.

2. A Trade-type Approach to Explain Poland's Trade Relations

In order to evaluate Poland's role in the European division of labour we will focus on an analysis of its trade relations particularly in the subspecies of intra-industrial trade (in the following: “intra-trade”). An adequate starting point to define intra-trade is a traditional Heckscher-Ohlin two country-model with two goods produced in each country utilising two factors of production: low qualified labour and human capital. It is assumed that one country is rich in human capital compared to the other country, and in one sector a vertically differentiated good is produced. Vertical differentiation rests on different qualities of a good’s varieties. Again, quality differences rest on the share of human capital in the production of the specific varieties. Moreover, it is assumed that the selection of varieties is determined by the consumers’ income: Consumers rather prefer higher qualities but their selection is restricted by their available incomes. Accordingly, a broad spectrum of different qualities is demanded.

Due to income disparities in both countries, in each country higher as well as lower qualities are demanded. If trade is introduced the country relatively rich in human capital specialises on higher qualities while the other country relatively rich in low qualified labour specializes on low quality product varieties. Hence, reciprocal trade in vertically differentiated products rests on differences between factor endowments similar to inter-industry trade. For this reason it is put into question whether trade in vertically differentiated products can be classified as intra-trade at all. It is the intention of Neo-Chamberlin- and Neo-Hotelling-models to explain just that part of foreign trade which does not rest on differences between factor endowments. In this sense, genuine intra-trade is limited to trade in horizontally differentiated products. That kind of reciprocal trade can be explained by economies of scale on imperfect product markets. It means that reciprocal or two-way-trade covers trade in vertically as well as in horizontally differentiated products.

It can be assumed that two-way trade, especially in vertically differentiated products, puts permanent pressure on the human capital intensive sector to push the development of product and process innovation. It can be concluded that quality competition leads to a higher growth of total factor productivity in this sector than in the labour intensive sector. Therefore, due to a structural change in favour of human capital intensive goods the demand for low qualified labour declines gradually.

2.1 How to Define Intra-industrial Trade

Against this background, intra-trade is defined as two-way-trade in differentiated products of the same commodity group. The increasing ability to produce differentiated commodities fuels the share of intra-trade in a country’s total industrial trade. The relevant shaping factors for this development are (relative) income level and (relative) market size of mutual trading partners:[1]

(I) The share of intra-trade in bilateral trade relations will increase with per capita incomes (*pci*) of trading partners relative to world *pci*. A high level of development is thought to be a prerequisite for innovative activities resulting in differentiated products. Moreover, high-

[1] Seminal works in explaining intra-industrial trade are, e.g., Bergstrand (1990), Clark (1993), Greenaway and Milner (1984; 1986) and Greenaway et al. (1994).

income countries exhibit a differentiated demand structure which permits to utilize scale economies in the production of a high number of product varieties.

(II) Development levels of mutual partners should not differ too much. Substantial income differentials imply differentials in factor remuneration and endowment as well as different demand patterns—with the consequence of dominant Heckscher-Ohlin-type inter-industrial trade.

(III) Intra-trade also depends on market size of partner countries measured against world standards. The ability to utilize scale economies in the production of an increasing number of product variants depends on the absorptive potential of the market.

(IV) Market sizes should not differ too much. Trade between a small and a large market impedes the ability to exchange differentiated products, because a significant differential in market sizes limits the potential of corresponding production structures at least in all cases of non-negligible scale economies.

In sum, intra-trade will occur primarily where mutual trading partners exhibit high levels of development as well as large markets. Any divergence from these prerequisites favours Heckscher-Ohlin inter-trade. This feature can be utilized in order to determine a countries' changing role in the international division of labour more precisely than simply looking at the location's key factors, such as total trade, *GDP* or *pci*. Analysing a countries' trade pattern with respect to changes in the relation of intra-trade and Heckscher-Ohlin inter-trade unveils a lot on the nature of the integration path of domestic enterprises and the structural change that has occurred in the pertinent economy.

2.2 How to Measure Intra-industrial Trade

However, empirical work on the respective trade types requires to measure and to distinguish precisely intra- and inter-trade flows. In this context, traditional indicators based on Grubel and Lloyd (1971; 1975) exhibit a major deficiency: They define the intersection of exports and imports values in any commodity group *i* as monopolistic intra-trade and the difference between the larger and smaller value as inter-trade.[2] Thus, the larger trade flow, although being homogeneous, is explained by two different theoretical approaches.

This shortcoming is circumvented if the intra-trade concept of Fontagné and Freudenberg (1997) is deployed for the analysis. The Fontagné-Freudenberg *"trade type-approach"* rests upon the assumption that trade relations can be subsumed under the heading of "intra-trade" if bi-directional flows of sufficient magnitude can be detected in single commodity groups. In this case, a group is completely assigned to intra-trade. The selection is made according to the criterion that the smaller flow (exports or imports) should account at least of 10 per cent of the

[2] The formula of the classical Grubel-Lloyd-Index (without correction factor for unbalanced trade) is given by $GL = \left[\sum_i \left[(Ex_i + \mathrm{Im}_i) - |Ex_i - \mathrm{Im}_i| \right] / \sum_i (Ex_i + \mathrm{Im}_i) \right] \cdot 100$.

larger one.[3] For this approach, commodity groups should be disaggregated to the lowest level possible. Usually, 8-digit-commodity groups of the "Combined Nomenclature" are used. Moreover, trade flows have to be on a strict bilateral base, otherwise a substantial aggregation bias would occur and counteract the gains from using deeply disaggregated data.[4]

In addition, the trade-type approach provides the option to identify two subspecies of intra-trade, *horizontal* and *vertical* intra-trade, which result from different forms of product differentiation, depending on their nature in the division of labour:

- *Horizontal* product differentiation means that products only differ in attributes such as design or marketing features while the quality is roughly the same. Hence, the versions are close substitutes, demand mirrors differing consumer preferences. Given the identical quality, prices of these versions should not differ significantly.
- In contrast, *vertically* differentiated products feature distinct quality differences. The product versions are still substitutes, but due to different technical features a clear hierarchy in quality between the versions exists. Correspondingly, prices vary significantly by product qualities.

The quality differences of vertically differentiated products, which translate into price differentials, suggest distinctly varying factor input ratios. These, in turn, may reflect unequal factor endowments of trading partners typical for Heckscher-Ohlin inter-trade. Therefore, vertical intra-trade can be considered being still intra-trade but with Heckscher-Ohlin as theoretical underpinning. A major consequence of this Janus-faced pattern is that vertical intra-trade may result in domestic price and quantity effects particularly for less skilled labour. In contrast, horizontal intra-trade governed mainly by tastes resp. a love for varieties is explained by the model of monopolistic competition and is considered close to be neutral towards domestic employment in highly industrialized countries.

To model this distinction between horizontal and vertical intra-trade the Fontagné-Freudenberg trade-type approach detects potential price differentials by calculating "unit values" p_i at the 8-digit level.[5] Horizontal intra-trade flows should exhibit only small export and import price differentials in contrast to vertical intra-trade flows: Price differentials should

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[3] Although Fontagné and Freudenberg (1997) have been criticized because of the arbitrariness of the 10-per cent-criterion one can conjecture this being a rather conservative assumption. Any significant case of bilateral trade within product groups is included by using this threshold.

[4] If the reporting country exports a commodity of a specific type to trading partner A without importing anything of that kind from there, while it imports the same quantity of the same commodity from trading partner B without selling anything of that kind to this destination, these flows would be counted as perfect intra-trade *vis-à-vis* partners A and B as a group—a result that would be definitely biased, because both flows would clearly qualify for Heckscher-Ohlin inter-trade in a bilateral perspective. Hence, trade flows have to be accounted for bilaterally.

[5] Some problems may arise as export and quantities are either denominated in units or in tons, and each way of calculating unit values bears its own deficiencies. However, these deficiencies shrink with disaggregation and are less relevant at the 8-digit-level. Cf. Greenaway et al. (1994: 81).

not exceed an interval of $0.85 < p_i < 1.15$, whereby the price gap of ± 15 per cent reflects transport and shipping costs and has been calibrated in a series of intra-trade studies.[6]

In sum, the Fontagné-Freudenberg trade-type approach provides an analytical two-step filtering procedure for total trade flows. In the first step, monopolistic intra-trade is separated from Heckscher-Ohlin inter-trade according to the criterion for bi-directional trade. In the second step, total intra-trade is partitioned into vertical and horizontal intra-trade depending on the size of price differentials. As a result, total trade is split into three baskets.

