Harmonization of Food Regulations and Trade in the Single Market: Evidence from Disaggregated Data

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This paper uses a structural gravity model based on Anderson and van Wincoop (2003) to quantify the effect of EU harmonization of food regulations on intra-EU trade for 1990-2001. We construct a database that identifies food products covered by harmonized regulations at a very detailed level. First, we find at different levels of aggregation, that harmonization of food regulations has contributed to more intra-EU trade. Next, we find that tariff equivalents of the costs of not harmonizing with food regulations, subject to the sub-sector the elasticity of substitution, vary significantly across some food sub-sector.

1. Introduction

The removal of technical barriers to trade (TBT) has been one of the major institutional factors affecting trade within the European Union (EU) in the food industry. The Commission of the European Communities (CEC, 1997) calculated that during the first phase of the White Paper´s food specific program (1985-1996) over 87% of intra-EU trade in processed food was affected by differences in regulations. The principle mechanism to eliminate TBT in the EU is mutual recognition of existing standards whereby a product lawfully produced and sold in any of the EU member states must be given free access to all other EU markets. Mutual recognition is, however, not an option if there are significant differences in the initial standards of the countries. In such cases, some degree of standard harmonization is a precondition for counties to allow products of other countries to access their markets. Specifically to the harmonization of food regulations, the EU has sought to remove differences in national regulations on a common set of binding requirements in form of detailed directives for a single or group of products.[1]

In this paper, we update and employ a specially constructed dataset that directly identify at the 8-digit tariff line codes of the European Combined Nomenclature (CN) trade classification food products that are covered by harmonization of food regulations. This database allows for a direct link with trade data from which we construct export weighted coverage ratios of the aggregate food sector and 10 NACE food sub-sectors for the 1990-2001 period and for each of

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[1] In practice, most of the food sub-sectors where technical regulations are important have now been harmonized under the so-called old approach, particularly in product areas where the mutual recognition was seen to be failing. The old approach is a harmonization approach based upon extensive product-by-product legislation carried out by means of detailed directives. For a detailed description of EU instruments to remove TBT, see Brenton *et al.* (2002).

the EU member states. We address two empirical questions: Does harmonization of food regulations lead to significant increases in trade between EU participating countries? What is the trade cost of not harmonizing with EU food regulations expressed as a tariff equivalence?

To provide a valuable answer to these two questions, we estimate these export weighted coverage ratios on imports across countries over the period for each food sub-sector and rely on a gravity model of international trade. As a prelude to derive the estimating equation, we present a simple, theoretical-grounded gravity model based on Anderson and van Wincoop (2003). In the gravity model, the unobservable trade cost is itself a function of a set of observable variables including the harmonization of food regulations. Here, we assume that harmonization of food regulations reduces trade costs between trading partners. The estimated effect of harmonization of food regulations allows us to compute a tariff equivalence using an elasticity of substitution we obtain from related literature. The tariff equivalence is interpreted as an estimated tariff that would have the same effect of a trade cost that arises from un-harmonized EU food regulations. We deliberately refer to "trade costs that arise from un-harmonized regulations" instead of explicitly referring to "trade costs that are equivalent to TBT". The trade costs that we are capturing include TBT costs but also other transaction costs that are generated from un-harmonized regulations in those sectors where (i) countries maintain their own domestic regulations (ii) domestic regulations are not deemed to be important and (iii) mutual recognition is applied.

Our evidence broadly confirms the hypothesis that EU harmonization of food regulations increases trade. Results based on regression by sub-sector separately suggest that this effect of the harmonization of food regulations varies significantly but remains positive for all sub-sectors with the exception of condiments. An important feature in our exercise is that we allow for a variation in time for detailed sectors when making inferences about the effect of harmonization of regulations. Next, we find that tariff equivalents of the costs of not harmonizing with food regulations, subject to the sub-sector the elasticity of substitution, vary significantly across some food sub-sector.

The most similar papers to this are Otsuki *et al.* (2001), Calvin and Krissoff (1998) and Haveman and Thursby (2000). Otskuki *et al.* (2001) suggest that technical regulations in individual countries in the EU constitute a considerable obstacle to exports of developing countries. The authors further calculate potential export losses as a result of more stringent aflatoxin regulations resulting from upward harmonization at the EU level such that the level of harmonized regulations are higher than domestic regulations. This data is obtained from a FAO survey of mycotoxin standards on food combined with information extracted from a EU Directive. The level of the stringency of food standards is expressed in the maximum allowable contamination. Using a gravity equation, the authors estimate that aflatoxin standards imposed by individual EU member countries are a major barrier to African exports of dried fruits and nuts. Using these estimates, they calculate the impact of EU harmonization of aflatoxin standards on African exports and find an estimated trade loss that is even higher than before harmonization when each of the EU countries imposed their own national standard. Calvin and Krissoff (1998) estimate the tariff equivalents to technical regulations in the apple sector. They compare CIF prices of U.S. apples in Japan with wholesale prices of Japanese apples. They assume that the price gap consists of the customs tariff rate and the TBT equivalent tariff rate. These authors find that the tariff equivalent of technical regulations is higher than the customs tariff rate. Haveman and Thursby (2000) construct non-tariff barriers (NTBs) coverage ratios collected from 6-digit Harmonized System (HS) level agricultural products. Their primary result shows that NTBs reduce agricultural trade more than tariffs.[2]

