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Harmonisation of food regulations and trade in the Single Market: evidence from disaggregated data

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Summary

A structural gravity model is used to quantify the effect of harmonisation of EU food regulations on intra-EU trade during 1990–2001. We construct a database that identifies food products covered by harmonised regulations at a very detailed level. We find, at different levels of aggregation, that harmonisation of food regulations has led to more intra-EU trade, and that the tariff equivalents of the cost of not harmonising food regulations, subject to the sub-sector elasticity of substitution, vary significantly across some food sub-sectors.

Keywords: gravity, food regulations, technical barriers to trade, tariff equivalence, European trade

JEL classification: F15, Q17, Q18

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 (1997) calculated that, during the first phase of the 1985 White Paper's (CEC, 1985) food specific programme (1985–1996), over 87 per cent of intra-EU trade in processed food was affected by differences in regulations. The principal mechanism for eliminating 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 harmonisation is a precondition for countries to allow products of other countries to access their markets. Specifically in the case of harmonisation of food regulations, the EU has sought to remove differences in national regulations on a common set of binding requirements in the form of detailed directives for a single or group of products.[1]

In this paper, we address two empirical questions: Does harmonisation of food regulations lead to significant increases in trade between EU participating countries? What is the trade cost, in terms of tariff equivalents, of not harmonising with EU food regulations? To this end, we updated a specially constructed database that, at the 8-digit level of the tariff line codes in the European Combined Nomenclature (CN) trade classification, directly identifies food products that are covered by harmonisation of food regulations. This database allows for a direct link with trade data from which we construct export-weighted trade coverage ratios of the aggregate food sector and ten NACE food sub-sectors for the 1990–2001 period and for each of the EU member states. We estimated these export-weighted coverage ratios on imports across countries over the period for each food sub-sector in order to quantify the extent of harmonisation of food regulations.

A gravity model of international trade was then constructed, in which the unobservable trade cost is itself a function of a set of observable variables including the harmonisation of food regulations on the assumption that harmonisation of food regulations reduces trade costs between trading partners. The estimated effect of harmonisation of food regulations allowed us to compute a tariff equivalent using an elasticity of substitution obtained from related literature. A tariff equivalent is interpreted as the tariff rate that would have the same effect of a trade cost arising from unharmonised EU food regulations. We deliberately refer to 'trade costs that arise from unharmonised regulations' instead of explicitly referring to 'trade costs that are equivalent to TBT'. The trade costs that we capture include TBT costs, but also other transaction costs that are generated by unharmonised 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. An important feature in our exercise is that we allowed for variation over time for specific sectors when making inferences about the effect of harmonisation of regulations.

Our evidence broadly confirms the hypothesis that EU harmonisation of food regulations increases trade. Results based on separate regressions by sub-sector suggest that the effect of harmonising food regulations varies significantly, but remains positive for all sub-sectors, with the exception of condiments. We also find that tariff equivalents of the costs of not harmonising with food regulations, subject to the sub-sector the elasticity of substitution, vary significantly across some food sub-sectors.

1 In practice, most of the food sub-sectors where technical regulations are important have now been harmonised under the so-called old approach, particularly in product areas where the mutual recognition was seen to be failing. The old approach is a harmonisation 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).

Other authors have attempted to measure various effects of EU TBT. Otsuki *et al.* (2001) suggested that technical regulations in individual EU countries constitute a considerable obstacle to developing countries' exports. The authors calculated potential export losses as a result of more stringent aflatoxin regulations, expressed as the maximum allowable contamination resulting from upward harmonisation at the EU level, such that the level of harmonised regulations are higher than domestic regulations. Using a gravity equation, they estimated that aflatoxin standards imposed by individual EU member countries are a major barrier to African exports of dried fruits and nuts, and that the post-harmonisation trade loss is even higher than before harmonisation when each of the EU countries imposed their own national standard. Calvin and Krissoff (1998) estimated the tariff equivalent of technical regulations in the Japanese apple sector. They compared c.i.f. prices of imported US apples with wholesale prices of Japanese apples. Assuming that the price gap consists of the customs tariff rate and the TBT equivalent tariff rate, they found that the tariff equivalent of technical regulations is higher than the customs tariff rate. Haveman and Thursby (2000) constructed non-tariff barrier (NTB) coverage ratios for six-digit Harmonised System level agricultural products. Their primary result shows that NTBs reduce agricultural trade more than tariffs.[2]

Related papers include Swann and Temple (1996) and Moenius (1999). Both papers validate empirically the hypothesis that country-specific standards act like barriers to trade, while the bilateral harmonisation of standards promotes trade. The number of country-specific standards, however, do not act like barriers to trade. Because of data limitations, these papers focused on the trade impact of voluntary standards rather than on TBT.

Key differences between our paper and Otsuki *et al.* (2001) are: (i) the testable hypothesis of the effect of regulations, (ii) the quantification of harmonisation, (iii) a generalisation of the method for examining this effect and (iv) a much wider coverage of food sub-sectors. The central question of our paper is whether harmonisation of food regulations within the EU has increased trade between member countries. We are merely interested in trade costs that would arise if member countries did not comply with harmonisation. In contrast, Otskui *et al.* questioned whether harmonisation of regulations within the EU has decreased the level of trade with non-member countries more than before harmonisation. In that context, the trade impact depends on the cost of meeting the standard and the stringency of harmonised regulatory level. African countries face an upward harmonisation such that the stringency level of harmonised regulations is higher than domestic regulations, resulting in a comparative cost disadvantage that could dampen African exports.

Our paper is organised as follows. In Section 2, we derive the gravity equation. Section 3 presents preliminary data and discusses methodological issues related to the quantification of food regulations. In Section 4, we discuss some econometric issues. In Section 5, results are presented and discussed. In the final section, we conclude.

