Harmonization of Regulations and Trade: Empirical Evidences for the European Manufacturing Sector

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Chapter V: Data

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INTRODUCTION

Trade in manufactures among European Union countries (EU) and between EU and Central and Eastern European countries (CEEC) is now essentially free of tariff and non-tariff restrictions. One of the most important factor(s) affecting trade between EU members and between EU and CEEC countries is the removal (or at least the reduction) of technical barriers to trade (TBTs). Previous analysis of the completion of the Single Market in the existing EU countries suggests that the removal of TBTs may be of great significance. The Commission of the European Communities calculated that, in 1996, over 79% of intra-EU trade in manufacturing was been affected by harmonization of technical regulations.

The main objective of this thesis is to analyze to what extent harmonization of regulations, at the level of the EU, has affected bilateral trade in the manufacturing sector in Europe. We distinguish between two types of EU regulations: product-specific regulations and environmental regulations. The basic model is the gravity model of international trade with some empirical extensions.

The thesis is divided in five chapters. In the first chapter, we review the theoretical and empirical foundations of the gravity model. This is done in three parts. In the first part, we make a brief review on how the gravity equation has been derived within the context of trade theories: Heckscher-Ohlin, monopolistic competition and Ricardian technologies.

In the second part of this chapter, we survey some applications of the gravity model. Many applications have been carried out such as, analyzing trade preferential agreements, forecasting potential trade between partners, the estimation of interregional and international trade (border effects). A special attention is devoted to the application of the gravity model in measuring the trade impact of various types of non-tariff barriers.

Finally, we discuss some econometric issues related to the application of the gravity equation. Particular attention is given to panel data sets; the problem of censored data; and an application of the gravity model in spatial econometrics.

Whatever the theoretical framework in support of the gravity model, they all yield a similar functional form. Therefore, the best conclusion to be drawn is that of Deardorff (1995): "just about any plausible model of trade would yield something very like the gravity model, whose empirical success is therefore not evidence of nothing, but just a fact of life”.

Chapter two examines how harmonization of technical regulations across EU countries has affected the pattern of bilateral trade flows of individual EU countries taking into account the downward impact of national border on trade flows.

We first consider some economic and econometric refinements of the gravity model. In particular, the model allows for (i) a more flexible income response; (ii) a competitiveness effect that is composed in a general and a specific (i.e. bilateral) component; and (iii) a theoretical consistent measure of remoteness. In addition, we also provide some deeper insights in the econometric analysis of the gravity model applied to a panel dataset. In this chapter, the incidence of harmonization of regulations is constructed as a coverage ratio that directly enters the gravity equation. We separate out the effect of the harmonization of regulations on trade (of total manufacturing) in the case of bilateral imports and domestic trade.

The results suggest that: (i) the level of border effects is quite robust to our specification of the gravity equation when comparing to other EU related literature; (ii) the border effect has not declined between 1990-1998; (iii) harmonization of technical regulations cannot explain the presence of border effects; and (iv) the impact of harmonization of regulations is positive on EU imports.

The third chapter questions whether our results at an aggregated level of the total manufacturing sector are the same at a more detailed level. We use the final specification adopted from the previous chapter. We disaggregate trade of manufacturing sectors in five types of categories: four categories are matched to the different approaches used by the Commission to the removal of such barriers while one category is an aggregate of the sectors where technical barriers to trade are not present.

Two major results deserved to be emphasized. First, harmonization of regulations cannot explain differences in border effects between manufacturing sectors regulated by harmonization of regulations and manufacturing sectors where technical barriers to trade do not apply. Second, we observe significant differences in various coefficients of the gravity model applied to trade in the different sub-groups of manufacturing sectors. These are explained and a *special* attention is given to what extent institutional factors may explain differences in the level and evolution of border effects within the different groups of harmonization approaches.

Chapter four investigates the link between environmental regulations and exports with particular reference to the Single Market and enlargement. We estimate a system of simultaneous equations: (i) an export-gravity equation modeling the impact of domestic environmental regulations on exports and (ii) an equation modeling EU harmonization of regulations and exports on domestic environmental regulations.

The second equation is an attempt to answer two questions: (i) whether countries may wish to reduce the level of stringency of domestic environmental regulations as a response to higher exports - this argument is rooted in the literature of endogenous protection - and (ii) how national environmental policies and harmonized environmental regulations have collided.

The results find support for the prediction that the level of domestic environmental regulations has a large negative effect on exports. The impact of domestic environmental regulations on exports is twice as large when it is treated as an endogenous variable. A further issue that emanates from this empirical finding is that more harmonization (the higher the share of exporting manufacturing sectors that are subject to EU environmental regulation) has been accompanied by more stringent domestic environmental regulations in CEEC countries and lower levels of domestic environmental regulations in EU countries. In addition, we find that countries are unlikely to reduce the level of domestic environmental regulations as a response to more exports.

Chapter five describes the data sources and discusses data methodology that has been used in chapter two, three and four. In addition, we present some graphs and tables of the data. A particular attention is given to the data on EU harmonization of product and environmental regulations.

CHAPTER I

A SURVEY OF THE THEORETICAL AND EMPIRICAL FOUNDATIONS OF THE GRAVITY MODEL

1. Introduction

For about forty years, the gravity model of international trade has become the standard tool in explaining bilateral trade flows and still remains at the core of empirical research. Specifically applied to international trade, the gravity model predicts that the volume of trade between countries should increase with their size (as measured for instance, by GDP) and decrease with transaction costs (typically measured by bilateral distance).

In section 2, we make a brief and synthetic review about the way in which the gravity equation has been derived within the context of different trade theories. We also consider some analytical results and empirical work that have evaluated different theoretical views. Different theories have been developed in support of the gravity model. At present, there are three micro-foundation approaches that led to a derivation of the gravity model:

(i) Anderson (1979), Bergstrand (1985, 1989) and Deardorff (1995) share the view that a gravity equation can easily be derived from an Armington model of trade of homogenous goods which is driven by differences in factor endowments.

(ii) Helpman and Krugman (1985) claim that gravity equations can easily be reconciled from general equilibrium models with monopolistic competition allowing for trade of differentiated goods.

(iii) Eaton and Kortum (2002) start from a Ricardian model with a continuum of goods from which they derive a structure that resembles the gravity model.

In section 3, we survey some applications of the gravity. The wide range of applications of gravity equation in trade policy is a perfect illustration of its success in empirical trade analysis. In general, the main interest lies not in the traditional coefficients from the gravity (income, distance) but rather in the coefficients of various forms of trade barriers that can be easily appended to the equation. Many applications have been carried out such as, analyzing trade preferential agreements, forecasting potential trade between partners and the estimation of interregional trade flows (border effects). A special attention has been devoted to the trade impact of various types of non-tariff barriers (NTBs). These are explored in the remainder of the section.

In section 4, we generalize the discussion of the functional form of the gravity equation and present three major topics that remain at discussion in the econometric analysis of the gravity model namely: (i) the application of the gravity model to panel data sets; (ii) dealing with truncated data sets; and (iii) extensions to spatial econometrics.

2. Theoretical Foundations of the Gravity Model

In its earliest form, Tinbergen (1962) and Pöyhonen (1963) posited the following gravity model equation:

$$X_{ij} = A \frac{Y_i Y_j}{D_{ij}} \quad , \tag{1}$$

where X_{ij} are the exports from country i to country j, Y_i and Y_j are country i and j*'s* respective national incomes (GDPs), D_{ij} is a measure of the bilateral trade distance between the two countries and A is a constant. The first justification for the gravity model is rooted in physics. This approach appealed to physical laws of gravitation to arrive at the conclusion that the flow of goods from country i to country j equal the product of the potential trade volumes of the two countries divided by a resistance or distance factor.

Using this framework, Tinbergen (1962) and Pöyhonen (1963) did the first econometric studies of trade flows based on the gravity equation.[1] They concluded that incomes of trading partners and the distances between them are statistically significant and of the expected positive and negative signs, respectively. Regressions of equation (1) in logarithms of bilateral trade volumes on the GDP's of trading partners and the distance between them typically yield R^2's « in the range of 0.65 to 0.95 » (Harrigan, 2001). This has led many researchers to use variants of the gravity equation as a benchmark for the volumes of trade.

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[1] In this chapter, we limit our discussion to the application of the gravity model to international trade. Notwithstanding, the gravity model has also been applied to other domains that have a spatial character such as, explaining migration between countries, the demand of a transport mean between two points. In section 4.3., we extend this issue and focus on the spatial dimension that can be econometrically captured by the gravity model.

The gravity equation has been a model in search of a theory. Indeed, it was often criticized because it lacked theoretical foundations. These foundations were subsequently, developed by many authors.

Originally, Anderson (1979) derived a gravity model based on preferences that are homothetic and identical across all countries. Assuming that each country specializes completely in the production of its own good, the volume of trade of country *i* to country *j* (X_{ij}) can be presented by:

$$X_{ij} = \theta_i Y_j \quad , \tag{2}$$

where Y_j is country's *j* income (denoted in real GDP) and θ_i denotes the fraction of income spent on country *i*'s products (the share is equal across importers). Since production of every country *i* must equal exports, then:

$$Y_i = \sum_{j=1}^{n} X_{ij} = \theta_i \sum_{j=1}^{n} Y_j \quad , \tag{3}$$

or

$$\theta_i = \frac{Y_i}{\sum_{j=1}^{n} Y_j} = \frac{Y_i}{Y_w} \quad , \tag{4}$$

where Y_w is the real world GDP (= $\sum_{j=1}^{n} Y_j$). Substituting equation (4) into equation (2), yields:

$$X_{ij} = \frac{Y_i Y_j}{Y_w} . \tag{5}$$

This simple gravity equation is analogous with equation (1) for $A=1/Y_w$ and $D_{ij}=1$. The interpretation of equation (5) is that the functional form of the gravity equation is encompassed by the expenditure system of the trading partners: the adding-up constraint of an expenditure system combined with homothetic preferences, unitary income elasticities and prices are assumed to be constant in all countries.

Anderson (1979), then, in an appendix, presented a theoretical justification for the gravity model based on CES preferences and goods that are differentiated by country of origin (the Armington assumption). The author shows that when consumers have both identical homothetic preferences, a sufficient condition for obtaining a gravity equation is perfect product specialization in the sense that each commodity is produced in one country.

Bergstrand has explored the theoretical derivation of the gravity equation in a series of papers. Bergstrand (1985), like Anderson (1979), used CES preferences over Armington-differentiated goods to derive a reduced form equation for bilateral trade flows from a general equilibrium model. He specified CES preferences with a different elasticity of substitution between imported and domestic goods, on the one hand, and that among imports, on the other hand. He demonstrated that a gravity model can be derived from simple assumptions including perfect substitutability of goods across countries and expands the gravity equation with price indices from the existence of nationally differentiated products. Using GDP deflators to approximate these price indices, he estimated his system in order to test this assumption of goods differentiation. Coefficient estimates suggest that elasticities of substitution among imports are higher (exceeding unity) than between domestic and imported products (below unity) and concludes that imports were closer substitutes for each other than for domestic goods.

Bergstrand (1989, 1990) extends the theoretical foundation presented in Bergstrand (1985) to incorporate factor-endowment variables from the Heckscher-Ohlin model and accounts for taste preferences *à la* Linder who suggested that countries with similar per capita incomes will have similar demands. He defined demand from a nested Cobb-Douglas-CES-Stone-Geary utility function allowing for manufactured goods and non-manufactured goods with a minimum consumption requirement of the non-manufactured good (common to a Stone-Geary utility function). The supply is defined by assuming the Dixit-Stiglitz (1977) monopolistic competition (and therefore product differentiation among firms rather than among countries) applied to a two sector economy allowing for different factor proportions. From his analytical framework, it is suggested that a gravity model can be understood from theories of perfect competitive Heckscher-Ohlin models applied to inter-industry and monopolistic competition that assumes intra-industry trade. In the first paper, Bergstrand used this framework to obtain a version of the gravity equation. In the second paper, Bergstrand elaborated on the theoretical propositions that intra-trade industry is promoted by supply (Hecksher-Ohlin model) and demand considerations (Linder hypothesis of tastes).

2.1. Monopolistic Competition

Since Anderson (1979) and Bergstrand (1985, 1989, 1990), it has been increasingly recognized that the gravity equation prediction can be derived from very different structural models. Bergstrand's work has been extended in deriving a gravity equation from monopolistic competition models of trade. In the monopolistic competition model, developed by Helpman-Krugman (1985, section 8.2.), a number of varieties interacts with firms who face increasing returns to scale in production. With identical homothetic CES preferences on the demand side, strong symmetry assumptions on the supply side, and zero transport costs, the result of Helpman-Krugman model is a simple equation for bilateral trade:

$$X_{ijk} = s_j X_{ik} = s_i s_j X_{wk} \quad , \qquad (6)$$

where X_{ijk} is country *i*'s exports of good *k* to country *j*; s_j is the share of country *j* in world expenditure, X_{wk}; and X_{ik}, is country *i*'s output of good *k* equal to GDP_i. Summing over all goods *k* gives the gravity model of equation (1) for $A= 1/X_{wk}$ and D_{ij}=1. Equation (6) holds whenever consumers face the same prices and trade is balanced. This implies that the generalization of the gravity equation as shown in (6) assumes that country *i* consumes a fraction s_i of every good that is produced in the world economy in the same way that it exports a fraction 1-s_i of every good that it produces, with a fraction s_j of its output being exported to country *j*. In a monopolistic competitive, the Helpman-Krugman model predicts that intra-industry trade may exist within a group of 'industrialized countries" as long as complete specialization occurs in production. In addition, trade volumes should be related both to the size of the importing country (reflecting demand) and to the exporting country (reflecting the number of varieties produced).

2.2. Ricardian Technology

In a recent paper, Eaton and Kortum (2002) develop a multi-country perfectly competitive Ricardian model with a continuum of goods from which they derive a structure that resembles the gravity model. However, the set of assumptions that are posited by the Ricardian model yields different implications from those derived from the Armington assumption or the monopolistic competition model. Most notably, in the Eaton and Kortum (2002) model, it is assumed that more than one country may produce the same good while in the cases of Armington or monopolistic competition each country is unique. The novelty of their model is that specialization occurs from comparative advantage that is interactively linked to the level of technology and geographic trade barriers.

The foundation of their model is the assumption that country *i*'s efficiency in producing good *g*, $z_i(g)$, is the realization of a random variable drawn from a Fréchet distribution:[2]

$$F_i(z) = e^{-T_i z^{-\theta}} \quad , \tag{7}$$

where T_i reflects country *i*'s absolute level of technology and θ is a parameter that relates to the heterogeneity of goods in countries' relative efficiency, and hence, measures the comparative advantage. A larger value of θ implies lower productivity differences across countries. The parameters T_i and θ that are used in a distribution of extreme values such as, the Fréchet distribution may not be a plausible representation of the real world. Several questions at this point can be raised. First of all, it is questionable that differences in the level of technology and, hence, comparative advantage between developed and developing countries are so large to be presented in such framework. Secondly, the distribution is very sensitive to the value of the two parameters and, finally, it is questionable that such a sophisticated form to present technologies is needed.

The cost of supplying a good *g* from country *i* to country *j* is:

$$p_{ij}(g) = \left(\frac{c_i}{z_i(g)} \right) \tau_{ij} \quad , \tag{8}$$

where τ_{ij} is the iceberg transport factor between country *i* and *j* and the input cost of producing good *g* is $c_i / z_i(g)$, where country *i* has wages c_i. However, country *j* will only import from country *i* if $p_j(g)$ is the lowest across all sources *i*, $p_j(g) = \min\{p_{ij}(g); i = 1,...., N\}$, with *N* is the number of countries. It can then be shown (after a few steps) that the price index:

$$P_j = \sum_{i=1}^{n} T_i \left(c_i \tau_{ij} \right)^{-\theta} \quad , \tag{9}$$

[2] Strictly speaking, it is a simplified version of the so called Type II (or Fréchet) generalized extreme value distribution. Typical examples to which such distributions may apply, are tests of financial bubbles, predicting rainfall, etc.

which is a parameter derived from the probabilistic distribution of prices of country *j,* is conditioned on the technology and input and transportation costs of all countries.[3] This price index falls as *j* becomes more isolated from *i* (as reflected in a higher τ_{ij}). Expression (9) confirms to the general point that relative distance matters for international trade. This is an important point to which we return in section 2.4. To link the model to international trade, the authors express exports from country *i* to country *j* as:

$$X_{ij} = Y_j \frac{T_i (c_i \tau_{ij})^{-\theta}}{P_j}. \tag{10}$$

Expression (10) looks like a gravity equation in that bilateral trade is related to the importer's total expenditure, Y_j and to geographic barriers, τ_{ij}. In this model, if country *i* has a higher state of technology, lower input costs or lower geographic barriers, more goods will be exported to country *j*.

2.3. An Empirical Test of the Gravity Equation

The gravity equation derived from a monopolistic competition framework gave prediction on intra-industry trade that can be tested using sectoral data on production and trade. This is in contrast to the Heckscher-Ohlin model where the gravity equation is used to explain inter-industry trade of homogenous goods. In such models, trade is driven by differences in factor endowments while in the former, trade of differentiated goods is driven by similarities in factor endowments.

The first formal attempt to provide a link between the gravity equation and monopolistic competition came from Helpman (1987). In particular, he tested for the relationship between differences in relative factor endowments and the share of intra-industry trade in bilateral trade flows. He used the absolute value of differences in GDP per capita as a proxy for differences in factor endowments. For a sample of 14 OECD countries, Helpman found that the larger the shares of bilateral intra-industry trade the more similar were the countries' per capita income. He concluded that the empirical evidence support the theory.

Subsequent studies showed, however, that this relationship might not be robust. Hummels and Levinsohn (1995) borrowed Helpman's equation and fit the same regression to a new set of countries that are not all OECD member. They specifically choose

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[3] Expression (9) is obtained by substituting the expression (8) that solves for $p_{ij}(g)$ into the distribution defined by (7).

countries that they feel do not meet the assumption of monopolistic competition (this idea was also made by Deardorff, 1995). Using this new dataset, the regression fitted the data quite well when it should not have, given the assumption of monopolistic competition. In another exercise, they allow for more realistic trade in an OECD data-set in which some trade is intra-industry and some is inter-industry. According to their regression results, it seemed that intra-industry is more a function of country pair-specific effects than factor differences.

Hummels and Levinsohn cast a shadow over the monopolistic competition theory and the gravity equation since they find that the theory holds given their hypothesis that non-OECD countries do not meet its assumption of monopolistic competition. However, they did not shut the door on the gravity model. They recognized that assuming complete specialization (in either homogenous or differentiated goods) may be problematic to any theoretical explanation of the gravity model. This is because trade is usually an amalgam of both homogenous goods driven by differences in factor endowments and differentiated goods driven by similarities in factor endowments.

Evenett and Keller (2002) develop a model of intra/inter-industry trade where trade is not completely specialized. This is a special case Helpman did not consider, which Hummels and Levinsohn suggested may change their evaluation of the monopolistic competition. Since intra-industry trade is based on models of imperfect competition, this can be interpreted as supporting the view that the gravity model is linked to imperfect competition. In particular, they show that the gravity equation works rather better between countries for which intra-industry trade is more important. To reach such conclusions, their approach is to derive the gravity model from two different theoretical views (Heckscher-Ohlin and monopolistic competition) allowing for perfect and imperfect specialization and examine whether the gravity works better in sub-samples of country pairs that are thought to better fit the presumptions of different models.

Debate on the issue continues. At the theoretical level, Deardorff (1995) undermines the argument of monopolistic competition by showing that the gravity equation can easily be motivated in a Heckscher-Ohlin model without assuming product differentiation. He relaxes the assumption that factor prices are equalized between countries so that countries specialize in producing different goods. The idea is that in a world with transportation costs, the Heckscher-Ohlin model can not have factor price equalization between two trading countries.[4] This highlights the key that countries produce different goods (not necessarily different ones); whether they do so because of product differentiation by monopolistic competition or merely because of the Heckscher-Ohlin model with perfect specialization.

So, along these lines, the Heckscher-Ohlin model would be responsible for the gravity's success in explaining inter-industry, bilateral trade flows among countries with factor endowment differences and low shares of intra-industry. Whatever the theoretical framework in support of the gravity model, they all yield a similar functional form. Therefore, the best conclusion to be drawn is that of Deardorff (1995): "just about any plausible model of trade would yield something very like the gravity model, whose empirical success is therefore not evidence of nothing, but just a fact of life".

2.4. Further Theoretical Considerations of the Gravity Model

One of the key features in the models of Anderson (1979), Bergstrand (1985, 1989) and Deardorff (1995) is that consumers regard goods as being differentiated by the location of production, known as the "Armington assumption" (Armington, 1969). The standard specification for Armington preferences is a variant of the CES functional form:

$$U_j = \left(\sum_i \beta_i C_{ij}{}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)} \quad \text{s.t.} \quad \sum_i p_{ij} C_{ij} = Y_j \quad , \qquad (11)$$

where C_{ij} is the consumption by country j consumers of goods from country i and $\sigma>0$ is the common elasticity of substitution between any two consumption goods. β_i is the preference parameter that consumers in each country spend on their incomes on the product from country i.[5] An important feature of the gravity equation is that the preference parameter is identical and homothetic for all consumers everywhere so that identical fractions of income are spent by all countries. This makes the derivations of the gravity model easily possible. However, homotheticity is an extreme assumption which has received regular empirical rejection. As Samuelson and Swamy (1974) note:

4 If they did have factor price equalization, price of goods would be identical and neither country could overcome transportation costs.

5 In a model of monopolistic competition, the parameter β_i can be reinterpreted as the preference parameter valuing product variety.

> "Empirical evidence is abundant that the Santa Claus hypothesis of homotheticity in tastes and in technical change is quite unrealistic. Therefore we must not be bemused by the undoubted elegances and richness of the homothetic theory … We must accept the sad facts of life and be grateful for the more complicated procedures that economic theory devises."

Some authors have empirically validated the argument that tastes are non-homothetic. Thursby and Thursby (1987) estimate an equation that controls for the usual gravity variables (distance, adjacency, GDP's) and find that countries with similar incomes per capita trade more. In a recent paper, Mitra and Trindade (2003) use the gravity equation and find that the inequality of income distribution matters for trade. In particular, the authors augment the gravity equation with an income inequality measure. By specifically controlling for rich and poor countries, the results suggest, in line of those from Thursby and Thursby (1987); that as inequality increases in rich countries, their imports increase while imports from poor countries decrease.

Theoretically, Deardorff (1995) shows that by deviating from the homotheticity assumption and allowing in equilibrium, that each country spends a different share of its income on each good, the simple derivation to obtain the gravity equation does not work. The main result he obtains from such a deviation of preferences is that two countries will not trade in the same proportion as indicated by a simple gravity equation explained by their incomes along. In essence, if one country produces more what another over-consumes then they will trade more intensely.

Anderson's and Bergstrand's models, and most other explanations for the negative effect of distance on trade, assume that transport costs, τ, are of the "iceberg" form, where for every $\tau > 1$ units shipped to from the exporter, only 1 unit arrives at the importer's location, the other $\tau-1$ units having "melted" in transit. In empirical applications, it is assumed that all other barriers to trade (e.g. transaction costs, quality of infrastructure, tariffs, and non-tariff barriers) are captured by an increasing function of a distance-dependent variable which we denote as D_{ij}. This way, the price of any good of country *i* to country *j* can be decomposed into a product of two terms:

$$p_{ij} = p_i D_{ij} \quad , \tag{12}$$

where p_i is a f.o.b. price for country *i*'s exports and D_{ij} is empirically captured by a distance-dependent variable that proxies the transportation costs ($D_{ij} = \tau$). The iceberg assumption is crucial in deriving the gravity equation based on preferences given by equation (11). Some authors have investigated the relationship between transportation costs, the quality of infrastructure and distance. Hummels (1999) uses detailed data on freight rates and supports the argument that a relationship exists between geographical distance and transportation costs. A number of other authors (Roberts and Tybout, 1997; Bernard and Jensen, 2004) have shown that there are important fixed costs to trade which are independent of distance. Bougheas *et al.* (1999) predict a positive relationship between the level of infrastructure and trade.

To solve the model (see Deardorff, 1995), the demand function that arises from (11) is given by:

$$C_{ij} = \frac{Y_j \beta_i}{p_{ij}^{\sigma} \left(\overline{P}_J\right)^{1-\sigma}} \quad , \tag{13}$$

where

$$\overline{P}_J = \left(\sum_i \beta_i \; p_{ij}^{1-\sigma} \right)^{1/1-\sigma} , \tag{14}$$

is a CES index of all landed prices in country j. To get the standard gravity model, the model imposes market clearance. The nominal value of exports of country i to country j is $X_{ij}=p_{ij} C_{ij}$ so that the expenditure of all countries j on goods produced in country i are $\sum_j p_{ij} C_{ij}$. Let $\theta_i = Y_i / Y_w$ be the share of country's i income in world income, Y_w; then, $Y_i = \sum_j p_{ij} C_{ij}$ and substituting the value of C_{ij} from (13) into this expression, yields the following expression for β_i:

$$\beta_i = \frac{Yi}{Y_w} \frac{1}{\sum_j \theta_j \left(\frac{p_{ij}}{\overline{P}_J} \right)^{1-\sigma}} . \tag{15}$$

Substituting (15) into (13) and using (12), the volume of exports of country i to country j can then be written as:

$$X_{ij} = \frac{Y_i\, Y_j}{Y_w\, D_{ij}} \left[\frac{\left(\dfrac{D_{ij}}{\overline{P}_J} \right)^{1-\sigma}}{\sum\limits_h \theta_h \left(\dfrac{D_{ih}}{\overline{P}_h} \right)^{1-\sigma}} \right] \quad \text{with } i,j,h = 1, \dots n. \tag{16}$$

Without loss of generality, prices of all goods in the countries of production can be normalized to be one, that is $p_i=1$, for all i. The CES price index (14) is then given by:

$$\delta_j = \left(\sum_i \beta_i\, D_{ij}^{(1-\sigma)} \right)^{1/1-\sigma} . \tag{17}$$

We also include a measure (part) of remoteness, ρ_{ij}, written as:

$$\rho_{ij} = \frac{D_{ij}}{\delta_j} . \tag{18}$$

Expression (18) is defined as the bilateral distance weighted by the price index. Substituting expression (18) into (16) yields the gravity equation:

$$X_{ij} = \frac{Y_i\, Y_j}{Y_w D_{ij}} \left(\frac{\rho_{ij}^{\;1-\sigma}}{\sum\limits_h \theta_h\, \rho_{ih}^{\;1-\sigma}} \right) . \tag{19}$$

Expression (19) is the gravity equation for exports of country i to country j and includes the basic variables income (GDP) and the distance. The term in brackets is the relative distance effect or remoteness that has been introduced by Deardorff (1995). The gravity equation (19) reduces to the simple gravity equation (1), in the very unlikely case, when the term in brackets equals unity. In addition to a CES structure and iceberg transportation costs, the development of (19) makes the point that controlling for relative distance is crucial to estimating a well-specified gravity model. This has led to an important implication for the empirical application of the gravity model. We will return to this issue in the next section.