The paper is organized as follows. In section 2, we derive the gravity equation. In section 3, we present preliminary data and discuss methodological issues related to the quantification of food regulations. In section 4, the results are presented. In section 5, we conclude.

2. Gravity Model

The general approach to measure the impact of NTB is based on the so-called gravity model of international trade. To gauge the impact of regulations and standards, the gravity model is then augmented with frequency-type measures usually expressed in the number of regulations in an industry, trade-weighted coverage ratios, number of printed pages of a regulation, etc.

To place some microeconomic foundation on the empirical estimation, we follow the model of Anderson and van Wincoop (2003) who reconcile a theoretical-grounded gravity model that emerges from a general equilibrium model. The interested reader is directed to that paper for an in-depth consideration of the gravity model. Here we simply outline the salient features of the model and incorporate the incidence of the harmonization of technical regulations. To write the standard gravity model, we derive the imports of country i from country j of sector k as:

$$M_{ijk} = \frac{E_{ik} Y_{jk}}{Y_{wk}} \left(\frac{T_{ijk}}{P_{ik} P_{jk}} \right)^{(1-\sigma k)} \qquad (1)$$

where:

[2] The economic literature includes TBT in the broader category of NTBs.

$$P_{ik} = \left[\sum_j \frac{Y_{jk}}{Y_{wk}} \left(\frac{T_{ijk}}{P_{jk}} \right)^{(1-\sigma k)} \right]^{1/(1-\sigma k)} \quad (2)$$

$$P_{jk} = \left[\sum_i \frac{E_{ik}}{Y_{wk}} \left(\frac{T_{ijk}}{P_{ik}} \right)^{(1-\sigma k)} \right]^{1/(1-\sigma k)} \quad (2')$$

and Y_{wk} is the world output for sector k, Y_{jk} is the output in country j for sector k, E_{ik} is the expenditure in country i for sector k, T_{ijk} is the trade cost factor, P_{ik} and P_{jk} are price indices referred to as "multilateral trade resistances" as it depends positively on trading barriers with all trading partners, and σ_k is the elasticity of substitution between foreign sectors k.

In empirical specifications, the unobservable trade cost factor, T_{ijk}, is usually captured by an increasing function of a distance-dependent variable and other trade barriers. We add the trade costs that arise from un-harmonized regulations, NH, in the trade costs function and an additional set of other controls, Z, which we motivate below. Hence, the trade cost function - usually expressed in its multiplicative form - is written as:

$$T_{ijk} = (D_{ij})^{\delta k} NH^{(1-\rho ijk)} \Pi_g Z_g^{\theta ijk} \quad (3)$$

and in log form:

$$\ln T_{ijk} = \delta_k \ln D_{ij} + (1-\rho_{ijk}) \ln NH + \Sigma_g \theta_{ijk} \ln Z_g \quad (4)$$

where D_{ij} stands for the bilateral distance between country i and country j, NH is the trade cost that arises from un-harmonized regulations and ρ_{ijk} increases from a value of 0 to 1 as bilateral trade within each sub-sector k is increasingly subjected to harmonized food regulations. In equation (3), the ad-valorem tariff equivalent which we denote $\tau_{ijk} = NH^{(1-\rho ijk)}$ increases from a value of zero to NH as *bilateral trade within each sub-sector k is increasingly subjected to harmonized food regulations*: $\tau_{ijk} \to 0$ as $\rho_{ijk} \to 1$ and $\tau_{ijk} \to NH$ as $\rho_{ijk} \to 0$[3].

Log-linearizing equation (1) and combining with equation (4), the stochastic log-linear form of the gravity model for estimation is written as:

$$\ln M_{ijk} = \alpha_k + \ln E_{ik} + \ln Y_{jk} + \tau \ln D_{ij} + \Phi \rho_{ijk} + \lambda \theta_{ijk} + (\sigma_k - 1) \ln P_{ik} + (\sigma_k - 1) \ln P_{jk} + \varepsilon_{ijk} \quad (5)$$

where $\alpha_k = (1 - \sigma_k) \ln NH - \ln y_{wk}$, $\tau = (1 - \sigma_k)\, \delta_k$, $\Phi = (\sigma_k - 1) \ln NH$ and $\lambda = (1 - \sigma_k)\, \Sigma_g \ln Z_g$.

