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A GRAVITY MODEL FOR COMPONENTS OF IMPORTS

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Abstract: *This paper develops a gravity model to explain different components of imports. It is shown that specific variables from competing trade theories affect each component differently: As economic sizes or relative factor endowments become similar, the volume of intra-industry imports, especially that of its horizontal component increases. Furthermore, the typical variables of an extended gravity model have different impact on each component: Colonial relations are important determinants of inter-industry imports whereas cultural proximity based on religion and language plays a more crucial role in determining intra-industry imports. Overall, the significance of these different effects suggests that the proposed decomposition of imports into its components removes a widespread but unnecessary restriction in the gravity models.*

JEL Classifications: *F10, F14*

Keywords: *Horizontal and vertical intra-industry trade, cultural proximity, religion*

INTRODUCTION

Gravity models of international trade independently developed by Tinbergen (1962), Poyhonen (1963) and Linneman (1966) have been successfully used to explain international trade flows (Baldwin, 1994; Eichengreen and Irvin, 1998; Feenstra, 1998). In its simplest form, the volume of bilateral trade between two partners is assumed to increase with the size of their economy, and to decrease with the cost of trading. While the economic sizes represent the exporter's production capacity and the importer's buying power, the geographical distance between economic centers of the trade partners is typically used to measure cost of trading.

This basic model can be augmented with many factors, including specific variables from competing trade theories such as similarity in economic sizes from the Increasing Returns Theory, and relative factor endowments from the Heckscher-Ohlin Theory. In many applications, the model has also been extended to include variables such as colonial relations, and those that capture cultural proximity. The theoretical background for the gravity model and the literature on the additional factors can be found in Section 2.

More recently, econometric issues about the specification of the gravity models are being raised. Arguments made emphasize the importance of removing unnecessary restrictions on the parameters of the model. These range from choosing imports rather than total trade as the

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dependent variable (Baldwin, 1994) to using separate time, importer, exporter, and bilateral interaction fixed effects (Matyas, 1997; Egger and Pfaffermayr, 2003). A discussion of these issues is presented in Section 3.

An overlooked but binding restriction is the use of the same parameters for different components of imports. Imports consist of inter-industry as well as vertical and horizontal intra-industry parts. Each part is different in nature and, in fact, explained by a different trade theory. Therefore, the natural next step in efforts to remove unnecessary restrictions from the gravity model is to account for the differences in components of imports. Section 4 elaborates on this need to decompose imports to its components in gravity models, and briefly discusses the decomposition technique. The resulting model is presented in Section 4.

According to the results presented in Section 5, the effects of the basic gravity model variables as well as those of specific variables from competing trade theories indeed vary for each component of imports. An analysis of the varying impact of colonial relations and cultural proximity provides further support for the need to treat each component of imports separately in gravity models.

LITERATURE ON GRAVITY MODELS

The most parsimonious gravity model has the bilateral total trade between two countries as a function of the product of the sum of their Gross Domestic Products (GDP) and the geographical distance between the economic centers. The model is in log-linear form, and shows a positive relationship between total trade and GDPs, and a negative relationship with the distance. Although intuitive, these relationships were not embedded in any international trade theory until recently. Tinbergen (1962) and Poyhonen (1963) offered intuitive explanations for their models, and Leamer and Stern (1970) derived these relationships from a probability model of transactions, but none relied on the standard trade theories.

Several authors in search for a theoretical basis later came up with models that are based on the Increasing Returns Trade Theory. In particular, Anderson (1979) derived a role for transport costs with a model of homogenous goods that employs product differentiation by country of origin, also known as the Armington assumption. Armed with this specification of the demand, Anderson was able to explain the GDP variables in the model. Bergstrand (1985, 1989) developed this analysis further within the increasing returns framework. In particular, he specified the supply side of economies suggesting GDP deflators as additional variables to be included in the gravity model. Separately, Helpman (1981) and Helpman and Krugman (1985) integrated monopolistic competition of the New Trade Theory to provide another theoretical foundation to the gravity model, where the Armington assumption was replaced by product differentiation among firms. More recently, Deardorff (1998) derived the gravity equation from two cases of the Heckscher-Ohlin Theory. Feenstra (2004) supported this interpretation, noting the compatibility of the gravity model with a particular form of the Heckscher-Ohlin Theory based comparative advantage. It is noteworthy that in each of these explanations, there is complete specialization by countries in a particular good, without which bilateral trade is indeterminate. These papers now provide the previously missing theoretical underpinnings for the gravity model. Consequently, Evenett and Keller (2002) showed how the data can be used to discriminate between the alternative trade theories and thus found theoretical support for each in gravity models. Harrigan (2002) provides an excellent evaluation of this literature.