Against this backdrop of the Fontagné-Freudenberg trade-type approach, we test the hypothesis that Poland's integration into the EU Internal Market concentrates on Heckscher-Ohlin inter-trade, at least for the time being. The income differentials between the core members of the EU-15 and the new member Poland are still substantial. Poland's per-capita-income accounted for roughly 50 per cent of the EU-15 core member's average in 2007 (Eurostat 2008). Although having the biggest economy among the new EU-members, the Polish market is still small in terms of relative purchasing power. Hence, we should expect intra-trade not being dominant in Poland's trade relations with the core EU members and vertical intra-trade having by far more weight than horizontal. As a result, Poland's integration into the EU Internal Market should be governed by trade relations which exert adjustment pressure on the core economies of the EU-15, particularly with respect to less-skilled labour.

2.3 Stylized Facts on Poland's Foreign Trade Relations

We analyse Poland's inter- and intra-trade for the years since 1999. The analysis is based on trade data from Eurostat's Comext-Database which supplies bilateral flows on the 8-digit commodity groups. Polish special trade in sufficient disaggregation has been recalculated by Eurostat back to 1999, which marks the beginning of our observation period ending in 2004, the year of Poland's EU accession.

Table 1 displays the changes that have occurred in Poland's inter- and intra-trade relations vis-à-vis its main trading partners in Europe between 1999 and 2004: It depicts the shares of the three trade types in total bilateral EU-25 trade.[7] Only three cases can be identified in which the share of the Heckscher-Ohlin inter-trade type, constituting roughly 70 to 100 per cent of bilateral total trade in 1999, has increased: Estonia, Finland and Ireland. In two other cases—the Netherlands and Portugal—roughly equal shares of Heckscher-Ohlin inter-trade are reported.

[6] Cf. Abd-el-Rahman (1991), Greenaway et al. (1994) and Fontagné et al. (1997).

[7] In fact we have regionally disaggregated trade data for some 185 countries which we will deploy in the gravity estimates in the next section.

Table 1 Polish Inter- and Intra-Trade with the EU-25, 1999 and 2004[a]

	1999			2004		
Country	Inter-Trade	Intra-Trade		Inter-Trade	Intra-Trade	
		vertical	horizontal		vertical	horizontal
Austria	76.7	17.9	5.3	72.9	21.0	5.9
Belgium	82.7	14.6	2.6	72.7	18.9	8.4
Cyprus	99.3	0.4	0.1	21.0	7.9	71.0
Czech Republic	61.5	26.6	11.8	41.6	38.0	20.1
Danmark	67.3	26.1	6.5	52.3	26.0	21.4
Estonia	78.9	5.8	15.2	86.2	11.8	1.5
Finland	69.5	28.2	2.2	71.0	25.7	3.1
France	74.4	21.8	3.6	57.3	28.6	13.8
Germany	60.5	33.6	5.8	44.4	38.9	16.7
Greece	94.5	4.9	0.5	88.8	8.6	2.2
Hungary	69.5	18.3	12.1	63.3	24.8	11.7
Ireland	83.1	12.5	3.9	90.9	7.8	1.0
Italy	75.2	21.8	3.0	70.2	24.8	4.9
Latvia	95.8	3.3	0.7	92.7	5.4	1.7
Lithuania	88.7	8.8	2.2	84.2	12.6	2.8
Luxembourg	89.6	9.8	0.5	86.1	5.6	8.2
Malta	99.8	0.1	0.0	11.9	42.1	45.9
Netherlands	68.5	28.4	3.1	68.1	27.1	4.7
Portugal	88.4	8.2	3.3	87.4	9.9	2.6
Slovakia	83.8	11.8	4.3	67.5	20.8	11.5
Slovenia	87.6	7.3	5.0	84.8	9.7	5.3
Spain	80.4	14.0	5.5	69.9	17.0	13.1
Sweden	74.6	22.5	2.7	64.7	31.2	3.9
United Kingdom	77.6	19.0	3.1	60.4	28.5	10.9

[a]Shares of bilateral total trade in per cent.

Source: Eurostat (2006); own compilation and calculation.

In case of the other Polish trade partners the share of the inter-trade type has shrunk, often distinctly, whereby both forms of intra-trade have gained substantial weight. Apart from the two outlier cases of Cyprus and Malta changes are most distinct for the Visegrad 4 countries—particularly Czech Republic (–20 percentage points in inter-trade) and Slovakia (–16), less so Hungary (–6)—and Western European countries, such as United Kingdom (–17), France (–17), Germany (–16), Denmark (–15), Spain (–11), Belgium (–10), and Sweden (–10).

Distinct corresponding increases of vertical intra-trade flows between +4 and +12 percentage points are reported again for destinations in Visegrad-4 and Western European countries. At the same time, a look at Polish horizontal intra-trade renders the impression that Western European partners take the lead (+6 to +15 percentage points) ahead of Visegrad 4 partners (+7 to +8). Moreover, the increase in horizontal intra-trade is larger than in vertical intra-trade for the majority of Western European partners, in contrast to trade with Visegrad 4 partners.

Two observations appear to be surprising in this context: first, the high share of intra-trade in Poland's bilateral total trade, and second, the significant increase of horizontal intra-trade with large high income Western European partners. The first observation is still in line with the notion that Poland's trade is ruled by inter-industrial trade relations. It must not be ignored that vertical intra-trade which still rules total intra-trade with most partners (Table 1) can be explained by inter-industrial relations. Thus, this finding is consistent with Poland's role as a catching-up country.

So, the second observation is more puzzling, because a rising share of horizontal intra-trade normally would indicate a more visible catching-up process. Due to the relative low income level of Poland horizontal trade with Western partners should not be of major importance. At best, trade with Visegrad-4 partners—countries of a similar level of income—might feature a visible share of intra-trade of the horizontal type.

In order to shed more light on the geographical and structural determinants of Poland's vertical and horizontal intra-trade flows we will analyse these in terms of a modified gravity model.

3. Modelling Gravitational Forces on Poland's Inter- and Intra-trade Flows

A way to identify the role Poland has developed particularly in the European division of labour since the beginning of the stepwise accession process is a gravity approach separately applied to the three types trade, i.e. Heckscher-Ohlin inter-trade, vertical and horizontal intra-trade. The approach is related to running gravity estimates for different commodity groups often found in the pertinent literature, but differs insofar as the Fontagné-Freudenberg trade type approach serves as an analytical filter deployed beforehand in order to clarify what is really contained in the dependent variable. It combines the virtues of a structurally disaggregated gravity model with those of an analytical processing in terms of the intra-trade approach. Thus, we run a filtered gravity in the vein of Feenstra, Markusen and Rose (1998; 2001).

Gravity models are often used in trade and integration analyses to assess the shaping forces of international trade flows. They assume that high incomes or population figures of trading partners unfold gravitational forces to undertake economic interaction, because these features promise high revenues from business deals with numerous well funded clients. Transaction costs, which may vary with real or virtual distance, can be expected to impede the impact of the gravitational forces on the intensity of trade relations.[8]

Gravity models date back to Linder (1961), Tinbergen (1962) and Linnemann (1966). A number of contributions show that the standard gravity equation is consistent with several trade models: Bergstrand (1985; 1989) illustrated that a generalized gravity equation is consistent with Heckscher-Ohlin-models and models with monopolistic competition. Anderson (1979) and Deardorff (1995; 1998) found the gravity model to be in accordance with a wide range of trade models including the Heckscher-Ohlin-model. Evenett and Keller (1998) analysed to what extent the Heckscher-Ohlin-theory and the increasing returns trade theory account for the empirical success of the gravity equation. They showed that both models predict the gravity equation, and that models of imperfect product specialisation better explain the variation of trade flows than perfect product specialisation models. Feenstra, Markusen and Rose (1998; 2001) showed the consistency of the simple gravity equation with several theoretical models of trade: a gravity-type equation can arise from different trade models. Thus, the gravity model can be used to explain different types of trade, even if the theoretical background of the various analysed flows is not identical. Nevertheless, the estimated coefficients should differ significantly between these groupings of trade flows.