3 We thank a referee for this notation.

Obviously, the better countries' goods are substitutes for one another, the higher value of σ_k, and the greater is the extent to which bilateral trade flows are constrained by trade costs. Given some value for the elasticity of substitution (σ_k), the estimation of equation (5) permits a direct identification of the trade cost that arises from not harmonizing with technical regulations (NH). Under the condition that we approximate α_k by a constant in the empirical model given below, the trade cost of an un-harmonized situation is written as: NH = exp [$\Phi/(\sigma_k$ -1)] where Φ is an estimated coefficient. The derivation of trade cost from un-harmonized food regulations is further discussed in section 5.2.

2.1. Empirical Specification

The empirical specification of the gravity model is based on equation (5) and the general form of our estimating equation is written as:

$$ln\ M_{ijkt} = \alpha_k + \beta_e\ ln\ E_{ikt} + \beta_y\ ln\ Y_{jkt} + \tau\ ln\ D_{ij} + \pi\ X' + \varepsilon_{ijkt} \tag{6}$$

with time, t = 1,…T where α_k in equation (5) is now replaced by an intercept in equation (6), M_{ijk} is the volume of imports by country i from country j of sector k, E_{ik} is the sector k expenditure in country i, Y_{jk} is the value of sector k output in the exporting country j, D_{ij} is the distance between the trading centers of the two countries. The vector X is a set of characteristics that, amongst others, include multilateral resistance effects (P_{ik}, P_{jk}), other geographic characteristics, cost competitiveness, harmonization of food regulations (ρ_{ijk}). The error term ε_{ijk} is further discussed in section 4.1. All variables are expressed in logarithm with the exception of harmonization of food regulations (ρ_{ijk}) and dummies.

Income Elasticities: According to equation (5), the standard gravity exercise is to impose the restriction that elasticities of E_{ik} and Y_{jk} are constrained to one. While the assumption of constant expenditure and output elasticities make sense at an aggregated level, it becomes questionable at a more disaggregated level. Indeed, when consumption expenditure rises and output grows, the structure of import demand and supply may change. To allow for a more flexible demand and output response, we include β_e and β_y as free parameters to be estimated.

Multilateral Resistance Effects or Remoteness: Many authors include importing and exporting country specific effects, respectively denoted as μ_i and υ_j , to correct for multilateral trading resistance factors denoted as P_i and P_j in equation (2).[4] The measurement of μ_i and υ_j is further discussed in section 4 (see equation 9).

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[4] The estimation of the stochastic form of equation (5) subjected to a number of conditions (depending on the number of countries and sectors) defined in equations (2) requires a non-linear estimator of a complex system.

Adjacency and Language: Typically, the gravity studies on European trade add a dummy variable to indicate whether the two countries share a common language and another dummy to indicate whether they share a common land border. In our sample, those EU member countries that share a common language also share a common land border. We therefore use an alternative specification of including a dummy, *AL*, for countries sharing a common border and language and a dummy, *AN*, for countries sharing a common border but not a common language. We anticipate that the signs of *AL* and *AN* be positive.

Cost Competitiveness: As changes in competitiveness may vary across countries in order to explain import from a specific country, we also include a measure of competitiveness based on the relative unit labor costs, $Rulc_{ij}$, between the importing and the exporting country, *i* and *j*, of total manufacturing, namely:

$$ln\ Rulc_{ijt} = ln\ [(Ulc_{it}/\sum_h \lambda_{ih} Ulc_{ht}) / (Ulc_{jt}/\sum_h \lambda_{ih}\ Ulc_{ht})] \quad (7)$$

where Ulc_i and λ_h denote respectively the unit labor cost of country *i* and the share of country *h* in total exports of manufacturing from country *i*. We use the average bilateral trade flows during the 1990-2001 period as the weighting factor, λ_{ih}. A relative loss in the competitiveness of the importing country should increase its imports. We therefore anticipate that the sign of $lnRulc_{ij}$ be positive.

Coverage Ratio of Harmonized Food Regulations: In our model, the harmonization of food regulations is measured by an export-weighted coverage ratio, ρ_{ijk}, from country *j* to country *i* for sector *k*. The idea is that country *i* imports more the more country *j* satisfies with EU harmonization since it can more easily penetrate foreign markets. As further explained in section 3.2, this weighting scheme is chosen to reduce the bias due to simultaneity arising from the fact that more harmonization is demanded in heavily traded sectors. As such, trade weighting as a source of bias is reduced as the left hand side of the equation is only a small part of the trade weight on the right hand side. We anticipate that the sign of ρ_{ijk} be positive.