3. Empirical Applications

3.1. General Framework

The theoretical-grounded structure of the gravity models has led many researchers to investigate a number of empirical regularities. A general purpose of most of the gravity empirical applications is to identify factors that exert a trade-enhancing or trade-reducing effect on volumes. Most commonly, estimated gravity equations take a log-linear form of equation (19):

$$x_{ij} = \alpha + \beta_1 y_i + \beta_2 y_j + \beta_3 d_{ij} + \sum_k \beta_k Z^k + \varepsilon_{ij} \qquad \text{with } k = 4 \ldots K \quad , \qquad (20)$$

where x_{ij} is the log of exports from country i to country j, y_i and y_j are the log of the GDP of the exporter and the importer, respectively; d_{ij} is the log of the bilateral distance between country i and j; Z^k captures a set of observables, k, to which bilateral trade barriers can be related. In equation (20), the dependent variable is expressed in the log of exports between two countries. By notation, any variable x is the log of X.

In many studies, authors prefer to explain imports rather than exports as the dependent variable. Indeed, it may well be so that imports are statistically better measured. As we will see later, McCallum (1995) uses total trade and in this chapter we will consider that m_{ij} is identical to m_{ji}.

A common assumption is that distance is also included and is usually measured as the great circle distance between capital cities. The subsequent empirical literature enters additional observables associated with - geographic variables - common languages, common border, so-called remoteness variables which are intended to capture the average distance of all countries, etc. and - policy variables - different regulations and product standards, currency zones, regional integration agreements, etc. Some studies also include population in the equation on the ground that as population increases faster than income (a decrease in GDP per capita), a country will import less.

In this section, we explore three applications of the gravity model that are at the forefront of recent empirical research in international trade policy linked to trade-enhancing or trade-reducing effects: (i) the estimation of border effects; (ii) the analysis of trade preferential agreements including forecasting potential trade between partners; and (iii) the measurement of non-tariff barriers.

3.2. Border Effects and Distance

3.2.1. Border Effects

One avenue of this empirical research is to reveal a significant puzzle regarding the level of trade. Beginning with McCallum (1995), the gravity model has been used to compare intra-national trade between Canadian provinces to international trade between Canadian provinces and US states. Specifically, the regression estimated by McCallum is:

$$(x_{ij} + x_{ji}) = \alpha + \beta_1 y_i + \beta_2 y_j + \beta_3 d_{ij} + \beta_4 Border + \varepsilon_{ij} \quad , \qquad (21)$$

where *Border* is a dummy that takes the value of unity for trade within a country; d_{ij} is the distance between any two provinces or states; and y_i and y_j are the province or state's GDP's. The author finds that Canadian provinces are about twenty times more likely to trade amongst themselves than they are to trade with US States after controlling for size and distance between economic centers. The data set applied by McCallum appeared to be unique in identifying trade amongst the regional subsets of trading partners. He uses a Statistics Canada dataset for 1988 that consists of imports and exports for each pair of provinces as well as between each of the ten provinces and each of the 50 US states.

Notice that the data availability makes it difficult to replicate McCallum's research for other countries. Wei (1996) constructed a 'border effect' measure based on a quasi-accounting identity where domestic trade is measured by the difference between domestic production and exports. The effect of crossing a border is captured by including a dummy variable.

Wei (1996) estimated the border effect for OECD countries and finds on average, that countries trade 9.6 times more (measured as the antilog of this coefficient) with themselves than with foreign countries. This method of constructing an estimate of trade within a country that has been initiated by Wei (1996) has subsequently been used in many empirical studies. Helliwell (1997) revisits the OECD data and finds a border effect of 13. Nitsch (2000) is the first paper that constructs a sample for EU countries by using a detailed dataset compiled by Eurostat. He finds evidence of a substantial border effect in Europe, with internal trade being on average larger by a factor of ten than trade with other EU partners. In addition, he also finds that the level of the border effect declined during the 1980's.

3.2.2. Distance

Such an application of the gravity model requires a measure of the trading distance both between countries and within a country. Originated by Wei (1996) and Helliwell (1997, 1998), these authors use for internal distances, one quarter of the distance to the nearest neighbor. As noted by Nitsch (2000), this method relies too much on the geography of neighboring countries, and too little on the geography of the home country. Later studies have tended to move towards measures based on internal distance estimates that combine the theoretical structure of the gravity model with information about the distribution of population and economic activity within the country (Helliwell and Verdier, 2001; Chen, 2004; Nitsch, 2000).

3.2.3. Remoteness

Following the work of Deardorff (1995), more recent papers on border effects also improve the basic bilateral gravity model by including distance measures of each country's alternative trading partners in addition to bilateral distances (Wei, 1996; Wolf, 1997; Helliwell 1997, 1998; Nitsch, 2000). This is closely related to equation (18) that states that the relative distance of trading partners also have an impact on the volume of trade.

Remoteness of a country is defined as the weighted average distance with all its trading partners. A common practice is that the weights are given by the GDP of the trading partners, although in Deardorff (1995) distances were weighted by a price index and according to the same author, remoteness is expressed in relative terms. Originally, Wei (1996) introduces an empirical approximation of the concept of remoteness defined as:

$$r_i = \ln\left(\sum_{k \neq j} D_{ik} / GDP_k\right) \quad . \tag{22}$$

In this framework, there are two remoteness variables: one for the importer and one for the exporter and their values vary from year to year due to changing GDP's. This variable as we discuss in chapter 2 does raise a series of questions. In particular, it may yield to strange interpretations of idiosyncratic shocks in the GDPs of the trading partners and usually the coefficients of both variables have contradicting signs.

The study of Anderson and van Wincoop (2003) has made a significant contribution in modeling alternative trading opportunities using the gravity model. One of the features of their model is the inclusion of the border effect itself in the design of the variable measuring alternative trading partners. The authors note that a gravity model implies that trade barriers reduce size-adjusted (bilateral) trade between large countries more than between small countries, and (correspondingly) raise size-adjusted internal trade within small countries more than within large countries. Helliwell (2001, pp. 25) notes that this is not important for studies that use internal trade of one of the countries, coupled with bilateral trade between the countries (such as the one that we cite in this section), "as long as it is recognized that the border effect being calculated compares the intensity in internal and external trade for that country alone".

3.3. Regional Integration

Another extension of the gravity model is its design to evaluate the impact of regional trade agreements (RTAs). These RTAs are generally used as a generic descriptor of a range of different forms of integration agreements, including, free trade agreements (e.g., NAFTA), custom unions (e.g., MERCOSUR) or a common market (e.g., EU).

Most gravity analyses of RTA typically add dummy variables in order to assess the trade potential associated with integration. The equation below can be considered as a 'standard' gravity equation with dummies so to capture integration effects:

$$(x_{ij} + x_{ji}) = \alpha + \beta_1 y_i + \beta_2 y_j + \beta_3 d_{ij} + \beta_4 RTA + \varepsilon_{ij} \quad , \qquad (23)$$

where y_i, y_j, d_{ij} are the core variables as defined in equation (20) and *RTA* is a dummy variable taking the value 1 for when two countries in a given pair belong to the same regional grouping. In this particular framework, it is assumed that the economic variables: incomes and distance, define the 'normal' level of trade. On the assumption that the gravity model is well specified the RTA dummy then, seeks to capture systematic deviations from this normal pattern of trade due to RTA membership.

A fairly common finding in this literature (see Greenaway and Milner, 2002) is that the effects of RTAs are positively associated with trade. In this framework, the simple interpretation of positive coefficient, β_4, is that intra-regional trade is stimulated by an RTA which is not a real surprising result since such agreements are primarily aimed at reducing tariff and/or non-tariff barriers. Obviously, when RTAs have a small degree of real integration, the coefficient β_4 may become insignificant and even take negative sign. For example, Hassan (2001) finds negative effects for both ASEAN and SAARC in Asia; Sharma and Chua (2000) reported no RTA effects for ASEAN and nor did Soalaga and Winters (2001) for Mercosur.

Recent work has gone beyond the simple study of examining whether RTAs have a positive trade effect. Frankel and Wei (1995) examine the extent to which increasing intra-regional trade can be attributed to the RTAs itself or to 'natural factors'. In other words, it is observed that even without the formation of RTAs, countries trade more with their neighbors than with countries from which they are far remote. So their idea is to estimate the RTA effect after controlling for all 'natural' factors related to geographical clusters.

The gravity equation that they estimate has the basic form of equation (23) with the following RTA dummies: EAEC (East Asia), APEC, EFTA, ANDEAN, MERCOSUR and NAFTA. They augment the equation with a number of geographical dummies: (i) dummy for 'adjacency' to indicate whether two countries share a common land border; (ii) a dummy for 'language' when both countries speak a common language; (iii) a dummy when two countries had colonial links. In addition, they also add GDP per capita to capture specialization from the Helpman-Krugman model predicting that as countries become more developed, they tend to specialize more and trade more. In order to investigate the extent to which RTAs are influencing trade patterns in contrast to some natural determinants, they pursue the idea that by controlling for these dummy variables (i-iii) and GDP per capita, the level of intra-regional trade would be due solely to these variables unless the RTA dummies would be significant. They found significant RTAs in the Latin American and European region while this was not the case for the North American and Asian regions.

Another interesting extension of the RTA gravity literature is to investigate the trade potential associated with regional integration. The calculation of trade potentials has been mainly applied to trade between EU and CEEC countries. The most cited studies are Wang and Winters (1991), Hamilton and Winters (1994), Baldwin (1994) Gros and Gonciarz (1996) and Nilsson (2000). In these cited studies, the basic idea is first to estimate a gravity model applied to a set of countries that are already integrated in the world system, such as OECD or EU countries. The potential volume of trade, for example, between CEEC and EU countries is then interpreted as the volume of trade that would prevail if trade were explained by the same factors determining trade between OECD or EU countries in the model. For example, low ratios of potential to actual

CEEC trade with the EU would indicate a high level of integration between EU and CEEC countries.

The findings by Winters (1991) and Hamilton and Winters (1994) suggest that differences between potential and actual trade for CEEC countries are small. On the contrary, Baldwin (1994) predicts that the ratio of potential to actual trade CEEC exports to the EU12 varies between 1.2 (Romania) and 5.2 (Bulgaria). Baldwin's projections have been further analyzed in Gros and Gonciarz (1996) and Nilsson (2000). Gros and Gonciarz (1996) find that the GDPs of the CEEC countries in Baldwin (1994) are overvalued and adjust their own projections for the overvaluation of the GDP figures and update the estimated trade potentials of Baldwin (1994) for 1989 with actual data for 1992. Nilsson (2000) updates the previous projections of Baldwin (1994) and Gros and Gonciarz (1996). Both papers conclude that there is any unused export potential from CEEC to EU countries.

3.4 Currency Unions

In line with the regional integration literature, Andrew Rose and a number of co-authors (e.g. Rose, 2000; Frankel and Rose, 2002; Rose and van Wincoop, 2001; Glick and Rose, 2002) have attempted to show the impact of currency arrangements on bilateral trade flows using the gravity model. The simple technique is to use a dummy for "common currency" in order to capture the impact of currency agreements. The basic argument is to consider that currency unions increase trade. This argument is not explicitly grounded in theory but rather it has an empirical focus. An important issue is related to a number of econometric problems (method of estimation, inferences, etc.) that may arise. These are quite general and may be applied to the generic estimation of the gravity model, which we present in the next section. One should be cautious on the interpretation of the results including statistical inferences on potential trade if two trading countries are part of a currency union. One particular problem that is specific in estimating the impact of currency unions or even a monetary agreement on trade is its endogeneity. We return to this in the paragraph below.

Rose (2000) estimated the effect of currency union membership on international trade. Rose exploited a large dataset covering 186 countries from 1970 through 1990 and found that bilateral trade was higher for a pair of countries that used the same currency than for a pair of countries with their own currency. More precisely, the coefficient on a currency union dummy was found to be positive and significant. Using different specifications of the gravity model, its value did not fall below 1.2, implying an effect of currency union on trade around 300% ($e^{1.2}$)[6]. Rose and Glick (2002) extended the dataset of Rose (2000) to over 200 countries from 1948 to 1997 and found that a pair of countries that joined a currency union experienced a near doubling of bilateral trade.

In Rose and van Wincoop (2001) and Frankel and Rose (2002), the authors are not simply trying to determine that currency unions may improve trade but also establish the argument that currency unions are welfare improving. The basis of this argument is simple and follows from an endogeneity issue; namely, that currency unions increase trade, and trade increases output and thus welfare. In line with the empirical gravity literature, the endogeneity problem between trade and output (GDP) is highlighted. A standard technique has become to use instrumental variables since GDP and exports are most likely jointly determined in equilibrium (McCallum, 1995; Harrigan, 2001; Helliwell, 1997) and in order to deal adequately with this problem, the empirical gravity literature uses population as an instrument. However, it is generally noted that the lack of instruments does not permit to deal adequately with this problem.

In this paper, however, the authors go one step further and an interesting approach of this work is that they also investigate whether or not currency unions may affect income through other channels than trade. In assessing the impact of currency unions on trade and output, Frankel and Rose (2002) use the exogenous regressors of the gravity model (distance, population, adjacency, language) to form a predicted variable of trade, which is then used as an instrument for a regression where the dependent variable is income. In essence, the income regressor has shifted to the LHS of the equation and an instrumented version of trade has shifted to the RHS which is then augmented with a dummy for common currency. The main conclusion is that (i) currency unions increase trade; and (ii) trade raises income but currency unions do not.

[6] This result should be interpreted with some degree of caution. It is implausible to believe that a country, for example, like Denmark would triple trade by joining a single currency. The country has already established a minimum condition for joining the EU. In addition, in a hypothetical world it is plausible that between any countries monetary unions can be formed. However, in reality it is unthinkable for some countries to sign a common currency agreement.

3.5. *Non-Tariff Barriers*

The gravity model has also been applied for identifying the impact of regulatory policy barriers. In this subsection, we will review and evaluate the methodology and results of selected studies that have related trade flows to measures of non-tariff barriers (NTBs) using gravity-type equation of international trade. Based upon several types of NTBs (regulations, standards, technical barriers to trade), we may distinguish the mainstream literature into three categories:

(i) The studies of Harrigan (1993) and Head and Mayer (2000) use crude indicators of NTBs in investigating its trade impeding effect. The effect of regulations (technical barriers to trade) is implicitly incorporated in the data.

(ii) Swann and Temple (1996) and Moenius (1999) discuss the hypothesis that country-specific standards act like barriers-to-trade while the bilateral harmonization of standards promote trade. These papers focus on the trade impact of voluntary standards rather than on TBTs (more generally due to data limitations); in particular, they investigate *institutional* standards that are produced by the coordinated efforts of standard setting bodies.

(iii) Otskuki *et al.* (2000) suggest that technical regulations in developed countries constitute a considerable obstacle to exports of developing countries and collect data that precisely investigate the impact of European harmonization of aflatoxin standards on food sectors.

3.5.1. Summary of Studies

Harrigan (1993) derives a gravity equation based on a monopolistic competition model and regress, for 1983, cross-country trade flows on trade barriers and production. The data on bilateral trade flows between 13 OECD countries is applied to twenty-eight 3-digit industries. The data on trade barriers come from a comprehensive inventory of NTBs from the United Nations Commission on Trade and Development (UNCTAD). These data consist of indicator variables of about 20 different types of NTBs. To construct the NTBs variables, coverage ratios for each type of NTB were measured by the percentage of imports covered by one or more NTB. These various categories of NTBs were then aggregated into three broad categories of price, quantity, and threat measures (e.g., price monitoring).

Harrigan (1993) estimates the share of bilateral imports weighted by the GNP of the importing country on the three broad categories of NTBs, the partner's country production in industry, average tariffs and a freight factor. The author found that only five industries have estimated price NTB effects that are negative while three effects are positive and the rest of the estimated effect were not significant. Quantity NTB effects were reliably negative while most of the estimated threat NTB effects are not statistically significant. The author concluded that a great heterogeneity across industries exists and concluded that tariffs and transport costs were a more substantial barrier to trade in manufactures between developed countries than were non-tariff barriers.

When deriving a gravity model from a monopolistic competition framework, a series of (likely unrealistic) assumptions are being made. The author tests two restrictions: (i) homotheticity implying that the elasticity of imports with respect to production should be unity; and (ii) tariffs and transport costs should be the same in both directions between countries. These restrictions were rejected at most of the cases. However, the reported results suggest that caution should be made in the interpretation. The author's work has thus reflected another possible drawback from using the gravity model since differences between theoretical abstraction and empirics suggest that a regression model may suffer from unrealistic hypotheses and may only reflect such discrepancy and not the real impact of NTBs.

Head and Mayer (2000) apply a gravity approach to 3-digit NACE data for EU countries and assess whether there is any correlation between the estimated border effect and two indirect measures of EU non-tariff barriers (NTBs). The first measure is based on a 1980s survey of EU firms conducted by the European Commission. From this survey, the authors construct three variables representing the stringency of NTBs in terms of standard differences, public procurement and customs formalities. The second set of indicators comes from Buigues *et al.* (1990) which classified European industries into three levels of barriers: low, moderate, and high.

To evaluate the extent that NTBs can account for border effects, the authors firstly estimated the border effect at industry level, using a derived gravity equation from a monopolistic competition model. The industry-level border effects were then regressed on the two measures of NTBs. The authors found that NTBs explain at most 10 percent of the variation in border effects and that the effects are often insignificant. The study concludes that the indicator of non-tariff barriers before and during the Single Market

Program cannot explain the variation in the size of estimated border effects and consequently suggest that consumer preferences may be an explanation for border effects.

Swann and Temple (1996) present an econometric analysis of the effect of standards on UK trade performance, using trade for eighty-three 3-digit SIC manufacturing codes over the period 1985-1991. Counts of the number of German and UK standards by industry were taken from the Perinorm database.

A distinction was made between internationally equivalent standards where the national standard was found to be identical to an international standard and national standards where it was not. The count measures of standards assume that all standards have equal weights across industries and that different standards would impose identical economic effects.

Swann and Temple (1996) estimated three panel models: a British net export, export and import equation on stocks of British and German national and international standards. In these trade equations, the other explanatory variables are relative export and import prices applied to manufacturing sectors and total manufacturing, the volume of exports, the volume of imports and fixed industry effects.

The authors found that British national standards raise imports and exports with an elasticity of 0.34 and 0.48, respectively. The coefficients of UK international standards in both equations are positive, though not significantly different from zero. The impact of German standards on British imports were positive but had a negative effect on British exports. The authors then concluded that UK standards appear to increase UK exports and imports. The authors suggested that the imposition of British national standards convey the message of quality abroad which may explain the increase in exports while the positive effect of imports may be attributed to higher costs for domestic producers. In addition, they suggested that the negative impact of German standards on British exports could be explained by a protective impact. Note that these two findings are inconsistent and the authors did not elaborate on this. They further concluded that UK national standards appear to have a stronger effect than international standards. The results are not based on any theoretical model and are derived from empirical evidence. This raises some questions. It is plausible to suggest in a panel framework that the effect of national standards change over time? In the context of EU harmonization of standards, do national standards between EU countries differ between countries?

Moenius (1999) advanced this approach by incorporating standards count data from Perinorm for 12 countries and 471 4-digit industries from the Standard International Trade Classification (SITC) into a gravity-based analysis of bilateral trade volumes over the period 1980-1995. The author also distinguishes between country-specific standards, measured by the number of documents specifying a technical requirement within a country, and bilateral shared standards, measured by the number of documents linked between two countries covering the same code. The number of links is then counted as the number of standards.

Moenius (1999) regress bilateral trade volumes on counts of shared standards and a set of dummy variables that control for country-pair effects (intended to capture for instance, income and distance) and yearly-time effects. He finds that one percent increase in the number of shared standards increases bilateral trade volumes by one-third of a percent. Using the same gravity specification, but adding a lagged dependent variable to control for first-order autoregressive errors, yields similar results. The author, then, concludes that shared standards can play a significant role in promoting trade.

The impact of country-specific standards is even more intriguing. In a second exercise, the author regress import volumes on the same variables but included the number of the importing and exporting country-specific standards as additional explanatory variables. The result is that country-specific standards in importing countries promote trade, as do country-specific standards of the exporting country. By repeating the same exercise for one-digit industries, the author finds that importing country-specific standards promote trade in manufacturing but hinder trade in non-manufacturing, such as agriculture.

In the food and agricultural sector, Otskuki *et al.* (2000) suggest that technical regulations in developed countries constitute a considerable obstacle to exports of developing countries. The authors used the gravity equation method to determine the effect of European harmonization of aflatoxin standards on African exports[7]. They estimate the exports, between 1989-1998, of cereals and fruits from 9 African countries to the EU15: using both countries' GDP's, their bilateral distance, a dummy for colonial ties,

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[7] Aflatoxins are a group of structurally related toxic compounds which contaminate certain foods and result in the production of acute liver carcinogens in the human body. The harmonization of this particular standard was to implement a uniform standard for total aflatoxins setting the acceptable level of the contaminant in certain foodstuff.

fixed time-effects and exporting country-effects. Standards enter directly the equation and are measured as the maximum aflatoxin level imposed on imports of food products by the EU countries. This data is obtained from a FAO survey of mycotoxin standards and from an EU Directive.

The results show that new (and more stringent) EU standards are likely to be a major barrier to African exports of dried fruits and nuts: it implies that a 10 percent tightening of aflatoxin standards will reduce African exports by 14.3 percent for cereals and 3% for dried fruits.

The authors went one step further and also provide results on how trade flows between Africa and Europe would have been under conditions in which an existing less stringent standard (indicated by guidelines set by CODEX) would have been imposed. The results still reveal that the Commission's standard will impose far greater trade impediments when comparing trade under international standards for cereals and dried fruits. This extended exercise reveals an interesting result since they not only report the trade implications under an observable standard but also with comparables in order to obtain a real measure of the quantity reduction of the EU harmonization of aflatoxin standards on exports. Perhaps a problem in the estimation of African trade to the EU is the failure to allow for institutional or local factors that typically channel African exports. It is known that African exporters are comprised of large international companies. Such companies may find it easier to adjust their exporters conforming EU standards compared to small scale African companies. By not taking into account factors that are related to the source of exporters, the reported results on technical barriers to trade may be overstated.

4. The Econometrics of the Gravity Model

Research has also made progress in the econometric issues in estimating the gravity model. However, it must be noted that this literature is still in an early stage. Perhaps, because the empirical success of the gravity model is usually expressed on the basis of the goodness of fit, this has led to a lack of attention on the econometric analysis of the model. In this section, we present three major topics that remain at discussion in the econometric analysis of the gravity model: (i) the application of the gravity model applied to panel data sets; (ii) dealing with truncated data sets; and (iii) extensions to spatial econometrics. We provide a brief overview of each topic.

4.1 Log-linear and Zero Gravity

A common consensus among researchers is that the log-linear form of the gravity equation is the correct specification. This has an important implication since the microeconomic foundation of the gravity model is directed towards the application of a log-linear functional form. Sanso *et al.* (1993) have questioned the log-linearity of the gravity equation. Using data for 16 OECD countries from 1964 to 1987, they modify the gravity equation in a generalized functional form defined by a Box-Cox transformation which is then estimated for each year separately. The authors' question whether or not a permanent structure would exist for the entire sample. They find evidence that a unique functional form exists since the Box-Cox transformation shows a stable evolution through time. The authors conclude that the log-linear specification, although not optimal, represents the best functional form among those tested.

Log-linear gravity equations are used in almost all empirical applications; however, a problem of log-linearity is that it is incompatible in cases where trade between countries is zero. Since the gravity model usually uses a large sample of countries and years, it is very likely that for some observations trade assumes the value of zero, in which case the logarithmic transformation is not possible. There are several reasons for observing pairs of countries with zero trade. Two countries may not trade because they are small, distant, or both; or other factors such as large costs (e.g., information on foreign markets, tariff and non-tariff barriers, transportation costs, etc.) may hinder trade. Other reasons for zero trade may be due to the data collection itself (see Feenstra *et al.*, 1997 for a careful discussion on international trade data issues and treatments). For example, zeros may be the result of rounding errors. If trade is measured in thousands of dollars, it is possible that for pairs of countries for which bilateral trade did not reach a minimum value, the value of trade is registered as zero. The zeros could also have been wrongly recorded as missing values or the trade data can suffer from many other forms of errors depending on the quality of the data itself (Feenstra *et al.*, 1997).

The literature has adopted a number of procedures to deal with this problem (see Frankel, 1997, for a description of the various procedures). The first has been to omit zero value bilateral flows (e.g., Wang and Winters, 1991; Frankel and Wei, 1993). This approach of truncating the sample is clearly not the most appropriate since it disregards important information about why low levels of trade occur and may lead to inconsistent estimates. As argued by Coe and Hoffmaister (1998: pp.10), "omitting these observations represent a non-random screening of the data that may lead to biased or inconsistent estimates". According to Greene (1981), the size of the bias is inversely proportional to the share of the sample included in the regression. Thus, the smaller the share of observations included in the sample the greater the bias. The second option has been to substitute the value of zero for small values, such as 0.001, before taking the logs, instead of simply discarding these observations (e.g., Linnemann, 1966). This ad hoc procedure allows estimation of the model through OLS since the values of the log of the dependent variable are definite. The problem is that the log of a very small number is a very large negative number, and as the OLS technique gives larger weights to extreme values, these observations would receive a weight that is too large in the estimates (Frankel, 1997). A third approach directly addresses the censored data for the endogenous variable by employing the Tobit model (e.g., Soloaga and Winters, 2001). This procedure implicitly incorporates information in the zero observations, with the positive observations being used to estimate the value of trade, given the trade is positive, while the observations at zero are used to estimate the probability that trade is positive.