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

2. Gravity model

The usual approach to measuring the impact of NTBs in the literature is based on the so-called gravity model of international trade, which is then augmented with frequency-type measures such as the number of regulations in an industry, trade-weighted coverage ratios and/or the number of printed pages of a regulation.

Typically in a log-linear form, the gravity model assumes that the volume of trade between country pairs is promoted by their economic size or income and constrained by their geographic distances. Other country characteristics can easily be added. For example, Frankel (1997) added dummy variables for common language and border. Deardorff (1998) argued that the relative distance of trading partners should also affect the volume of trade. Wei (1996) and Helliwell (1997) extended this concept and defined a 'remoteness' variable to capture third country effects. Whether and how remoteness should be included in the model was further discussed by Helliwell (2001) and Anderson and van Wincoop (2003).

Despite a consistently high statistical fit in empirical work, the gravity model has been criticised for its lack of a theoretical foundation. In response, the gravity equation has been derived within the context of trade theories: Heckscher–Ohlin, monopolistic competition and Ricardian technologies.[3] It is worth emphasising that whatever the theoretical framework used to support the gravity model, they all yield a similar functional form. Therefore, the best conclusion to draw is that of Deardorff (1998: 12): "Just about any plausible model of trade would yield something very like the gravity model, whose empirical success is therefore not evidence of anything, but just a fact of life".

To give a microeconomic foundation to the empirical estimation, we follow Anderson and van Wincoop (2003), who developed a theoretical-grounded gravity model that emerges from a general equilibrium model. The interested reader is directed to their paper for an in-depth consideration of the gravity model. Here we simply outline the salient features of the model and describe how the harmonisation of technical regulations was incorporated. The standard gravity model expresses the imports of country i from country j of sector k as:[4]

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

3 For a recent survey of the gravity theory, see Feenstra (2002, 2003).

4 The Anderson and van Wincoop (2003) model can easily be extended to a set of many differentiated goods. A key feature of their model and most other theoretical-derived gravity models (e.g. Deardorff, 1998) is that consumers regard goods as differentiated by the location of production (the 'Armington assumption'). When each country is assumed to be endowed with just one good, the standard specification of the utility function underlying a gravity equation is usually a constant elasticity of substitution (CES) functional form. Where the Armington assumption entails that each country is specialised in a unique set of many goods, the underlying CES function assumes that preferences are CES across these many goods within a sector (i.e. each sector has a distinct aggregator of goods) but Cobb–Douglas across sectors. In both frameworks, the solution to the CES functional form subject to a budget constraint yields identical results (with or without the subscript k). The reader is referred to the recent work of Anderson and van Wincoop (2004).

where:

$$P_{\mathrm{ik}} = \left[\sum_{j} \frac{Y_{\mathrm{jk}}}{Y_{\mathrm{wk}}} \left(\frac{T_{\mathrm{ijk}}}{P_{\mathrm{jk}}} \right)^{1-\sigma_{\mathrm{k}}} \right]^{1/(1-\sigma_{\mathrm{k}})} \tag{2}$$

$$P_{\mathrm{jk}} = \left[\sum_{i} \frac{E_{\mathrm{ik}}}{Y_{\mathrm{wk}}} \left(\frac{T_{\mathrm{ijk}}}{P_{\mathrm{ik}}} \right)^{1-\sigma_{\mathrm{k}}} \right]^{1/(1-\sigma_{\mathrm{k}})} \tag{2$'$}$$

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 they depend 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 added the trade costs arising from unharmonised regulations, NH, into the trade cost function and an additional set of other conditioning variables, Z, explained below. Hence, the trade cost function, usually expressed in its multiplicative form, is written as:

$$T_{\mathrm{ijk}} = (D_{\mathrm{ij}})^{\delta_{\mathrm{k}}} \mathrm{NH}^{(1-\rho_{\mathrm{ijk}})} \Pi_{\mathrm{g}} Z_{\mathrm{g}}^{\theta_{\mathrm{ijk}}} \tag{3}$$

and in log form:

$$\ln T_{\mathrm{ijk}} = \delta_{\mathrm{k}} \ln D_{\mathrm{ij}} + (1 - \rho_{\mathrm{ijk}}) \ln \mathrm{NH} + \Sigma_{\mathrm{g}} \theta_{\mathrm{ijk}} \ln Z_{\mathrm{g}} \tag{4}$$

where D_{ij} is the distance between country i and country j, NH is the trade cost that arises from unharmonised regulations and ρ_{ijk} increases from a value of zero to one as bilateral trade within each sub-sector k is increasingly subjected to harmonised food regulations. In equation (3), the *ad valorem* tariff equivalent, which we denote $\tau_{\mathrm{ijk}} = \mathrm{NH}^{(1-\rho_{\mathrm{ijk}})}$, increases from a value of zero to NH *as bilateral trade within each sub-sector* k *is increasingly subjected to harmonised food regulations*: $\tau_{\mathrm{ijk}} \to 0$ as $\rho_{\mathrm{ijk}} \to 1$ and $\tau_{\mathrm{ijk}} \to \mathrm{NH}$ as $\rho_{\mathrm{ijk}} \to 0$.[5]

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

$$\begin{aligned} \ln M_{\mathrm{ijk}} = {} & \alpha_{\mathrm{k}} + \ln E_{\mathrm{ik}} + \ln Y_{\mathrm{jk}} + \tau \ln D_{\mathrm{ij}} + \Phi \rho_{\mathrm{ijk}} + \lambda \theta_{\mathrm{ijk}} \\ & + (\sigma_{\mathrm{k}} - 1) \ln P_{\mathrm{ik}} + (\sigma_{\mathrm{k}} - 1) \ln P_{\mathrm{jk}} + \epsilon_{\mathrm{ijk}} \end{aligned} \tag{5}$$

where

$$\alpha_{\mathrm{k}} = (1 - \sigma_{\mathrm{k}}) \ln \mathrm{NH} - \ln y_{\mathrm{wk}}, \; \tau = (1 - \sigma_{\mathrm{k}}) \delta_{\mathrm{k}},$$
$$\Phi = (\sigma_{\mathrm{k}} - 1) \ln \mathrm{NH} \quad \text{and} \quad \lambda = (1 - \sigma_{\mathrm{k}}) \Sigma_{\mathrm{g}} \ln Z_{\mathrm{g}}$$