3.1 Reformulating the Gravity Equation

Gravity models are widely applied in all subspecies of economics literature where both the attractiveness of economic units (agents, regions, countries, etc.) and the hampering force of

[8] The various real and virtual distances are referred to as "trade costs" in the pertinent literature (cf. Carrère and Schiff 2004, Anderson and van Wincoop 2004).

distance are supposed to play a distinct role in shaping the intensity of interchange. However, a recent paper on the "Log of Gravity" by Santos Silva and Tenreyro (2005) has shaken the gravity community. It questions the widely used log-linear model specification estimated by OLS in the context of gravity models which model the relationship between the interaction variable and the attracting and retarding forces by the equation

ln (dependent variable) = f [ln (independent variables)].

Santos Silva and Tenreyro (2005: 6) argue that the log-linear OLS-estimator not only has the uncomfortable feature of skipping observations for which the dependent variable, such as the trade flow to partner country *j*, equals zero—a problem which already has been addressed for long in the gravity literature.[9] Moreover, because of Jensen's inequality[10] the log-linear estimator produces biased coefficients (= elasticities) if the data contain a substantial portion of heteroscedasticity. Hence, Santos Silva and Tenreyro suggest to substitute the OLS estimator by a Poisson estimator, i.e. to estimate a count model, not only for gravity models but also for constant elasticity models in general. As a by-product of the Poisson technique, zero observations of the dependent variable can be included because the count model estimates the equation

Level (dependent variable) = f [ln (independent variables)].

Thus, e.g. Soloaga et al. (2006: 10) have re-estimated their former log-linear trade gravity models according to the suggestion to use Poisson count models. As trade data usually violate the condition $E(y_i|x_i) = Var(y_i|x_i)$, a feature which is required by the simple Poisson model,[11] they have estimated their new model using a negative binomial regression that allows for over-dispersion, i.e. $E(y_i|x_i) < Var(y_i|x_i)$ with $Var(y_i|x_i) = E(y_i|x_i) + \eta g[E(y_i|x_i)]$. As a consequence, they receive unbiased estimates.

We follow this new approach not only in order to circumvent the problem of Jensen's inequality and get unbiased coefficients. Rather, our data set contains a lot of zero observations particularly due to the definition of vertical and horizontal intra-trade. Of course, our gravity model is meant to explain also these "zeroes", i.e. why there is no intra-trade for many countries in the sample. The traditional log-linear OLS approach, however, simply skips these observations, because *ln(0)* is not defined. Hence, a simple log-linear OLS approach would presumably

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[9] Cf. e.g. Eichengreen and Irwin (1996) who suggested to estimate $\ln(Trade_{ij} + 1)$ instead of $\ln(Trade_{ij})$ in order to circumvent the zero problem, a method that rests on the "scaled OLS"-model. See Greene (2003: 766–8) on this model.

[10] Jensen's inequality means that the expected value of the logarithm of a random variable does not equal the logarithm of its expected value, i.e. $E(\ln y) \neq \ln E(y)$. As a result, log-linearization of the multiplicative gravity equation yields biased estimates. Cf. Santos Silva and Tenreyro (2005: 3).

[11] Cf. Greene (2003: 743–4).

not be appropriate for our question by which forces intra-trade is driven; OLS-estimates are only reported as benchmarks.[12]

Thus, we estimate the simple Poisson model first, check for overdispersion and, if it is found, estimate a negative binomial model. This is done twice: (i) in a two-step QMLE estimation of a Negbin-II model[13] using the overdispersion parameter η estimated separately before in the context of the simple Poisson model, now applying it as a constraint for a Negbin estimation at the mean,[14] and (ii) in a generalized negative binomial MLE model with an overdispersion parameter η_i estimated jointly which allows for varying degrees of overdispersion for each trade flow as proposed by Soloaga et al. (2006: 10) and Devillanova and García Fontes (2004: 473–4). The Poisson as well as the QMLE NegBin model will be consistent in any case even if residuals should not follow correctly the Poisson distribution, because in both models the QMLE procedure is used.[15] For the generalized MLE NegBin model to be valid we explicitly have to assume that the Poisson assumption holds. While the QMLE models assume a uniform overdispersion factor, the generalized MLE NegBin model allows for an individual overdispersion factor. We will report the results of all three models of the Poisson family. It will become clear that results are somewhat similar whether estimates are done by MLE or QMLE.

Except the "Log of Gravity" innovation and the fact that we estimate a single-country-gravity, the model specification follows conventional paths in the gravity literature.[16]

We estimate the non-linear count equations from the Poisson family

$$X_{fti} = \exp(\alpha + \beta_1 \ln GDP_{tj} + \beta_2 \ln GDP_{tPL} + \beta_3 \ln PCI_{tj} + \beta_4 \ln DIST_{PL-j} + \sum_k \delta_k DUM_k) * \varepsilon$$

with X = Poland's exports as dependent variable, f = trade type according to Fontagné-Freudenberg, t = 1999, ..., 2004 (time index), i = 1, 2 (model index), j = index of bilateral trading partners, k = index of dummies and ε = error term.

Independent variables cover logs of Poland's trade partners' gross domestic products and per-capita-incomes $\left(GDP_{tj}, \text{resp. } PCI_{tj}\right)$ as gravitational forces, Poland's own GDP_{tPL} as a time trend and indicator of export growth in terms of Polish economic development, and the

[12] In most cases the Tobit model might be appropriate to cope with this zero observation problem because it principally provides for including the zero observations as well. However, as long as the dependent variable *Trade* is still denoted in logs, the Tobit procedure will not solve the problem that $\ln Trade_{ij}$ is not defined for $Trade_{ij} = 0$ either and the pertinent observation still has to be excluded from the estimation. An alternative would be to regress the *level of Trade* on the dependent variables, either in levels or logs. This approach is applied, e.g., by Eichengreen and Irwin (1996). We have performed this task but received highly non-normally distributed residuals, rendering the Tobit level option being not applicable because of inconsistent estimators (Greene 2003: 771): The Jarque-Bera statistic which tests for the Null-hypothesis of normally distributed errors exhibits extremely high values in the range of 55,248.91 to 4,444,041.0 for all three subcategories leading one to reject the normality hypothesis at all standard significance levels.

[13] See Cameron and Trivedi (1986; 1990) for a classification of NegBin models.

[14] This two-step procedure is suggested by Wooldridge (1997: 379–380; 2002)

[15] QMLE only requires the conditional mean to be correctly specified.

[16] As an example for single-country gravity estimates see, e.g., Abraham et al. (1997).

geographical distance $DIST_{PL-j}$ between Warsaw and the trading partners' capitals (or economic centers) as a factor for transportation costs. In addition to these usual variables, up to eleven contiguity dummies $(k = 1...11)$ are included to control for different kinds of virtual distances, proximities and neighbourhood effects. We pool data from 1999 to 2004 in order to alleviate a potential bias from outliers in individual years.

We estimate the gravity equations separately for all three subspecies of trade, i.e. for Heckscher-Ohlin inter-trade, vertical intra-trade and horizontal intra-trade. For each subspecies, we define two specifications which are intended to test either an aggregated or a disaggregated version of the deployed contiguity dummies DUM_k as defined in Table 2: Model 1 represents an integration path between the two poles of East and West, i.e. either integrating into the European Union with its subgroups old core members of EU-15 and the group of the ten new member states of 2004, or keeping up old ties with the CIS. In Model 2, we look at smaller groups or even single countries among Poland's Western and Eastern neighbours in order to discern more clearly the real centers of gravity on Polish export, particularly of intra-trade.

3.2 Data Sources

The Eurostat (2006) Comext raw data of Polish exports to partner countries at the 8-digit CN-level, covering the observation period 1999 to 2004, were filtered according to the Fontagné-Freudenberg trade type procedure described in section 2.2. These trade data denominated in € have been transformed to US-$ by the yearly averaged official exchange rates supplied by Deutsche Bundesbank (2006), because the GDP and PCI dataset provided by the World Bank (2006) is denominated in US-$. The vector of geographical distances has been calculated with the indo.com (2004) distance calculator. In the sample 185 Polish trading partners were included for which complete data sets were available. The descriptive statistics are to be found in Table 2.