Although the use of Tobit seems to be the most popular method for researchers dealing with the presence of censored data, recent work of Santos-Silva and Tenreyro (2003) have proposed an alternative solution to estimating (Tobit, OLS) the log-linear form of the gravity model in the presence of censored data. In addition, this method also deals with the strong presumption that errors are heteroscedastic and biased. Hence, a non-linear method is called for, and these authors propose a simple pseudo-maximum likelihood approach that performs well in Monte Carlo experiments. To see how this works in a more general interpretation, consider the following stochastic model, $y_i=\exp(x_i\beta)\eta_i$, the procedure recommended, by Santos-Silva and Tenreyro estimates the β by solving the set of equations $\Sigma_i(y_i - \exp(x_i\beta)\eta_i = 0$. The key issue is that they assume that the errors follow a generalized Poisson distribution - with the variance equal to the conditional expectation of the dependent variable - where $Var(y_i|x)=E(y_i|x)=\exp(x_i\beta)$. In contrast, the authors show that a more standard non-linear estimation in the presence of zero trade may be inefficient since it gives more weight to observations with a high conditional expectation for the dependent variable. Since high values for the dependent variable are typically associated with high variance, this is equivalent to giving more weight to more noisy variables.

4.2. Panel Estimation

Deeper insights in the proper econometric analysis have advocated for panel econometric methods. This is because, instead of testing a cross-section model for all importing and exporting countries at one point in time, a pooled model is tested for all importing and exporting countries through time. The pooled analysis then concerns the possibility to capture the variation between three dimensions simultaneously: a two dimensional effect between importing and exporting countries and a time dimension.

In a series of papers, Mátyás (1997, 1998), Egger (2000, 2001), and Cheng and Wall (1999) have used the advantages of panel techniques to test the trade determinants using the gravity equation. Mátyás (1997) validated the evidence that the correct gravity specification is a three-way model using importing, exporting and time effects, which can then be estimated by a fixed or random effect model. A general form of such an equation is written as:

$$x_{ijt} = \eta_i + v_j + \lambda_t + \beta_1 y_{it} + \beta_2 y_{jt} + \sum_k \beta_k d_{ijt}^k + \varepsilon_{ijt} \quad , \tag{24}$$

where η_i is the exporting country effect, v_j is the importing country effect and λ_t are the time-specific effects attributed to the panel data modeling. If only cross-section data are used, $\lambda_t=0$ and when only time series data are used, $\eta_i = v_j = 0$. The author then goes on to show how the specific effects turn out to be significant in the empirical analysis.

However, it is not clear whether one should apply a random or a fixed effects model. Mátyás (1997) assumed the effects were observable from the data and therefore adopted a fixed effect approach. In Mátyás (1998), it is noted that when the number of countries in a dataset is large, a random effect approach should be performed. However choosing between random or fixed effects seems to be more open to a subjective nature, Mátyás (1998) notes "… if one is specifically interested in the "openness" of economies, a fixed effect should be used …for strictly more policy reasons, the random effect may be preferred …". Egger (2000) shows, using a similar panel specification, that the random effect is strongly rejected in favor of a fixed effect by a Hausman specification test. More recently, Egger (2001) demonstrates that due to a possible correlation of individual effects with the explanatory variables, a Hausman-Taylor (1981) model is the correct answer to the specification question. Here the specific effects are treated as random and represented by an interaction term ω_{ij} rather than $\eta_i + v_j$. This approach has two advantages: (i) using a random effect allows for time-invariant variables not subsumed in the specific effects and (ii) the Hausman-Taylor (1981) approach overcomes the correlation between the ω_{ij} and any of the explanatory variables.

Cheng and Wall (2002) continue the debate on the empirical estimation of the gravity model and find evidence that the gravity model tends to overestimate trade between low-trade countries, and underestimate it between high-trade countries. They argue that the gravity specification should account for the pair-wise heterogeneity of bilateral trade relationships. In particular, they augment the gravity model for a country pair with a unique intercept, α_{ij}, which is different for each direction of trade $(\alpha_{ij}=\alpha_{ji})$. The other variables include a time dummy, the GDP's and population of the importing and exporting country. They estimate this model using fixed effects and assume that all time-independent variables (distance, language and adjacency) and other omitted variables are absorbed in the country-pair intercepts. Their model is statistically supported: (i) the likelihood ratio with and without the trading-pair heterogeneity reject the null that the two models are the same; and (ii) there is no obvious correlation between residuals and the log of exports.

However, one might argue that important determinants of trade (distance, adjacency, language) subsumed into country-pair effects are hidden from the analysis. They counter this argument by regressing the country-pair effect on distance, adjacency and language. The results reveal that only the distance effect is a statistically significant determinant of the country-pair effects. However, given a low fit (0.04) they conclude that very little of the country-pair effects are explained by these variables.

4.3. Extensions of Spatial Econometrics to the Gravity Model

The general condition that determines gravity model (1) is that the volume between two areas is directly proportional to the relative attractiveness of each area and inversely proportional to some function of the geographic separation of these areas. The gravity model of international trade typically assumes that these areas are defined as countries, regions, etc. while the geographic distance is assumed to be a convenient empirical approximation for transportation costs. In addition, the measurement of remoteness also suggests that alternative distance matters. However, in the gravity literature applied to international trade, little attention has been devoted to a spatial dimension that defines the attractiveness of a country.

Most relevant to the idea that a spatial dimension is accompanied with the attractiveness of a country is the above mentioned paper of Bougheas *et al.* (1999). The authors introduce infrastructure in the bilateral trade model and show that location and endowment play a significant role in determining bilateral trade. In such a model, trade depends on the development or investment of transport cost reducing infrastructure. In such a framework, the location of the investing country is crucial in determining trade opportunities with other countries.[8]

Porojan (2001) applies already developed tools in spatial econometrics to a gravity model of international trade. The basic idea put forward is to infer from the residuals, spatial features that would characterize trade flows. In essence, the error term from the general gravity equation (20) is transformed into a general form that accounts for residual autocorrelation, written as:

$$\varepsilon = \lambda W \varepsilon + \nu \quad , \qquad (25)$$

where the null hypothesis is that $\lambda = 0$. If this hypothesis is rejected this implies that the volume of trade flows in/from a region affects the size of trade flow in/from the neighboring regions (countries) only if trade is above that considered "normal" by the model (Porojan, 2001). The W is defined as a weighting matrix that is intended to capture the "degree of potential interaction" between neighboring locations. In Porojan (2001) this matrix is defined as a dummy for two countries sharing a same land border or a small water border. In essence, this matrix can be defined in many ways. This basic formulation of the error term captures two types of information: similarity among attributes and similarity of location (Porojan, 2001).

5. Conclusion

The general conclusion of this survey is that there has been continuing progress both in the underlying theory and the estimation of the gravity model. We have seen that the gravity model can be understood from various foundations. This makes it difficult to select one theoretical model that really helps us to understand the gravity equation. As a result, conditions needed to integrate the gravity equations are mixed, estimating

[8] The fact that localization matters has become an important issue in the economic geography literature. The idea is that firms choose its location so to minimize transportation costs and essentially in such models, the location of markets influences profits of firms which determine the size and the attractiveness of an area.

functional forms are sometimes a-theoretical or econometric suggestions are mixed. However, it is a fact that the gravity model works and fits the data well. Perhaps, it is more to a challenge to find a theory that yields exactly to a gravity form than the other way around.

Empirical research linked to the gravity model has renewed trade analysis by explaining the importance of various trade determinants in addition to the core variables of income and distance. Indeed, the composition of trade whether intra or inter-industry as well the direction of trade whether between developing, developed or a combination of both, all seem to play a significant role for foundation of the gravity model.

CHAPTER II

AN EXTENDED VERSION OF THE GRAVITY MODEL APPLIED TO INTRA-EUROPEAN TRADE OF MANUFACTURING GOODS

1. Introduction

A number of recent econometric studies based on a gravity equation have found evidence that the downward impact of excessive intra-national trade (border effect) has become an important feature characterizing the international exchange between countries. McCallum (1995) and Helliwell (1996, 1997, 1998) find that Canadian provinces are about twenty times more likely to trade amongst themselves than they are to trade with US States after controlling for size and distance between economic centers. Wei (1996) introduces a methodology that ruled out the reliance on national trade data and finds on average, that countries trade ten times more with themselves than with foreign countries. Nitsch (2000) finds evidence of a substantial border effect in Europe, with internal trade being on average larger by a factor of ten than trade with other EU partners and that the magnitude of the border effect declined during the 1980's.

In this paper, we re-examine the evolution of the border effects (home bias) within intra-European trade. We start from the standard gravity model and consider several methodological issues both from an economic and econometric point of view. This yields a specification that allows for a more flexible income response, a competitiveness effect, that distinguishes a general and a specific component, and an alternative measure of remoteness. Next, a special attention is given to the effect of EU harmonization of technical regulations on trade in manufacturing goods.

The data on technical regulations come from the Commission's review of the impact of the Single Market in the EU (CEC, 1998). This study provides information at the 3-digit level of the NACE classification of whether trade is affected by technical regulations and the dominant approach used by the Commission to the removal of such barri-

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ers in the EU. In the appendix and further in chapter 5, we discuss the data that has been used in this chapter.

The paper continues in section 2 with a brief survey of the literature on the gravity model. Section 3 presents the standard specification of the gravity model. Section 4 provides some preliminary results. In section 5 we propose several modifications and extensions to the standard model. Section 6 is devoted to further econometric considerations. Our results are presented in section 7 while section 8 threats the impact of the harmonization of regulations at an aggregate level of manufacturing.

2. Brief Survey of the Literature

Since the pioneering work of Tinbergen (1962) and Pöyhonen (1963), the gravity model has become the standard tool to study bilateral trade.[1] Typically in a log-linear form, the model considers that the volume of trade between two countries is promoted by their economic size (income) and constrained by their geographic distances. Other characteristics of countries can easily be added. For example, Frankel *et al.* (1995) add dummy variables for common language and common border. Deardorff (1995) argue that the relative distance of trading partners should also have an impact on the volume of trade. Wei (1996) and Helliwell (1997) extend this concept and define ‘remoteness variable’ that captures third country effects. Whether and how remoteness should be included in the model has been discussed later on by Helliwell (2001) and Anderson and van Wincoop (2003).

Although its empirical success can be attributed from the model’s consistently high statistical fit, it was also criticized because it lacked a theoretical foundation. These foundations were subsequently developed by many authors. Anderson (1979) presented a theoretical justification for the gravity model based on CES preferences with differentiated goods (Armington). Bergstrand (1985, 1989) uses also CES preferences to derive a reduced form equation for bilateral trade flows from a general equilibrium model. Helpman-Krugman (1985) derives a gravity equation from a monopolistic competition framework. Their model predicts that intra-industry may exist within a

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1 Alternative approaches such as a complete demand system by country *à la* Barten *et al.* (1976) were never popular. It is worth wile noticing that we checked a specification in shares allowing for quasi-homothetic preferences rather than in logs but this was statistically rejected with respect to the conventional log-linear form.

group of 'industrialized countries" as long as complete specialization occurs. On the other hand, Deardorff (1995) undermines the argument of monopolistic competition by showing that the gravity equation can easily be motivated in a Heckscher-Ohlin model without assuming product differentiation. He relaxes the assumption that factor prices are equalized between countries, so that countries specialize in producing different goods. In a recent paper, Eaton and Kortum (2002) develop a multi-country perfectly competitive Ricardian model with a continuum of goods from which they derive a structure that resembles the gravity model. In their model, specialization occurs from comparative advantage that is interactively linked to the level of technology and geographic trade barriers.

Whatever the theoretical framework in support of the gravity model, they all yield a similar functional form. Therefore, the best conclusion to be drawn is that of Deardorff (1995):"just about any plausible model of trade would yield something very like the gravity model, whose empirical success is therefore not evidence of nothing, but just a fact of life".

3. The Standard Gravity Model and Border Effects

Typically, the gravity model has the form:

$$m_{ijt} = \alpha + \beta_1 y_{it} + \beta_2 y_{jt} + \delta d_{ij} + Z'\theta + \varepsilon_{ijt} \quad , \qquad (1)$$

with time, $t = 1, \ldots T$: m_{ij} is the volume of imports by country i from country j; y_i and y_j are the logs of real income (GDP) of country i and country j respectively; d_{ij} is the distance between the trading centers of the two countries; Z' is a set of characteristics that, (amongst others) include the border and remoteness effects; ε_{ijt} defines the error term (further discussed in section 3.5). All variables but dummies, are expressed in logarithm and by notation any variable x is the log of X.

3.1. Border Effects

Beginning with McCallum (1995), the gravity model has been used to compare domestic trade with international trade. Using 1988 data, McCallum finds that Canadian provinces are about 20 times more likely to trade amongst themselves than they are to trade with US states after controlling for size and distance between economic centers. However, data limitation makes it impossible to replicate McCallum's research for the EU. We follow the methodology introduced by Wei (1996) which avoids the reliance on national trade data. He constructs a "border effect" measure based upon the definition that what a country imports to itself is the difference between domestic production and exports. The border effect is then estimated by including a dummy variable. Wei (1996) estimated the border effect for OECD countries and finds, on average, that countries trade 10 times more with themselves than with foreign countries. This method has subsequently been used in several empirical studies. Helliwell (1997) revisits the OECD data and finds a border effect of 13 separating out the effect of language from the land border effect. Nitsch (2000) finds evidence of substantial home bias in Europe, with domestic trade being on average larger by a factor of 16 than trade with other EU partners. His results also suggest that the magnitude of the border effect declined during the 1980s.

3.2. Internal Distances

The application of a gravity model requires a measure of the trading distances within a country itself. Wei (1996) and Helliwell (1997, 1998) use for internal distances one quarter of the distance to the nearest neighbor. As noted by Nitsch (2000), this method relies too much on the geography of neighboring countries and too little on the geography of the home country. He shows that the radius of a circle or 0.56 times the square root of the area may be a good approximation for the average distance. In the present study, we follow Nitsch's method. Helliwell and Verdier (2001) move towards a measure of internal distances that incorporates information about the distribution of population within a country. Nitsch (2000) applies their method to Canada and obtains a scaling factor of 0.5 that is very close to his own method of using 0.56. One should be aware that the magnitude of the border effect is sensitive to the assumption about internal distances. More precisely, any measure that monotonically increases internal distance also increases the border effect.

3.3. Remoteness

A measure of "remoteness" is now commonly included in the gravity model: Wei (1996); Helliwell (1997, 1998); Nitsch (2000); Chen (2004). Remoteness of an importing country i in relation to any trading partner j is given as the weighted average distance between country i and all trading partners other than j, where the weights are given by the GDP of the trading partners. In the studies mentioned above, remoteness r_{ij}, is defined as:

$$r_{ijt} = ln\left[\sum_{k \neq j} \frac{D_{ik}}{Y_{kt}}\right], \qquad (2)$$

and both r_{ij} and r_{ji} are included in the regression. However, as we will see in section 5.3.1., this measure is open to criticism and yields results that are difficult to interpret. In particular, it becomes incompatible with steady-state and may yield to strange interpretations of idiosyncratic shocks in the GDP's of the trading partners.

3.4. Other Characteristics

The gravity model can easily be appended with various institutional, cultural or historical characteristics. Typically, gravity studies on European trade add a dummy variable to indicate whether two countries speak the same language, share a common land border or member of a regional trade or currency agreement.

3.5. Estimation Method

Parallel to the search for a solid theoretical foundation, researchers have also investigated the econometric issues linked to the estimation of a gravity model. In a series of papers, Mátyás (1997, 1998), Egger (2000, 2001), and Cheng and Wall (1999) have used the advantages of panel techniques to test the trade determinants using the gravity equation. The pooled analysis then concerns the possibility to capture a variation between three dimensions: a two dimensional effect between importing and exporting countries and a time dimension.

With panel data it is not clear, at least a priori, if one should estimate a random or a fixed country effects model. Mátyás (1997) assumed that the effects were observable from the data and therefore adopted a fixed effect approach. However, the same author (Mátyás, 1998), noted that the choice between random or fixed effects is rather subjective and suggest using a random effect if the number of countries is large.

In this paper, we estimate the gravity model using an iterated maximum likelihood version of the generalized least squares (GLS) allowing for random effects.[2] For the random effect, the error term in equation (1) is written as:

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[2] As an alternative, we could have used a version of the feasible generalized least squares (FGLS) using the Park-Kmenta or the Beck-Katz method. This method is based on the assumption that the variance and covariance matrix is unknown and finds a consistent estimator. The method consists of two sequential FGLS transformations: first, it eliminates serial correlation of the errors then it eliminates contemporaneous correlation of the errors. This method is less efficient than the model with random effects or OLS for data where the number of cross sectional units are larger than the number of time

$$\varepsilon_{ijt} = \mu_i + \upsilon_j + \xi_{ijt} \quad , \tag{3}$$

where μ_i and υ_j are the random unobserved effects of the importing and exporting country respectively (at a given time) while ξ_{ijt} is a random component over countries and time. However, we note that this estimation method yields results that do not differ much from ordinary least squares. This point is further confirmed in section 7 where we compare the final model proposed in this chapter using both OLS and GLS allowing for random effects.

4. Preliminary Results

Nitsch (2000), who has adopted equation (1) in his study of EU-intra trade in manufacturing, provides a good benchmark model. We replicate his model to EU trade in total manufacturing for 1990-1998. We estimated equation (1) by GLS allowing for random effects and follow the standard framework of using population as instruments for the GDP's. For the sake of comparison, imports and GDPs are taken in nominal terms (underlined here to avoid confusion with constant price values). We also note that the reported results on the intercept and the home variable are constant over time. This is consistent with preliminary tests confirming section 6.3.2.

Denoting by A_{ij} and L_{ij}, two dummies that indicate that countries share the same land border and language, respectively; and by H_{ii}, the home effect, the resulting equation is (with standard errors of the coefficients in parentheses):

$$\underline{m}_{ijt} = -6.62 + .89\,\underline{y}_{it} + .69\,\underline{y}_{jt} - .79\,d_{ij} + .36\,A_{ij} + .38\,L_{ij} + .76\,r_{ijt} - .58\,r_{jit} + 2.59\,H_{ii} \tag{4}$$

$$(.57) \quad (.01) \quad (.01) \quad (.03) \quad (.05) \quad (.10) \quad (.08) \quad (.08) \quad (.08)$$

$R^2 = 0.97$; $L = -1000.15$; Random effects (variance): $\sigma^2_\mu = .20$, $\sigma^2_\nu = .45$, $\sigma^2_\xi = .18$

$BP = 39.1$; $N = 1260$.

Our results are largely consistent with those from Nitsch. All coefficients except for remoteness have the expected sign, standard errors are low and the overall fit is high.[3]

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points (N>T) because the estimated covariance matrix tend to underestimate the true variability of the estimator. See Beck and Katz (1995, pp. 636), Judge *et al.* (1985, pp. 492), Greene (2000, pp. 608) and Wooldridge (2002, pp. 158, 263) for a technical explanation of using the GLS and the implications when N>T.

[3] Here and throughout, R^2 is the squared correlation between actual and predicted values; L is the value of the log of the likelihood function at its estimated maximum., BP is the Breusch-Pagan test for heteroscedasticity and N is the number of observations.

Notice, however that our dataset differs somewhat to the one employed by Nitsch. His dataset is for the period 1983-1990, and does not include Sweden, Austria and Finland.

The importing and exporting income elasticities, 0.89 and 0.69 respectively, are very similar to those obtained in Nitsch (2000). The coefficient of distance variable is slightly larger from previous studies where the consensus estimate is 0.6 (Leamer, 1997). Chen (2004) suggests that reported distance coefficients that are much higher than the general agreed 0.6 elasticity could be explained by the use of different transport modes. For example, in the European Union, 57.8% of total intra-EU trade went by road whereas most global trade is transported over sea.

Nitsch (2000) follows Helliwell's (1997) and incorporates two dummies that take the value of one only in the case of bilateral trade between countries that share a common language (L_{ij}) and have a common border (A_{ij}). The coefficients of both language and adjacency dummies are found to be statistically significant. The coefficient of the home variable ($H_i = 2.59$) means, that on average, EU10 countries trade about 14 times more with itself than they do with another EU country after controlling for other variables. This results, for the EU, is fairly close to Nitsch' (2000) estimate of 16.

5. Extending the Gravity Model

Despite its attractiveness, a model such as equation (4) raises a series of questions. In this section, the following questions will be addressed:

(i) The model imposes, without testing, constant income elasticities. Although, theoretically very convenient, this restriction may be empirically not validated and, if this is the case, it could be a source of the present degree of heteroscedasticity.

(ii) In principle, data on trade and income should be expressed in real terms but the choice of a deflator deserves particular attention.

(iii) The model ignores a price competitiveness effect, which certainly plays an important role in the evolution of intra-European trade.

(iv) As mentioned before, the definition of remoteness of the importing and exporting country are not only questionable, their coefficients are inversely signed.

5.1. Price Deflator and Competitiveness

5.1.1. Choice of a Deflator

For the sake of comparison, Nitsch's equation (4) was estimated in current values. In principle, as we are dealing with time series, imports and incomes should be expressed in real terms. Although with the present sample the results are hardly different, the estimation in nominal terms may lead, for instance, to erroneously reject the hypothesis that α is constant through time.

However, the choice of an adequate deflator is not straightforward. Indeed, several authors have criticized the traditional procedure of using the implicit deflator of imports on the grounds that it incorporates a signal of a change in quality or in other various factors of the same nature. One should also add that a substantial part of intra-EU trade is in fact intra-firm trade and the evolutions of firm's internal prices may differ from those of market prices. Therefore, some authors have opted for the GDP deflator. But the latter raises also problems. In particular, it represents above all an index of domestic costs (cf. infra). Moreover, since inflation is not homogenous across goods and services, the more disaggregated the analysis the less relevant it might be. An alternative approach consists in modeling the export prices but that requires very restrictive assumptions on the structure of preferences and of the cost function and, in our opinion, it is well beyond the scope of this paper.

We took the pragmatic view to compare the empirical merits of (both in logs) the import price deflators, p_{it}^{m}, and the GDP deflators, p_{it}^{y}, and re-estimate model (4) as:

$$(\underline{m}_{ijt} - p_{it}^{m}) = \gamma\,(p_{it}^{y} - p_{it}^{m}) + RHS\ (4) \quad , \qquad (5)$$

where *RHS (4)* is the right hand side of equation (4). This estimated value of γ is close to 0.9 significantly different from both zero and unity. Thus, although the GDP deflator appears empirically better, in fact it does not matter which deflator is used as long as their ratio, that we shall denote P_{it}, is incorporated in the model.

5.1.2. The Competitiveness Effect

With the functioning of the European Monetary System and, for the last years of our sample, the prospect of the European Monetary Union, maintaining competitiveness has been a major objective in the conduct of macroeconomic policy for country members and even for their non-member neighbors.[4]

Now, in particular for manufacturing goods, production techniques do not differ dramatically across the EU countries and thus unit costs of capital, energy and raw materials evolve in a parallel way. However, wage formation -- as well as gains in labor productivity -- is, especially in short run, country specific. Provided that the distribution of value added remains stable over time, its deflator evolves exactly as the same rate as unit labor cost. Thus, P_{it} that compares the GDP deflator to the average price of imported manufacturing goods is generally considered as a good proxy of competitiveness. However, it only captures a general substitution effect on the domestic market.[5]

As changes in competitiveness vary across countries, in order to explain imports from a specific country, we also include a measure of competitiveness based on the relative unit labor costs between the importing and exporting countries, namely:

$$rulc_{ijt} = (ulc_{it}/\textstyle\sum_k \omega_{ik} ulc_{kt})/(ulc_{jt}/\textstyle\sum_k \omega_{jk} ulc_{kt}) \quad , \qquad (6)$$

where ulc_i and ω_{ik} denotes respectively the unit labor cost of country i and the share of country k in total import (of manufacturing goods) of country i. The weights (ω_{ik}) are computed from the average bilateral trades during the period 1990-1998.

5.2. *The own Income Effect*

While the assumption of constant own income elasticity makes sense in a macroeconomic relationship, it becomes questionable at a less aggregated level.[6] Indeed, when income grows, the structure of final demand, and therefore the structure of imports, changes. This evolution is probably more flexible than the one implied by the standard model. Consider the import ratio s_k of a commodity (in our case, an industrial sector) k

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[4] For a theoretical argument, see among others, Giavazzi and Pagano (1988). As a practical example, the first Government of Mitterand (France, 1981) has shown how rapidly by inflating a country can create a trade deficit with, subsequently, a stabilization adjustment in terms of incomes and prices policy.

[5] Notice that in the case of imperfect competition, P_i captures a price effect while, in the price-taker case, it represents a supply effect (i.e. a loss in profitability). In both cases, a relative loss in the competitiveness of the importing country should increase its imports.

[6] The importance of the income elasticity at a more detailed level of manufacturing is further explored in chapter 3.

for a given country i: $s_{ik} = M_{ik}/Y_{ik}$. According to equation 1 and ignoring the likely negligible effect of an income variation on the measure of remoteness, the evolution of s_{ik} is given by:

$$\partial s_{ik}/\partial ln y_i = s_{ik} (ß_1 + ß_2 - 1) .$$

The estimated income elasticity ($ß_1 + ß_2$) for manufacturing goods is significantly above unity and thus, on a steady state, their import ratio is supposed to grow at a constant rate. This is not very plausible. To the contrary, one expects that as income increases, the share of most manufacturing goods will, at some income level, start to decline. To allow for such a shape, we specify $ß_1$ as:

$$ß_1 = ß_{11} + ß_{12}\, yc_{it} , \qquad (7)$$

where yc_{it} is the logarithm of current per capita income, Yc_{it}, with respect to an arbitrary reference level $Yc°$:

$$yc_{it} = ln(Yc_{it}/Yc°) . \qquad (7')$$

We choose $Yc°$ as the average per capita GDP of the EU countries in 1995 and thus $ß_{11}$ is the estimated income elasticity at that point. The reader will notice the analogy of this specification with the quadratic version of the almost ideal demand system proposed by Banks *et al.* (1997) in the context of households expenditure panels. Empirically, this specification has also the advantage of reducing the problem of heteroscedasticity generally present with panel data.