5 We thank a referee for this notation.

Obviously, the closer substitutes countries' goods are for one another, the higher the value of σ_k, and the greater 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 direct identification of the trade cost that arises from not harmonising with technical regulations (NH). When we approximate α_k by a constant in the empirical model given below, the trade cost of an unharmonised situation is written as $\mathrm{NH} = \exp[\Phi/(\sigma_k - 1)]$, where Φ is an estimated coefficient. The derivation of trade cost from unharmonised 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:

$$\ln M_{ijkt} = \alpha_k + \beta_e \ln E_{ikt} + \beta_y \ln Y_{jkt} + \tau \ln D_{ij} + \pi X' + e_{ijkt} \qquad (6)$$

with time, $t = 1, \ldots, T$, where α_k in equation (5) is now replaced by a constant 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 and D_{ij} is the distance between the trading centres of the two countries. The vector X is a set of characteristics that include multilateral resistance effects (P_{ik}, P_{jk}), other geographic characteristics, cost competitiveness and harmonisation of food regulations (ρ_{ijk}). The disturbance term e_{ijk} is discussed in Section 4.1. All variables are expressed in logarithms, with the exception of harmonisation of food regulations (ρ_{ijk}) and dummies.

Income elasticities. In the standard gravity exercise, the elasticities of E_{ik} and Y_{jk} are constrained to one. While the assumption of unit elasticities of expenditure and output makes sense at an aggregated level, it becomes questionable at a more disaggregated level. To allow for a more flexible demand and output response, we included β_e and β_y as parameters to be estimated freely in equation (5).

Multilateral resistance effects. Many authors, in particular Hummels (2001), Rose and van Wincoop (2001), Anderson and van Wincoop (2003) and Eaton and Kortum (2001), have included 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).[6] The measurement of μ_i and υ_j is discussed in Section 4.1.

6 The estimation of the stochastic form of equation (5) subject 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. Because this requires some customised programming, many authors have opted for using country-specific dummies instead of estimating the multilateral trading resistance factors.

Adjacency and language. The gravity model can easily be extended by including various institutional, cultural or historical characteristics. Typically, 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 used 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 expect the signs of coefficients of AL and AN to be positive.

Cost competitiveness. As differences in competitiveness between countries may influence bilateral trade flows, we also included a measure of competitiveness based on the relative unit labour costs, $\mathrm{Rulc_{ij}}$, between the importing and the exporting country, i and j, of total manufacturing, namely:

$$\ln \mathrm{Rulc}_{\mathrm{ij}t} = \ln\left[\frac{(\mathrm{Ulc}_{\mathrm{i}t}/\sum_{\mathrm{h}} \lambda_{\mathrm{ih}}\mathrm{Ulc}_{\mathrm{h}t})}{(\mathrm{Ulc}_{\mathrm{j}t}/\sum_{\mathrm{h}} \lambda_{\mathrm{ih}}\mathrm{Ulc}_{\mathrm{h}t})}\right] \tag{7}$$

where $\mathrm{Ulc_i}$ and λ_h denote, respectively, the unit labour cost of country i and the share of country h in total exports of manufacturing from country i. We used 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 expected $\ln \mathrm{Rulc_{ij}}$ to have a positive coefficient.

Coverage ratio of harmonised food regulations. In our model, the harmonisation 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 for each particular sector k, country i imports more from country j the more country j complies with EU harmonisation, since it can more easily penetrate foreign markets. As further explained in Section 3.2, this weighting scheme was chosen to reduce the bias due to simultaneity arising from the fact that more harmonisation 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. The sign of ρ_{ijk} was expected to be positive.

3. Data

3.1. Trade data

Trade data for 1990–2001 came from the Comext database of Eurostat and were collected at the 8-digit level of the European CN trade classification and at the four-digit NACE revision 1 industrial classification.[7] Our sample covered ten NACE sub-sectors: meat (151), fish (152), fruits and vegetables

7 The statistical classification of economic activities in the European Community (NACE) is the industrial classification used by the statistical office of the European Communities (Eurostat).

(153), oils and fats (154), dairy and cheese (155), grain (156), sugar (1583) and cacao (1584), tea and coffee (1586), condiments (1587) and miscellaneous food products (bread—1581, biscuits—1582, homogenised food—1588, food n.e.c.—1589). The data is available in values (euros) and volumes (tons). We deflated the import data by the GDP deflator (1995 = 100) to obtain a real flow of trade. Importing countries are Denmark, France, Germany, Greece, Italy, Ireland, The Netherlands, Portugal, Spain and UK, and the exporting countries are the previous ten countries and the remaining EU countries: Belgium and Luxembourg treated as one region, Finland, Sweden and Austria. Importing countries were restricted to ten by data limitations. Our sample therefore includes 1560 observations ($10 \times 13 \times 12$) for each sector k.

3.2. Data on the harmonisation of technical regulations

To measure the extent of harmonisation of technical regulations in the food industry, we used a purpose-built database extracted from work by Brenton *et al.* (2002). The product classification of the database follows the detailed CN classification of the EU to allow a link with the trade data in order to identify CN product codes that are covered by the relevant harmonisation initiatives of technical regulations.[8] Changes in the annual CN classification throughout our 1990–2001 sample period created some problems. 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 1990–2001, we used correlation tables (available from Eurostat) between yearly CN classifications in order to update the CN product classification of the database accurately with the trade data from the Comext database.