3. Data

3.1. Trade Data

Trade data come from the Comext database of Eurostat and are collected at the 8-digit level of the European CN trade classification and at the 4-digit NACE revision 1 industrial classification. Our sample covers ten NACE sub-sectors: meat (151), fish (152), fruits &

Because such an empirical measurement requires some customs programming, many authors have opted for using country-specific dummies.

vegetables (153), oils & fats (154), dairy & cheese (155), grain (156), sugar (1583) & cacao (1584), tea & coffee (1586), condiments (1587) and miscellaneous food products (bread - 1581, biscuits - 1582, homogenized food - 1588, food n.e.c. - 1589). The data is available in values (euros) and volumes (tons). We deflate the imports data by GDP (GDP deflator, 1995=100) to obtain a real flow of trade. Our sample covers the 1990-2001 period. The importers 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 and the remaining EU countries: Belgium and Luxembourg treated as one region, Finland, Sweden and Austria. The choice of ten importing countries was limited by data. Our sample therefore includes 1560 observations (10*13*12) for each sector k.

3.2. Data on the Harmonization of Technical Regulations

To measure the incidence of harmonization of technical regulations in the food industry, we use a purpose built database that is extracted from previous work of Brenton *et al.* (2002). The product classification of the database follows the detailed CN classification of the EU to allow a direct link to the trade data. This work identifies CN product codes that are covered by the relevant harmonization initiatives of technical regulations.[5] Changes in the annual CN classification throughout our 1990-2001 sample period led to some attributions. In the database, product codes match the CN 1998 product classification so that a direct link with trade data is only available for 1998. To collect data for 1990 to 2001, we used correlation tables (available from Eurostat) between yearly CN classifications in order to accurately update the CN product classification of the database with the trade data from the Comext database.

Our model captures the incidence of harmonization of food technical regulations through trade coverage ratios that are calculated for each sub-sector and time-period as follows. In the dataset, the incidence of harmonization of TBT is signalled by a binary indicator variable, ρ_l, taking the value of 1 if harmonization applies against the bilateral trade of product l and 0 otherwise. A value of zero is applied when (i) harmonization of regulations is not applied and countries maintain their own domestic regulations, (ii) domestic regulations are not deemed to be important and (iii) mutual recognition is applied. Due to the lack of further data, we are unable to distinguish between (i)-(iii). These binary indicators are aggregated to form a trade coverage ratios, ρ_{ijk}, applicable between country i and country j for sub-sector k. The coverage ratio of the sub-sector k is defined as $\rho_{ijk} = \sum_{l \in k} w_{ijl}\, \rho_l$ where $\rho_l = \max(\rho_l)$ and $\sum_{l \in k} w_{ijl} = 1$. If the weights, w, are proportional to the level of bilateral trade, then the coverage ratio is equal

[5] Each EU Directive that stipulates a harmonization initiative identifies the scope of products or sub-sectors to which it is pertained.

to the percentage of bilateral trade of a sub-sector covered by the harmonization of technical regulations. We use export-weighted coverage ratios of each country *j* to country *i*. Ideally, but unavailable set of weights would be the level of production. Using imports as a weight would be a worse approximation to the ideal average because the actual values of imports that are measured at the left hand side of the gravity equation could be reflected by the presence of harmonization of regulations.

3.3. Other Data

We extract production and expenditures on human consumption for food sub-sectors and member states from the New Cronos database of Eurostat. Consumption expenditure is not available for the tea & coffee, condiments and miscellaneous food sub-sectors. For these first two sub-sectors we calculate consumption from supply, imports and exports. For the miscellaneous food sub-sector we use the aggregate food consumption. Missing data on production are approximated by applying a trend of the gross rate of value-added (in quantity) in each NACE sub-sector that is also available from the New Cronos database. Following the conventional method in the gravity literature, we measure distances between member states with the direct great circle distance between the economic centers, i.e., capital cities. Gross capital formation, gross domestic product (constant and current), population and unit labor costs in total manufacturing are obtained from the New Cronos database. For values of unit labor costs unavailable for some countries and years, we approximate the missing observations by using the average growth rate of observations before and after the missing observations.

4. Results

Table 1 reports the results by applying the maximum likelihood random-effects Tobit estimation procedure and specify the error term in equation (6) as:

$$\varepsilon_{ijkt} = \mu_{ik} + \upsilon_{jk} + \xi_{ijkt} \qquad (8)$$

where for each k regression, μ_{ik} and υ_{jk} are the unobserved random effects of the importing and exporting country respectively while ξ_{ijkt} is a random component over countries and time.[6] In the random effect model, the unobservable or non-measurable factors (μ_{ik}, υ_{jk}) control for unobserved importer and exporter heterogeneity as well as for what Anderson and van Wincoop (2003) term "multilateral resistance".

[6] As an alternative, we could use fixed effects in a Tobit procedure. For a discussion on the bias of such an alternative estimator see Honoré (1992) and Wooldridge, 2002, pp. 540-542.