5.3. Geographical characteristics

5.3.1. Remoteness

The two remoteness variables in equation (2) where originally adopted by Wei (1996). However, the estimated coefficients are inversely signed which is not compatible with theory.[7] However, this formulation presents drawbacks of being not homogenous with respect to distance and income. More precisely, on a steady-state where all GDPs increase at a constant rate, remoteness should not change. This will occur when the two

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[7] In a three-country case, if trade with country *k'* that is more remote from country *i* but not from *j* (m_{ij} should increases), r_{ij} is supposed to increase. Similarly, if country k' is more remote from country *j* but not from country *i* (m_{ij} should increases), r_{ji} is supposed to increase.

variables have identical coefficients with the opposite sign and this might explain the results obtained in equation (4).

To avoid this problem, the variable that should enter is relative remoteness. In that spirit, we measure remoteness with a slightly different specification than equation (2):

$$r_{ijt} = ln \left[\frac{D_{ij}/Y_{jt}}{\sum_{k \neq j} D_{ik} / Y_{kt}} \right], \tag{8}$$

This new definition of remoteness is expected to give a negative sign since for a given distance from other countries *k*, greater bilateral distance reduces trade while for a given bilateral distance, greater distance from other countries increases trade. It is worth noticing that in Deardorff (1995) remoteness also enters in relative terms where the weights are the domestic price indices rather than GDPs.

5.3.2. Adjacency and Language

We also take a different specification of the dummies for countries that share a same border and language as in our sample, three member countries that share the same language also share the same border. The effect of the language dummy is then captured by an overlapping effect of the adjacency dummy. We therefore propose an alternative specification of including a dummy for countries sharing a same border *and* language (*AL*) and a dummy for countries sharing the same border but not the language (*AN*). We follow Helliwell (1997) and Nitsch (2000) method of assigning a value of one only in the case of bilateral trade flows.

6. Econometric Procedures

Combining the proposed modifications, the model becomes:

$$m_{ijt} = \alpha + \beta_{11} y_{it} + \beta_{12} yc_{it} * y_{it} + \beta_2 y_{jt} + \delta\, d_{ij} + \mu\, AN_{ij} + v\, AL_{ij} + \rho\, r_{ijt}$$
$$+ \pi\, P_{it} + \lambda\, rulc_{ijt} + \eta\, H_{ii} + \varepsilon_{ijt} \;. \tag{9}$$

6.1. Estimator Consistency

As noted by the literature (Wooldridge, 2002; Beck and Katz, 1996), OLS estimates often violate the OLS standard assumptions when they are applied to pooled data. This is because the pooled OLS regression across country *i* and time *t*, assumes that (i) the errors are independent from a period to a next (no serial correlation); (ii) the errors variance is constant across countries (homoscedasticity); and (iii) errors are not correlated across countries (no contemporaneous correlation). However some complications may be likely to be present. For example, given the large differences between imports from different countries, heteroscedasticity is likely to occur and since the gravity specification includes characteristics (adjacency, language, distance) that are not interdependent over time, serial correlation is likely to be present. For this purpose, we performed some diagnostic tests.

A series of Breusch-Pagan tests were carried out for different time periods. The null hypothesis of homoscedasticity is rejected in most of the cases and the Jarque-Bera test rejects the null hypothesis of normality. We also test for first-order autocorrelation in the residuals. Using the first-order autoregressive process (AR1), there is very strong evidence of serial correlation.

We correct for the problem of AR(1) errors, heteroscedasticity and contemporaneous correlation by providing an iterated maximum likelihood version of the generalized least squares (GLS) allowing for random effects. In the random effect model, the serial correlation is exploited in the composite error term in a generalized least squares framework (Wooldridge, 2002).[8] In the presence of an AR (1) process, the usual remedy is to include dynamics. We tested for co-integration and cannot reject it. This suggests that it is worth to investigate a dynamic version of the model which we omit for the purpose of this paper.

6.2. Instruments

As the error term is most likely correlated with y_i and y_j most empirical studies use the log of the population as an instrument for the log of the GDP variables. However, as noted by McCallum (1995), the lack of instruments does not permit to deal adequately with this problem. In this spirit, we choose the following set of instruments: (i) GDP's from the two previous years; (ii) current population and (iii) gross capital formation from the current and the two previous years. The model is estimated in a two-stage least squares method. In the first stage estimation, the regressions of the GDP for each country are performed for the years 1982-1998. In order to compare the 2SLS estimates with (i) the population instrument and (ii) the new set of instruments, the Haus-

[8] In the random effect model, the serial correlation is generally regarded as a useful measure of the relative importance of the unobserved effect. In our example, this correlation is equal to the ratio of the variance of μ_i and ν_j to the variance of the composite error. See Wooldridge (2002, pp. 259).

man test (1978) for endogeneity yields a t-test value of 1.38 and thus does not permit to reject the hypothesis that the new instrumented GLS and the GLS estimates using population as instrument are statistically equivalent at the 5% significance level.

6.3. Tests

The estimation of equation (9) was accompanied with several tests. First, we tested for possible influential observations through a detailed analysis of the residuals, DFIT values, cooks distances and leverages. Second, we tested for the restriction that both the intercept and the coefficient of the border effect are constant over time.

6.3.1. Influential Observations

We proceeded to a preliminary analysis of examining influential observations by investigating the DFIT values. We then looked at the residuals and leverage statistics. These statistics were expressed in averages with normalized standard deviations by importing country, exporting country and year. The leverage statistics do not suggest any unusual features that would induce an anomaly of the fitting data and reports a range of values that are stable across countries and time. Subsequently, the residuals suggested that Ireland, the UK and Greece are potential outliers. We then looked at all the residuals from each observation and found that UK imports from Ireland are potentially influential. For the years, the residuals show in 1993 a slightly break. From those tests we concluded that no observations appear to be pathological.

6.3.2. Parameter Restrictions

As written above equation (9) incorporates restrictions on the intercept and the constancy of the border effects and this of course should be tested. First, we estimated yearly cross-section models, and inspected that the intercept showed a somewhat upward trend while our parameter of interest, the border effect, remained constant over time.

As a second insight into the analysis, we test the restriction that the border effect and the intercept is the same in each time period using the likelihood ratio test (LR). To do so, we transformed the gravity model into an unconstrained model where we include time dummies and allow the border effect to vary over time, written as:

$$m_{ijt} = \alpha_t + \eta_t H_{ii} + RHS\,(9)\,, \qquad (10)$$

where *RHS (9)* is the right hand side of equation (9). In the general model (10), the coefficients of the intercept, α_t, and the coefficient of the border effect, η_t, is allowed to change over time. When we impose the restriction that the intercept is constant over time, the value of the log-likelihood ratio test is 13.8 (the cut-off value of χ^2 with 8 restrictions is 15.5 at the 5% significance level). Alternatively, imposing the restriction of η_t to be constant, the value of the test is 9.46. This set of restrictions can not be rejected at the 5% confidence interval. The value of the log-likelihood ratio test is 23.26 (the cut-off value of the χ^2 with 16 restrictions is 26.3). Notice however that allowing a different constant for 1993 was at the margin of rejection. We also tested whether there was a trend in α_t and η_t which was also rejected.

7. Results

Equation (9) estimated by GLS, allowing for random effects yields:

$$\begin{aligned} m_{ijt} = &- \underset{(.41)}{4.85} + \underset{(.01)}{.87}\, y_{it} - \underset{(.004)}{.021}\, yc_{it} * y_{it} + \underset{(.03)}{.66}\, y_{jt} - \underset{(.04)}{.8}\, d_{ij} + \underset{(.05)}{.17}\, AN_{ij} + \underset{(.08)}{.45}\, AL_{ij} \\ &- \underset{(.07)}{.34}\, r_{ijt} + \underset{(.04)}{.91}\, P_{it} + \underset{(.01)}{.16}\, rulc_{ijt} + \underset{(.08)}{2.48}\, H_{ii} \end{aligned} \qquad (11)$$

R^2=0.98; L=-934.41; Random effects (variance): σ^2_μ=.18, σ^2_ν = .36, σ^2_ξ = .18

BP = 23.87; N = 1260.

We first note that all coefficients have the correct signs and relative low standard errors. The Breusch-Pagan test reveals that heteroscedasticity is still somewhat high although it has been reduced with respect to equation (4).

Income Elasticities The coefficients of the income elasticities of the importing and exporting countries are very similar to those of regression (4). Imports are more sensitive to home GDP than foreign GDP. It is worth noticing that enlarging the instruments for GDP's hardly affects the income elasticities. The own income elasticity is slightly smaller than the EU average of 1995. This result indicates that as income grows the share of total manufacturing goods has a slow and declining income elasticity most likely in favor of services. Of course, it may substantial vary across sectors and we shall return to this issue in the next chapter.

Price Variables Both the coefficient of the general effect and the coefficient of the specific effect must be taken into account. For example; if country *i* experience a loss of competitiveness of 1% with respect to all its EU partners, imports will drop by slightly more than a percent (.9 + .16). This result is somewhat in contrast to studies that have used labor costs to explain export performance [Wolf (1997), Carlin, Glyn and Van Reenen (1999)]. A possible explanation is that we restrict our analysis to intra EU trade and also that our sample is more recent. Indeed, current trends in international trade and the associated increase in international competition suggest a heightened importance of relative costs in performance.

Geographic Variables The coefficients of bilateral distance and remoteness have the correct negative signs and are significant determinants of trade flows with an estimated elasticity of -.8 and -.34 respectively. The dummies for countries that share a same language and border (*AL*) and same border but different language (*AN*) are also found to have statistically significant effects with the correct signs. The effect of countries sharing a common language and land border is three times larger than for neighboring countries speaking different languages.

The Border Effect The estimated coefficient of the border effect is 2.48 and it remains quite robust with the present specification of the gravity equation. It implies that domestic trade is 12 times higher than intra-EU trade.

Remoteness has the correct sign and is highly significant. In the literature however there is no general consensus of whether the variable should be there. To show the empirical importance of whether this variable should be there, we re-estimated equation (11) and dropping remoteness. The results are presented in table 1, column (2) in the appendix of this chapter. The most notable change is a drop of almost 10% in the income elasticity of the exporting country while the other variables remain robust.

Some further Tests As a further diagnostic check, we re-estimate the basic gravity model without the augmented variables. In table 1, column (3), the results reveal an increase in the elasticities of the geographic variables (*AN*, *AL*) and a minor increase of the border effect. Generally speaking, we conclude that the border effect remains quite robust to alternative specifications of the gravity model. In addition, we also re-estimated equation (11) using OLS. The results reported in table 1, column (1) confirm that similar results are yielded using both estimation methods.

8. Harmonization of Technical Regulations

The removal of technical barriers to trade (TBTs) has been one of the major factors affecting intra-EU trade. The Commission (1998) calculated that, in 1996, over 79% of intra-EU trade in manufacturing was been affected by harmonized technical regulations.

In the empirical literature, the general approach to measure the effect of non-tariff barriers has been based on the gravity model of international trade (see amongst others, Harrigan, 1993; Moenius, 1999; Head and Mayer, 2000; Otsuki *et al.* 2000). To gauge the impact of regulations, standards and other NTBs, the gravity model is then augmented with frequency-type measures (e.g. number of regulations in an industry, trade-weighted coverage ratios) that quantify the impact of NTBs.

In this section, we will attempt to test to what extent the impact of harmonization of regulations has promoted EU trade. The idea is that country *i* will import more from country *j* that proportionally satisfies EU regulations more than an EU average. We assume that trade is affected starting the year that an EU Directive, which we denote as *k*, is published.[9]

We construct a variable defined as:

$$S_{jt} = \left[\frac{x_j^{k(t-1)}}{x_j} - \frac{x_{eu}^{k(t-1)}}{x_{eu}} \right] \quad . \qquad (12)$$

The first term in brackets is a coverage ratio of the average (1990-1998) EU exports of country *j* that are subject to the harmonization of regulations in total average exports of country *j* and the second term is similarly constructed for average intra-EU exports.

During the period 1990-1998, the most important change in harmonized regulations occurred in 1993 with the introduction of the machine directive. The scope of manufacturing sectors that are affected by of other new harmonized regulations (lifts, gas appliances, low voltage equipment, etc.) were of minor importance in 1990, 1991, 1994 and 1995.

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9 This assumption is probably not true since for some countries it may take more time to transpose the EU Directive in its national regulations. Chapter 5 provides a detailed discussion on the construction of this variable.

The effect of the share variable on intra-EU trade and domestic trade is determinate. First the impact of harmonization for a given county increases trade and reduces domestic trade. Moreover, the country that complies with EU harmonization more than the EU average, the more it should be able to penetrate foreign markets.

We first separate out the effect of the removal of TBTs on imports in the case for international trade (when $i \neq j$) and domestic trade (when $i=j$). To do so, we multiply s_{jt} with ($1-H_{ii}$) for the case of EU bilateral trade and interacts s_{jt} with H_{ii} for the case of domestic trade. The resulting equation (with standard errors in parentheses) is:

$$\begin{aligned} m_{ijt} = &-5.50 + .83\, y_{it} - .021\, yc_{it}{*}y_{it} + .66\, y_{jt} - .46\, d_{ij} + .15\, AN_{ij} + .49\, AL_{ij} \\ &(.39) \quad (.01) \quad (.004) \quad (.05) \quad (.04) \quad (.04) \quad (.07) \\ &- .35\, r_{ijt} + .88\, P_{i,t} + .16\, rulc_{ijt} + 2.95\, s_{jt} {*}(1- H_{ii}) + .20\, s_{jt} {*} H_{ii} \\ &(.09) \quad (.04) \quad (.01) \quad (.12) \quad (.61) \\ &+2.38\, H_{ii} \\ &(0.07) \end{aligned} \tag{13}$$

R^2=0.95; L=-892.13; Random effects (variance): σ^2_μ=.12, σ^2_ν = .57, σ^2_ξ = .18

BP = 28.14; N = 1260.

The harmonization of EU regulations plays an important role in explaining trade. The coefficient of s_{jt}*(1-H_{ii}) is strongly significant and positive. This suggests that any country j that is above the EU average share of harmonization significantly exports more to country i. In the case of domestic trade, we do not find any significant impact of harmonization of technical regulations on a possible reduction of border effects. The coefficient of s_{jt}* H_{ii} is .20 and not significantly different from zero. We also ran equation (13) on a sample that omits all the observations for domestic trade. The resulting equation (with standard errors in parentheses) is:

$$\begin{aligned} m_{ijt} = &-6.16 + .83\, y_{it} - .018\, yc_{it}{*}y_{it} + .70\, y_{jt} - .56\, d_{ij} + .16\, AN_{ij} + .42\, AL_{ij} \\ &(.42) \quad (.01) \quad (.004) \quad (.05) \quad (.04) \quad (.04) \quad (.07) \\ &-.23\, r_{ijt} + .88\, P_{it} + .19\, rulc_{ijt} + 2.43\, s_{jt} \\ &(.09) \quad (.04) \quad (.01) \quad (.12) \end{aligned} \tag{14}$$

R^2=0.98; L=-631.60; Random effects (variance): σ^2_μ=.20, σ^2_ν = .37, σ^2_ξ = .19

BP = 23.71; N = 1170.

From equation (14), the coefficient of the share variable, s_{jt}, remains strongly significant and positive. The significance and sign of the other coefficients in equation (13) and (14) are generally in the same line from those obtained from resulting equation (11).

To conclude, the results reported in this section, suggest that harmonization of technical regulations has played a significant role in explaining intra-EU trade. It is apparent that the application of harmonization of EU regulations plays an important role in promoting the extent of cross-border trade. However, we do not find evidence that harmonization decreases border effects. In a somewhat related paper, similar conclusions are reached. Head and Mayer (2000) apply a gravity approach to 3-digit NACE data for the EU countries. They find that crude indicators of non-tariff barriers before and during the Single Market Program cannot explain the variation in the size of estimated border effects.[10]

9. Conclusion

This chapter is an attempt to provide some further insights into the estimation of an appropriate functional form of a gravity model applied to EU bilateral trade flows in total manufacturing taking into account the downward impact of border effects. A special attention is given to the impact of harmonization of regulations in explaining EU bilateral trade and domestic trade.

We considered several methodological issues. From an economic point of view, we provided a theoretical consistent measure of remoteness, added competitiveness that is composed into a general and bilateral component and accounted for a flexible income response. From an econometric point of view, we considered a method of estimation and proposed a version of a general least squares estimation allowing for random effects.

Several results are presented. First of all, we find evidence that the level of border effects is quite robust to a standard specification of the gravity equation such as the one estimated by Nitsch (2000) and to a more detailed specification of the gravity model

[10] The authors use two indirect measures of EU non-tariff barriers (NTBs). The first measure is based on a 1980s survey of EU firms conducted by the European Commission. From this survey, the authors construct three variables representing the magnitude of the NTBs in terms of standard differences, public procurement and customs formalities. The second set of indicators comes from Buigues *et al.* (1990), which classified European industries into three levels of barriers: low, moderate, and high.

that we consider in this paper. In particular, we find that domestic trade in the EU is about 14 times larger than EU-bilateral trade. Secondly, we find that the border effect has not declined for 1990-1998. Thirdly, we find that harmonization of technical regulations cannot explain the presence of border effects while it has a positive impact on EU imports. Finally, our results indicate that the augmented economic variables play an important role in explaining EU bilateral trade.

DATA APPENDIX

Trade Data

Trade data are taken from Eurostat (Comext). Bilateral trade data is recorded in euros. We deflate the imports data by an import unit price index – using 1995 as the base year – in order to obtain a real flow of trade. Our sample covers the period 1990-1998. The importing are the following ten EU countries: Denmark, France, Germany, Greece, Italy, Ireland, the Netherlands, Portugal, Spain, and United Kingdom while the exporting countries are the previous 10 countries + the remaining EU countries: Belgium and Luxembourg treated as one, Finland, Sweden and Austria. The choice of 10 importing countries was limited by data availability: Sweden, Finland, Austria and Belgium/Luxembourg are omitted because there is no production data reported before 1995. The sample therefore covers a total of (10*14*9) = 1260 observations.

Other Data

Internal distances d_{ii}, are taken from Nitsch (2000). For distances between countries d_{ij}, we follow the conventional method in the gravity literature and measure the direct (great circle) distance between the economic centers (capital cities).

Production data are taken from the database Newcronos (Eurostat). Some in-between-year observations are missing from the Newcronos database. Missing data, then, are approximated by applying a trend of the gross rate of value-added (in quantity) in each NACE sector.

Gross Capital Formation (1995 Prices), GDP in current and constant prices, unit labor costs and population are obtained from the Newcronos database. For the Netherlands, Denmark and Spain, some missing values of unit labor costs were unavailable. For these countries, we approximated these missing observations using labor cost indexes that were computed by the European Commission (DG-ECOFIN). The series can be downloaded from ECODATA (available from the Belgian Ministry of Economic Affairs, http://ecodata.mineco.fgov.be).

3. Data on Harmonization of Technical Regulations

The data on technical regulations come from the Commission's review of the impact of the Single Market in the EU (CEC, 1998). This study provides information at the 3-digit level of the NACE classification of whether trade is affected by technical regulations and the dominant approach used by the Commission to the removal of such barriers in the EU. We derived the trade data according to the same NACE industrial classification applied to a panel of 15 EU countries of 1990-1998. Trade was then aggregated into one broad group, consisting of all sectors that are subject to the harmonization of technical regulations.

A more detailed analysis of the data is given in chapter 5.

Table 1: Further Tests

	1	2	3
y_i	0.87	0.85	0.77
	(0.01)	(0.01)	(0.01)
y_j	0.65	0.56	0.76
	(0.03)	(0.02)	(0.01)
$yc_i{*}\ y_i$	-0.022	-0.025	-
	(0.004)	(0.004)	
d_{ij}	-0.79	-0.69	-0.74
	(0.04)	(0.03)	(0.03)
AN_{ij}	0.16	0.13	0.39
	(0.06)	(0.05)	(0.06)
AL_{ij}	0.45	0.50	0.83
	(0.08)	(0.08)	(0.09)
r_{ij}	-0.30	-	-
	(0.07)		
$rulc_{ij}$	0.16	0.15	-
	(0.01)	(0.01)	
P_i	0.91	0.92	-
	(0.05)	(0.04)	
H_i	2.48	2.45	2.56
	(0.09)	(0.10)	(0.09)
Intercept	-4.82	-4.89	-6.65
	(0.45)	(0.50)	(0.44)
Random effects (variance)			
σ^2_μ	-	0.19	0.23
$\sigma^2\nu$	-	0.43	0.44
$\sigma^2\xi$	-	0.18	0.18
L	-936.86	-945.35	-1176.18
Observations	1260	1260	1260
Estimation Method	**OLS**	**RE-GLS**	**RE-GLS**

The results of equation (9) using OLS are listed in column (1).

CHAPTER III

THE IMPACT OF HARMONIZATION OF TECHNICAL REGULATIONS ON BORDER EFFECTS AND INTRA-TRADE IN THE EUROPEAN UNION

1. Introduction

In this chapter, we re-examine how EU harmonization of technical regulations have affected the pattern of bilateral trade flows of individual EU countries taking into account the downward impact of national border on trade flows. We use the gravity specification adopted from the previous chapter. We disaggregate trade of manufacturing sectors in six types of categories: four categories are matched to the different approaches used by the European Commission to the removal of technical barriers to trade (TBTs), one category that comprises an aggregate of all harmonization approaches, and one category where technical barriers to trade are not important.

We have several questions. We are particularly interested to see:

(i) whether there are differences in the border effect when applied to sectors where technical regulations are not deemed to be a potential trade barrier, to sectors where technical harmonization is important. Within this latter group, we are also able to assess whether there are differences in the size of the estimated border effect between sectors according to the approach adopted to the removal of TBTs.

(ii) whether the magnitude of the border effect has fallen since the creation of the Single Market. Within this we are particular interested to see:

   a. whether the border effect is lower for sectors, which have already been subjected to the harmonization of technical regulations; "old approach sectors".[1]

This chapter draws on some ideas that were initially developed in a paper entitled "The Extent of Economic Integration in Europe: Border Effects, Technical Barriers to Trade & Home Bias in Consumption" written in collaboration with Paul Brenton during my fellowship at the Centre for European Policy Studies.

[1] The policy environment in sectors subject to detailed harmonization under the old approach has changed little over this period, see CEC (1998).

b. whether sectors subject to the new approach and mutual recognition in the EU, where we might expect the impact of economic integration in the form of the Single Market to be the strongest, have experienced a greater fall in the border effect during our sample period of 1990 to 1998.

(iii) whether there are significant differences in the parameter values of the gravity model when applied to manufacturing sectors at a more detailed level.

The data on technical regulations come from the Commission's review of the impact of the Single Market in the EU (CEC, 1998). This study provides information at the 3-digit level of the NACE classification of whether trade is affected by technical regulations and the dominant approach used by the Commission to the removal of such barriers in the EU: new approach, old approach, mutual recognition, multiple harmonization approaches as well as an aggregate of sectors for which technical barriers are deemed to be unimportant. We derived the trade data according to the same NACE industrial classification applied to a same panel of 14 EU countries for 1990-1998 that has been proposed in chapter 2. Trade in each sector was then aggregated into these five broad groups. All the other data is the same as in chapter 2. In chapter 5, we give a more detailed analysis of the data.

This paper continues in section 2 with a brief overview of the EU approach to the removal of TBTs. In section 3, we present the empirical gravity model. In section 4, we present the results. In section 5, we provide some statistical inferences and in the final section we conclude.

2. EU Approach to the Removal of Technical Barriers to Trade

EU policy related to technical regulations and testing and certification requirements is currently based upon two approaches: enforcement of the mutual recognition principle and, if this fails, the harmonization of technical standards across member states. Each approach will now be discussed in turn.

2.1. The Mutual Recognition Principle

The basic EU approach to this issue of differences in national regulations is the principle of mutual recognition, which was developed on the basis of a European Court of Justice case law, the Cassis de Dijon and Dassonville judgments. The mutual recognition approach is based on the idea that products manufactured and tested in accordance with the technical regulations of one member state can offer equivalent levels of protection to those provided by corresponding domestic rules and procedures in other member states. Thus, once a product is legally certified for sale in any member state it is presumed that it can be legally placed on the market of any member state, and as such has free circulation throughout the whole of the Single Market. The application of the mutual recognition principle requires a degree of trust between different countries and regulatory authorities that another country's regulation can offer equivalent levels of protection and that such regulations are effectively implemented ensuring that products actually conform to the requirements of the regulations. Hence, the principle of the mutual recognition plays a significant role in the internal market since it ensures free movement of goods (and services) without making it necessary to harmonize national regulations. 'Mutual Recognition' tends to apply where products are new and specialized and it seems to be relatively effective for equipment goods and consumer durables, but it encounters difficulties where the product risk is high and consumers or users are directly exposed.

2.2. Harmonization of Technical standards

Where 'equivalence' between levels of regulatory protection embodied in national regulations cannot be presumed, the EU has sought to remove TBTs through agreement on a common set of legally binding requirements (= harmonization). Subsequently, no further legal impediments can prevent market access of complying products anywhere in the EU market. EU legislation on harmonizing technical specifications has involved two distinct approaches, the 'old approach' and the 'new approach'.