Our aim is to test the hypothesis that harmonisation of food regulations increases intra-EU trade. Although the harmonisation process might not have removed all obstacles to trade, we expect remaining barriers for sectors regulated by EU initiatives to be at a minimum. A CEC (1998) study assessing the effectiveness of different instruments to remove TBT shows that on a five-point scale from low to high, trade of almost all products subject to harmonisation ranges between four (=measures are implemented, but some barriers remain) and five (=measures are successful and all significant barriers are removed).

A significant volume of EU food legislation had been adopted well before the 1990–2001 period of our sample. Only the directives on food inspection and nutritional labelling were actually adopted in 1989 and 1990, respectively.[9] The CEC (1997) study, indeed, reports that significant progress on Single market food legislation by companies was already expected in the

8 Each EU Directive that stipulates a harmonisation initiative identifies the scope of products or subsectors to which it pertains. The so-called 'pink book' (vol. 0–1) of the Commission lists all directives that are published with the aim of harmonised measures. In this database, only 'directives' were incorporated and should be distinguished from 'regulations' or other legal documents that are not binding to member states.

9 For a complete list of EU food measures, see CEC (1997), p. 19.

1985–1992 period. The impact on EU bilateral trade might, however, have been delayed because of lagged reactions to legislative changes. We did not make any data adjustments with a view to taking possible delays into account.

We extracted 1284 specific 8-digit CN product codes from the ten selected NACE food sub-sectors. Table 1 gives the frequency of the 8-digit 1998 CN product codes covering each of the ten food sub-sectors as well as the frequency of these product codes being subject to EU harmonisation of food regulations within each sub-sector. The number of products by sub-sector that are subject to harmonisation varies substantially. For example, harmonisation of regulations in sub-sectors such as oils and fats (154) and sugar (1583) and cacao (1584) has a high product coverage while harmonisation of technical regulations in some sub-sectors, especially meat (151), covers a small number of products. It is impossible to infer from this table the extent of the harmonisation of food technical regulations for each sub-sector because information on trade volumes is missing.

Our model captures the incidence of harmonisation of food technical regulations through trade coverage ratios that are calculated for each sub-sector and time-period as follows. In the database, harmonisation of TBT is coded by a binary indicator variable, ρ_l, taking the value of 1 if harmonisation applies against the bilateral trade of product l and zero otherwise. A value of zero is applied when (i) harmonisation of regulations is not applied and countries maintain their own domestic regulations, (ii) domestic

Table 1. Share of products regulated by EU harmonised regulations in 1998 by food sub-sector

Food sub-sector (NACE Rev. 1)	Description	1998 CN codes	1998 CN codes subject to harmonisation	CN codes subject to harmonisation as percentage of total CN codes
151	Meat	193	36	19
152	Fish	242	119	49
153	Fruits and vegetables	373	289	77
154	Oils and fats	82	78	95
155	Dairy	89	47	53
156	Grain	81	62	77
1583, 1584	Sugar and cacao	58	52	90
1586	Tea and coffee	15	9	60
1587	Condiments	35	25	71
158x[a]	Miscellaneous foods	116	71	61
151–158[b]	Food industry	1284	788	61

[a]Miscellaneous (158x) consists of the following sub-sectors: bread (1581), biscuits (1582), homogenised food (1588), food n.e.c. (1589).
[b]Feed (157) is not considered in our analysis because it is far from being a final good.

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), (ii) and (iii). These binary indicators are aggregated to form 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 to the percentage of bilateral trade of a sub-sector covered by the harmonisation of technical regulations. We use export-weighted coverage ratios of each country j to country i. Ideally, production levels would be used as weights, but data were not available. Using imports as weights would be a worse approximation to the ideal average because the actual values of imports on the left-hand side of the gravity equation could be picked up by the harmonisation variable.

3.3. Other data

We extracted production and expenditure 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 and coffee, condiments and miscellaneous food sub-sectors. For these first two sub-sectors, we calculated consumption as supply plus imports minus exports. For the miscellaneous food sub-sector, we used the aggregate food consumption. Missing data on production were approximated by applying the trend in the gross rate of value-added (as a quantity) in each NACE sub-sector that is also available from the New Cronos database.

To this database, we added a number of other variables that are necessary to estimate the gravity model. Following the gravity literature, we measured distances between member states as the direct great circle distance between economic centres, i.e. capital cities.[10] Gross capital formation, gross domestic product (constant and current), population and unit labour costs in total manufacturing were obtained from the New Cronos database. Where values of unit labour costs were unavailable for some countries and years, we approximated the missing observations using the average growth rate of values before and after the missing observations.

3.4. Preliminary data analysis

Table 2 shows the trade ratios covered by harmonised food regulations by sub-sector and an aggregate of all sub-sectors for each country's exports to the EU-15 and averaged over the 1998–2001 period. Boldface highlights those percentages that are unusually low or high compared to the EU trade coverage ratio of the corresponding sub-sector. For example, the second column of Table 2 indicates that 61 per cent of intra-EU trade in food manufactures are affected by harmonised technical regulations. Germany and Greece have

10 These data were obtained from the web service http://www.indo.com/distance/.

Table 2. Trade coverage ratios of food sub-sectors subject to EU harmonised regulations, 1998–2001 (%)