This equation is estimated for each sector, k, separately. The overall fit is high in each of the regressions and, for most of the variables, standard errors are low. [7]

Consumption Expenditure and Production Elasticities: The elasticity coefficients of consumption expenditure (E) of the importing and production (Y) of the exporting country have the expected sign and are statistically significant at the 99% confidence interval. Taking into account the possible endogeniety that may occur between these two variables and trade, we have used a set of several instruments. With the exception of meat (151) and fish (152), imports are more sensitive to foreign production (supply effect) than own consumption expenditure. These differences are most pronounced for tea & coffee (1586) and miscellaneous food (158x). With the exception of the aggregate food sector (All), meat (151) and dairy (155), we do not find both of the expenditure and production elasticities close to unity as being imposed from theory. As a robust check, a joint F-test using the linear restriction that both coefficients are equal to one is rejected for these three food categories.

Distance, Adjacency and Language: The coefficients of bilateral distance (D) and 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 expected signs. It is not surprising that the coefficient of bilateral distances that supposedly represents transportation costs varies across product categories.

Cost Competitiveness: The relative unit labor costs ($Rulc_{ij}$) is still taken at the level of manufacturing. If country i experiences a loss of competitiveness of 1% with respect to its trading partner, imports raises between 0.1% and 0.5%. In general, the coefficient retains this positive and expected sign with the exception of fish (152) and tea & coffee (1586) while it is not an important determinant for imports of condiments (1587). We observe the highest impact on imports for fruits & vegetables (153) and grain mill (156).

Harmonization of Food Regulations: With the exception of condiments (1587), we find a significant (>99%) and positive effect on EU imports. For each particular sector *k*, the coefficient shows to what extent a country j that complies with EU harmonization penetrates more easily other member states' markets. . A coefficient of 1.55 for the aggregate food sector suggests that country j´s exports coverage ratio of EU harmonized food regulations increase

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7 We underwent many preliminary tests not reported in the paper. Influential observations were tested using Cook distances, leverages and DFIT values. No observations appear to be pathological. In addition, we also tested for heteroscedasticity in the spirit of the Breusch-Pagan-Godfrey test, normality using the Jarque bera test. We also tested for serial correlation and found strong evidence of a AR(1) process. This suggest it is worth to further investigate a dynamic model which we omitted for the purpose of this paper. It is noted that a AR(1) process is exploited in the error term (see Wooldridge, 2002, for a further discussion).

trade with 4.7% (4.7 = exp (1.55)) if there were complete harmonization. The coefficient varies across sub-sectors. The effect of harmonized food regulations is smaller for meat (151), dairy (155) and tea & coffee (1586) and surprisingly larger for sugar & cacao (1583 & 1584).

4.1. Evolution of Harmonization of Good Regulations over Time

We now turn to the analysis of changes in the effect of harmonization of food regulations over time. In particular we are interested whether there has been an increasing effect of EU regulations on trade over time. Our method of estimating gravity model (6) imposes restrictions that the intercept and effect of EU harmonization are invariant through time. This model may be too restrictive because the effect of EU harmonization that we obtain from table 1 is the same throughout the entire period.

We test these restrictions using the likelihood ratio test (LR). To do so, we transform the gravity model into an unconstrained model where we include time dummies and allow the coefficient of the harmonization of food regulations to vary over time, written as follows:

$$ln\ M_{ijkt} = \alpha_{kt} + \Phi_t\, \rho_{ijkt} + RHS\ (6) \qquad (9)$$

where RHS (6) include the remaining variables of the right hand side of equation (6). In the general model (9), the coefficients of the intercept, α_{kt}, and the coefficients of harmonized food regulations, Φ_t, are allowed to change over time.

Table 2 summarizes the results of the four log-likelihood ratio tests undertaken for each regression of sector k. The test reveals that none of the two restrictions are rejected with respect to regressions on oils & fats (154), sugar & cacao (1583, 1584), condiments (1587) and miscellaneous foods (158x). The restriction that the intercept is constant over time is never rejected for the remaining sectors. The restriction that the effect of the harmonization food regulations is the same over time is rejected for the aggregated food sector (all), meat (151) and fruits & vegetables (153). For these three sectors, the year-by-year evolution is presented in table 3 where we employ a regression with yearly intercepts and time-dependent harmonization effects as suggested by the test.

For the 1990-2001 period, we observe that the effect of harmonization of food regulations in the aggregate food sectors (all) increased from a coefficient of 1.18 to 1.98. The evolution of the effect of harmonized regulations in meat (151) follows a U-shape form with an initial coefficient of 1.4, reaching a bottom value of coefficients that are not statistically different from zero during the 1993-1995 period and with a gradual increase from 1996 to 2001. For fruits & vegetables (153), the effect of harmonized regulations increases from a coefficient of 1.19 in 1990 to 1.77 in 2001.