2.2.1. Old Approach

The initial approach adopted in the EU to harmonizing technical specifications was based upon extensive product-by-product or even component-by-component legislation carried out by means of detailed directives. Now known as the 'old approach' this type of harmonization proved to be slow and cumbersome. In the 1980s the ineffectiveness of this approach was recognized when it became apparent that new national regulations were proliferating at a much faster rate than the production of harmonized EU directives (Pelkmans, 1987). This failure arose because the process of harmonization had tended to become highly technical as it sought to specify individual requirements for each product category (including components). This resulted in extensive and drawn-out consultations. In addition delays arose because the adoption of old approach directives required unanimity in the Council of Ministers. As a result the harmonization process proceeded extremely slowly. The old approach applies mostly to products (chemicals, motor vehicles, pharmaceuticals and foodstuffs) by which the nature of the risk is clearly apparent.

2.2.2. New Approach

In an attempt to overcome the drawbacks of the 'old approach' to the elimination of technical barriers to trade, the Commission launched in 1985 its 'New Approach to Harmonization and Technical Standards', focusing on the need to reduce the intervention of the public authorities and on accelerated decision-making procedures prior to a product being placed on the market. For example, a key element in the adoption of the 'new approach' is that the Council on the basis of majority voting can adopt directives. The new approach applies to products, which have "similar characteristics" and where there has been widespread divergence of technical regulations in EU countries. What makes this approach 'new' is that it only indicates 'essential requirements' and leaves greater freedom to manufacturers on how to satisfy those requirements, dispensing with the 'old' type of exhaustively detailed directives. The new approach directives provide for more flexibility by using the support of the established standardization bodies, CEN, CENELEC (European Standardization Committee for Electrical Products) and the national standard bodies. The standardization work is achieved in a more efficient way, is easier to update and involves greater participation from industry.

3. The Quantification of Harmonization of Technical Regulations in the Gravity Model

In the empirical literature, the general approach to measure the effect of non-tariff barriers has been based on the gravity model of international trade (see amongst others, Harrigan, 1993; Moenius, 1999; Head and Mayer, 2000; Otsuki *et al.* 2000).[2] Typically in a log-linear form, the model considers that the volume of bilateral trade is promoted by their economic size and constrained by their geographic distances. To gauge the impact of regulations, standards and other NTBs, the gravity model is then

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[2] See chapter 1 for a survey of this literature.

augmented with frequency-type measures (e.g. number of regulations in an industry, trade-weighted coverage ratios) that quantify the impact of NTBs.

In this paper, we disaggregate trade of manufacturing sectors in six types of categories: four categories are matched to the different approaches used by the Commission to the removal of such barriers, one category that comprises an aggregate of all harmonization approaches, and one category where technical barriers to trade are not important.

The use of such data collection, as an input in an econometric approach, distinguishes itself from other studies since we no longer rely on the construction of indicators (e.g., frequency ratios such as, the number of product categories subject to a NBT, etc.) or other related proxies. Our data collection engenders a useful exercise in identifying the incidence of harmonization of technical regulations on trade. Namely, we not only report the implications of domestic trade under the harmonization of regulations but also trade patterns under conditions in which no regulations are imposed. This allows us to obtain comparables of a possible quantity reduction of the EU harmonization of regulations on domestic trade.

3.1. The Empirical Model

Standard gravity equations are usually based on many specifications that sometimes include variables that do not have any theoretical grounds. Instead, we adapt a gravity specification of a model outlined in chapter 2 in order to capture the incidence of the harmonization of regulations on domestic trade. In that chapter, we have derived a functional form of the equation that is clearly defined such that misspecification is minimized. In addition to the core variables (income, distance, remoteness) the gravity specification is augmented with other trade determinants. These trade determinants have revealed a unique nature on characteristics of intra-EU trade applied to total manufacturing.

Here we simply outline the salient features of the model. The specification has the following form:

$$m_{ijkt} = \alpha_k + \beta_{11k} y_{it} + \beta_{12k} yc_{it} * y_{it} + \beta_{2k} y_{jt} + \delta_k d_{ij} + \mu_k AN_{ij} + \nu_k AL_{ij} + \rho_k r_{ijt} + \pi_k P_{ikt} + \lambda_k rulc_{ijt} + \eta_k H_{iik} + \varepsilon_{ijt} \quad , \qquad (1)$$

with time, $t = 1, \ldots T;$ k refers to the group of manufacturing sectors according to the six types of categories: m_{ij} is the volume (in logarithm) of imports by country i from country j; y_i is the level of (in logarithm) income (GDP) in country i; y_j is the level of (in logarithm) income (GDP) in country j; d_{ij} is the distance (in logarithm) between the trading centers of the two countries, AL_{ij} and AN_{ij} are dummies for when countries share the (i) same border effect and same language, and (ii) same border but different language, respectively; yc_i is the per-capita income in country i with reference to the per-capita income for the EU in 1995, H_{ii} captures the border effect by a dummy equal to 1 for domestic trade (when $i = j$) and 0 for international trade (when $i \neq j$).

We include two measures of competitiveness. P_{ik} captures a general component of competitiveness and is measured by the difference between the logs of the import unit prices and the GDP implicit deflators: (p_{it}^{y}-p_{ikt}^{m}). We also include a measure of competitiveness based on the relative unit labor costs, $rulc_{ijt}$, between the importing and exporting country, namely:

$$rulc_{ijt} = (ulc_{it}/\sum_h \omega_{ih} ulc_{ht})/(ulc_{jt}/\sum_h \omega_{jh} ulc_{ht}) \quad , \tag{2}$$

where ulc_i and ω_{ih} denotes respectively the unit labor cost of country i and the share of country h in total imports (of manufacturing goods) of country i.[3] The weights are computed from the average bilateral trades during the period (1990-1998).

To calculate the relative distance of trading partners (remoteness), r_{ij}, we define

$$r_{ij} = \ln\left(\frac{D_{ij}/Y_j}{\sum_{k \neq j} D_{ik}/Y_k}\right) \quad , \tag{3}$$

where the remoteness of country i in relation to trading partner j given as the ratio of the weighted distance between country i and country j divided by the weighted-average distance between country i and all trading partners other than j. The weights are given by the GDP of the trading partners.

4. Econometric Results

4.1. Estimation

We estimate the gravity model using an iterated maximum likelihood version of the generalized least squares allowing for random effects (GLS-RE). For the random ef-

[3] There were too many missing values in the Eurostat data for collecting unit labor costs by sectors.

fect, we decompose the error term in equation (1) in three unobserved components written as:

$$\varepsilon_{ijt} = \mu_i + \nu_j + \zeta_{ijt} \quad , \tag{4}$$

where μ_i and ν_j are the random unobserved effects of the importing and exporting country, respectively (at a given time); and ξ_{ijt} is a random component over countries and time.

In all subsequent regressions, we replace the predicted values of the GDPs (for each year and country) from a regression on several endowment measures that are used as instruments. The set of instruments are (i) the GDPs from the two previous years - this should be sufficiently to capture the variability from cyclical or temporary disturbances, (ii) current population and (iii) gross capital formation, as a proxy for investment, from the current and two previous years. The regression of the GDPs for each country is estimated between the periods 1982-2000.

4.2. Results

We now to turn to table 1 and apply the gravity model to two broad aggregates: column (1) an aggregate of sectors subject to new approach, old approach, mutual recognition and a small number of sectors where multiple harmonization approaches apply and (column 2) to those were technical regulations do not cause barriers to trade.

The overall fit is high in each regression and for most of the variables, standard errors are low. The importing and exporting elasticities are strongly significant and have the correct sign. For both groups, the own importing income elasticity (import demand) is larger than the elasticity of the exporting country (exporter's GDP reflects how large a range of products a country has to offer). This is consistent with the assumption that higher demand of imports is more sensitive to the home GDP than the foreign GDP. This effect is more pronounced for imports of sectors that are not regulated by technical barriers to trade. The effect that accounts for non-constant income elasticities ($yc_{it}*y_{it}$) is significant and has the expected negative sign in both samples. This effect is twice as large for imports subject to harmonization of technical regulations.

The estimated elasticity of imports with respect to distance, d_{ij}, is –0.90 and –0.40 respectively, for the group of sectors where harmonization of regulations is applied and the group of sectors were technical regulations do not cause barriers to trade. The general consensus of the distance variable in the literature is 0.6 (Leamer, 1997). Remoteness, r_{ij}, has the expected negative sign. The results on the coefficients of bilateral distance and remoteness suggest that differences in the effect of these two variables are more pronounced across both samples. It reveals that these variables intended to capture trade frictions other than those that are accounted for in our gravity model have a more dampening effect for trade in sectors that are regulated by EU harmonization. This result is somewhat consistent with the fact that trade in sectors that are not regulated by EU harmonization are characterized by a lesser degree of specialization or complexity. This may reflect an interpretation that for those sectors, there is a lower cost in transportability being captured by the bilateral distance variable.

The dummies for countries that share a same language and border (AL_{ij}) and same border but different language (AN_{ij}) are also found to be statistically significant, with the correct signs. These dummies have a slightly larger effect on imports of the group of sectors where TBTs are not present.[4]

Both coefficients that capture the competitiveness effects are statistically significant with a correct sign in both groups. A general effect of competitiveness, that is the index ratio of the GDP deflator and unit import prices, P_{ik}, is omitted in the estimation for the group of sectors where harmonization of regulations is applied and has an elasticity for 0.72% for the group of sectors were technical regulations do not cause barriers to trade. In the first regression, we omitted this variable since the coefficient of the ratio was significant not different from 1 (0.98). As a result, we re-estimated the regression using the GDP deflator as suggested from this result.

A bilateral effect captured by relative unit labor costs, $rulc_{ij}$, increases imports with an elasticity of 0.15% and 0.14% respectively for the group of sectors where harmonization of regulations is applied and the group of sectors were technical regulations do not cause barriers to trade. These results indicate that imports in sectors that are regulated by EU harmonization are more sensitive to differences between domestic and foreign price inflation while differences in a specific bilateral price effect, captured by relative unit labor costs, are less apparent between both groups.

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4 We assign zero to the two dummies for the observation that captures intra-national trade. This permits us to capture the border effect on intra-country trade by not taking into account the geographical effects of language and adjacency captured by the dummies (*AL*, *AN*).

The estimated parameters of the border effect, H_i, are large and strongly significant in both samples. We find that the border effect remains substantial for products where the EU has sought to introduce harmonized technical regulations to remove technical barriers to trade. It implies that domestic trade is 11.1 ($e^{2.41}$) times higher than the country's trade with its partners. On the other hand, we find a border effect of factor 11.5 for products where differences in technical regulations are not deemed to be important constraints upon intra-EU trade. The results suggest that harmonization of technical regulations cannot explain the variability of border effects. Nevertheless, we would expect that those industries where no TBTs persist would have a lower intensity of domestic trade than those industries where the EU has sought to introduce harmonized technical regulations so to remove TBTs.

In a somewhat related paper, similar conclusions are reached. Head and Mayer (2000) apply a gravity approach to 3-digit NACE data for the EU countries. They find that crude indicators of non-tariff barriers before and during the Single Market Program cannot explain the variation in the size of estimated border effects.[5]

Finally, we provide results for our three groups of products where harmonization of technical regulations are important grouped according to the approach adopted in the EU to the removal of technical barriers to trade (column 3-5) and for a small number of sectors where multiple harmonization approaches apply (column 6).

All the coefficients have the expected sign and a large variability is present among some of the coefficients. In all four categories, the income elasticities of both the importer and exporter are significant with the expected signs. Hence, the income effect of the exporter is exceptional large for sector regulated by multiple harmonization approaches and low for sectors regulated by mutual recognition. The effect that accounts for non-constant income elasticities has the expected negative sign and is significant, at the 95% confidence interval, for all groups except for mutual recognition. This effects is most pronounced for imports of sectors under the old approach, exactly those sectors that are somewhat dominated by the food industry and other traditional industries (chemicals, steel) that are characterized by a lesser degree of specialization. We

[5] The authors use two indirect measures of EU non-tariff barriers (NTBs). The first measure is based on a 1980s survey of EU firms conducted by the European Commission. From this survey, the authors construct three variables representing the magnitude of the NTBs in terms of standard differences, public procurement and customs formalities. The second set of indicators comes from Buigues *et al.* (1990), which classified European industries into three levels of barriers: low, moderate, and high.

return to this issue in section 5.1, were we re-estimate the gravity model on a more detailed level of sectors subjected to each harmonization approach.

In all four cases, bilateral distance and remoteness are strongly significant determinants of trade flows. The elasticities of these variables are unusual high for trade in sectors that are regulated by multiple harmonization approaches. The dummies for countries that share a same language and border (AL_{ij}) and same border but different language (AN_{ij}) are also found to be statistically significant except for the group of sectors where mutual recognition is applied.

The results on the coefficients of the competitiveness variables, P_i and $rulc_{ij}$, are statistically significant with expected signs in all four groups. Again, for the old approach sectors, this coefficient was not statistically different from 1 (1.007) and therefore omitted from the regression using the GDP deflator as an appropriate deflator for the dependent variable.

There is a much wider variability in the elasticities of unit labor costs ranging from 0.08 for new approach sectors to 0.27 for sectors regulated by mutual recognition while the coefficients that capture a general competitiveness range from 0.86 for sectors regulated by multiple harmonization approaches to 1.007 for old approach sectors.

The coefficient of the border effect is significantly positive but varies across categories. The coefficients of the border effects for new and old approach sectors are 2.7 and 2.6 respectively. A coefficient of 1.46 for the border effect for products under mutual recognition indicates the lowest intensity of domestic trade. The border effect for sectors that are regulated by a combination of harmonization approaches is 2.55. These results suggest that the presence of border effects is important but that the extent of this bias against trade with other EU countries varies according to the approach to the removal of technical barriers to trade.

4.3. Evolution over time

We now turn to the analysis of changes in border effects over time. In particular we are interested whether reduction in border effects occurred for sectors that are identified as being subjected to the harmonization of technical barriers to trade. Our method of estimating gravity model (1) imposes restrictions that the border effect and the intercept are the same for all time t. This model may be too restrictive because it assumes that the border effects that we obtain from table 1 are the same throughout the entire period.[6]

Table 2, in the appendix, summarizes the results of the four log-likelihood ratio tests (consistent with the test described in the previous chapter), undertaken for each regression subject to category *k*. .

The test reveals that none of the two restrictions are rejected with respect to the regressions on sectors that are subject to an aggregate of harmonization approaches, old approach and others. The restriction that the intercept is constant over time is rejected for sectors under the mutual recognition, new approach and no harmonization. The restriction that the border effect is the same over time is solely rejected for sectors under the new approach. We note that from the data (see chapter 5, section 2.1.2) the trade proportion of new approach sectors in sectors subject to an aggregate of harmonization approach is relatively small. This may explain why the restriction of constant border effects is not rejected in the latter group.

The year-by-year evolution of the border effect for sectors under the new approach is presented in table 3, where we employ a regression with intercepts and time-dependent border effects as suggested by the test. For the period 1990-1998, we observe that the border effects have decreased from of a coefficient of 3.06 to 1.98. Between 1992-1993 and 1997-1998, the new approach increases slightly. This result suggests that the intensity of internal trade relative to EU trade has decreased for new approach sectors; exactly those sectors were we would anticipate that the impact of harmonization would be most pronounced.

A final issue to note is that we find empirical evidence that the border effect for trade in sectors that are regulated by mutual recognition has the lowest level. This suggests that the application of the mutual recognition is a powerful tool in promoting cross-border integration in Europe. However, our results also indicate that the intensity of domestic trade relatively to EU bilateral trade remains unchanged for 1990-1998. We might have expected that over time, cross-border trade increases because it avoids the

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6 In Chapter 2, we do not reject the assumption that the restricted gravity model (1) is reasonable on an estimation of intra-EU bilateral trade of 'total manufacturing'. This assumption may not apply on a gravity model estimation of several groups of manufacturing sectors aggregated according to the several harmonization approaches that we consider in this paper.

systematic creation of harmonization rules under the old approach and to a lesser extent, the new approach.

This points out to some limitation of the application of the mutual recognition principle. Related literature (Brenton, 2002; CEC, 1999; CEC, 2000; Pelkmans, 1998) notes that there are still obstacles with the application of the MRP preventing full benefit of a Single Market from being gained. For example, a European commission's study (CEC, 2000) recognizes that difficulties with the application of the principle of mutual recognition appear particularly in the new technology sectors and for complex products. Brenton (2002) notes that the enforcement of mutual recognition can be a timely consuming process. CEC (1999) reports an average length of procedures for cases of infringement of mutual recognition of 15.5 months (Brenton, 2002). According to Pelkmans (1998), the application of the mutual recognition is demanding because its credibility in the market place critically hinges on very extensive monitoring, accessibility of the monitoring authority for complaints and the legal and manpower capacity to impose legal and easy-access to justice. This reflects, in part, a lack of confidence in acts adopted by the authorities of the member states and administrative delays.

5. Diagnostics

As a further diagnostic, we also re-estimated gravity model (1) according to the specification that has been suggested by the likelihood-ratio tests on the sample of non-technical regulations and mutual recognition sectors. The coefficient of the border effect is 2.46 for the sample of non-technical regulations and 1.54 for the mutual recognition sample. When this is measured against the estimates of the most restricted estimation (see table 1) yielding coefficients of 2.45 and 1.46, respectively, it is clear that our estimates of the border effect are robust.

We also compared the other coefficients including for the regression on new approach sectors to those we obtained from the restricted model (from table 1). The most notable change occurs in the sample of new approach sectors: the income elasticity of the exporting country is 1.07 measured against .82 from the restricted model.

5.1. Test on a more disaggregated analysis

In table 4 of the appendix, we re-estimated the gravity model on a very few number of sectors that have a similar nature of characteristics within each harmonization approach. We are merely interested to see how the coefficients on the various variables would change and are validated when we consider a much more detailed level of aggregation. From the table, it is inferred that there is a much larger variability of the various coefficients of each variable. With few exceptions of some coefficients, all coefficients retain the expected sign and are significantly different from zero.

Of main interest, the border coefficient shows a much larger variability within each category. In particular, basic chemicals, being regulated by mutual recognition, have a border coefficient that is not significantly different from zero. The border effect for the machinery sectors being regulated by the new approach is considerably large while those for the food sectors (old approach) and footwear, leather, wool, cotton (no regulation) have a coefficient of 1.48 and 1.79 respectively.

Some differences between those sectors regulated by one of the harmonization approaches and those that are not regulated become more apparent. The effect of bilateral distances is more pronounced for those sectors that are regulated by each of the harmonization approaches. This is consistent with the finding from the previous section.

The income elasticities are much more pronounced for machinery and basic chemicals. The per-capita own income elasticity is declining for those sectors that are regulated by each of the harmonization approach. Labeling machinery, as a (relative) much more specialized sector, shows the slowest declining income elasticity. The results that we obtained in this table reveal that generally speaking, all other coefficients retain the expected sign with low standard errors.

6. Summary of the Results and Conclusion

Our results suggest that the impact of policy related barriers such as harmonization of technical regulations are of relatively minor importance in explaining the variability of border effects between sectors where harmonization approaches are present and sectors where differences in technical regulations are not thought to be important barriers to trade. The presence of large border effects found in each of these two categories does not exhibit any declining trend.

Secondly, evidence suggests some degree of variability of the level of border effects across each group of sectors that are regulated by a type of harmonization approach. We find that sectors where harmonization of regulations are of minor importance, mutual recognition, exhibit small border effects. Old approach sectors where there have been substantial efforts to remove regulatory barriers to trade still reflect large border effects. In addition, the border effect of these sectors has remained constant over time. New approach sectors where the harmonization of regulations is less complicated exhibit an increasing trend of cross-border integration.

For EU policy, this provides some insights to what extent the approaches that they have adopted are successfully removing technical barriers to trade and integrating European markets. It is apparent that the application of the mutual recognition plays an important role in limiting the extent of cross-border constraints and a more effectively implementation of this approach would clearly result in additional gains over time. The same is true for the new approach. We find that efforts to remove technical barriers in these sectors have led to less intra-national trade during the period of analysis. An important implication of these two results is that a higher degree of market integration has been possible for sectors that are regulated by EU policies that require the lowest degree of complicated harmonization procedures.

At present, we would conclude that the presence of border effects appear to be relatively robust. These results do suggest that policy factors such as harmonization of technical regulations do reveal some importance in evaluating the presence of border effects. However, harmonization of technical regulations can not be the only factor since we find substantial and persistent border effects for sectors where technical regulations are not important. The key issue regarding the estimated levels of the border effect is that we accounted for a large set of other economic factors in the specification of the gravity model. These other economic factors have been derived from an exercise on validating a functional form of the gravity model that contains persuasive trade determinants that are typical to intra-European trade.

In addition, comparing the coefficient of each of these determinants including the border effects with different samples of manufacturing sectors, has revealed important information on the gravity equation applied to intra-EU trade. The general conclusion is that in practice our gravity equation can be estimated on different levels of aggregated data: (i) total manufacturing sectors and (ii) several sub-groups of manufacturing sectors.

APPENDIX

Table 1: Gravity Estimates of Groups of Sectors regulated by the different Harmonization Approaches

	Technical Regulations (1)	No Technical Regulations (2)	New Approach (3)	Mutual Recognition (4)	Old Approach (5)	Other Technical Regulations (6)
y_i	0.87	0.82	0.83	0.86	0.97	0.87
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
y_j	0.74	0.49	0.82	0.57	0.72	1.03
	(0.03)	(0.03)	(0.05)	(0.04)	(0.05)	(0.04)
$yc_i * y_i$	-0.025	-0.012	-0.039	-0.009	-0.065	-0.036
	(0.004)	(0.005)	(0.006)	(0.005)	(0.006)	(0.006)
d_{ij}	-0.90	-0.40	-0.81	-0.93	-0.84	-1.38
	(0.04)	(0.05)	(0.07)	(0.06)	(0.06)	(0.06)
AN_{ij}	0.16	0.21	0.31	0.05	0.25	0.21
	(0.06)	(0.06)	(0.08)	(0.07)	(0.09)	(0.10)
AL_{ij}	0.45	0.59	0.74	0.07	0.60	0.44
	(0.09)	(0.10)	(0.12)	(0.10)	(0.12)	(0.11)
r_{ij}	-0.50	-0.34	-0.82	-0.57	-0.36	-1.02
	(0.07)	(0.08)	(0.12)	(0.10)	(0.11)	(0.09)
$rulc_{ij}$	0.15	0.14	0.08	0.27	0.14	0.12
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
P_i	-[c]	0.72	0.87	0.91	-	0.86
		(0.06)	(0.08)	(0.06)		(0.06)
H_i	2.41	2.45	2.73	1.46	2.61	2.55
	(0.09)	(0.10)	(0.14)	(0.10)	(0.12)	(0.11)
Intercept	-4.42	-7.66	-10.13	-3.12	-8.44	-5.61
	(0.45)	(0.50)	(0.63)	(0.54)	(0.62)	(0.58)
Random effects (variance)						
σ^2_μ	0.22	0.21	0.04	0.06	0.40	0.34
$\sigma^2\nu$	0.40	0.43	0.37	0.46	0.34	0.40
$\sigma^2\xi$	0.17	0.25	0.18	0.06	0.18	0.18
R^2 [(a)]	0.92	0.90	0.87	0.88	0.88	0.89
[(b)] Test unobserved effects	0.83	0.69	0.69	0.89	0.80	0.80
Observations	1260	1260	1260	1260	1260	1260
Estimation Method	RE-GLS	RE-GLS	RE-GLS	RE-GLS	RE-GLS	RE-GLS

Notes: Standard errors are reported in parentheses. (a) R^2 is the squared correlation between actual and predicted values. (b) Test for unobserved, random effects: $(\sigma^2_\mu + \sigma^2\nu)/\sigma^2_\mu + \sigma^2\nu + \sigma^2\xi) > 0$ (See Wooldridge, 2002, pp. 259). (c) For the groups that comprise an aggregated of Technical Regulations and the Old Approach Products, the price index ratio, Pi, is not statistically different from 1 (their values are 0.98 and 1.007 respectively). We therefore dropped this variable from the regression and deflated the dependent variable using the GDP deflator.

Table 2: Likelihood Ratio Tests

	Technical Regulations	No Technical Regulations	New Approach	Mutual Recognition	Old Approach	Other Technical Regulations
α_{kt} ; η_{kt} against α_{kt} ; η_k	11.54	7.66	**19.47**	3.79	10.50	6.63
	(.17)	(.46)	(.01)	(.87)	(.23)	(.57)
α_{kt} ; η_{kt} against α_k ; η_{kt}	3.57	**22.05**	**34.43**	**33.48**	0.67	3.45
	(.89)	(.00)	(.00)	(.00)	(.99)	(.90)
α_{kt} ; η_k against α_k ; η_k	2.36	**59.67**	-	**17.55**	1.71	1.71
	(.96)	(.00)		(.02)	(.99)	(.99)
α_k ; η_{kt} against α_k ; η_k	10.38	-	-		11.53	7.07
	(.24)				(.17)	(.52)

Notes: The table list the χ^2 distribution with 8 degrees of freedom. P- values of the significance level are reported in parentheses.

Table 3: Evolution of border effect for New Approach sectors, 1990-1998

	Border Effect
1990	3.06
1991	2.78
1992	2.67
1993	2.71
1994	2.43
1995	2.19
1996	1.98
1997	1.87
1998	1.98

Notes: The table list the coefficient of the border effect, H_i, multiplied by a time dummy for each year between 1990-1998. The coefficients are obtained from regressing gravity model (1) augmented with time-dependent intercepts. Not reported in the table, all coefficients are significant at 95% significance level.

Table 4: Gravity Estimates of Groups of related sectors regulated by Different Harmonization Approaches.