Member state	All (151–158[a])	Meat (151)	Fish (152)	Fruits and vegetables (153)	Oils and fats (154)	Dairy (155)	Grain (156)	Sugar and cacao (1583 and 1584)	Tea and coffee (1586)	Condiments (1587)	Miscellaneous foods(158x[b])
Austria	65.3	12.1	47.9	**78.6**	**68.2**	**73.4**	60.0	99.9	53.2	**40.4**	83.4
Belgium/ Luxembourg	62.3	**23.5**	53.2	65.6	88.8	54.0	59.0	90.9	73.2	18.2	85.4
Denmark	**50.3**	14.5	57.4	65.9	**97.4**	64.4	69.7	97.3	43.6	31.7	78.0
Finland	55.5	15.5	46.2	54.6	**67.2**	53.9	**29.1**	**74.0**	57.2	22.4	79.5
France	58.5	15.3	49.1	59.6	91.0	61.1	63.7	95.3	**31.7**	**34.6**	82.8
Germany	**68.4**	21.8	**71.3**	75.6	86.9	64.6	68.4	97.4	55.2	23.9	88.7
Greece	**68.4**	14.1	**34.2**	76.1	95.7	49.3	59.0	91.3	55.2	26.8	85.5
Ireland	64.8	**8.7**	53.5	63.1	**69.2**	64.4	65.3	99.6	**21.7**	14.4	**95.8**
Italy	67.9	**23.2**	53.2	72.2	94.4	54.5	52.4	94.8	**84.2**	**4.9**	62.1
The Netherlands	**52.2**	**9.2**	68.7	51.8	**97.3**	69.9	59.1	97.0	48.6	26.1	87.4
Portugal	63.8	**9.0**	**80.5**	**80.8**	86.2	60.6	59.5	83.6	44.2	**9.5**	**51.0**
Spain	**45.8**	15.3	61.2	**41.7**	**97.5**	**40.2**	78.1	99.4	46.8	29.1	67.4
Sweden	58.0	14.2	44.9	69.9	74.0	54.6	56.8	97.4	**29.1**	24.9	81.3
UK	64.2	12.1	**42.7**	65.5	86.1	63.2	**84.9**	95.2	53.5	18.8	84.2
EU15	61.4	15.9	57.6	65.2	91.2	62.4	65.5	93.1	53.2	22.1	89.4

The coverage ratios indicated in boldface are for those numbers that are the lowest or the highest compared to EU average coverage ratios by each sub-sector.
[a]Except for feed (157).
[b]Miscellaneous (158x) consists of the following sub-sectors: bread (1581), biscuits (1582), homogenised food (1588), food n.e.c. (1589).

the highest (and identical) trade coverage ratios of 68 per cent while the Netherlands, Denmark and Spain have the lowest trade coverage ratios of around 49 per cent. The trade coverage ratios for the remaining countries are close to the level of the EU-15 as a whole.

There is substantial variation in trade coverage ratios among sub-sectors and countries. Across sub-sectors, the EU trade coverage ratios of oils and fats (154) and sugar (1583) and cacao (1584) are the highest, while those of meat (151) and condiments (1587) are unusual low. These ratios also reflect the sub-sectoral composition of exports of each of these countries to the EU. The figures suggest that exports of Portugal to the individual EU-15 member states are generally characterised by rather high trade coverage ratios in fish (152) and fruits and vegetables (153). Compared with the EU-15 as a whole, France and the UK reveal some similarities in their trade coverage ratios, but with divergences in tea and coffee (1586) and condiments (1587).

The main messages from Table 2 are the overall magnitudes and the variation across countries as well as sub-sectors in the share of trade covered by the harmonisation of regulations applied to the food industry. We also recognise that this share is not only affected by differing national regulations, but also by the level and composition of export volumes.

4. Econometric considerations

With the extensions discussed in Section 2.1, the model takes the form:

$$\ln M_{\mathrm{ijk}t} = \alpha_{\mathrm{k}t} + \beta_{\mathrm{e}} \ln E_{\mathrm{ik}t} + \beta_{\mathrm{y}} \ln Y_{\mathrm{jk}t} + \tau \ln D_{\mathrm{ij}} + \lambda \mathrm{AN}_{\mathrm{ij}} + \omega \mathrm{AL}_{\mathrm{ij}} + \pi \ln \mathrm{Rulc}_{\mathrm{ij}t} + \Phi \rho_{\mathrm{ijk}t} + e_{\mathrm{ijk}t} \tag{8}$$

We now discuss the estimation method and comment on some methodological issues.

4.1. Estimation procedure

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) and Egger (2000) used panel data techniques to estimate gravity equations, thereby allowing the possibility of capturing variation along three dimensions: a two-dimensional spatial effect involving importing and exporting countries and a time dimension.

In this paper, we follow their technique (see Wooldridge, 2002, for details) and specify the disturbance term in equation (8) as:

$$e_{\mathrm{ijk}t} = \mu_{\mathrm{ik}} + \upsilon_{\mathrm{jk}} + u_{\mathrm{ijk}t} \tag{9}$$

where for the kth regression, μ_{ik} and υ_{jk} are the unobserved random effects of the importing and exporting country, respectively, while u_{ijkt} is a random component over countries and time.[11] In the random effects 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) called 'multilateral resistance'.

The database contains zero-trade values for some countries and years. Among the different procedures for dealing with zero values in the dependent variable, we adopted the random-effect Tobit (weighted maximum likelihood) estimation procedure for a censored dependent variable. We added one to all trade flows before taking logarithms to avoid creating missing variables.[12]

4.2. Instruments

Usually, a theoretically consistent gravity equation such as model (8) imposes the restriction that the elasticity of imports with respect to consumption and production is equal to unity, i.e. $\beta_e = \beta_y = 1$ (Anderson and van Wincoop, 2003). Our model allows for non-unitary consumption and production elasticities by estimating β_e and β_y. Since consumption and production may be endogenous with respect to imports, we replaced these variables with their predicted values from a regression on several instruments. For the production variable, the instruments are sub-sector production from the previous 2 years (this should be sufficient to capture the variability from cyclical or temporary disturbances), gross capital formation (as a proxy for investment) from the current and previous 2 years and unit labour costs from the current and previous years. For the consumption expenditure variable, the instruments are GDP from the current and previous years, and current population. Regressions of production and consumption for each country were estimated for the 1990–2001 period. Comparing the instrumented Tobit estimates allowing for random effects estimates with those without instruments, the Hausman test for endogeneity clearly indicated that the Tobit estimates, without using instruments, are an inconsistent estimator for this equation ($\chi^2(2) = 77.34$).