These estimates show that harmonization in food regulations has increased intra-EU imports in all food products by around two thirds and in fruits & vegetables by around one third during the 1990-2001. Several sanitary crises in the meat sub-sector during the same period have, however, severely disturbed intra-EU trade, which may explain the declining and then rising effect of harmonization in food regulations on intra-EU imports in this particular sub-sector.[8]

4.2. Trade Costs of Non-Harmonized Food Regulations

In the previous subsection, we discussed the magnitude of the coefficient on the trade coverage ratio of EU harmonized food regulations in the gravity equation. Recall from section 2 that we can use this coefficient to compute a trade cost that arises from non-harmonized food regulations (*NH*).

These trade costs can be expressed as if there were a tariff level, referred to as a *tariff equivalent*, which means estimating tariffs that would have the same effect of a trade cost that arises from un-harmonized EU food regulations. The tariff equivalence is interpreted as an estimated tariff that would have the same effect of a trade cost that arises from un-harmonized EU food regulations. We deliberately refer to "trade costs that arise from un-harmonized regulations" instead of explicitly referring to "trade costs that are equivalent to TBT". Based on the nature of the data on harmonization that we have discussed in section 3.2., the trade costs that we are capturing include TBT costs but also other transaction costs that are generated from un-harmonized regulations in those sectors where (i) countries maintain their own domestic regulations (ii) domestic regulations are not deemed to be important and (iii) mutual recognition is applied. The estimate of the tariff equivalent of *NH* is defined as: $NH = \exp[\Phi/(\sigma_k - 1)]-1$, where Φ is the estimated coefficient of the trade coverage ratio of EU harmonized food regulations for each sector *k*.

This implies that we need an estimate of an elasticity of substitution σ_k between any pair of countries' products in sub-sector *k* to obtain an estimate of trade barriers. It is noted that estimates of trade costs based on trade flows are very sensitive to assumptions about the elasticity of a substitution. Because long-run estimates of elasticities of substitution are more appropriate for policy analysis than short-run estimates, we prefer to rely on cross-sectional estimates from Hummels (2001). These estimates avoid the downward bias often found in

[8] The eruption of Bovine Spongiform Encephalopathy (BSE) cases in the UK since 1985 resulted in disruptions in bovine meat imports from UK followed by a general EU ban on imports of bovine meat from UK in 1996 until 1999 and from Portugal in 1998 until 1999 with some member states extending the UK import ban longer. The dioxin crisis and foot-and-mouth disease disturbed trade with Belgium in 1999 and the UK in 2001 respectively.

time-series studies resulting from misspecification in the single-equation estimation (McDaniel and Balistreri, 2003). They are derived from an underlying structural model with a general equilibrium that includes monopolistic competition.

In table 4, we report the elasticities of substitution from Hummels (2001) estimated by OLS at the 2-digit level of SITC that are significant and correspond to the food sub-sectors of interest of our study. The elasticity of substitution for the aggregate food sector is not available from Hummels (2001). We use the elasticity of substitution for the aggregated food sector from Erkel-Rouse and Mirza (2002) estimated by GMM.[9] McDaniel and Balistreri (2003) notes that the level of aggregation is important because generally, higher estimated elasticities are found with higher disaggregated data. This aggregation assumption is also reflected in our choice of elasticities.

Table 4 gives the tariff-equivalence of trade costs that arise from not harmonizing with food regulations for matching food sub-sectors and the aggregated food sector. We observe a varying range of comparable tariff equivalents: these are (i) *low* (about 10%) for meat (151) and dairy (155), (ii) *medium low* (about 27%) for grain mill (156) and tea & coffee (1586), (ii) *high* (about 60%) for fish (152) and oils & fats (154) and (iii) very *high* (about 200%) tariff equivalents of trade costs for fruits & vegetables (153) and the aggregate food sector. This latter result is due to the low estimate of the elasticity of substitution that has been found in the literature. The coefficients (in column 4) are obtained from regressing models (8) allowing for time-dependent intercepts as suggest from the likelihood ratio tests in table 4. Messerlin (2001) computes the tariff equivalents of crude NTBs for the EU. For 1999, the tariff equivalents of NTBs amount to about 100% for the dairy as well as the meat sector.

5. Conclusions

In this paper, we used a gravity model to measure the trade impact of harmonizing food regulations among close trade partners in the European Union. We found support for the prediction that the EU harmonization of food regulations has a large positive effect on intra-EU trade at an aggregated and sub-sector levels of the food industry. Results based on regression by sub-sector separately suggest that this effect of the harmonization of food regulations varies significantly but remains positive for all sub-sectors with the exception of condiments. This empirical finding suggests that there are positive trade-enhancing effects from the implementation of EU harmonized regulations in the food industry.