	(i) No regulation Footwear, Leather, Wool, Cotton[1]	(ii) New Approach Machinery	(iii) Old Approach Processed Food	(iv) Mutual Recognition Basic Chemicals
y_i	0.67	0.87	0.90	0.79
	(0.04)	(0.04)	(0.03)	(0.04)
y_j	0.62	1.56	0.83	1.53
	(0.06)	(0.08)	(0.07)	(0.10)
$yc_i * y_i$	0.022	-0.05	-0.10	-0.13
	(0.012)	(0.012)	(0.01)	(0.01)
d_{ij}	-0.90	-1.61	-1.47	-1.40
	(0.11)	(0.11)	(0.10)	(0.12)
AN_{ij}	0.08	0.11	0.73	0.59
	(0.16)	(0.16)	(0.14)	(0.17)
AL_{ij}	0.10	0.26	0.98	0.54
	(0.04)	(0.24)	(0.21)	(0.26)
r_{ij}	-1.45	-1.59	-0.75	-1.48
	(0.20)	(0.20)	(0.18)	(0.25)
$rulc_{ij}$	0.39	0.13	0.11	0.16
	(0.04)	(0.04)	(0.03)	(0.05)
P_i	0.87	0.50	0.71	0.40
	(0.13)	(0.13)	(0.11)	(0.14)
H_i	1.79	3.23	1.48	0.29
	(0.23)	(0.22)	(0.20)	(0.24)
Intercept	-10.14	-11.35	-5.39	-6.94
	(1.23)	(1.19)	(1.06)	(1.28)
Random effects (variance)				
σ^2_μ	0.40	0.40	0.33	0.40
$\sigma^2\nu$	0.58	0.58	0.44	0.60
$\sigma^2\xi$	0.18	0.18	0.17	0.11
L	-995.903	-975.31	-895.40	-998.29
Observations	1260	1260	1260	1260
Estimation Method	**RE-GLS**	**RE-GLS**	**RE-GLS**	**RE-GLS**

Notes: NACE codes are for (i) 431, 432, 433, 435, 441, 442, 451 (ii) 321, 322, 323, 324, 325, 326, 327 (iii) 412, 413, 414, 415, 416, 417, 418, 419, 421 (iv) 251

CHAPTER IV

ENVIRONMENTAL POLICY AND TRADE IN AN ENLARGED EUROPE: AN EMPIRICAL ASSESSMENT

1. Introduction

A number of recent econometric studies suggest to date that the impact of domestic environmental regulations[1] on trade has been small. The tested hypothesis on trade and environmental regulations is an implication of most theoretical work that has shown that a weakening of domestic environmental regulations (considered as a comparative advantage due to a cost advantage) increases a country's exports or decreases a country's imports (see Copeland and Taylor, 2003, for a review of the theoretical literature). There are two main kinds of empirical evidence advanced. First, it is noted that the cost of meeting environmental regulations form a small part of total costs of production. For example, in the 24 most polluting industries in the US, Tobey (1990) found that environmental regulations accounted for 1.92% - 2.8% of total costs. Second, there have been (mainly US) studies that found support for the prediction that domestic environmental regulations have a larger effect on trade when they are treated as endogenous.

The view that environmental regulations should be set endogenously is rooted in the literature of endogenous protection (e.g. Trefler, 1993). According to this literature, trade liberalization will put pressure on governments to weaken environmental policy to help firms in response to an increase of trade competitiveness. For example, Ederington and Minier (2003) found evidence that after explicitly controlling for the endogeneity of domestic environmental policy (i) more stringent environmental policies act as a barrier to trade and (ii) domestic environmental policy is responsive to pressures from increasing trade liberalization effects.

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[1] We treat domestic environmental regulations, domestic environmental standards, and cost of domestic environmental protection synonymously.

In this paper, we analyze the link between environmental policy and trade with particular reference to Europe. There are two points that we address. The first, rather obvious point is to test how the level of domestic environmental regulations has impacted trade. The second point we want to focus on is the question of whether governments (countries) may wish to weaken their environmental policies in order to achieve trade objectives. In particularly, we look how national environmental policies and harmonized environmental regulations at the EU level have collided and influenced trade.

Inferences made in the case of the movement towards harmonization, as in the EU, are not straightforward. If we view the harmonization of EU environmental regulations purely as a trade instrument, its impact on domestic environmental regulations would be according to the prediction of the theory of endogenous protection substitutable: namely, more harmonized environmental regulations (= reduction of technical barriers to trade and hence, more exports) would lead governments to reduce the level of their domestic environmental protection. However, the link between EU harmonized regulations and initiatives at the domestic level are more than a trading instrument.

In recent years, the EU has recognized that the "trade-promoting effect of harmonized regulations coupled with growing environmental challenges and greater environmental awareness at the national level should no longer move along separate paths but should reveal some degree of synergy" (CEC, 1999).[2] This anecdotal evidence suggests that trade and environmental policy are linked through the harmonization of EU environmental regulations because more specific legislative instruments, intended to ensure both the protection of the environment and free trade are incorporated in the harmonization of environmental regulations.[3]

With particular reference to the completion of the Single market, the interaction between domestic and harmonized environmental regulations at the EU level tend to reduce the flexibility to lower or increase the stringency of domestic regulations since it is bounded between a certain minimum and maximum level. In other words, member countries may lower their own environmental standards to e.g. the lowest common denominator of an individual member state, conformed to a minimum EU standard.[4] These minimum EU standards set a regulatory floor that ensures that all member states require at least a baseline level of envi-

[2] See http://europa.eu.int/internal_market/en/update/general/263en.pdf (June, 1999)

[3] In section 2, we review some of the areas where the legislation of the EU Environmental Policy has incorporated are greater awareness to environmental protection.

[4] See Esty and Gerardin (1997) for a general discussion on the environmental policy in the EU

ronmental protection of their industries. On the other hand, domestic governments may also have economic incentives to adopt stricter domestic regulations in light of the Single market.[5] However, these are bounded up to a certain level such that these initiatives do not restrict intra-EU trade. In the context of EU enlargement, such incentives are straightforward because EU policy has been oriented towards a number of Central and Eastern European countries (CEEC) countries to adopt more stringent process and product regulations in order to conform to the EU.[6]

To address this analysis, we estimate a system of simultaneous equations: an equation modeling the impact of domestic environmental regulations on exports and an equation modeling the determination of exports and the harmonization of EU environmental regulations on domestic environmental regulations. A special attention is given to the fact that in the context of CEEC enlargement, an asymmetric nature exists related to the environmental policy both at the EU and national level.

In order to discern the impact of the harmonization of environmental standards and evaluate the cost of complying with domestic environmental regulations, we use a constructed database drawn from two sources. The data on EU environmental regulations come from the detailed study undertaken for the Commission's review of the impact of the Single Market in the EU. We measure the incidence of the harmonization of EU standards on trade that differentiate sectors according to a European classification, which specifically identifies sectors where the EU has sought to introduce the harmonization of environmental regulations. In order to calculate the compliance cost with domestic environmental regulations, we use an indicator of the economic resources spent on environmental protection in total manufacturing. This data comes from Eurostat (Newcronos) and is available for some European and Central

[5] Stricter domestic standards may also create advantages solely at the national level. For example, Vogel (1999) notes "stricter environmental regulations may not make a nation poorer, neither do they make it richer; greater wealth leads to a preference for strong regulatory standards, not the reverse…". In addition, the same author argues that stricter environmental regulations can improve the public benefits (e.g. better health leads to productivity, reduction of health-care expenditures) and if such environmental regulations are seen as a form of collective consumption, then "many citizens in relatively affluent countries would be expected to increase their consumption of such goods, even at the price of some reductions in their levels of private consumption".

[6] There is also some theoretical support for initiatives of governments to adopt stricter domestic regulations when being part of a regional integration agreement. Alpay (2000) highlight the incentive to adopt more stringent environmental policies so to favorably influence world prices. In a more recent paper, Gulati (2003) assumes that the adoption of free trade agreement of a small country implies exogenous prices and no control of domestic rates of protection. In such a framework, the author shows that stricter domestic environmental policies (e.g. pollution taxes) passed on producers (exporters) has an *efficient effect* and can improve the environment.

Eastern countries. In chapter 5, we describe the sources of the data that are analyzed and discuss some graphs.

The paper continues in section 2 by discussing EU and CEEC policies of environmental regulations. In section 3, we present a brief literature review. In section 4 we discuss our empirical model. The results and conclusions are presented in the final sections.

2. Environmental Policy in EU and Candidate Countries

In the context of environmental policy in EU and CEEC candidate countries, the objective of preserving free trade within the Single Market and promoting environmental protection presents a great challenge (Bailey, 1999). With the completion of the Single market, the European Commission (EC) has used the harmonization of environmental standards as a strategy to eliminate environmental obstacles to trade. In the process of harmonization initiatives, directives are then adopted, which require member and candidate member states to replace national regulations by harmonized procedures and standards.

In recent years, the EC has increasingly relied on the "new approach" to harmonization.[7] The central characteristic of the "new approach" is that it limits harmonization to the EC level of "essential requirements" necessary to ensure the free movement of a product. If a product meets these specifications, it benefits from the presumption that it satisfies the EC's essential requirements and thus should be allowed to circulate freely throughout the EU. The EC has, for example, adopted total harmonization in the areas of waste and packaging waste, chemicals, vehicle emission standards, machinery, etc.

However, the EC has also become increasingly sensitive to environmental objectives that do not specifically have an economic motivation.[8] Within this context, these environmental objectives should not prevent member states from adopting legitimate environmental standards through the principle of subsidiarity which allows member states to introduce further the restrictions to protect the environment. With this principle of subsidiarity, the environmental policy in the EU has allowed member states to retain considerable control (or sovereignty) to the domestic implementation that has been agreed in the environmental objectives of the EU program. As a result, member states may maintain or introduce more or less stringent protection measures as long as (i) these initiatives do not restrict trade in the EU; and

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[7] Noted in the report "Efficiency and accountability in European standardization under the new approach", COM (1998) Final.

[8] Article 130 declared, "environmental protection requirements shall be a component of the Community's other policies" (CEC, 1995).

(ii) are conform to a minimum level of domestic environmental protection defined by the EC.

In recent years, the EC has undertaken many initiatives in order to achieve a high degree of environmental protection and to preserve free trade in the EU. For example, in the area of Waste, Directive 94/62 defines the essential requirements regarding waste packaging and sets targets for the recovery and recycling of packaging waste. In the area of chemicals, Directive 88/379 known as the “Preparation Directive”, rules have been introduced for the gaseous preparation for safety data sheets and child resistance fastenings. Directive 93/67 sets up harmonized risk assessment procedures to be followed by manufacturers and importers for all new chemical substances that they place on the market. In the area of vehicles, Directive 94/414 limits the emissions of motor vehicles and new rules are, in co-operation of stakeholders in member states, frequently updated. The EC has also adopted an eco-labeling scheme designed to inform consumers about the environmental qualities of products and to ensure that these products achieve high levels of environmental friendliness. This policy, however, does not override national eco-label schemes.

2.1. The Green Acquis

In the forthcoming enlargement, the environmental protection procedure does not perfectly coincide between the EU and CEEC countries. This relates to the EC’s believe that “there is a gap between the level of environmental protection in CEEC countries compared with the situation in the EU” (CEC, 2000). Dziegielewska (1999) notes that the “EU countries are mainly concerned with global environmental problems, such as decreasing greenhouse gas emissions, ozone-layer protection, acidification reductions, etc. while the candidate countries are primarily interested in solving the most pressing local environmental problems such as, waste, lead reductions.”

The candidate countries’ policies aimed at the protection of the domestic environment is far more integrated and guided by the EU guidelines than the current members. In order to retain environment sustainability, the EU has adopted the environmental acquis which relates to a compliance procedure with environmental regulations (aimed at the environmental protection) that need to be transposed in the national regulations of the candidate countries. In practice, it imposes major physical investments from candidate countries related to relatively few directives, with the most costly ones related to water, pollution control and power.[9] Meeting the acquis is a condition for EU membership. However, the approximation to the

[9] See Hager (2002, pp. 5) for a list of all the Directives that are related to the acquis.

environmental regulations is a continuing process where problems and priorities are addressed during and after the accession period. The compliance cost as a result of meeting the acquis is estimated between 2% to 3% of the GDP and are borne by both the private industry and the public sector. These costs will be partially compensated by the European Union. It is expected that the EU covers about 10% to 20% of the national expenditures in the environmental sector (CEC, 1999).

3. Literature

In this section, we mainly focus on the evidence from empirical literature of linking environmental policy on trade flows in an endogenous setting. This literature predicts that domestic governments may have incentives to manipulate environmental policy to help domestic firms in response to trade liberalization. This suggests that environmental policy can be used as a trade instrument to protect industries (second-best trade models, endogenous protection). For these reasons, previous work that treated environmental policy as exogenous was getting biased results. If trade considerations play a role in the setting of environmental regulations as is assumed by second-best trade models (Gawande, 1999; Trefler, 1993), these regulations should be treated as endogenous.

The endogeneity of environmental domestic regulations are accounted for by estimating a simultaneous equation where in the first stage of the estimation a set of instruments are used that account for government instruments that proxy a trade liberalization effect such as tariffs, non-tariff barriers, etc. The evidence indicates that after explicitly controlling for the endogeneity of domestic environmental policy, more stringent environmental policies act as a barrier to trade. These results were in contrast with earlier findings (Tobey, 1990; Van Beers and van Bergh, 1997; Harris *et al*., 2000) that did not account for the endogeneity of domestic environmental regulations and found that environmental policies across countries or sectors have minor effects on trade flows.

The concern that regulations will be relaxed in industries that face significant foreign competition is motivated by a seminal empirical paper of Trefler (1993) who notes that empirical research has found only a small impact of tariff reductions on trade flows. He suggests that it arises from treating trade barriers as exogenous. Trefler (1993) finds that when non-tariff barriers are treated as endogenous, the impact of NTBs on imports is 10 times higher. Gawande (1999) finds evidence that governments do substitute higher levels of NTBs for a loss in tariff protection. A tariff cut by 10 % raises the price NTB coverage with 7% while the quantity NTB coverage would go up with 13.2%.

With particular reference to environmental regulations, Levinson and Taylor (2002) present a simple model with endogenous environmental policy and suggest an empirical strategy testing for the impact of regulations on trade flows. They estimate a simultaneous model similar to Trefler (1993) and show that when the environmental policy is treated as exogenous it does not explain exports. However, when they treat abatement costs as endogenous, the ambiguity disappears and more stringent regulations lower net exports significantly.

Similarly, Ederington and Minier (2003) carry out an exercise using imports from a cross-section of all US manufacturing industries. The authors find that environmental regulations (measured as the share of abatement costs in total costs) have a significant but very minor effect on trade flows. A 1% change in costs raises import penetration by 0.53% points. In contrast, a three-stage least squares estimation (3SLS) which accounts for the endogeneity, yields an elasticity of 35. The authors also find evidence that environmental policy is being used as an indirect instrument for protecting industries since import penetration has a negative effect over environmental policy. This is consistent with the prediction that environmental policy is responsive to pressures from increasing trade liberalization effects.

Antweiler *et al.* (2001) study theoretically and empirically the effect of trade openness on pollution levels into scale, technique and composition effects. In their study, whereas all countries will set stricter environmental policies due to income and output increases following trade liberalization, the total effect depends on factor endowments. The authors provide evidence that the overall trade openness has a negative impact on the pollution level.

Fredericksson and Mani (2003) develop a testable theory of how environmental policy is affected by the degree of trade integration and level of political turbulence in countries with high level of corruption. They test and empirically confirm the hypothesis that trade integration raises the stringency of environmental policy but that this effect disappears as the level of political uncertainty rises.

4. The Empirical Model

In this section, we describe the specifications of the export equation and the domestic environmental regulation equation taking into account the EU harmonization of environmental regulations.

4.1. The Export Equation

The empirical literature on testing the trade effects of the domestic environmental regulations has mainly followed the standard Heckscher-Ohlin model of trade, which is driven by differences in factor endowments (for example, Tobey, 1990; Van Beers and van den Bergh, 1997; Harris *et al*., 2002; Xu, 2000). Anderson (1979) and Bergstrand (1989, 1990) have theoretically validated the consistency of the gravity model with factor endowment differences. Helpman and Krugman (1985) have derived a gravity equation from a monopolistic competition framework while Deardorff (1995) complemented the Heckscher-Ohlin interpretation with intra-industry from which a gravity model has been reconciled.[10]

Typically in a log-linear form, the model considers that the volume of trade is promoted by their economic size (income) and constrained by their geographic distances. Other characteristics of counties can easily be added. For example, Frankel *et al.* (1995) add dummy variables for common language and common border. Deardorff (1995) argues that the relative distance of trading partners should also have an impact on the volume of trade. Wei (1996) and Helliwell (1997) extend this concept and define 'remoteness variable' that captures third country effects.

To estimate the effect of environmental regulations on trade flows, we adapt a gravity specification that is similar to the model outlined in chapter 2. The specification has the following form:

$$x_{ijt} = \alpha + \eta\, c_{it} + \nu\, AD_{ij} + \beta_1 y_{it} + \beta_2 y_{jt} + \rho\, r_{ijt} + \delta\, d_{ij} + \lambda\, rulc_{ijt,} + \varepsilon_{ijt} \quad , \qquad (1)$$

with time, $t = 1, \ldots T$: x_{ij} is the value of exports by country i to country j; y_i is the level of income (GDP) in country i; y_j is the level of income (GDP) in country j; d_{ij} is the distance between the trading centers of the two countries, AD_{ij} is a dummy variables to reflect the effects of adjacency (border) between i and j, and $\mathbf{c_i}$ measures the share of the cost of environmental protection (compliance with domestic environmental regulations) in production (of total manufacturing) of country i. All continuous variables are expressed in logarithms.

To calculate the relative distance of trading partners (remoteness), r_{ij}, we define:

$$r_{ij} = \ln\left(\frac{D_{ij}/Y_j}{\sum_{k \neq j} D_{ik}/Y_k} \right) \quad , \qquad (2)$$

where the remoteness of country i in relation to trading partner j is given as the ratio of the weighted distance between country i and country j divided by the weighted average distance

[10] In a theoretical derivation of the gravity model, Deardorff (1995) relaxes the assumption that factor prices are equalized between countries, so that countries specialize in producing different goods. This highlights the key that is that countries produce different goods (not necessarily different ones); whether they do so because of product differentiation by monopolistic competition or merely because of the H-O model with perfect specialization.

between country i and all trading partners other than j. The weights are given by the GDP of the trading partners. This new remoteness measure is expected to give a negative sign since for a given distance from other countries k, greater bilateral distance reduces trade while for a given bilateral distance, greater distance from other countries increases trade.

Although generally ignored in the empirical gravity literature - with the exception of Bergstrand (1989) - the model should theoretically also take into account price competition because of the heterogeneous competition which characterizes trade flows. We include a measure of competitiveness based on the relative unit labor costs, $rulc_{ij}$, between the exporting and importing countries, namely:

$$rulc_{ij} = (ulc_i/\sum_k \omega_{ik} ulc_k) \,/\, (ulc_j/\sum_k \omega_{jk} ulc_k) \,, \qquad (3)$$

where ulc_i and ω_{ik} denotes respectively the unit labor cost of country i and the share of country k in total export (of manufacturing goods) of country i. We use the average bilateral trades during the period (1995-2000) as the weighting factor. A relative loss in the competitiveness of the exporting country should decrease its exports.

4.2. The Domestic Environmental Regulation Equation

It is feasible, for instance, that if exports were declining due to stringent environmental regulations, the reaction of the government may be to reduce the stringency of the regulations to boost the trade competitiveness of these industries. In such a situation, it is necessary to estimate simultaneous equations, whereby the impact of regulations on net exports is estimated in a manner that controls for simultaneity between these two variables.

An important feature we would like to investigate is whether the revealed synergy between the harmonization of EU environmental regulations and the level of the domestic environmental protection may have impacted trade. To do so, we instrument the domestic environmental protection variable with an EU policy variable that captures the harmonization of EU environmental regulations. We follow the empirical studies on endogenous protection in assuming that this function can be approximated by a linear regression. This function is written as:

$$c_{it} = \alpha + \sigma \bar{s}_{ijt} + \delta\, x_{ijt} + Z'\theta + \eta_{ijt} \,, \qquad (4)$$

where c_i measures the domestic environmental regulations, $\bar{s}_{ij}$ is a coverage ratio that is equal to the percentage of sectors that are covered by EU harmonization of environmental regulations and x_{ij} is the exports of manufacturing. Z' is a set of additional variables that we will motivate below. All variables, except for the coverage ratio, $\bar{s}_{ij}$, are expressed in logarithms.

In equation (4), a trade liberalization effect is separated out by two variables. Typically to the Single market, the instrument that presents the coverage ratio, $\bar{s}_{ij}$, equals to the percentage of exports in manufacturing that aggregates all the sectors that are subjected to an elimination of so called technical barriers that may arise when they are differences in environmental regulations across countries (see chapter 5 for the construction of this variable). This is the first instrument that accounts for a trade-liberalization effect in the Single market. A priori, we do not have an expected sign on σ. A negative sign would indicate that more harmonized environmental regulations would reduce the level of environmental protection which is in support of the prediction of the theory of endogenous protection. In this context of EU environmental regulations, member countries may lower or substitute their own environmental standards to, e.g. the lowest common denominator of an individual member state and still gain from the trade advantage of more harmonized environmental regulations. A second (standard) instrument that accounts for higher trade is exports, x_{ij}, and again, based on the literature of endogenous protection, we expect a negative correlation between exports and the level of domestic environmental protection (e.g. $\delta < 0$). This variable is intended to capture higher exports that would occur for other non-accounted trade liberalization measures.

Energy consumption (in industry), total investment (in tangible goods), lagged value-added (in manufacturing) and public expenditure of environmental protection (in manufacturing) are the other explanatory variables that we add in equation (4). It may well be that an increase in energy consumption leads to an increase in CO2 emissions, which may lead to higher levels of domestic environmental protection aimed at innovative and environment-friendlier activities. The impact of the public expenditure of environmental protection on industry expenditure depends partially on how this activity is organized within a country. For example, in the area of waste collection, which constitutes about 1/3 of the public sector spending, in some countries there is a tendency to privatize these activities. The other major part of the public spending includes regulation, control and surveillance which may be correlated with higher spending by the private industry. The data reveals that for CEEC countries the public sector expenditure is slightly above the EU average (as a percentage of GDP), which conforms to the context of enlargement and EU policies. We control for such differences between EU and CEEC countries in equation (4).

5. Econometric Results

5.1. Estimation

Parallel to the search for a solid theoretical foundation, researchers have also investigated the econometric issues linked to the estimation of a gravity model. In a series of papers, Mátyás (1997, 1998), Egger (2000, 2001), and Cheng and Wall (1999) have used the advantages of panel techniques to test the trade determinants using the gravity equation. The pooled analysis then concerns the possibility to capture a variation between three dimensions: a two dimensional effect between importing and exporting countries and a time dimension.

With panel data it is not clear, at least a priori, if one should estimate a random or a fixed country effects model. Mátyás (1997) assumed that the effects were observable from the data and therefore adopted a fixed effect approach. However, the same author (Mátyás, 1998) noted that the choice between random or fixed effects is rather subjective and suggests using a random effect if the number of countries is large.

In this paper, we estimate the gravity model using an iterated maximum likelihood version of the generalized least squares allowing for random effects (GLS-RE) in which we address the endogeneity by applying a two stage least squares allowing for random effects (2S-GLS-RE). For the random effect, we decompose the error term in equation (1) in three unobserved components written as:

$$\varepsilon_{ij} = \mu_i + \nu_j + \zeta_{ijt} \quad , \qquad (5)$$

where μ_i and ν_j are the random unobserved effects of the exporting and importing country respectively (at a given time); and ξ_{ijt} is a random component over countries and time.

In general with the estimation of standard gravity models, an additional endogeneity concern arises between GDPs and exports since the error term, ε_{ijt}, is presumably correlated with y_i and y_j. In all subsequent regression, we replace the predicted values of the GDPs (for each year and country) from a regression on several endowment measures that are used as instruments. The set of instruments are (i) the GDPs from the two previous years - this should be sufficiently in capturing the variability from cyclical or temporary disturbances, (ii) current population, and (iii) gross capital formation from the current and two previous years. The regression of the GDPs for each country is estimated between the periods: 1982-2000.

5.2. Results

It is insightful to first compare our results to the general literature that estimated a gravity variant of equation (1) wherein the level of domestic environmental protection is treated as exogenous (Tobey, 1990; Van Beers and van den Bergh, 1997; Harris *et al.*, 2002; Xu, 2000). Next, we simultaneously estimate equation (1) and equation (4) to allow for the endogeneity between exports and the level of domestic environmental protection, c_i, using the 2S-GLS-RE. Equation (1) tests the hypothesis that if domestic environmental policies, c_i, are a source of reducing comparative advantage then its sign should be negative and significant while equation (4) extends the hypothesis that the level of domestic environmental protection may be reduced when exports increase. In equation (4), the sign of the coverage ratio of EU harmonized environmental regulations, $\bar{s}_{ijt}$, on the level of domestic environmental regulations is *a priori* not determined. As we have previously discussed, the effect of EU harmonization of environmental regulations may have a positive or negative effect on the level of the domestic environment regulations. To capture the asymmetry between EU and CEEC environmental regulations, we interact a CEEC (if country i = CEEC) dummy with some of the variables. Table 1 presents the results for the GLS-RE and the 2S-GLS-RE of equation (1). We also present the results of the first stage estimation of the domestic environmental regulation equation (4).

In the GLS-RE estimate of equation (1) reported in column (1), all the coefficients have the expected signs and the model has a high R^2 of .89. The core variables of the gravity model (GDPs, distance) are highly significant and yield results that are in line with previous literature studies. On average a 1% increase in distance reduces bilateral trade by 1.1% and is somewhat higher to previous studies where the consensus estimate is 0.6.[11] The other geographic variables (remoteness and adjacency) are also very significant with the expected signs. Exporting and importing countries that share the same border increase trade 1.18 (= exp (.17)) times while a 1% increase in the relative distance to other trading partners reduces exports with .65%. The strong significance of the relative unit labor costs indicates an important export price determinant. On average, a 1% increase in relative unit labor costs decreases exports with .37%. The coefficient of the domestic environmental regulation variable, c_i, is negative and statistically significant at the 1% confidence level. In contrast with previous literature that have employed a variant of the gravity equation we do find evidence

[11] Chen (2004) suggests that reported distance coefficients that are much higher than the general agreed 0.6 elasticity could be explained by the use of different transport modes. For example, in the European Union, in 1998, 57.8% of total intra-EU trade went by road whereas most global trade is transported over sea.

that the cost of complying with domestic environmental regulations lowers exports and provides a source of comparative disadvantage. However, the estimate suggests that this effect is small. We are not aware of any other studies that have solely focused on the EU however some U.S. studies (Ederington and Minier, 2003; Robison, 1988) report elasticities between .5% and 1.3%. Our estimate implies that an increase of 1 percentage point in the level of domestic environmental regulations could expect exports to fall by .10 of a percentage point.