4.3. Parameter restrictions

Equation (8) incorporates restrictions on the constancy of the effect of harmonised food regulations that were tested using a likelihood ratio (LR) test. We

11 Alternatively, fixed effects could be used in a Tobit procedure. Unfortunately, there is no fixed-effect model that allows for fixed effects to be conditioned out of the likelihood beside a semi-parametric estimator for fixed-effect Tobit models developed by Honoré (1992). Although unconditional fixed-effect Tobit models may be fitted with indicator variables for the panel, these estimates are biased. Wooldridge (2002: 540–542) gives a technical explanation of using unobserved effects with Tobit estimation in a panel. In addition, using fixed effects makes it impossible to estimate directly the impact of variables that do not change over time (e.g. adjacency, language, distance).

12 The Comext database records the values of trade to a high degree of accuracy and these reported zeros are genuine zeros rather than missing values. Reported values being in thousands of euros, we add €1000 before transforming in logarithm.

transformed the gravity model into an unconstrained model with time dummies included and allowed the coefficient of the harmonisation variable to vary over time, as $\Phi = \Phi_t$. Thus, in the estimated model, the coefficients of the intercept, α_{kt}, and the coefficients of harmonised food regulations are time-dependent.

4.4. Additional tests

We tested for heteroscedasticity, in the spirit of the Breusch–Pagan–Godfrey test, using an auxiliary regression of the squared residuals on all the exogenous variables excluding dummies. The test statistic, Het(k), is distributed as χ^2 with k degrees of freedom. The null hypothesis of homoscedasticity was rejected in most of the cases. On the basis of the Jarque-Bera test, the hypothesis of normality was always rejected. We tested for serial correlation and found strong evidence of an AR (1) process. The usual remedy is to include dynamics. This suggests that it would be worth investigating a dynamic version of the model, but this is beyond the scope of this paper.[13]

4.5. Influential observations

Based on equation (8), we checked for possible influential observations using the DFIT values, Cook distances and leverages (for further details, see Cook and Weisberg, 1999).

The leverage statistics did not suggest any unusual features that would lead to an anomaly in the fitted values. However, the DFIT values and residuals suggested that Ireland, Denmark and Portugal (as exporting countries), in decreasing importance, are potential outliers for the sample with meat (151) and Ireland and The Netherlands (as exporting countries) with tea and coffee (1586). 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 each of the two sectors. The results are encouraging: the coefficient that captures harmonisation of food regulations for meat (151) is 0.65 and for tea and coffee (1586) it is 0.54. When this is compared against the full sample estimates of 0.77 and 0.82, respectively (see Table 3) it is clear that these estimates are indeed sensitive to the removal of outliers. As far as time is concerned, the residuals of 1993 show a slight structural break. However, allowing a different constant for 1993 was at the margin of rejection. From those tests we conclude that our results appear to be robust to outliers.

13 We corrected for the problem of AR(1) errors and heteroscedasticity by providing an iterated maximum likelihood version of the Tobit model allowing for random effects. In the random effect model, the serial correlation is exploited in the composite error term (see Wooldridge, 2002). In our equation, this correlation is equal to the ratio of the variance of μ_i and ν_j to the variance of the composite error.

Table 3. Gravity estimates of the impact of the harmonisation of food regulations on intra-EU trade, 1990–2001

	All (151–158[a])	Meat (151)	Fish (152)	Fruits and vegetables (153)	Oils and fats (154)	Dairy (155)	Grain (156)	Sugar and cacao (1583 and 1584)	Tea and coffee (1586)	Condiments (1587)	Miscellaneous 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
	(41.91)	(32.80)	(15.60)	(21.70)	(32.00)	(25.30)	(38.30)	(71.10)	(23.50)	(34.53)	(23.20)
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
	(32.33)	(26.46)	(9.87)	(61.00)	(26.88)	(22.48)	(30.18)	(26.70)	(36.06)	(57.20)	(37.85)
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
	(18.60)	(19.71)	(17.01)	(36.75)	(17.77)	(13.90)	(27.59)	(31.30)	(12.59)	(29.30)	(20.42)
AN	0.248	0.372	0.262	0.05	0.193	0.02	0.189	0.151	0.196	−0.172	0.155
	(3.54)	(6.20)	(3.28)	(0.29)	(1.48)	(0.88)	(1.18)	(1.68)	(1.23)	(1.32)	(1.41)
AL	0.401	0.592	0.695	0.699	0.297	0.241	0.541	0.657	0.704	0.371	0.413
	(5.72)	(3.48)	(4.34)	(5.83)	(2.12)	(2.19)	(2.08)	(5.05)	(2.71)	(2.65)	(3.44)
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
	(2.68)	(2.80)	(2.65)	(10.34)	(3.66)	(1.37)	(4.82)	(3.25)	(3.38)	(0.28)	(5.18)
ρ_{ijkt}	1.547	0.774	1.588	1.869	2.889	0.781	1.173	3.434	0.829	−0.325	1.703
	(19.33)	(4.83)	(13.23)	(23.36)	(26.26)	(4.81)	(9.78)	(26.42)	(6.63)	(2.98)	(20.77)

(*continued on next page*)

Table 3. (*continued*)

	All (151–158)[a]	Meat (151)	Fish (152)	Fruits and vegetables (153)	Oils and fats (154)	Dairy (155)	Grain (156)	Sugar and cacao (1583 and 1584)	Tea and coffee (1586)	Condiments (1587)	Miscellaneous food (158x[b])
Intercept	−7.258	4.062	−4.607	−8.096	−7.241	−5.020	−6.651	−1.217	−5.196	−6.662	−5.476
	(9.18)	(4.84)	(7.31)	(13.96)	(6.30)	(3.80)	(6.27)	(2.17)	(4.40)	(8.36)	(6.47)
σ_{μ}^{2} [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
Frequency ratio of $M_{ijkt} = 0$	0/1560	53/1560	77/1560	40/1560	133/1560	42/1560	72/1560	41/1560	276/1560	144/1560	47/1560

Note: t-statistics are in parentheses.
[a]Except for feed (157).
[b]Miscellaneous (158x) consists of the following sub-sectors: bread (1581), biscuits (1582), homogenised 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.