Table 2 Description of Variables

Variable	Observations	Mean	Std. Dev.	Min.	Max.
xinterd	1094[a,b]	123134.1	510849.8	0	7506396
xvertid	1094[b,c]	52865.28	372055.4	0	8048389
xhorid	1094[b,d]	20328.2	152520.8	0	3349121
gdp	1094[b]	1.83e+11	8.69e+11	4.65e+07	1.17e+13
gdppl	1094[b]	1.90e+11	2.89e+10	1.55e+11	2.42e+11
pci	1094[b]	6585.03	10168.39	89.47	69206.66
distpl	1094[b]	6522.21	7107.97	365	86414
border	= 1, if trading partner shares a common land border with Poland, = 0, if not				
eu15	= 1, if trading partner is a core member of the old EU-15, = 0, if not				
eunew04	= 1, if trading partner one of the new EU members of 2004, = 0, if not				
cis	= 1, if trading partner is member of the Commonwealth of Independent States, = 0, if not				
scand	= 1, if trading partner is a Scandinavian country, i.e. Denmark, Norway, Sweden or Finland, = 0, if not				
d	= 1, if trading partner is Germany, = 0, if not				
au	= 1, if trading partner is Austria, = 0, if not				
west	= 1, if trading partner is another Western European country, but not Germany, Austria or Italy, = 0, if not				
mediterran	= 1, if trading partner is Mediterranean EU-member, i.e. Italy, Spain, Portugal or Greece, but nor France, = 0, if not				
balt	= 1, if trading partner is either Estonia, Latvia, or Lithuania, = 0, if not				
visegrad	= 1, if trading partner is either Czech Republic, Hungary, Slovenia, or Slovakia, = 0, if not				
medisle	= 1, if trading partner is either Cyprus or Malta, = 0, if not				
rus	= 1, if trading partner is Russia, = 0, if not				
belukr	= 1, if trading partner is either Belarus or Ukraine, = 0, if not				
restcis	= 1, if trading partner is member of the Commonwealth of Independent States, but not Russia, Belarus, or Ukraine, = 0, if not				

[a]Of which 52 observations are = 0. — [b]Further 238 observations, either with X..> or = 0, had to be skipped because of missing values for the numerical independent variables GDP_j, PCI_j or $DIST_{PL-j}$. — [c]Of which 601 observations are = 0. — [d]Of which 716 observations are = 0.

Source: Eurostat (2006); Deutsche Bundesbank (2006); World Bank (2006); indo.com (2004); own compilation.

3.3 Results of Gravity Estimates

3.3.1 Entire sample

Looking first at the *aggregated Model 1* and at *Heckscher-Ohlin inter-trade* it becomes clear that indeed the Poisson- and Negative Binomial estimates exhibit a somewhat different picture than the simple OLS ones, but changes are not dramatic.[17] The gravitational power of market size (GDP) as well as the impeding effect of distance shrinks a little bit but both variables remain prime factors in explaining the intensity of economic interaction between countries (Table 3). The coefficients of the contiguity dummies for the new EU members and the CIS, which clearly dominated the OLS estimate, more than halve and follow the prediction of "Log of Gravity".

On the other hand, both the border and the EU-15 dummy, which represent either the supporting effect of contiguity or of trade agreements as well, clearly go up, not only in the simple Poisson estimate but also in both NegBin specifications. The PCI variable which was small but significant in OLS loses its explanatory power throughout the three count models. All models exhibit either highly significant F- or Wald-tests, the null hypothesis of coefficients not different from zero can clearly be rejected.

The simple Poisson model significantly suffers from overdispersion,[18] hence, NegBin is required in any case. While the constrained NegBin QML produces rather different sizes of coefficients, the generalized NegBin estimation largely mimics the results of the simple Poisson model. Although the Pseudo-R^2 according to McFadden is only 0.07 for generalized NegBin in contrast to 0.94 for simple Poisson, another goodness-of-fit measure which has been proposed by Wooldridge (2002: 653) attaches a good grade to the generalized NegBin model: the correlation of fitted and real values is only one base point below the high threshold of 0.93 given by the simple Poisson. These features and the better performance in the Wald test leave us with the conclusion that the generalized NegBin model is the preferable option.

[17] Please note that coefficients of numerical variables can be interpreted as elasticities because they represent semi-log marginal effects of the original coefficients of the count model. Although the dependent variable *X* of our count model is in levels and the independent ones are in logs, we arrive at elasticities if we calculate semi-log marginal effects $\frac{d \ln[f(indepv)]}{d\ indepv}$ at the sample mean because this type of marginal effects of our equation X = f [ln (*independent variables*)] will result in $\frac{d \ln(X)}{d \ln(indepv)} = \frac{indepv \cdot d\ X}{X \cdot d\ indepv}$ with values of marginal effects being equal to the original coefficients.

[18] The overdispersion factor η of the simple Poisson model is reported in the third column of NegBin QML, because it serves as a constraint in the QML estimation procedure as proposed by Cameron and Trivedi (1986).

Table 3 Results of Gravity Estimates of Model 1 — Poland's Exports (Heckscher-Ohlin Inter-Trade) 1999–2004[a]

Method	Log-linear *OLS*	Poisson *ML/QML*	Negative Binomial *QML*	Generalized Negative Binomial *ML*
Dependent Variable	$\ln X_{PL}$	X_{PL}	X_{PL}	X_{PL}
Constant	–25.57*** (–2.79)	–34.90*** (–5.88)	–6.50 (–0.42)	–31.34*** (–5.03)
$\ln GDP_j$	0.86*** (25.57)	0.70*** (24.83)	0.40*** (8.32)	0.59*** (20.58)
$\ln GDP_{PL}$	0.87** (2.43)	1.40*** (6.06)	0.48 (0.81)	1.30*** (5.49)
$\ln PCI_j$	0.10** (2.04)	–0.06 (–1.51)	0.14 (1.47)	0.73 (1.53)
$\ln DIST_{PL–j}$	–1.18*** (–16.42)	–0.99*** (–13.84)	–0.84*** (–10.42)	–0.91*** (–17.06)
BORDER	0.45*** (3.24)	0.79*** (8.07)	1.33*** (7.94)	0.83*** (7.17)
EU15	0.37** (2.32)	0.62*** (5.47)	1.01*** (5.74)	0.67*** (5.97)
EUNEW04	1.28*** (6.98)	0.59*** (3.89)	0.50*** (2.91)	0.68*** (4.83)
CIS	1.33*** (8.82)	0.45*** (2.94)	0.25 (1.16)	0.60*** (4.24)
$\bar{R}^2$	0.75	–	–	–
McFadden Pseudo $\bar{R}^2$	–	0.94	–	0.07
Wooldridge $\bar{R}^2$	–	0.93	0.91	0.92
Overdispersion η	–	–	0.04414*** (61.00)	Function of all independent variables
F	707.08***	–	–	–
Wald χ^2	–	3947.37***	1991.57***	2622.61***
n	1042	1094	1094	1094

[a]Robust standard errors, t- or z-values in brackets. — *** = significant at 1 per cent error level, ** = at 5 per cent, * = at 10 per cent.

Source: As Table 2; own calculations.

The generalized NegBin model tells us that Poland's Heckscher-Ohlin inter-trade in fact reacts positively to the gravitational power of large GDPs, but not as elastic as if they are estimated by OLS. The retarding effect of distance is "alive and well"[19], and the coefficient is still in the range to be found in conventional OLS analyses, albeit loses roughly one fifth of its value. Our four groups of contiguity dummies converge to 0.7, with none dominating the others as it is the case for *EUNEW04* in OLS. However, the conclusion that Poland's Heckscher-Ohlin inter-trade exports are more evenly distributed among its neighbours, would be misleading, as it will become clear when we turn to the disaggregated Model 2. We can only notice that the unbiased coefficients suggest more than proportional exports to all groups of neighbours, but with less than elastic values. The exception is the high elasticity of 1.3 of Poland's own GDP, this matching with the rapidly increasing export shares in the phase of Poland's EU-integration.