In column (2), when we allow for a separate coefficient of the domestic environmental regulation variable for CEEC countries, we do not find any variation across the two country groups. The coefficient of the domestic environment regulation variable when the CEEC countries are exporters, c_i*CEEC, deviates with only -.003 percentage points from an average coefficient of -.09 and is not significant. These results are somewhat surprising. For these countries, pressures and efforts at the domestic level to comply with the "green acquis" are much higher than current EU members. We therefore expected a much higher (negative) effect for the CEEC countries' export performance.

Next, as a second intermediate step before we report the simultaneous equation, we test for the endogeneity between the level of domestic and environmental protection using the Hausman (1978) specification test. From this test, we cannot reject the null hypothesis that the level of domestic environmental protection is endogenous. We find strong evidence of endogeneity of the domestic environmental regulation variable, c_i, at the 1% significance level (*t-statistic* = 2.65) suggesting that the 2S-GLS-RE against GLS-RE is more appropriate. This result confirms the empirical work of Ederington and Minier (2003) who find that the level of domestic environmental protection and trade are indeed endogenous.

In column (3-4), we report the results using the 2S-GLS-RE estimator where we treat the level of domestic environmental regulations endogenously. From column (3), we see that the coefficient estimate of the domestic environmental protection variable, c_i, is now about 2 times greater than its GLS-RE estimate. The average estimate implies that an increase of 1 percentage point in the expenditure of domestic environmental protection levels could expect exports to fall by .23 of a percentage point. The coefficient on the level of domestic environment regulations when the CEEC countries are exporters, c_i*CEEC is -.21 (-.23c_i + .02c_i*CEEC) and significant. This result is consistent with the work of Ederington and Minier (2003) who have found that when the level of domestic environmental regulations is modeled as endogenous, its impact on trade flows is much higher.

In column (4), we present the results of the environmental regulation regression (equation 4) from the simultaneous equation for the EU and CEEC country groups. In this paper, a crucial issue is the relationship between the harmonization of EU environmental regulations and domestic environmental protection. The net coefficient for the EU countries on the coverage ratio of EU harmonized regulations, $\bar{s}_{ijt}$ *EU, is -.32 and the net coefficient for the CEEC country groups, $\bar{s}_{ijt}$ *CEEC, is 1.04. An issue that emanates from this empirical finding is that more harmonization (the higher the share of exporting manufacturing sectors that are subject to EU environmental regulation) has led CEEC countries to increase their costs (in manufacturing) to protect their own environment while domestic environmental protection levels in EU countries have been lowered due to the harmonization of EU environmental regulations. The difference in coefficients between CEEC and EU countries suggests that the way the harmonization of environmental standards and domestic environmental protection has collided is far from symmetric between EU and CEEC countries.

The coefficient estimate of export is positive and significant. It does not support the prediction of the endogenous protection theory namely that domestic governments would tend to reduce the stringency of domestic environmental protection programs in order to increase the export competitiveness of these industries. This empirical finding suggests that there are some positive sides related to the implementation of domestic environmental regulations namely that a higher export performance to EU countries is not prioritized at the cost of the environment.

The other variables that are significant in column (4) are energy consumption and public expenditure in environmental protection. Specifically, we find that more consumption in energy leads to higher levels of environmental protection. For the CEEC countries, the coefficient of public expenditure in environmental protection is positive and suggests a (pronounced) complementary effect that leads to more spending by the industry in protecting the environment. However, this effect is negative and not significant for the EU countries. Finally, the coefficients of investment and (lagged) value added have a positive and significant impact.

6. Sensitivity Analysis

The results that we have obtained so far in our analysis are subject to greater doubt than the standard errors would suggest. Few studies have addressed the issue at the heart of this paper so that suitable comparisons by which to assess the robustness of the results presented here are not available. Three important sources of doubt remain: outliers, estimator consistency and the choice of our instruments.

6.1. Influential observations

The analysis of investigating the residuals, leverages and DFIT values reveals that there are a few problems with outliers. First we tested for DFITS values greater as the cut-off value suggested by Belsey, Kuh and Welsh (1980). These authors suggest that DFIT values greater than 2 times the square root of the number of variables divided by the number of observations deserve greater attention. Using this criterion we detected 9 observations in the total sample from which 6 observations are collided with the exports from Bulgaria to Greece while the other 3 observations were not centered on one particular country (Estonia – Denmark, Ireland –Greece, Poland-Germany). To proceed, we then expressed the residuals and leverage statistics in averages (with normalized standard deviations) and aggregated by exporting country (for all years) and year (for all exporting countries). The aggregate residuals and leverage statistics did not reveal any inconsistencies among countries and time points except for the residuals of Bulgaria, Estonia, Finland, Poland and Sweden. Instead of deleting these observations one at a time and reporting the new results, we omitted all the observations contained in a single exporting country for all time periods.[12] As there are 6 countries that deserve more attention, we performed 6 data adjustments, using the simultaneous specification reported in column (3-4) of Table 1. The results are encouraging. The coefficient of the domestic environmental regulation variable, c_i, varies between -.18 and -.27. When this is measured against the full sample estimate of -.23, it is clear that our estimate is not sensitive to the omission of outliers.

6.2. Estimator Consistency

As noted in the literature (Wooldridge, 2002), OLS estimates often violate their standard assumptions of serial correlation, heteroscedasticity and contemporaneous correlation when they are applied to panel. In a gravity framework, these assumptions may likely to be present. For example, given the large differences between exports from different countries, heteroscedasticity is likely to occur and since the gravity specification includes characteristics (adjacency, distance) that are not interdependent over time, serial correlation is likely to be present. For this purpose, we performed some diagnostic tests.

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[12] Also note that the omission of a particular observation for one country at a given time would lead to changing values for the remoteness variable, Rem_{ij} and $Rulc_{ij}$.

A series of Breusch-Pagan tests were carried out for different time periods. The null hypothesis of homoscedasticity is rejected in most of the cases and the Jarque-Bera test rejects the null hypothesis of normality. We also test for first-order autocorrelation in the residuals. Using the first-order autoregressive process (AR1), there is very strong evidence of serial correlation.

In a generalized least squares (GLS) model allowing for random effects, the problem of AR (1) errors, heteroscedasticity and contemporaneous correlation is exploited in the composite error term (Wooldridge, 2002).[13] In our estimation, this is equal to the ratio of the variance of μ_i and ν_j to the variance of the composite error (Wooldridge, 2002). In table 2, we reports details on the estimation of the variance components, which is generally regarded as a useful measure of the relative importance of unobserved effects. The variance components of the exporting and importing countries (respectively, σ^2_μ, σ^2_ν) are smaller than the variance of the idiosyncratic error (σ^2_ξ). Secondly, the variance of the exporting country is larger than the importing component. As expected, this result suggests that the variation between EU15 and CEEC countries should be larger than that among the EU15 countries.

A possible drawback of the GLS estimator with random components applied to a gravity equation is that some of the explanatory variables in equation (1) may be correlated with the random unobserved effects of the exporting (μ_i) and importing country (ν_j). Especially, the time-invariant, geographical variables (distance, adjacency*)* may generate a possible correlation with these unobserved effects. To verify the robustness of our results*,* we re-estimated equation (1) and (4) using our 2S-GLS-RE but in a Hausman-Taylor framework where we performed quasi-time demeaning on all the dependent variables, explanatory variables and the instruments.[14] The coefficient of the domestic environmental regulation variable, c_i, is -.27 while coefficients of the first stage regression (equation 4) remain robust. When we added the remoteness variable as a possible correlated variable with the random observed effects, c_i increases to -.29. When this is measured against the full sample estimate of -.23 it is clear that our results are robust when correcting for a possible correlation between some of the explanatory variables and the random unobserved effects.

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[13] In the presence of an AR (1) process, the usual remedy is to include dynamics. We investigated a dynamic model and cannot reject co-integration. Subsequently, this requires a rigorous investigation, which we omit for the purpose of this paper. As such we feel that the use of the RE model is well suited for our analysis.

[14] We follow the procedure outlined in Wooldridge (2002) who discusses the application of a Hausman-Taylor approach applied to the estimation of simultaneous equations with a random component. To proceed, we quasi-time demeaned all variables in the system and we instrument (y_i, y_j, Rem_{ij}, Rul_{ij}) on distance, adjacency. For the domestic environmental regulation variable, c_i we use the instruments from equation (2).

6.3. Exogeneity of the Instruments

Although, our results supports the argument for treating the level of domestic environmental regulations as endogenous, misspecification of the environmental regulation equation may be biased due to contemporaneous correlation. To address this possibility, we follow Trefler (1993) and in table 2, we report estimates of the domestic environmental regulation variable, c_i and c_i*CEEC* when each of the instruments is treated as an endogenous variable. In a 2SLS estimation, this is equivalent to omitting the suspected variable from the list.

From the table, it is suggested that the coefficient of c_i is larger (and significant) except when we omit the public expenditure on domestic environmental protection. The Hausman test statistic comparing the results using all instruments to a subset is reported in the last column. The usefulness of this test statistic is that if we fail to reject the null hypothesis then we can have some confidence in the total set of instruments of the instruments. The over-identification test statistics are not rejected at any reasonable level.

7. Conclusion

In this paper, we found support for the prediction that the level of domestic environmental regulations has a larger negative effect on exports when they are treated as endogenous. The impact of domestic environmental regulations on exports is twice as large. A 1% change in costs of complying with domestic environmental regulations reduces exports by 0.10% points. In contrast, a 2SLS, which accounts for the endogeneity yields an elasticity of .23. These results must be interpreted with some form of caution since it is somewhat sensitive to the choice of instruments that have been used in the first stage regression.

In our set of instruments we have also accounted for a specific variable that proxies an important aspect of the trade liberalization effect in the Single market namely, the harmonization of environmental regulations. We provide evidence that domestic regulations will be relaxed in manufactures facing increasing trade liberalization, due to the harmonization of environmental regulations, for EU countries while CEEC countries set more stringent regulations. This result is somewhat consistent with EU initiatives in environmental policy. On the other hands, the coefficient estimate of export that captures a more general liberalization effect is positive and significant. It does not support the prediction of the endogenous protection theory. It suggests that domestic governments would tend to reduce the stringency of domestic environmental protection programs in order to increase the export competitiveness of these industries. This empirical finding suggests that there are some positive sides related to the implementation of domestic environmental regulations namely that a higher export performance to EU countries is not prioritized at the cost of the environment.

APPENDIX

Table 1: Gravity Estimates

	(1) GLS	(2) GLS	(3) 2S-GLS	(4) c_i
Domestic env. reg. (c_i)	-0.10	-0.09	-0.23	
	(0.03)	(0.03)	(0.06)	
c_i *CEEC		-0.003	0.02	
		(0.01)	(0.01)	
GDP country *i*[1]	1.12	1.11	1.21	
	(0.03)	(0.07)	(0.07)	
GDP country *j*	0.81	0.81	0.82	
	(0.01)	(0.01)	(0.01)	
Distance	-1.09	-1.09	-1.21	
	(0.04)	(0.04)	(0.04)	
Remoteness	-0.65	-0.63	-0.65	
	(0.11)	(0.13)	(0.13)	
Adjacency	0.17	0.17	0.14	
	(0.07)	(0.07)	(0.07)	
Rel. Unit Labor Costs	-0.37	-0.36	-0.38	
	(0.02)	(0.03)	(0.03)	
Exports				0.02
				(0.01)
Harmon. EU Env. Reg.*EU				-0.32
				(0.06)
Harmon. EU Env. Reg.*CEEC				1.04
				(0.06)
Investment				0.40
				(0.03)
Value-added (lagged)				0.33
				(0.03)
Energy Cons.				0.24
				(0.02)
Public Exp. Env. Protect.*EU				-0.002
				(0.01)
Public Exp. Env. Protect.*CEEC				0.06
				(0.008)
Intercept	-5.78	-5.80	-6.30	-2.77
	(0.51)	(0.54)	(0.64)	(0.09)
Random effects (variance)				
σ^2_μ	0.69	0.80	0.43	
$\sigma^2\nu$	0.19	0.31	0.21	
$\sigma^2\xi$	0.92	0.87	0.82	
Observations	1764	1764	1764	
R^2	0.89	0.89	0.89	0.83

Notes - Standard errors are reported in parentheses. *yi* and *yj* are replaced by their fitted values. The R^2 is defined as the square root of the correlation between fitted and actual values.

Table 2: Sensitivity Analysis

	(1) c_i	(2) c_i*CEEC	(3) Hausman $\chi^2(8)$
Harmon. EU Env. Reg.	-0.28	0.03	4.49
	(0.06)	(0.02)	
Investment	-0.36	0.05	9.10
	(0.05)	(0.02)	
Value-added (lagged)	-0.23	0.02	10.94
	(0.07)	(0.02)	
Energy Cons.	-0.29	0.04	11.02
	(0.07)	(0.02)	
Public Exp. Env. Protect.	-0.16	0.01	8.99
	(0.07)	(0.02)	

Notes: c_i and c_i*CEEC report the estimates of the domestic environmental regulations variable when the corresponding instrument is treated as endogenous in the system. Standard errors are in parentheses. In column (3) the Hausman test statistic is compared with the environmental regression estimated with the total set of instruments from equation (2).

CHAPTER V

DATA

In this chapter, we discuss and describe the data sources and methodology that have been used throughout the thesis. We also discuss some tables and graphs of the data. For each of the three chapters we distinguish between three categories of data: trade data, data on regulations and other data. The data for chapter 2 and 3 are essentially the same while chapter 4 employs a different data set.

1. Trade Data

Trade data are taken from Eurostat (Comext Database) and are collected at the three digit NACE industrial classification (NACE70) which covers around 120 manufacturing industries. The data is available in values (euros) and volumes (tons).

1.1. Trade Data for Chapter 2 and 3

The main features of the trade data set that is the subject of chapter 2 and 3 are:

Variable: (i) **chapter 2**: imports of total manufacturing (ii) **chapter 3**: imports of manufacturing sectors that are subject to the various harmonization approaches used by the European Commission. (see section 2)

Year: 1990-1998.

Importers: 10 countries of the European Union including Denmark, France, Germany, Greece, Italy, Ireland, the Netherlands, Portugal, Spain and the United Kingdom.

Exporters: 10 previous mentioned countries plus the remaining EU countries: Belgium-Luxembourg (treated as one), Finland, Sweden and Austria.

Deflator: We deflated the imports by an import unit price index using 1995 as the base year.

1.2. Trade Data for Chapter 4

The main features of the trade data set that is the subject of chapter 4:

Variable: exports of total manufacturing

Year: 1995-2000.

Exporter: (i) each of the 14 countries of the European Union including Austria, Belgium-Luxembourg, Denmark, Finland, France, Germany, Greece, Italy, Ireland, the Netherlands, Portugal, Spain, Sweden and the United Kingdom, and (ii) the following Central and Eastern European countries (CEEC): Czech Republic, Hungary, Poland, Slovenia, Slovakia and Romania.

Imports: each of the 14 EU countries.

Deflator: We deflated the exports by GDP using 1995 as a base year.

2. Data on Regulations

In chapter 2 and 3, we merely focus on EU harmonized product regulations while in chapter 4 we distinguish between domestic environmental regulations and EU harmonized environmental regulations. We first describe some general quantification issues

2.1.Data on EU Harmonized Product Regulations for Chapter 2 and 3

Perhaps, the most important aspect of empirical work related to harmonization of technical regulations is its identification. It is difficult to measure the effect of removing technical barriers to trade, and indeed, they have been characterized as "… one of the most difficult non-tariff barriers imaginable to quantify" (Deardorff and Stern, 1997). This reflects in part problems relating to data and in many cases the impact of access to the Single Market has simply, and inadequately, been modeled as an ad hoc reduction in trade costs common across all suppliers.[1]

There are many reasons why such assumptions in a trade analysis could be flawed. However, technical regulations are not specified as some ex ante predictions. Rather, they are rules under which inspection and conformity assessment will be adequately for market entry and the precise reduction in trade costs depend on the initial volume of trade. It is evident that in order to develop useful evidence on the scope and consequences of harmonization of technical regulations for the EU, this requires a precise quantification and a comprehensive effort to analyze data at a level by sectors.

For chapter 2 and 3, the data we use to identify harmonized technical regulations come from the detailed study undertaken for the Commission's review of the impact of the Single Market in the EU (CEC, 1998). This study provides information at the 3-digit level of the NACE classification of whether trade is affected by technical regulations and the dominant approach used by the Commission to the removal of such barriers in the EU. In the appendix of

[1] For example, Gaisorek *et al*. (1991) and Brenton and Winters (1992) in different exercises assume that the completion of the Single Market implies a 2.5% reduction in trade costs for all EU members.

this chapter, Table 1 describes for each industry the dominant approach of the European Commission to the removal of technical barriers to trade.[2]

For sectors where technical regulations affect trade, the study classifies them as those where the barriers are overcome using mutual recognition, and those sectors where mutual recognition is insufficient or unsuitable so that either the old approach or the new approach to overcoming technical barriers is used. There are; however, a small number of sectors where a combination of approaches is identified. We include these in the analysis.

Two important issues emerge from the selection of this data. A first practical difficulty relates to *aggregation* in characterizing the regulations (1) across countries and (2) within sectors. In the degree of information revelation of regulations facing sectors, it is assumed that for these sectors, all trade is affected by the technical regulations. However, using this data we avoid any other problem that may be related to an aggregation across countries since we do not have to deal with any country-specific methods of administration. It is evident that sampling techniques and requirements could vary by trading partner but since we are only considering EU regulations, these are uniformly spread across the EU and candidate CEEC countries, which allows us to make a comparable analysis. We, therefore, contend that this issue of aggregation may be addressed satisfactorily though our analysis that permits careful and detailed investigation on the scope and consequences of the harmonization of technical regulations within a particular sector and across countries.

A second issue is the data adjustment that takes into account when a harmonization approach is applied to a particular NACE sectors. The CEC classification that assigns the harmonization approach to each sector is based on a survey that was conducted in 1996. Since we are using data in a panel framework, we accordingly needed to adjust the data when they became into effect. This is the case for only the category of sectors that regulated by the new approach and the category that comprises any combination with new approach products. The number of sectors that are regulated by old approach and mutual recognition are constant throughout 1990-1998.[3]

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[2] See Chapter 3, for a detailed description of the various EU harmonization approaches.

[3] DG-Market acknowledges the assumption for keeping the old approach and mutual recognition sectors unchanged during this time period. For a complete list of when new approach products where introduced see "Directives and Related Standards", Harmonization in the Single Market, published by CEN Management, (2000). This publication lists each directive in the new approach as well as the year the directive is applicable which is equivalent to when it is published.

We assume that the effect of a harmonized directive defined in the period *t-1* affects the sector in time *t*. During the period 1990-1998, the most important change in new approach regulations occurred in 1993 with the introduction of the machine directive. The scope of manufacturing sectors that are affected by of other new harmonized regulations (lifts, gas appliances, low voltage equipment, etc.) were of minor importance in 1990, 1991, 1994 and 1995.

2.1.1. The Quantification of EU Harmonized Regulations in Chapter 2

In chapter 2, we quantify the incidence of EU harmonized regulations as an export coverage ratio that directly enters the gravity equation. The export coverage ratio is aggregated to the share of total manufacturing that are subject to any of the four harmonization approaches (mutual recognition, old approach, new approach and a combination of any of the approaches) and is applicable between exports of each of the 14 exporting countries to the EU as an aggregate.

In our input data, the incidence of harmonization of regulations is signaled by an indicator variable, δ_{ijk}, taking the value of 1 if any of a harmonization approach, *l*, is applied against trade of sector k between country *i* and country *j*. These indicators are aggregated to form coverage ratios, $\bar{s}_{ij}$, applicable between country *i* and *j* in *total manufacturing*. The aggregate coverage ratio is then defined as: $\bar{s}_{ij} = \sum_{k \in K} w_{ijk}\, \delta_{ijkL}$ where δ_{ijkL}=max (δ_{ijkl}) and $\sum_{k \in K} w_{ijk} = 1$. If the weights, $w_{ijk,}$ are proportional to the level of bilateral trade between countries *i* and *j*, then these trade coverage ratios are equal to the percentage of sectors covered by the harmonization of EU regulations.

In chapter 2, we consider averaged exports between any country *j* and the EU aggregated as one region. For example, ideally, but unavailable set of weights, would be the level of production. Using the imports as a weight would a worse approximation to the ideal average because the actual values of imports that are measured at the left hand side of the equation could be reflected by the presence of harmonization of technical regulations. The method we opted is to measure the coverage ratio of each country's exports to the EU which is then based on a given set of reference countries which we defined as average EU. The construction of the reference countries is similarly to the coverage ratio of each country's exports to the EU using intra-EU averaged exports 1990-1998.

This share variable becomes time-variant by adjusting the share of exports accordingly to the time sectors became subject to the harmonization procedure (as we described in the previous section). For example, the Machine Directive in 1993 affects the exports data in 1994 and is therefore not included in the coverage ratio for the previous years.

2.1.2. The Quantification of EU Harmonized Regulations in Chapter 3

In chapter 3, we disaggregate the dependent variable, imports of manufacturing, into 6 categories: (i) new approach, (ii) old approach, (iii) mutual recognition, (iv) a combination of multiple approaches, (v) an aggregate of all harmonization approaches, and (vi) sectors where differences in national regulations do not constrain any trade flows.

In table 2 (in the appendix), we show for 1998 for each country the share of EU imports in manufacturing that are (i) regulated by the different harmonization approaches: mutual recognition, old approach, new approach and a combination of any approach, (ii) regulated by an aggregate of the four types of harmonization approaches, and (iii) where technical barriers to trade do not apply.

The share of manufacturing that is subject to the aggregate demonstrates that a very large proportion of intra-EU trade is in sectors affected by EU harmonized technical regulations.[4] On average more than 75% of intra-EU imports are in sectors where differences in technical regulations are important. The share ranges from 59% for Greece to 85% for Ireland.

The table demonstrates that there is a considerable variation across EU members in the share of trade affected by the different approaches to the removal of TBTs. For example, sectors where mutual recognition is used comprise a relatively large share of EU imports from Ireland (32%), Greece (30%) and Portugal (29%) but a small share of EU imports from Finland (5%) and Sweden (10%). Sectors characterized by the new approach comprise relatively larger shares of EU imports from Italy (20%), Austria, Denmark, Sweden, Germany (17%), but are less important from Greece (5%), Portugal, Ireland, Netherlands and Spain (8%). Sectors that are prone to the old approach comprise the largest share of total EU imports, relatively to the other approaches. It is of particular importance for Spain, Sweden and Finland (over 30%).

This table concludes that the removal of technical regulations varies by the different approaches and by EU members and there is considerable variation across EU members in the share of trade affected by technical regulations. However, we also recognize that this share is

[4] Previous analysis of the Single Market Program in the existing EU countries suggests that the removal of technical barriers to trade may be of great significance. CEC (1998) calculates that over 79% of total intra-EU trade may have been affected by technical regulations in 1996. In the graph, we only consider manufacturing.

not only affected by differing national regulations but also by the level and composition of import volumes.

2.2. Data on EU Harmonized Environmental Regulations for Chapter 4

Since a partial focus in chapter 4 is the relationship between exports, the harmonization of EU environmental standards and domestic environmental protection, we need a reliable measure of the incidence of EU harmonized environmental regulations at the level of sectors. The difference between EU harmonized product regulations and EU harmonization of environmental regulations is that the latter contains harmonized procedures that are product and process related.

To measure the incidence of EU harmonized environmental regulations, we first utilize information coming from the detailed study undertaken for the Commission's review of the impact of the Single Market in the EU (CEC, 1998). This study provides information at the 3-digit level of the NACE classification of whether trade is affected by harmonized environmental rules.[5] In our input data, the incidence is signaled by an indicator variable, δ_{ijk}, taking the value of 1 if the harmonization approach is applied against the exports of sector k from country i to country j. These indicators are aggregated to form coverage ratios, $\bar{s}_{ij}$, applicable from exporting country i to country j in *total manufacturing*. The aggregate coverage ratio is then defined as: $\bar{s}_{ij} = \sum_{k \in K} w_{ijk}\, \delta_{ijk}$ where δ_{ijk}=max (δ_{ijk}) and $\sum_{k \in K} w_{ijk} = 1$. If the weights, $w_{ijk,}$ are proportional to the level of bilateral trade between countries i and j, then these coverage ratios are equal to the percentage of sectors covered by a harmonization approach. We follow Leamer (1983) and use home export-weighted coverage ratios for each of the exporting countries. The 3-digit sectors subjected to the EU harmonization of environmental regulations are summarized in table 3 in the appendix. We note that the EU harmonized environmental regulations that have been considered in this chapter all have been introduced before 1995.

In figure 1, we compare the weighted coverage ratios of sectors that are subject to EU harmonized environmental regulations for each of the EU and CEEC exporting countries to the EU in the year 1995 and 2000. This figure illustrates that on average about 30% of intra-EU imports are in sectors where EU harmonized environmental regulations are important.

For the current EU member countries, the significance of these sectors ranges from around 20% of EU imports from Greece and Portugal to 35% of EU imports from Finland,

5 In addition to the information that contains the EU harmonization approach.

Denmark, Ireland, the Netherlands and Sweden and the UK. When comparing year 1995 with year 2000, except for Belgium (and Luxembourg.), Spain and Italy, in all other cases the shares of these sectors have fallen in a range between 0.1% for Ireland and the most notable change in a share of 10% for Finland. For the CEEC countries, with the exception of Bulgaria, the share of sectors remained fairly constant, ranging from around 7% for Romania to 20% for Hungary, Poland and Slovakia and for 25% for the Czech Republic and Slovenia.