5. Results

Table 3 reports the results of applying the maximum likelihood random-effects Tobit estimation procedure to equation (8). This equation is estimated for each sector, k, separately. The overall fit is high for each regression, and coefficients are significant for most of the variables.

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 1 per cent significance level. 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 and coffee (1586) and miscellaneous food (158x). With the exception of the aggregate food sector (all), meat (151) and dairy (155), the expenditure and production elasticities do not appear to be close to unity as would be required by theory. A joint F-test using the linear restriction that both coefficients are equal to one was 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) have the expected signs. Differences in these coefficients are pronounced across sub-sectors. It is not surprising that the coefficient of bilateral distances, which supposedly represents transportation costs, varies across product categories. The range of elasticities from low to high is -0.91 (all) to -1.88 (sugar and cacao). Trading countries that share a common language and border (AL) have more bilateral trade, *ceteris paribus*, than neighbouring countries speaking a different language (AN). Some coefficients of AN are not significant at the 5 per cent significance level for some sub-sectors.

Cost competitiveness. Relative unit labour costs (Rulc_{ij}) are measured at the level of manufacturing. If country i has a 1 per cent loss of competitiveness with respect to its trading partner, imports rise between 0.1 and 0.5 per cent. In general, this coefficient has the expected sign with the exception of fish (152) and tea and coffee (1586), while it is not significant for condiments (1587). We observe the highest impact on imports for fruits and vegetables (153) and grain (156).

Harmonisation of food regulations. With the exception of condiments (1587), harmonisation has a significant ($p < 0.01$) and positive effect on EU imports. For each particular sector k, the coefficient shows to what extent a country j that complies with EU harmonisation penetrates more easily other member states' markets. A coefficient of 1.55 for the aggregate food sector suggests that trade would grow by a multiple of 4.7 ($=e^{1.55}$) if there were complete harmonisation. In other words, if the export-weighted coverage ratio, ρ_{ijk}, from country j to country i for sector k reaches unity, country i imports would increase with a factor of 4.7. The coefficient varies across sub-sectors. The effect of harmonised food regulations is smaller for meat (151), dairy (155) and tea and coffee (1586) and surprisingly larger for sugar and cacao (1583 and 1584).

5.1. Evolution of harmonisation of good regulations over time

We now turn to the analysis of changes in the effect of harmonisation of food regulations over time. Our specification of the gravity model in equation (8) imposes the restrictions that the intercept and effect of EU harmonisation are invariant through time and this of course should be tested. In particular, we are interested in whether there has been an increasing effect of EU regulations on trade over time.

Table 4 summarises the results of the four LR tests (consistent with the test described in Section 4.3.) undertaken for each regression at sector level. The test reveals that neither of the two restrictions are rejected for oils and fats (154), sugar and 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 harmonisation food regulations is the same over time is rejected for the aggregated food sector (all), meat (151) and fruits and vegetables (153). For these three sectors, the year-by-year evolution is presented in Table 5, where we used a regression with yearly intercepts and time-dependent harmonisation effects as suggested by the test.

Over the 1990–2001 period, the effect of harmonisation of food regulations in the aggregate food sector ('all') increased from a coefficient of 1.18 to 1.98. The effect of harmonised regulations for meat (151) follows a U-shaped pattern, with an initial coefficient of 1.4, reaching a lower bound with coefficients that are not statistically different from zero during the 1993–1995 period and with a gradual increase from 1996 to 2001. For fruits and vegetables (153), the effect of harmonised regulations increases from a coefficient of 1.19 in 1990 to 1.77 in 2001.

These estimates show that harmonisation in food regulations has increased intra-EU imports in all food products by around two thirds, and in fruits and vegetables by around one third during the 1990–2001. Various veterinary and food safety crises in the meat sub-sector during the same period, however, severely disturbed intra-EU trade, which may explain the declining and then rising effect of harmonisation in food regulations on intra-EU imports in this particular sub-sector.[14]

14 The emergence of bovine spongiform encephalopathy in the UK in 1985 disrupted bovine meat imports from the UK, followed by a general EU ban on imports of UK bovine meat from 1996 until 1999 and from Portugal during 1998–1999, 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.

Table 4. LR tests

Hypothesis	All (151–158[a])	Meat (151)	Fish (152)	Fruits and vegetables (153)	Oils and fats (154)	Dairy (155)	Grain (156)	Sugar and cacao (1583 and 1584)	Tea and coffee (1586)	Condiments (1587)	Miscellaneous food (158x[b])
α_t; Φ_t against α_t; Φ	**32.05** (0.000)	**21.65** (0.013)	18.52 (0.070)	**24.61** (0.017)	15.78 (0.149)	18.94 (0.068)	11.12 (0.433)	15.10 (0.177)	12.18 (0.357)	7.70 (0.747)	17.47 (0.091)
α_t; Φ_t against α; Φ_t	**67.15** (0.000)	**24.02** (0.012)	**32.25** (0.000)	**28.86** (0.002)	11.92 (0.369)	**56.63** (0.000)	**28.45** (0.002)	16.20 (0.133)	**34.30** (0.000)	20.01 (0.051)	14.84 (0.189)
α_t; Φ against α; Φ	—	—	**23.91** (0.013)		19.24 (0.058)	**48.21** (0.000)	**41.48** (0.000)	6.00 (0.871)	**41.46** (0.000)	16.02 (0.140)	17.02 (0.101)
α; Φ_t against α; Φ	—	—	—		20.11 (0.049)	—	—	4.90 (0.933)	—	3.71 (0.977)	11.64 (0.421)

The table shows the χ^2 statistics 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), homogenised food (1588), food n.e.c. (1589). See text for an explanation of the test.