In the case of the Polish *vertical intra-trade* (Table 4) call even more for other estimation techniques than OLS because of the large number of zero observations. The coefficients of the numerical variables are more or less in line between OLS, simple Poisson and generalized NegBin. Only the two stage QML NegBin behaves differently, but the arguably high value of the GDP_{PL} elasticity and the rather low R^2 according to Wooldridge suggest that generalized NegBin again is superior. There are a couple of striking results for Poland's vertical intra-trade exports:

- the elastic reaction relative to the size of partners' GDP,
- an even higher distance impedance factor than for OLS (1.5) strengthening the conjecture that the main trading partners are Poland's neighbours compared with overall exports
- semi-elasticities of dummy groups *BORDER* (including Germany) and *EUNEW04* with values around 1.0,
- the "growth elasticity" for Poland's own GDP of 2.0, and
- the change in the algebraic sign of the *CIS* elasticity compared to OLS in combination with the clear gain in significance.

[19] Just to cite a paper of Carrere and Schiff (2004) who found the average distance of exports to remain rather constant in spite of all ongoing tendencies of globalization.

Table 4 Results of Gravity Estimates of Model 1 — Poland's Exports (Vertical Intra-Trade) 1999–2004[a]

Method	Log-linear *OLS*	Poisson *ML/QML*	Negative Binomial *QML*	Generalized Negative Binomial *ML*
Dependent Variable	$\ln X_{PL}$	X_{PL}	X_{PL}	X_{PL}
Constant	–71.71 (–3.74)	–46.30*** (–11.21)	–169.20 (–6.76)	–57.72*** (–8.43)
$\ln GDP_j$	0.96*** (8.93)	1.05*** (19.87)	0.53*** (5.94)	0.96*** (20.72)
$\ln GDP_{PL}$	2.39** (3.12)	1.55*** (9.12)	6.48*** (6.29)	2.01*** (7.50)
$\ln PCI_j$	0.42** (3.71)	0.20* (1.82)	0.44** (2.15)	0.19** (2.30)
$\ln DIST_{PL-j}$	–1.44*** (–8.99)	–1.73*** (–8.83)	–0.99*** (–8.10)	–1.51*** (–12.99)
BORDER	1.73*** (5.34)	0.85*** (7.86)	2.37*** (7.94)	0.93*** (9.49)
EU15	1.68** (5.27)	0.14 (0.35)	1.65*** (5.02)	0.69*** (3.59)
EUNEW04	1.91*** (5.07)	0.55 (1.46)	0.93*** (3.33)	1.00*** (3.72)
CIS	0.41 (1.09)	–1.01*** (–3.54)	–0.95 (–1.97)	–0.60*** (–1.90)
$\bar{R}^2$	0.72	–	–	–
McFadden Pseudo R^2	–	0.97	–	0.08
Wooldridge R^2	–	0.98	0.74	0.97
Overdispersion η	–	–	0.002785*** (8.34)	Function of all independent variables
F	310.85***	–	–	–
Wald χ^2	–	6158.86***	1591.62***	3821.47***
n	493	1094	1094	1094

[a]Robust standard errors, t- or z-values in brackets. — *** = significant at 1 per cent error level, ** = at 5 per cent, * = at 10 per cent.

Source: As Table 2; own calculations.

In the case of *horizontal intra-trade exports* (Table 5) the number of zero observations is even higher. Including all the zero observations by Poisson and NegBin estimation, the coefficients change compared to OLS distinctly but do not alter the overall picture: for partners' GDPs the elasticity is ⅓ higher, for Poland's own GDP the coefficient drops from very high 4.7 to still high 3.2, the distance impedance is 15 per cent smaller but still high, *EU15* is close to the OLS-level, *EUNEW04* and *CIS* absolute values are even higher. In contrast, *PCI* looses its explanatory power completely, and the *BORDER* coefficient is halved but remains elastic. Taking the generalized NegBin estimates as the most reliable one, Poland has strong trade links for this type of intra-trade with both old and new EU members, but definitely not with the *CIS*. Although this type of exports does not account for more than one tenth of total Polish exports it exhibits the greatest dynamic development, thus indicating Poland's catching-up process.

Table 5 Results of Gravity Estimates of Model 1 — Poland's Exports (Horizontal Intra-Trade) 1999–2004[a]

Method	Log-linear *OLS*	Poisson *ML/QML*	Negative Binomial *QML*	Generalized Negative Binomial *ML*
Dependent Variable	$\ln X_{PL}$	X_{PL}	X_{PL}	X_{PL}
Constant	–123.02*** (–6.29)	–73.76*** (–7.73)	–201.93 (–8.76)	–88.26*** (–6.87)
$\ln GDP_j$	0.63*** (4.50)	1.03*** (8.54)	0.30*** (4.87)	0.84*** (13.69)
$\ln GDP_{PL}$	4.72** (5.94)	2.59*** (6.83)	7.95*** (8.49)	3.24*** (6.61)
$\ln PCI_j$	0.22* (1.70)	–0.31* (–2.02)	0.18 (0.79)	–0.03 (–0.28)
$\ln DIST_{PL-j}$	–1.43*** (–7.44)	–1.19*** (–5.13)	–0.81*** (–5.21)	–1.19*** (–7.66)
BORDER	1.83*** (4.54)	0.84*** (3.17)	2.56*** (8.02)	0.99*** (5.32)
EU15	1.84** (5.10)	1.77*** (4.71)	2.69*** (8.07)	1.66*** (6.35)
EUNEW04	1.25*** (2.94)	2.04*** (4.55)	1.55*** (4.13)	1.88*** (6.30)
CIS	–1.24*** (–2.65)	–1.69*** (–4.73)	–2.43*** (–3.92)	–1.47*** (–4.31)
$\overline{R}^2$	0.66	–	–	–
McFadden Pseudo R^2	–	0.92	–	0.07
Wooldridge R^2	–	0.92	0.70	0.90
Overdispersion η	–	–	0.009734*** (8.34)	Function of all independent variables
F	133.45***	–	–	–
Wald χ^2	–	22118.08***	872.09***	2052.41***
n	378	1094	1094	1094

[a]Robust standard errors, t- or z-values in brackets. — *** = significant at 1 per cent error level, ** = at 5 per cent, * = at 10 per cent.

Source: As Table 2; own calculations.

The *disaggregated Model 2* which splits the dummy groups of Model 1 regionally has been estimated under the same premises as before.[20] The behaviour of the simple Poisson model, the two-stage QML NegBin and the generalized NegBin are the same as in Model 1. Again, we rely on the generalized NegBin model. Thus, we only comment on further effects which result from regional disaggregation: It becomes obvious that exports to single members either of the *EU15*, the new EU members, or the CIS differ significantly (Tables 6–8). Poland's exports are concentrated on specific partners within these groups, even after controlling for the partners' GDP, PCI and distance. This result holds for all three trade-types of Poland's exports:

- Among the core members of the EU-15, Germany definitely is the prime trading partner, with highly significant coefficients for all trade-types, being twice as high as the respective values of the other Western and Southern European EU-members.
- Among the new EU members, the other Visegrad countries qualify as prime trading partners particularly for intra-trade, whereas higher export elasticities in trade with the Baltic States has only occurred with respect to inter-trade and, less distinctly, to vertical intra-trade.
- Poland's trade relations with Eastern Europe are focused on the direct neighbours Belarus and Ukraine, both for inter-trade and for vertical intra-trade. As expected, Russia is overwhelmingly a prominent inter-trade partner, while even no intra-trade with the rest of the CIS can be observed.

Moreover, the estimates reveal an apparent tendency of more intense relations with the West, particularly Germany, with respect to vertical and especially to horizontal intra-trade. While the general result that intra-trade is conducted primarily with highly developed countries seems to be plausible, it is surprising that Poland exhibits higher elasticities for these types of trade than for traditional Heckscher-Ohlin inter-trade. In the case of Germany, the elasticity rises from 1.7 to 1.9 and 2.9, that of Western Europe from 0.8 to 0.9 and 1.5, and that of Southern Europe from 0.7 to 1.0 and 2.5. This effect is even more pronounced in view of the finding that the highest "average" partners' GDP elasticity is found for horizontal intra-trade. This result is a clear indication of Poland's progress particularly in the field of commodities which are typically traded only among highly developed countries. The notion of "trade on equal eyes' height" which already shows up when looking at Poland's total trade figures is significantly reinforced by this trade-type analysis.