The principal conclusion to be drawn from this figure is the overall importance of harmonized environmental regulations to trade between EU and CEEC countries. In addition, there is a variation across countries in the share affected to the harmonization of environmental regulations caused by differing national regulations. Between 1995 and 2000, the share of these sectors changed little over this period despite the increasing efforts of the EU in harmonizing the environmental standards or neutralizing inter-country differences in environmental regulations. Yet it would have been expected that these shares would have increased since the advantage of the harmonization of environmental standards is that it can remove trade impediments arising from differences in environmental standards. The fact that the share of exports that are not subject to harmonized regulations has increased may be attributed to the fact that there is a change in the trade composition. The data reveals that within an average of 30% of exports, several sectors are highly sensitive to fluctuations. It may also well be that a comparison between any other two years may reveal a different picture.

2.3. Data on Domestic Environmental Protection for Chapter 4

In order to calculate the compliance cost with domestic environmental regulations, we use an indicator of the economic resources spent on environmental protection in *total manufacturing* for each reported country between the periods 1995-2000. The data on the domestic environmental protection in *total manufacturing* comprises of an aggregate of different industries that are also available from Eurostat. (New Cronos/yearly statistical Eurostat publications; see footnote of table 5 in the appendix). We were unable to use data at the industry level because there were many missing observations at the industry level for the period before 2000. In the appendix, table 4 shows the level of environmental protection for each country and year. These data are available for both the industry and public sector and are listed in the appendix, table 4-5 by country and year.

We are aware that this is not an entire cost in alignment with the domestic environmental regulations since we are not including institutional and administrative costs. For the purpose of our study, the costs that we are capturing are directly related to the production process as well as those costs that serve to abate the pollution stemming from the production process. The environmental protection expenditure is classified in different activities according to the Single European Standard Statistical Classification of Environmental Protection Activities (CEPA) broken down in the following groups: water & soil, industrial pollution, air, noise, nature and forestry protection, as well as chemical substances and genetically modified organisms. These activities are aggregated due to missing observations

We rely on two sources. Wherever possible, we use data on the 'industry expenditure on environmental protection' from Eurostat (New Cronos). When the data are unavailable, we fill in missing observations with comparables from the various institutes of statistics This has been the case for Sweden, Austria, Czech Republic, and Ireland. To measure the expenditure on domestic environmental protection in total manufacturing, we deflate this variable by the GDP deflator using 1995 as the base.

3. Other Data

3.1. Other Data for Chapter 2 and Chapter 3

In Chapter 2 and 3, we add a number of other variables that are necessary to estimate the gravity model. Internal distances d_{ii}, are taken from Nitsch (2000), which were calculated by using the disk area procedure to obtain the average distance between economic centers. He shows that the radius of a circle (given by the inverse of the square root of π times the square root of the area) may be a good approximation for the average distance. For distances between countries d_{ij}, we follow the conventional method in the gravity literature and measure the direct (great circle) distance between the economic centers (capital cities). Table 6 in the appendix lists the bilateral distances in kilometers, the internal distances within each country as well as the area in kilometers of each EU member country.

This paper requires bilateral trade and production data in a compatible classification for 10 European countries over the period 1990-1998. Since we do not have any data on national trade, we follow Wei's (1996) methodology based upon the assumption that for any country *i*, domestic trade (imports from itself) is defined as the difference between its production and exports.[6] We extracted production data from New Cronos with reference to the domain of the 'business structural database'. The long time series, "covering enterprises with 20 persons employed and more", in NACE revision 1 (code at 3 digit level) were converted to NACE70

6 This definition has become the standard methodology for empirical studies that can not rely on national data , see for example: Helliwell 1997, 1998, for OECD countries; Nitsch, 2000, Chen, 2004 for EU countries.

(code at 3 digit level) in order to match with trade data extracted from Eurostat (Comext) database. The concordance lists the NACE revision 1 and the NACE70 at a 5 and 4 digit level code, respectively. Some in-between-year observations are missing from the New Cronos database. Missing data, then, are approximated by applying a trend of the gross rate of value-added (in quantity) in each NACE sector. Finally, Gross Capital Formation (1995 Prices) GDP (1995 Prices), Unit Labor Costs (1995 Prices) and population are obtained from the New Cronos database. For the Netherlands, Denmark and Spain, some missing values of unit labor costs were unavailable. For these countries, we approximated these missing observations using labor cost indexes that were computed by the European Commission (DG-ECOFIN). The series can be downloaded from ECODATA (available from the Belgian Ministry of Economic Affairs, http://ecodata.mineco.fgov.be).

In Table 7 in the appendix, we give the GDP per capita and its growth rate for each importing country.

3.2. Other Data for Chapter 4

Distance between countries is measured as the great circle distance between the national capitals. Value added (at factor cost) in total manufacturing, production in total manufacturing (1995 prices), gross investment (in tangible goods), gross capital formation (1995 Prices), GDP in current and constant prices (1995), population, energy consumption (in industry) and unit labor costs (constant) in total manufacturing are obtained from the Eurostat (New Cronos) database. For some of the variables that were not available in nominal terms (value-added, gross investment, energy consumption), we deflate this variable by the GDP deflator, using 1995 as the base. For the Netherlands, Denmark and Spain, some missing values of unit labor costs were unavailable. For these countries we approximated these missing observations using labor cost indexes that were computed by the European Commission (DG-ECOFIN). The series can be downloaded from ECODATA (available from the Belgian Ministry of Economic Affairs, http://ecodata.mineco.fgov.be).

APPENDIX

Table 1: NACE Sectors regulated by different Harmonization Approaches

NACE	Mutual recognition sectors	**NACE**	New Approach Sectors
1200	Coke ovens	2210	Iron and steel
1300	Extr. of petroleum and natural gas	2240	NF materials
2310	Extraction of building material	2410	Clay products for constr. Purposes
2510	Basic industry chem, petrochem.	2420 + 2430	Cement
2550	Paint, varnishing, printing ink	3140	Structural metal products
2600	Man-made fibers	3150	Boilers, reservoirs, tanks
3166	Manufacture of metal furniture	3165	Domestic heating appliances
3610	Shipbuilding	3210	Agricultural mach. Tractors
3620	Manuf of railway rol. Stock	3220	Machine tools working metal
3640	Aerospace equipment	3230	Textile machines, sewing
3650	Other transport. equipment	3240	Machines for food and chem. Industry
4110	Manufacture of oils and fats	3250	Machines for iron and steel
4240	Ethyl alcohol, spirit dist.	3260	Transmission equipment
4250	Wine of fresh grapes, cider	3270	Equipm. For use in spec. branches
4270	Brewing and malting	3280	Other mach.&equip.
4280	Soft drinks	3720	Medical and surg. Equipment
4340	Prep. Of flax, hemp, ramie	4620	Semi-finished goods
4360	Knitting industry	4630	Carpentry
4370	Textile finishing	4910	Manuf. of articles of jewelry
4390	Misc. textiles		
4530	Manuf. of clothing		
4550	Manuf. of household textiles		
4560	Manuf. of furs		

Table 1 (continued)

NACE	Old approach	NACE	No Regulations
1100	Extraction of solid fuels	1600	Electr., gas, steam
1400	Mineral oil refining	2110	Extr. Prep. of ore
1510	Extr. Nuclear materials	2120	Extr. Prep. of non-fer met. Ores
1520	Production of nuclear materials	2220	Man. of steel tubes
1700	Water supply	2230	Draw. Cold rolling of steel
2440	Manuf. of arts & asbestos	2320	Salt
2560	Chem. Prod	2450	Work of stones
2570	Pharm. products	2460	Grind, abras. prod.
2580	Soap, detergents	2480	Man. of ceramics
3450	Manuf. of radios & tv	2590	Man. of other chem.. prod.
3510	Manuf. of ass. Motor vehicles	311-313	Foundries, pressing, treat. of metal
3530	Man. Parts for motor vehicles	3160	Tools and finished goods
3630	Manuf. of (motor) cycles	3300	Office mach.
4120	Prep. of meat	3410	Wires & cables
4130	Manuf of dairy products	3520	Bodies for motor vehicles
4140	Proc. of fruit and vegetables	3710	Meas.& prec. instr.
4150	Proc. Preserv. of fish	3730	Optic. instr.
4160	Grain milling	3740	Man. of watches
4170	Man. of spaghetti	4310	Wool industry
4180	Starch and starch products	4320	Cotton industry
4190	Bread and flour	4330	Silk industry
4210	Cocoa and sugar conf.	4350	Jute industry
4220	Animal and poultry food	4410	Tanning; dressing of leather
4230	Man. of other food prod.	4420	Leather products
4290	Tobacco products	4510	Footwear
4710	Manuf. of pulp and paper	4610	Sawing and proc. of wood
4720	Proc. of paper and board	4640	Man of wooden containers
4740	Publishing	4650	Other wood. man.
		4660	Art. of cork
		4730	Printing and allied industries
		4810	Man. of rubber products
		4820	Rubber tires
		4920	Musical instr.
		4930	Photograph
		4950	Misc. manuf. ind.

Table 1 (continued)

NACE	Combination of Harmonization Approaches	
2210	Iron & steel	MRP + NA
2470	Man. of glass	OA + NA
3440	Man. of telec. equipm	MRP + NA
3460	Domestic electr. appl.	MRP + NA
3470	Man. of electr. lamps	MRP + NA
4110	Man. of oils & fats	OA + MRP
4380	Carpets	MRP + NA
4830	Construction products	OA + MRP + NA
4940	Toys	MRP + NA

Table 2: The Importance of the Harmonization Approaches to Technical Regulations: Coverage of EU (15) Imports from Member in 1998, %

	Old App.	**New App.**	**Mutual Recog-nition**	**Other**	**Total TBT**	**No Technical Reg.**
EU Imports from Member States						
Austria	26.29	17.97	11.40	15.08	70.74	29.26
Bel-Lux	30.03	10.62	13.74	19.25	73.64	26.36
Denmark	24.98	17.39	16.54	13.95	72.86	27.14
Finland	38.89	12.20	5.04	22.34	78.47	21.53
France	30.74	11.12	17.32	14.14	73.32	26.68
Germany	31.12	17.53	14.70	16.47	79.82	20.18
Greece	17.28	5.60	29.65	6.72	59.25	40.75
Ireland	22.06	9.45	32.34	20.73	84.58	15.42
Italy	17.98	20.90	17.84	15.78	72.5	27.50
Neths	27.17	7.95	22.22	17.71	75.05	24.95
Portugal	25.32	8.92	28.78	10.05	73.07	26.93
Spain	39.73	8.86	11.31	11.26	71.16	28.84
Sweden	33.91	16.43	10.45	18.21	79	21.00
UK	21.29	14.08	24.61	16.71	76.69	23.31
Intra-EU	27.91	13.39	18.14	16.03	75.47	24.53

Table 3: Sectors subject to EU Harmonization of Environmental Regulations

NACE			
110-140	Mining and Quarrying	321-328	Machines and equipment
151-152	Extract. & prod. of nuclear materials	342	Manuf. of electrical machinery
244	Manuf. of art. Asbestos	343	Electr. apparatus for industrial use
245	Work. of stones & non-met. prod.	347	Manuf. electr. lamps
247	Manuf. of glass & glassware	351	Manuf. motor vehicles
251-259	Basic industry chem, petrochem., pharm.	363	Man. of cycles, motor cycles
314	Structural metal products	411-419	Food products
315	Boilers, reservoirs, tanks	471-472	pulp and paper
316	Domestic heating appliances	481-482	Rubber products

Figure 1: Coverage ratio of Sectors subject to EU Harmonized Regulations in EU Imports of Manufacturing, 1995/2000

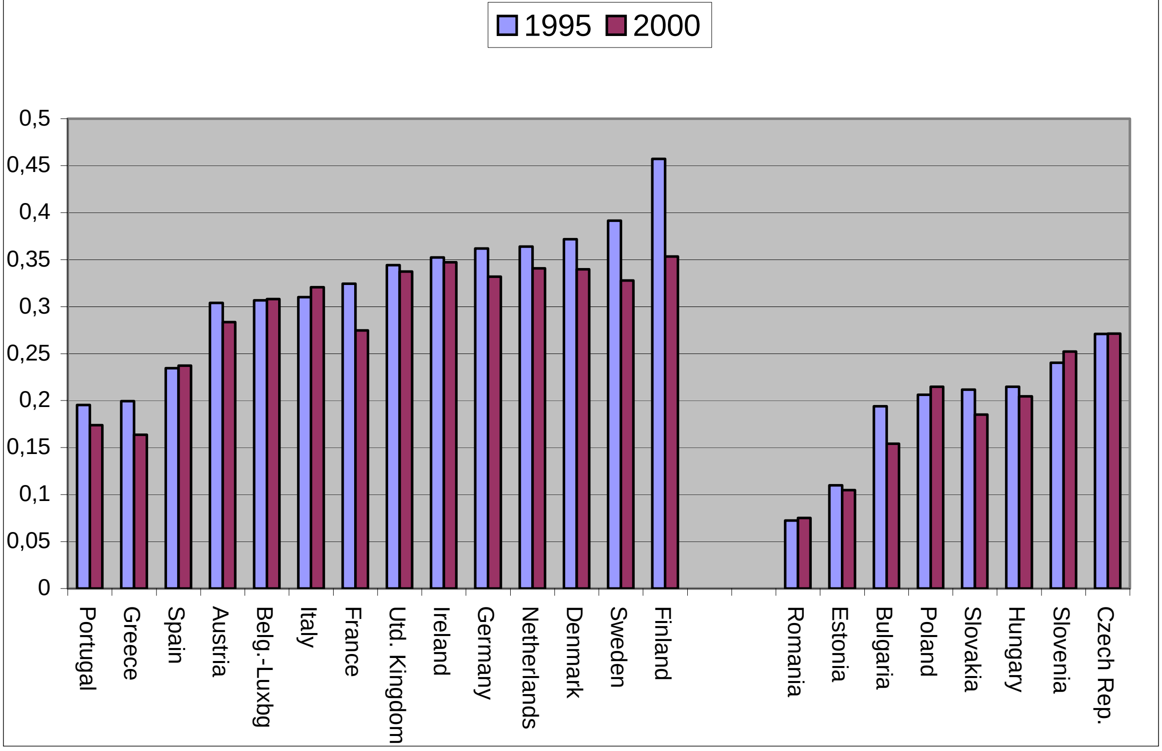

Table 4: Environmental Protection Expenditure by Industry in Total Manufacturing (in millions of euro)

	2000	1999	1998	1997	1996	1995
Austria	1148.7	1141.4	1208.0	1317.7	1229.5	1208.7
Belgium	1152.4	1164.8	1064.8	1243.5	1058.1	1286.7
Denmark	541.3	490.2	525.1	554.0	577.4	535.4
Finland	321.3	331.2	241.1	509.0	455.4	435.4
France	9980.0	9980.0	9981.8	9661.7	9221.9	8876.2
Germany	9660.2	9660.2	12067.5	12780.8	9222.0	9350.0
Greece	287.6	283.0	260.9	232.5	281.1	241.7
Ireland	197.6	184.4	165.9	152.5	137.4	127.1
Italy	1480.6	1439.3	1416.7	1391.7	1364.1	1349.3
Netherlands	1675.5	1662.2	1269.1	1392.6	1415.2	1543.2
Portugal	443.7	339.7	261.1	179.9	219.0	178.1
Spain	1454.6	999.8	823.8	680.6	667.8	655.1
Sweden	973.0	843.3	909.1	974.8	965.1	955.4
United Kingdom	6930.5	6029.7	6087.6	6175.0	5434.0	4781.9
Bulgaria	151.0	162.0	102.0	68.0	61.0	60.0
Czech Republic	1057.2	1023.9	1019.1	1029.8	1037.8	995.1
Estonia	44.1	48.1	56.5	56.5	315.8	6.2
Hungary	526.5	524.3	480.5	458.5	438.2	432.4
Poland	2497.1	2401.5	2675.0	2368.0	2217.0	691.0
Romania	298.0	384.1	460.8	358.7	309.1	275.1
Slovak Republic	189.9	248.7	504.5	502.9	477.6	451.2
Slovenia	85.0	63.8	62.7	78.0	57.7	73.3

Table 5: Total Environmental Protection Expenditure by Public Sector (in millions of euro)

	2000	1999	1998	1997	1996	1995
Austria	349.3	352.5	483.7	358.0	2415.8	2637.4
Belgium	1266.0	1113.4	1148.9	973.4	928.5	950.1
Denmark	2188.2	2100.3	1946.3	1881.3	1870.2	1768.2
Finland	509.3	480.8	519.8	537.5	528.5	542.5
France	12617.1	11650.0	10900.6	10428.4	10071.2	9307.9
Germany	10007.8	10108.2	10395.4	11219.8	13003.1	14644.4
Greece	722.5	729.8	702.4	681.3	664.7	564.9
Ireland	403.5	407.6	411.7	415.8	420.0	424.2
Italy	8592.0	8032.0	7527.0	7013.0	6587.0	5356.7
Netherlands	3950.9	3990.8	4031.1	4071.9	4546.7	4592.6
Portugal	729.0	665.2	627.5	774.8	753.7	682.3
Spain	4227.0	4269.6	3885.8	3551.7	3355.7	3664.9
Sweden	542.6	359.2	381.3	190.3	352.81	356.3
United Kingdom	7576.3	6624.3	5966.8	5541.5	5597.0	5652.9
Bulgaria	43.1	51.6	25.4	10.0	9.0	13.6
Czech Republic	296.8	299.8	313.4	376.8	369.8	316.5
Estonia	16.7	10.8	11.2	8.6	9.3	25.8
Hungary	216.8	219	92	92.2	93.4	94.7
Poland	1408.9	1314.6	1313.7	744.1	654.3	307.8
Romania	63.2	130.7	193.6	159.2	135.1	114.4
Slovenia	35.5	29.8	24.9	22.1	18.8	18.7
Slovak Republic	30.5	136.8	82.3	69.8	70.9	73.4

Additional Sources for Table 4 and 5

Eurostat Sources: (i) New Cronos (ii) *Environmental Protection Expenditure by Industry*. Statistics in Focus (2001, 2002, 2003) (iii) *Environmental Protection Expenditure in Accession Countries: Data: 1996-2000.* Eurostat (2002). (iv) Environmental Expenditure Accounts: Results of Pilot Applications (vi) For Sweden, Austria, Czech Republic, Hungary and Ireland, missing data has been appended with comparables for their respective statistical institutes.

Table 6: Bilateral and Internal Distances

International Distances: d_{ij}

	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	Netherl.	Portugal	UK
Belgium-L		769	319	2092	1316	262	776	1173	174	1712	320
Denmark	769		671	2136	2075	1029	1243	1531	623	2481	958
Germany	319	671		1802	1447	479	1088	960	365	1892	635
Greece	2092	2136	1802		2374	2101	2859	1054	2164	2859	2394
Spain	1316	2075	1447	2374		1054	1451	1365	1482	504	1264
France	262	1029	479	2101	1054		779	1108	428	1454	341
Ireland	776	1243	1088	2859	1451	779		1887	760	1640	464
Italy	1173	1531	960	1054	1365	1108	1887		1294	1866	1434
Netherlands	174	623	365	2164	1482	428	760	1294		1864	359
Portugal	1712	2481	1892	2859	504	1454	1640	1866	1864		1585
UK	320	958	635	2394	1264	341	464	1434	359	1585	

	Area 1000 km2	d_{ii}
Belg./Lux	33.1	4.6313
Danmark	43.1	4.763
Deutschland	248.7	5.6397
Ellas	132.0	5.3228
Espana	504.8	5.9936
France	544.0	6.031
Ireland	68.9	4.9978
Italia	301.3	5.7355
Nederland	41.0	4.7384
Portugal	92.0	5.1422
United Kingdom	244.1	5.6303

Table 7: GDP per Capita by Importing Country

	GDP per Capita (Yc_i)	Growth Rate of GDP per Capita (Yc)
Denmark	1.49	0.023 (0.001)
France	1.13	0.016 (0.002)
Germany	1.30	0.010 (0.001)
Greece	0.48	0.021 (0.003)
Italy	0.82	0.016 (0.001)
Ireland	0.79	0.077 (0.003)
Netherlands	1.16	0.026 (0.001)
Portugal	0.46	0.029 (0.002)
Spain	0.64	0.028 (0.002)
United Kingdom	0.83	0.026 (0.0006)

Notes: In column (2), the growth rate of the GDP per capita for each importing country is approximated by regressing GDP per capita on a trend. The coefficients of the trend are reported with standard errors in parentheses.

CONCLUSION

In this thesis, we analyzed the impact of EU harmonized regulations on bilateral trade flows of the manufacturing sector in Europe. We distinguished between two types of EU regulations. In chapter 2 and 3 we dealt with product-specific regulations while chapter 4 looked at environmental regulations both at the EU and at the level of EU member and non-member states.

The data on EU regulations comes from the European Commission's review of the impact of the Single Market in the EU. This study provides information at the 3-digit level of the NACE classification of whether trade is affected by technical regulations and the dominant approach used by the Commission to the removal of such barriers in the EU. One of the important features of this data is that it has enabled us to study the impact of EU regulations across countries, between groups of manufacturing sectors and, through our own efforts, across time.

A central feature that has contributed to a better understanding of the situation of EU harmonized regulations and trade flows has been the particular attention given to the functional form of the gravity model of international trade. The theoretical and empirical research devoted to the gravity model remains somewhat unclear: assumptions needed to derive the gravity equation are not well understood, econometric suggestions are somewhat mixed and sometimes a-theoretical variables are included.

In this study, we have made an attempt to provide some further insights in trying to understand the gravity equation. We developed and selected a specification of the gravity model based on some economic and econometric refinements that have been tested in a panel framework of EU bilateral trade of manufacturing at different levels of aggregation. The gravity model in chapters 2 and 3 is specified as an importing demand specification applied to various types of aggregation in manufacturing including the total manufacturing sector. In chapter 4, the gravity model is expressed as an exporting supply equation applied to total manufacturing.

The estimation results are in general well reconciled with the prediction of the model. The coefficient of the core variables of the gravity model, namely income, distance and relative distances (remoteness), all have the expected signs and are statistically significant. Trade between two countries are promoted by the incomes of the trading partners and constrained by their bilateral distance. In this study, we define remoteness in relative terms and is expected to enter the gravity equation with a negative sign. It is interpreted as follows: for a given distance from other countries, greater bilateral distance between bilateral trading partners reduces trade while for a given bilateral distance, greater distance from other countries increases trade.

For the importing demand equation, we introduced a variable that captures a more flexible income response that is usually implied by a standard gravity equation. More specifically, our estimation shows that the assumption of constant income elasticities is empirically not validated. We find that as income of the domestic country increases the share of manufacturing goods has a declining income elasticity. These elasticities are statistically significant and vary according to different levels of aggregation in the manufacturing sector.

In addition, we introduce a general and a specific, bilateral measure of competitiveness that plays an important feature to intra-EU trade. In the importing equation, we introduce both measures of competitiveness while in the exporting equation we only include the specific, bilateral measure of competitiveness. A more general effect for competitiveness, that is domestic inflation with respect to foreign price competition, measured by an import unit price index, is found to have a significant and positive impact on imports while a specific measure of competitiveness, based on relative unit labor costs, also increases imports. The coefficients of these two variables are found to be statistically significant at all types of aggregation in the manufacturing sector. In the export equation, we find that relative unit labor costs have a negative impact on exports. The expected signs are also significant.

In this study, we have also provided some further insights in the econometric analysis of the gravity model applied to a panel dataset. A particular attention has been given to an appropriate choice of the deflator, to the estimation method, to tests of the restriction of variables of interest and to other various statistical inferences.

The impact of the EU harmonization of regulations is explored in two applications of the gravity model. In chapter 2 and 3, we examine how EU harmonization of technical regulations has affected the pattern of bilateral trade flows taking into account the downward impact of national border on trade flows. Our findings are:

(i) Harmonization of technical regulations has a positive and significant impact on imports in total manufacturing. We find that, between 1990 and 1998, the share of sectors regulated by harmonization in total manufacturing increases imports with a factor of 10.

(ii) When we separate out the effect of the harmonization of technical regulations on domestic trade in total manufacturing, we find that harmonization cannot explain the presence of border effects.

(iii) Harmonization of regulations can not explain the variability of border effects between manufacturing sectors regulated by EU harmonization and manufacturing sectors where technical barriers to trade do not apply. In addition, we find that the presence of large border effects found in each of these two sectors do not exhibit any declining trend.

(iv) We find that sectors where harmonization of regulations is of minor importance, mutual recognition, exhibit small border effects. Old approach sectors where there have been substantial efforts to remove regulatory barriers to trade still reflect large border effects. In addition, the border effects of these sectors have remained constant over time. New approach sectors where harmonization of regulations is less complicated exhibit an increasing trend of cross-border integration.

In chapter 4, we study the link between environmental regulations and exports with particular reference to the Single Market and enlargement. We incorporate the methodology of endogenous protection and question whether countries may wish to weaken their environmental policies as a response to harmonized environmental regulations. The results find support for the prediction that the level of domestic environmental regulations has a large negative effect on exports. The impact of domestic environmental regulations on exports is twice as large when it is treated as an endogenous variable. A further issue that emanates from this empirical finding is that more harmonization (the higher the share of exporting manufacturing sectors that are subject to EU environmental regulation) has been accompanied by more stringent domestic environmental regulations in Central and Eastern European countries (CEEC) and lower levels of domestic environmental regulations in EU countries. In addition, we find that countries will not reduce the level of domestic environmental regulations as a response to more exports.

This study distinguishes itself from others in the literature by explicitly dealing with the harmonization of regulations at the EU level and its unique methodology in understanding the various determinants of European trade. However, a more in-depth and sophisticated study requires further research in several areas. First of all, one of the shortcomings is that the data on EU regulations are only available at a 3-digit NACE level of sectors. It is desirable to look at a more detailed level of products that are covered by relevant harmonization initiatives of technical regulations. Second, the gravity model that we have used is static. However, there are economic arguments that suggest that trade is a dynamic process. Finally, in the context of EU harmonization of regulations, the scope of our investigation dealing with solely European countries should be expanded to non-EU countries. This should enable us to identify important aspects of possible trade diversion or trade creation effects with the rest of the world.

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