Table 5. Evolution of harmonisation of food regulations, 1990–2001

Year	All (151–158)	Meat (151)	Fruits and vegetables (153)
1990	1.182	1.395	1.187
	(10.94)	(4.96)	(5.71)
1991	1.327	0.935	1.805
	(13.14)	(2.30)	(8.76)
1992	1.338	0.688	1.463
	(12.74)	(2.34)	(6.59)
1993	1.339	− 0.312	2.281
	(13.00)	(0.28)	(10.81)
1994	1.592	0.181	1.808
	(15.61)	(0.97)	(7.93)
1995	1.819	0.348	1.633
	(20.21)	(0.98)	(6.61)
1996	1.820	0.615	1.932
	(20.22)	(1.97)	(7.70)
1997	1.826	0.954	1.643
	(18.08)	(1.95)	(6.47)
1998	1.898	0.473	1.805
	(18.98)	(2.18)	(7.25)
1999	1.935	0.898	1.482
	(21.50)	(2.48)	(5.66)
2000	2.031	1.243	1.889
	(20.31)	(3.91)	(7.77)
2001	1.984	0.983	1.771
	(19.85)	(2.67)	(7.03)

t-statistics are in parentheses. The table lists the coefficient of harmonisation of food regulations, ρ_{ijkt}, (from Table 3) multiplied by a time dummy for each year between 1990 and 2001. The coefficients are obtained from estimating gravity model (8) augmented with time-dependent intercepts.

5.2. Trade costs of non-harmonised food regulations

In the previous sub-section, we discussed the magnitude of the coefficient on the trade coverage ratio of EU harmonised food regulations in the gravity equation. As explained in Section 2, we can use this coefficient to compute a trade cost that arises from non-harmonised food regulations (NH). We deliberately refer to trade costs arising from unharmonised regulations instead of from TBT. Given the nature of the data on harmonisation discussed in Section 3.2, the trade costs that are captured in our model *include* TBT costs, but also other transaction costs that are generated from unharmonised regulations in those sectors where countries maintain their own domestic regulations, where domestic regulations are not deemed to be important and where mutual recognition is applied.

These trade costs can be expressed as a tariff equivalent, calculated as $\mathrm{NH} = \exp\,[\Phi/(\sigma_k - 1)] - 1$, where Φ is the estimated coefficient of the trade coverage ratio of EU harmonised food regulations for each sector k.

Therefore, we need an estimate of the 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 time-series studies resulting from misspecification in the single-equation estimation (McDaniel and Balistreri, 2003).

In Table 6, 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.[15] 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 6 gives the tariff equivalents of trade costs due to unharmonised food regulations for matching food sub-sectors and the aggregated food sector.

We observe a range of comparable tariff equivalents: they are (i) *low* for meat (151) and dairy (155), (ii) *medium* for grain (156) and tea and coffee (1586), (iii) *high* for fish (152) and oils and fats (154) and (iv) *very high* tariff equivalents of trade costs for fruits and vegetables (153) and the

Table 6. Tariff equivalents of the cost of EU non-harmonised food regulations (%)

NACE	Description	Elasticity of substitution[a]	Coefficient[b]	Tariff equivalent (%)
151	Meat	8.00	0.70[c]	10.5
152	Fish	4.76	1.56	51.5
153	Fruits and vegetables	2.46	1.72[c]	224.8
154	Oils and fats	6.59	2.88	67.6
155	Dairy	7.01	0.62	10.0
156	Grain	5.45	1.08	27.4
1586	Tea and coffee	4.60	0.85	26.6
151–158[d]	Food industry	2.6	1.67[c]	183.9

[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 estimating model (8) allowing the intercept to vary over time as suggested by the LR-test.
[c]Average coefficient from Table 5: $(\sum_t \Phi_t)/12$.
[d]Except for feed (157).

15 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.

aggregate food sector. This latter result is due to the low estimate of the elasticity of substitution found in the literature. The coefficients (in column 4) are obtained from regressing models (8) allowing for time-dependent intercepts as suggested by the LR tests (Table 4). Messerlin (2001) computed the tariff equivalents of crude NTBs for the EU. For 1999, the tariff equivalents of NTBs amounted to about 100 per cent for the dairy and meat sectors.

6. Conclusions

This paper describes a method based on a gravity model for measuring the trade impact of harmonising food regulations among close trade partners in the EU. In contrast to the typical gravity-based approach that attributes departures of trade flows from what the gravity model can explain to a mix of country or industry-specific effects, including NTBs, our approach explicitly incorporates a measure of technical regulation harmonisation into the gravity model and can, therefore, isolate the specific trade effects of such harmonisation.

We found support for the hypothesis that EU harmonisation of food regulations has a large positive effect on intra-EU trade at aggregate and sub-sector levels of the food industry. Results based on regression by sub-sector separately suggest that the effect of harmonising 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 harmonised regulations in the food industry, and provides some evidence on how successful harmonisation is in removing TBT and integrating EU markets in the food industry.

The theoretically based functional form of the gravity equation allows the estimation of tariff equivalents of trade costs of unharmonised EU food regulations. Conditional on the sub-sector elasticity of substitution, we observe a range of comparable tariff equivalents.

As with any other preliminary study, the present study suggests some future projects. Since our trade cost estimates are very sensitive to assumptions about the elasticity of substitution, it would be interesting to calculate constant elasticities of substitution that emerge from the theoretically based gravity equation. Another extension of this paper is to examine the impact of EU harmonisation of regulations on imports from countries outside the EU, and to test to what extent harmonisation of EU regulations improves trade with the rest of the world. Much would depend on the strictness of the harmonised regulations compared to the initial level of regulations before harmonisation. Finally, an interesting research question would be how much the harmonisation of food regulations across EU countries has affected the pattern of bilateral trade flows of individual EU countries taking into account the downward impact of national borders on trade flows.

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