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[9] Hummels (2001) uses 1992 cross-sectional data on imports to the US, New Zealand, Argentina, Brazil, Chile and Paraguay and Erkel-Rouse and Mirza (2002) use panel data of imports between pairs of OECD countries from 1972 and 1994.

The theoretically funded functional form of the gravity equation allows for the estimation of tariff equivalents of trade costs of not harmonizing EU food regulations. Subject to the sub-sector elasticity of substitution between origins, these tariff equivalents of regulatory policy barriers range from 153% for grain mill, 131% for the whole food industry, 100% for dairy and 89% for fish.

For EU policy, this provides some evidence to what extent the harmonization approach is successfully removing technical barriers to trade and integrating EU markets in the food industry. It is clearly evident that harmonization of EU food regulations is a further instrument to deeper integration of intra-EU trade. However and ignored in this paper due to data limitation is that in practice, complying with EU food regulations can entail a cost that can induce a significant burden for exporters that could be omitted if MRP can be achieved. However, the Mutual recognition approach is still limited due to the administrative and cultural burden of recognizing food regulations from individual member states to a EU equivalent.

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Table 1: Gravity Estimates of the Impact of the Harmonization of Food Regulations on Intra-EU Trade, 1990-2001

	All (151-158[a])	**Meat (151)**	**Fish (152)**	**Fruits & Veg. (153)**	**Oils & Fats (154)**	**Dairy (155)**	**Grain Mill (156)**	**Sugar & Cacao (1583 & 1584)**	**Tea & Coffee (1586)**	**Condi-ments (1587)**	**Misc. Food (158x[b])**
Ln E_{ik}	0.838	0.984	0.936	0.868	0.960	1.012	1.149	0.711	0.940	1.036	0.693
	(0.02)	(0.03)	(0.06)	(0.04)	(0.03)	(0.04)	(0.03)	(0.01)	(0.04)	(0.03)	(0.03)
Ln Y_{jk}	0.970	0.794	0.691	1.22	1.344	1.124	1.231	1.267	1.803	1.716	1.514
	(0.03)	(0.03)	(0.07)	(0.02)	(0.05)	(0.05)	(0.04)	(0.01)	(0.05)	(0.03)	(0.04)
Ln D_{ij}	-0.908	-1.183	-1.701	-1.476	-1.599	-1.252	-1.931	-1.878	-1.763	-1.758	-1.021
	(0.05)	(0.06)	(0.01)	(0.04)	(0.09)	(0.09)	(0.07)	(0.06)	(0.14)	(0.06)	(0.05)
AN	0.248	0.372	0.262	0.05	0.193	0.02	0.189	0.151	0.196	-0.172	0.155
	(0.07)	(0.06)	(0.08)	(0.17)	(0.13)	(0.24)	(0.16)	(0.09)	(0.16)	(0.13)	(0.11)
AL	0.401	0.592	0.695	0.699	0.297	0.241	0.541	0.657	0.704	0.371	0.413
	(0.07)	(0.17)	(0.16)	(0.12)	(0.14)	(0.11)	(0.26)	(0.13)	(0.26)	(0.14)	(0.12)
Ln $Rulc_{ij}$	0.134	0.224	-0.159	0.415	0.256	0.164	0.482	0.130	-0.575	-0.022	0.259
	(0.05)	(0.08)	(0.06)	(0.04)	(0.07)	(0.12)	(0.10)	(0.04)	(0.17)	(0.08)	(0.05)
ρ_{ijkt}	1.547	0.774	1.588	1.869	2.889	0.781	1.173	3.434	0.829	-0.325	1.703
	(0.08)	(0.16)	(0.12)	(0.08)	(0.11)	(0.19)	(0.12)	(0.13)	(0.125)	(0.109)	(0.082)
Intercept	-7.258	4.062	-4.607	-8.096	-7.241	-5.020	-6.651	-1.217	-5.196	-6.662	-5.476
	(0.79)	(0.84)	(0.63)	(0.58)	(1.15)	(1.32)	(1.06)	(0.56)	(1.18)	(0.797)	(0.846)
σ^2_{μ} [(c)]	0.402	0.94	0.42	0.69	0.98	0.96	0.97	0.62	1.26	0.65	0.68
$\sigma^2 \nu$	0.830	1.21	0.71	0.79	1.45	1.34	1.30	0.95	1.47	1.33	1.15
$\sigma^2 \xi$	0.523	0.74	0.51	0.68	1.18	1.12	0.98	0.73	1.11	0.95	0.79
R^2 [(d)]	0.736	0.809	0.685	0.751	0.821	0.708	0.808	0.921	0.712	0.612	0.677
Log-Likelihood	-1441.58	-1365.19	-1697.45	-1552.12	-1296.96	-1590.99	-1359.261	-923.744	-1475.006	-1988.96	-1741.12
Het(k)[(e)]	76.5	136.76	49.37	96.75	42.92	123.96	105.12	78.12	69.87	101.15	56.12

Notes: (a) except for feed (157) (b) miscellaneous (158X) consists of the following sub-sectors: bread (1581), biscuits (1582), homogenized food (1588), food n.e.c. (1589) (c) variance of the random components (d) R^2 is the squared correlation between actual and predicted values. (e) see explanation in text.