[20] The *BORDER* dummy has been skipped as all bordering countries to Poland are accounted for by small country groups.

Table 6 Results of Gravity Estimates of Model 2 — Poland's Exports (Heckscher-Ohlin Inter-Trade) 1999–2004a

Method	Log-linear *OLS*	Poisson *ML/QML*	Negative Binomial *QML*	Generalized Negative Binomial *ML*
Dependent Variable	$\ln X_{PL}$	X_{PL}	X_{PL}	X_{PL}
Constant	–25.61*** (–2.79)	–34.31*** (–5.80)	–6.11 (–0.39)	–28.19*** (–5.71)
Ln GDP_j	0.86*** (25.08)	0.71*** (22.55)	0.40*** (8.28)	0.59*** (19.17)
ln GDP_{PL}	0.87** (2.43)	1.38*** (6.02)	0.46 (0.78)	1.19*** (6.31)
Ln PCI_j	0.11** (2.03)	–0.04 (–1.06)	0.14 (1.41)	0.07 (1.26)
ln $DIST_{PL-j}$	–1.18*** (–14.84)	–1.03*** (–14.35)	–0.82*** (–9.53)	–0.93*** (–14.66)
SCAND	0.15 (0.68)	0.34** (2.15)	0.66*** (2.65)	0.30 (1.57)
DE	1.10*** (5.30)	1.40*** (8.26)	2.54*** (10.05)	1.68*** (9.31)
AU	–0.34 (–1.57)	–0.31** (–2.22)	0.22 (0.93)	–0.25 (–1.52)
WEST	0.42** (2.21)	0.70*** (5.60)	1.21*** (5.31)	0.78*** (5.21)
MEDITERRAN	0.62*** (3.07)	0.53*** (3.70)	1.19*** (6.05)	0.67*** (4.48)
BALT	2.05*** (9.90)	1.52*** (9.37)	1.35*** (6.00)	1.39*** (7.86)
VISEGRAD	1.21*** (6.31)	0.86*** (6.44)	1.08*** (5.45)	0.87*** (6.29)
MEDISLE	1.00*** (2.83)	0.62* (1.74)	0.05 (0.13)	0.34 (0.95)
RUS	1.19*** (7.06)	0.92*** ((6.20)	1.83*** (7.04)	1.18*** (8.02)
BELUKR	2.09*** (8.58)	1.55*** (7.42)	1.98*** (6.24)	1.74*** (8.35)
RESTCIS	1.35*** (8.20)	0.75*** (4.95)	0.17 (0.74)	0.48*** (2.74)
$\bar{R}^2$	0.76	–	–	–
McFadden Pseudo R^2	–	0.95	–	0.07
Wooldridge R^2	–	0.94	0.93	0.95
Overdispersion η	–	–	0.052012*** (49.00)	Function of all independent variables
F	1352.09***	–	–	–
Wald χ^2	–	4976.38***	7054.59***	4665.18***
n	1042	1094	1094	1094

[a]Robust standard errors, t- or z-values in brackets. — *** = significant at 1 per cent error level, ** = at 5 per cent, * = at 10 per cent.

Source: As Table 2; own calculations.

Table 7 Results of Gravity Estimates of Model 2 — Poland's Exports (Vertical Intra-Trade) 1999–2004[a]

Method	Log-linear *OLS*	Poisson *ML/QML*	Negative Binomial *QML*	Generalized Negative Binomial *ML*
Dependent Variable	$\ln X_{PL}$	X_{PL}	X_{PL}	X_{PL}
Constant	–72.95*** (–3.82)	–49.02*** (–11.07)	–170.27 (–6.86)	–46.52*** (–14.67)
Ln GDP_j	0.95*** (8.39)	0.99*** (15.62)	0.52*** (5.95)	0.98*** (17.67)
ln GDP_{PL}	2.43*** (3.17)	1.68*** (9.82)	6.51*** (6.46)	1.59*** (12.02)
Ln PCI_j	0.37*** (3.15)	0.12 (1.24)	0.40* (1.89)	0.08 (0.76)
ln $DIST_{PL–j}$	–1.31*** (–7.17)	–1.56*** (–9.86)	–0.88*** (–7.29)	–1.47*** (–15.04)
SCAND	2.21*** (5.01)	0.88*** (3.02)	1.83*** (4.04)	1.00*** (4.06)
DE	3.50*** (6.39)	1.68*** (6.89)	4.00*** (8.22)	1.88*** (9.92)
AU	1.57*** (3.29)	–0.24 (–1.11)	1.31*** (2.69)	–0.01 (–0.05)
WEST	2.04*** (5.21)	0.75*** (4.59)	2.09*** (4.98)	0.90*** (5.48)
MEDITERRAN	1.96*** (5.73)	0.86*** (5.76)	1.97*** (4.84)	0.99*** (7.49)
BALT	2.71*** (7.09)	0.68** (2.49)	1.30*** (3.87)	0.80*** (3.69)
VISEGRAD	3.41*** (8.66)	1.68*** (6.82)	2.69*** (8.73)	1.80*** (9.82)
MEDISLE	1.58* (1.94)	2.36*** (4.70)	0.82 (1.35)	2.23*** (4.30)
RUS	2.21*** (5.12)	–0.16 (–0.56)	1.96*** (4.54)	–0.04 (–0.20)
BELUKR	3.16*** (7.75)	0.72** (2.03)	2.25*** (4.71)	0.84*** (3.20)
RESTCIS	0.11 (0.24)	–1.44*** (–3.44)	–2.25*** (–3.83)	–1.72*** (–4.38)
$\bar{R}^2$	0.73	–	–	–
McFadden Pseudo R^2	–	0.98	–	0.08
Wooldridge R^2	–	0.98	0.76	0.99
Overdispersion η	–	–	0.003063*** (11.69)	Function of all independent variables
F	391.58***	–	–	–
Wald χ^2	–	12610.95***	1991.93***	14097.62***
n	493	1094	1094	1094

[a]Robust standard errors, t- or z-values in brackets, *** = significant at 1 per cent error level, ** = at 5 per cent, * = at 10 per cent.

Source: As Table 2; own calculations.

Table 8 Results of Gravity Estimates of Model 2 — Poland's Exports (Horizontal Intra-Trade) 1999–2004[a]

Method	Log-linear *OLS*	Poisson *ML/QML*	Negative Binomial *QML*	Generalized Negative Binomial *ML*
Dependent Variable	$\ln X_{PL}$	X_{PL}	X_{PL}	X_{PL}
Constant	–123.79*** (–6.31)	–67.12*** (–6.53)	–208.95*** (–8.85)	–74.68*** (–8.85)
Ln GDP_j	0.58*** (3.95)	0.95*** (7.64)	0.28*** (4.69)	0.79*** (11.96)
ln GDP_{PL}	4.79*** (6.02)	2.58*** (6.33)	8.20*** (8.66)	2.81*** (8.63)
Ln PCI_j	0.18 (1.30)	–0.22* (–1.67)	0.18 (0.75)	–0.06 (–0.50)
ln $DIST_{PL–j}$	–1.36*** (–6.43)	–1.81*** (–6.50)	–0.70 (–4.46)	–1.27*** (–6.91)
SCAND	1.81*** (3.70)	0.57 (1.54)	2.21*** (4.57)	1.05*** (2.74)
DE	4.45*** (6.56)	1.91*** (4.06)	5.22*** (10.52)	2.76*** (7.54)
AU	1.72*** (3.20)	–0.22 (–0.57)	2.14*** (4.26)	0.53 (1.35)
WEST	1.98*** (4.09)	0.93*** (2.76)	2.75*** (6.79)	1.37*** (4.50)
MEDITERRAN	2.32*** (4.60)	1.80*** (7.69)	3.57*** (7.38)	2.36*** (6.79)
BALT	0.98** (2.30)	–0.55* (–1.65)	1.26** (2.25)	0.35 (0.71)
VISEGRAD	3.21*** (8.52)	1.56*** (5.07)	3.51*** (9.18)	2.39*** (6.17)
MEDISLE	0.67 (0.66)	2.97*** (4.46)	0.38 (0.71)	1.96*** (3.17)
RUS	1.18** (2.59)	–1.55*** (–4.03)	1.26*** (2.62)	–0.69* (–1.79)
BELUKR	0.73* (1.68)	–1.60*** (–4.37)	0.83 (1.36)	–0.62 (–1.40)
RESTCIS	–1.69*** (–2.64)	–3.12*** (–4.20)	–4.00*** (–4.55)	–2.85*** (–4.83)
$\bar{R}^2$	0.68	–	–	–
McFadden Pseudo R^2	–	0.94	–	0.271
Wooldridge R^2	–	0.96	0.71	0.93
Overdispersion η	–	–	0.010701*** (6.70)	Function of all independent variables
F	166.84***	–	–	
Wald χ^2	–	4307.67***	1080.36***	3550.14***
n	378	1094	1094	1094

[a]Robust standard errors. — t- or z-values in brackets, *** = significant at 1 per cent error level, ** = at 5 per cent, * = at 10 per cent.

Source: As Table 2; own calculations.

Finally, Poland's "growth elasticity" increases with the degree of intra-trade, i.e. horizontal intra-trade exports have increased most in relation to the country's own GDP in the observation period with an elasticity of nearly 2.8, followed by vertical intra-trade with 1.6, while traditional Heckscher-Ohlin exports only exhibit a growth factor of 1.2. Again, the analysis indicates a quality-upgrade that occurred in Polish trade.

3.3.2 Temporal Dimension

In this context, the question is to be answered what the temporal dimension of this progress is. Since our observation period covers the last five pre-accession years 1999 to 2003 and the EU accession year 2004, any development in the course of Poland's accession progress would be hidden in our pooled estimation. In order to check for such dynamics, we have split the observation period into two three years sub-periods, estimated these sub-samples separately, and tested for stability of coefficients between both sub-periods.[21] Results can be inferred from Tables 9–10.

Actually, Poland's "growth elasticity" has been definitely higher in the sub-period 1999–2001 compared to 2002–2004 for vertical intra-trade (Table 9). Apparently, Poland trade shifted towards vertical intra-trade at a relatively early phase of its accession process, at least at the millennium's turn.[22] With respect to horizontal intra-trade, the results are controversial (Table 10). Poisson tells the same story as for vertical exports, while Generalized NegBin even shows a highly significant negative coefficient for 1999–2001. This indicates a dispersed growth in trade with different partners in the first sub-period.

[21] Nevertheless, we pooled three years in each sub-period to rule out potential outlier effects in single years. The test for stability of coefficients has been performed by reformulating the pertinent models with different variables for the two sub-periods. We can reject the H_0 of stable coefficients between sub-periods both for vertical and for horizontal intra-trade at less than 1 per cent significance level: As can be inferred from Tables 9–10, neither the coefficients of the numerical variables $\ln GDP_j$, $\ln GDP_{PL}$, $\ln PCI_j$ and $\ln DIST_{PLj}$ nor the contiguity dummies appear to be the same in the two sub-periods. Hence, a split-up is warranted. We have restricted this analysis to simple Poisson and Generalized NegBin and both intra-trade types.

[22] Limitations in the availability of 8-digit trade data—these are provided only from 1999 onwards—bar us from further elaborating this notion.

Table 9 Results of Gravity Estimates of Poland's Vertical Intra-Trade, Results for Poisson and Generalized Negative Binominal Regressions for Sub-periods 1999–2001 and 2002–2004[a]

Method	Poisson *ML/QML*			Generalized Negative Binomial *ML*		
Dependent Variable $Xverti_{PL}$	1999–2004	1999–2001	2002–2004	1999–2004	1999–2001	2002–2004
Constant	–49.02*** (–11.07)	–57.03*** (–5.61)	–49.73*** (–5.28)	–46.51*** (–14.67)	–66.89*** (–8.82)	–46.07*** (–8.06)
Ln GDP_j	0.99*** (15.62)	1.16*** (15.22)	0.93*** (11.96)	0.98*** (17.67)	1.17*** (12.55)	0.97*** (15.08)
ln GDP_{PL}	1.68*** (9.82)	1.95*** (5.10)	1.72*** (4.72)	1.59*** (12.02)	2.23*** (7.94)	1.59*** (6.69)
Ln PCI_j	0.12 (1.24)	0.18** (2.04)	0.10 (0.87)	0.08 (0.76)	0.19* (1.81)	0.03 (0.33)
ln $DIST_{PL–j}$	–1.56*** (–9.86)	–2.03*** (–14.51)	–1.37*** (–6.89)	–1.47*** (–15.04)	–1.79*** (–12.03)	-1.43*** (–12.91)
SCAND	0.88*** (3.02)	0.21 (0.96)	1.15*** (3.14)	1.00*** (4.06)	0.66** (2.35)	1.16*** (3.97)
DE	1.68*** (6.89)	1.01*** (4.55)	1.94*** (6.34)	1.88*** (9.92)	1.40*** (5.01)	1.88*** (9.08)
AU	–0.24 (–1.11)	–0.71*** (–3.12)	–0.05 (–0.18)	–0.01 (–0.05)	–0.17 (–0.63)	–0.06 (–0.29)
WEST	0.75*** (4.59)	0.34* (1.67)	0.92*** (4.56)	0.90*** (5.48)	0.70*** (2.76)	0.88*** (5.15)
MEDITERRAN	0.86*** (5.76)	0.64*** (3.68)	0.94*** (5.14)	0.99*** (7.50)	0.89*** (4.61)	0.92*** (6.63)
BALT	0.68** (2.49)	0.57* (1.81)	0.78** (2.24)	0.80*** (3.69)	1.26*** (3.60)	0.74*** (3.11)
VISEGRAD	1.68*** (6.82)	1.45*** (5.84)	1.82*** (5.80)	1.80*** (9.82)	1.99*** (7.13)	1.76*** (8.43)
MEDISLE	2.36*** (4.70)	0.32 (0.48)	2.50*** (4.79)	2.23*** (4.30)	0.36 (0.49)	2.76*** (6.02)
RUS	–0.16 (–0.56)	–0.10 (–0.43)	–0.13 (–0.37)	–0.04 (–0.20)	0.36 (1.36)	–0.25 (–1.24)
BELUKR	0.72** (2.03)	0.84*** (2.66)	0.73 (1.64)	0.84*** (3.20)	1.51*** (4.44)	0.64** (2.30)
RESTCIS	–1.44*** (–3.44)	–0.62* (–1.67)	–1.70*** (–3.12)	–1.72*** (–4.38)	–0.38 (–0.83)	–2.11*** (–4.11)
McFadden Pseudo R^2	0.98	0.99	0.97	0.08	0.10	0.08
Wooldridge R^2	0.98	0.97	0.99	0.99	0.96	0.99
Wald χ^2	12610.95***	12367.91***	12448.40***	14097.41***	14093.48***	9087.84***
N	1094	549	545	1094	549	545
[a]Robust standard errors. z-values in brackets, *** = significant at 1 per cent error level, ** = at 5 per cent, * = at 10 per cent.						

Source: As Table 2; own calculations.