Table 2: Likelihood Ratio Tests

Hypothesis	All (151-158[a])	Meat (151)	Fish (152)	Fruits & Veg. (153)	Oils & Fats (154)	Dairy (155)	Grain Mill (156)	Sugar & Cacao (1583 & 1584)	Tea & Coffee (1586)	Condi-ments (1587)	Misc. Food (158x[b])
$\alpha_t ; \Phi_t$ against $\alpha_t ; \Phi$	**32.05**	**21.65**	18. 52	**24.61**	15.78	18.94	11.12	15.10	12.18	7.70	17.47
	(.000)	(.013)	(.07)	(.017)	(.149)	(.068)	(.433)	(.177)	(.357)	(.747)	(.091)
$\alpha_t ; \Phi_t$ against $\alpha ; \Phi_t$	**67.15**	**24.02**	**32.25**	**28.86**	11.92	**56.63**	**28.45**	16.20	**34.30**	20.01	14.84
	(.000)	(.012)	(.00)	(.002)	(.369)	(.000)	(.002)	(.133)	(.000)	(.051)	(.189)
$\alpha_t ; \Phi$ against $\alpha ; \Phi$			**23.91**		19.24	**48.21**	**41.48**	6.00	**41.46**	16.02	17.02
	-	-	(.013)		(.058)	(.000)	(.000)	(.871)	(.000)	(.140)	(.101)
$\alpha ; \Phi_t$ against $\alpha ; \Phi$					20.11			4.90		3.71	11.64
	-	-	-		(.049)	-	-	(.933)	-	(.977)	(.421)

Notes: The table lists the χ^2 distributions with 11 degrees of freedom. P-values of the significance level are reported in parentheses. (a) except for feed (157) (b) miscellaneous (158X) consists of the following sub-sectors: bread (1581), biscuits (1582), homogenized food (1588), food n.e.c. (1589). See text for an explanation of the test.

Table 3: Evolution of Harmonization of Food Regulations, 1990-2001

Year	**All (151-158)**	**Meat (151)**	**Fruits & Veg. (153)**
1990	1.182	1.395	1.187
	(.108)	(.281)	(.208)
1991	1.327	.935	1.805
	(.101)	(.407)	(.206)
1992	1.338	.688	1.463
	(.105)	(.285)	(.222)
1993	1.339	-.312	2.281
	(.103)	(.426)	(.211)
1994	1.592	.181	1.808
	(.102)	(.383)	(.228)
1995	1.819	.348	1.633
	(.009)	(.392)	(.247)
1996	1.820	.615	1.932
	(.009)	(.312)	(.251)
1997	1.826	.954	1.643
	(.101)	(.491)	(.254)
1998	1.898	.473	1.805
	(.100)	(.217)	(.249)
1999	1.935	.898	1.482
	(.009)	(.362)	(.262)
2000	2.031	1.243	1.889
	(.100)	(.318)	(.243)
2001	1.984	.983	1.771
	(.100)	(.368)	(.252)

Notes: The table lists the coefficient of harmonization of food regulations, ρ_{ijkt}, (from table 3) multiplied by a time dummy for each year between 1990-2001. The coefficients are obtained from regressing gravity model (8) augmented with time-dependent intercepts.

Table 4: Tariff Equivalents of the Cost of EU Non-Harmonized Food Regulations (%)

NACE	Description	Elasticity of Substitution[a]	Coefficient[b]	Tariff Equivalent
151	Meat	8.00	0.70[d]	10.5%
152	Fish	4.76	1.56	51.5%
153	Fruits & Veg.	2.46	1.72[d]	224.8%
154	Oils and Fats	6.59	2.88	67.6%
155	Dairy	7.01	0.62	10.0%
156	Grain mill	5.45	1.08	27.4%
1586	Tea & Coffee	4.60	0.85	26.6.%
151-158[c]	Food Industry	2.6	1.67[d]	183.9%

Notes: (a) trade elasticities are obtained from Hummels (2001) with the exception of the aggregated food industry (151-158) from Erkel-Rouse and Mirza (2002), see text for further details. (b) coefficients are obtained from regressing model (8) allowing the intercept to vary over time as suggested by the LR-test. (c) except for feed (157). (d) average coefficient from table 5: $[\sum_t \Phi_t]/12$