Table 10 Results of Gravity Estimates of Poland's Horizontal Intra-Trade, Results for Poisson and Generalized Negative Binominal Regressions Sub-periods 1999–2001 and 2002–2004[a]

Method	Poisson *ML/QML*			Generalized Negative Binomial *ML*		
Dependent Variable $Xverti_{PL}$	1999–2004	1999–2001	2002–2004	1999–2004	1999–2001	2002–2004
Constant	–67.12*** (–6.53)	–106.49*** (–3.66)	–46.11** (–2.47)	–74.68*** (–8.85)	7.74 (1.37)	–28.92*** (–13.59)
Ln GDP_j	0.95*** (7.64)	1.19*** (8.98)	0.88*** (5.96)	0.79*** (11.96)	1.20*** (13.27)	0.74*** (7.92)
ln GDP_{PL}	2.58*** (6.33)	3.85*** (3.40)	1.81** (2.49)	2.81*** (8.63)	–0.70*** (–3.00)	1.19*** (27.72)
Ln PCI_j	–0.22* (–1.67)	0.12 (0.73)	–0.20 (–1.27)	–0.06 (–0.50)	0.08 (0.79)	–0.15 (–1.58)
ln $DIST_{PL–j}$	–1.81*** (–6.50)	–2.29*** (–9.04)	–1.65*** (–5.04)	–1.27*** (–6.91)	–1.86*** (–8.42)	–1.41*** (–5.62)
SCAND	0.57 (1.54)	0.25 (0.57)	0.61 (1.35)	1.05*** (2.74)	1.04** (2.23)	0.89* (1.87)
DE	1.91*** (4.06)	1.35*** (2.84)	2.03*** (3.51)	2.76*** (7.54)	2.09*** (4.70)	2.59*** (5.41)
AU	–0.22 (–0.57)	–0.40 (–0.90)	–0.21 (–0.45)	0.53 (1.35)	0.56 (1.19)	0.19 (0.39)
WEST	0.93*** (2.76)	0.56 (1.54)	1.00** (2.40)	1.37*** (4.50)	1.28*** (3.41)	1.33*** (3.47)
MEDITERRAN	1.80*** (7.69)	1.96*** (6.61)	1.70*** (5.69)	2.36*** (6.79)	2.43*** (6.31)	2.21*** (5.07)
BALT	–0.55* (–1.65)	0.81 (1.54)	–0.80** (–2.06)	0.35 (0.71)	1.97*** (3.57)	–0.63 (–1.08)
VISEGRAD	1.56*** (5.07)	2.43*** (6.97)	1.45*** (3.87)	2.39*** (6.17)	3.30*** (7.55)	1.77*** (3.42)
MEDISLE	2.97*** (4.46)	0.22 (0.26)	2.90*** (4.13)	1.96*** (3.17)	0.70 (0.82)	2.34*** (3.52)
RUS	–1.55*** (–4.03)	–0.79** (–2.39)	–1.49*** (–3.22)	–0.69* (–1.79)	–0.21 (–0.62)	–1.04** (–2.09)
BELUKR	–1.60*** (–4.37)	–[b]	–1.67*** (–3.84)	–0.62 (–1.40)	0.60 (1.29)	–1.36*** (–2.66)
RESTCIS	–3.12*** (–4.20)	–[b]	–3.77*** (–3.59)	–2.85*** (–4.83)	0.12 (0.15)	–3.36*** (–3.68)
McFadden Pseudo R^2	0.94	0.97	0.93	0.27	0.10	0.09
Wooldridge R^2	0.96	0.82	0.97	0.93	0.76	0.88
Wald χ^2	4307.67***	1685.83***	3138.20***	3550.14***	4143.70***	1.216e+6***
N	1094	549	545	1094	549	545

[a]Robust standard errors. — z-values in brackets, *** = significant at 1 per cent error level, ** = at 5 per cent, * = at 10 per cent. — [b]Estimated without these variables because of lacking convergence in ML optimization procedure including the variables.

Source: As Table 2; own calculations.

At the same time, the distance impedance factor has decreased for both trade types in both models. Hence, Poland has proceeded in capturing new markets for its sophisticated exports in the course of time. Moreover, the gap between vertical and horizontal distance impedance remains intact only for Poisson, but not for Generalized NegBin. One might infer from Poisson that it is still more challenging to engage in "true" horizontal intra-trade in the world market than it is the case for "Heckscher-Ohlin-affine" vertical intra-trade. But Generalized NegBin questions this interpretation.

A central conclusion can be drawn from the interdependence of the partners' GDP coefficient, the distance factor mentioned above and the dummies of the main trading partners. On the one hand, the coefficients of GDP_j decrease a little bit for both forms (Poisson) or even distinctly for horizontal exports according to Generalized NegBin. The coefficients of PCI_j loose any significance, both effects hinting at a fading attraction of large and rich markets on average. On the other hand, the distance elasticities indicate that more distant markets are penetrated. An explanation is given by the dummies of all the Western European partners: The quasi-elasticities for Germany and the rest of Western Europe increased substantially between the sub-periods. As these dummies interact with the numerical variables, the conclusion must be that Poland concentrated its efforts in exporting goods in the fields of vertical and horizontal intra-trade on the core EU-members in 2002–2004. Other large and rich markets outside the EU lost in relative importance during the second sub-period, and a regionally wider dispersion of trade flows follows from the decreasing distance impedance.

With respect to the division of labour among the group of larger Central and Eastern European EU accession states—apart from the three Baltic states—a mixed picture emerges: the coefficients for vertical intra-trade either in- or decrease, that for horizontal intra-trade clearly go down. Hence, differences in development levels become obvious. But it is not possible to discern whether Poland falls behind or goes ahead the other Visegrad 4 countries. Last but not least, the disintegration from the former socialist division of labour represented here by the CIS countries has intensified in the course of time, making Poland's Westward shift more visible.

4. Summary and Conclusions

The analysis of Poland's regional and sectoral trade patterns in the pre-accession period from 1999 to 2004 clearly underpins its changing role in the new EU division of labour. The question whether the basic hypothesis—the country would still concentrate on exports of the standardized Heckscher-Ohlin inter-trade type—can be rejected or not cannot be answered unanimously. The answer crucially depends on the particular set of trade relations to be analysed. Yet, the hypothesis can definitely be rejected with respect to Poland's trade relations with the rich industrialised economies in Western Europe. The share of traditional inter-trade in Polish total exports has markedly decreased vis-à-vis both old and new EU-members in the course of accession, while both vertical and horizontal intra-trade flows have increased to substantial levels. It is only the dominance of inter-trade in most bilateral trade relations in the observation period which may still be considered as a heritage of past economic structures.

The results of the trade-type filtered gravity model confirm the assumption that Poland's economy has undergone substantial structural change in the course of integrating into the Common Market of the EU. The core members of the old EU-15, and among this group particularly Germany as Poland's prime trading partner, have increasingly emerged as centres of gravity for Polish exports of intra-trade type commodities which are traded primarily among wealthy and mutually resembling industrialized economies. It appears striking that coefficients of numerical variables as well as of pertinent country dummies exhibit an increase of Poland's trade intensity with the rich core of the EU by (i) weight of the trading partner, (ii) the level of genuine intra-trade, and (iii) over time. Thus, Poland's economy has been apparently integrated into European international production networks covering domestic locations linked to those in the core member states of the EU, but presumably also in other new EU-members. The latter's non-negligible role is underlined by positive and significant coefficients for respective country dummies in intra-trade gravity equations.

These findings of the filtered gravity analysis are in line with earlier results from the analysis of Polish sectoral trade patterns.[23] The technology content of trade with EU-15 countries significantly increased in the observation period, indicating a successful integration of Polish enterprises into (Western) European networks of production. It becomes obvious that Poland no longer plays the role of a workbench for labour intensive, standardized products.[24] As indicated by the growing intra-trade share, a two-way trade in technology intensive products with highly developed countries is emerging.

The analysis reveals a quite different picture of Polish trade relations with Eastern European partners as well as with the rest of the world beyond Europe. These trade relations are characterized by still dominating traditional inter-trade. However, this dissenting evidence does not object the findings above: With respect to Eastern partners the dominance of inter-trade even supports the notion that Poland is increasingly integrated into Western production networks. Accordingly, traditional inter-trade determines relations of partners with significant differences in economic development. This relationship that is true for most of Poland's CIS partners as well as for less developed non-European economies. With respect to the large sample covering developed and less developed economies from other continents, we find the role of distance being largely levelled out for traditional Heckscher-Ohlin inter-trade. The markets of industrialized countries beyond Europe have not yet been penetrated with technologically sophisticated products from Poland, since standardized products still dominate.

The different patterns of Polish trade relations with Western European countries apparently arise from a specific industrial integration: Obviously, the Polish catching-up process is of technological nature, covering only parts of the Polish economy, namely enterprises integrated

[23] Cf. e.g. Zarek (2006: 116–123); Laaser and Schrader (2006: 272–273).

[24] An earlier analysis of Kaminski and Smarzynska (2001) already anticipated this role fdi plays for the integration of Poland into global production networks.

into international networks of production. As long as technological knowledge does not diffuse to Polish enterprises outside these networks, the catching-up process is limited to these industrial islands. This evidence of a fractional integration into the EU division of labour might explain why the overall Polish catching-up process is less visible than it could be expected in view of the dynamic development of Polish intra-trade.

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