With this theoretical support, the use of gravity models in explaining trade flows became a standard, and many other variables were added to the basic model. In particular, modified versions of the gravity model included specific variables from competing trade theories: The Heckscher-Ohlin Trade Theory explains trade by differences in factor intensities. Hence, relative factor endowments or dissimilarity in per capita GDP of partners are frequently used to capture factor intensity differences. In contrast, the Increasing Returns Trade Theory implies higher trade volumes, when there are scale economies, or when income levels are similar. Based on the Helpman and Krugman (1985) model that successfully incorporates monopolistic competition of the Increasing Returns Theory into a Heckscher-Ohlin framework, a number of empirical tests explaining bilateral trade flows have been performed (Balassa, 1986; Helpman, 1987; Balassa and Bauwens, 1987). Most of these have focused on two characteristics of partner countries: Difference in relative factor endowments (or per capita incomes as first suggested by Linder, 1961) and similarity in economic sizes of partners, both of which increase trade as expected by the Heckscher-Ohlin and the Increasing Returns Theory, respectively.

The last set of fairly common additions to the basic gravity model is factors that reflect the cost of trade other than geographical distance. Frankel *et al.* (1995) show countries with colonial links, therefore sharing common language and/or religion, trade more with each other. Such commonality reduces the costs of trading resulting from the ease of communication, trust, familiarity of markets, institutions and business practices. Later, Rauch (1999) developed a theory of network that explains how commonality of language, culture and laws impacts the volume of bilateral trade. This theory among similar others, and the intuitiveness of the idea that countries with cultural proximity or past colonial relations are likely to trade more each other lead to gravity models that often include dummy variables to account for such factors between trading partners.

IMPLICIT CONSTRAINTS IN THE GRAVITY MODEL

Despite its success in explaining trade flows, a number of issues are raised in the literature regarding the econometric specification of the gravity models. One such issue is the type of data used and the corresponding analysis. Wang and Winters (1991) argue for using cross-sectional data, where the values of model's variables are averaged over the period of analysis. They claim that averaging reduces the effects of temporary disequilibria and shocks. However, averaging has an econometric problem: It forces the parameters of the model to be the same for every year. Therefore, panel analyses with year fixed effects provide more correctly specified models. The idea is to allow the constant of the model to be different for each year using fixed effects terms. In such a model, year fixed effects will capture cyclical influences commonly shared by all countries.

Matyas (1997) takes this idea further to argue that a correctly specified model should have separate constants not only for each year, but also for each exporter and importer. He claims that cross-sectional models and time series models unnecessarily set the year fixed effects and the country fixed effects to zero, respectively. In this model, known as the triple-indexed model, the exporter and importer fixed effects control for all time-invariant country characteristics, in particular the openness of a country with respect to its partners.

Within this context, Egger and Pfaffermayr (2003) remove one more restriction from the model by adding bilateral interaction fixed effects to the triple-indexed model. They argue that without these effects, the triple-indexed model ignores relevant information; therefore suffering from omitted variable bias and consequently resulting in inconsistent estimates. Formulated this way, bilateral fixed effects capture any time-invariant influences for a country pair, including preferential trade agreements, common language, common border, past colonial relations, and cultural proximity. The exporter and importer effects will capture any remaining country fixed effects of a country after controlling for the usual factors. Bilateral effects are the same for the whole duration of analysis. If there has been a change in memberships in PTAs during this period, these bilateral fixed effects will fail to capture such changes.

Another econometric problem is the choice of the dependent variable. Among others, Baldwin (1994) argues that using the total trade as the dependent variable imposes an unnecessary constraint of equal coefficients for imports and exports. Most authors widely accepted this argument, and in fact, estimated the gravity equation using import data on the assumption that countries tend to monitor their imports more carefully than their exports.

This paper continues with this trend of removing unnecessary constraints from the gravity model, with an appropriate choice of the dependent variable. Gravity models have been typically used to explain the volume of total trade or imports. However, these are composed of significantly different components that are, in fact, explained by different trade theories.

Inter-industry trade is a consequence of different factor endowments and the resulting specialization predicted by the Heckscher-Ohlin trade models. This trade theory has successfully explained the trade primarily between developed and developing countries. On the other hand, intra-industry trade has been significant between developed countries, resulting in a series of research to become the Increasing Returns Trade Theory.

Intra-industry trade is composed of two significantly different parts. Horizontal intra-industry trade occurs when similar products are simultaneously exported and imported mainly due to product differentiation and increasing returns to production. In contrast, vertical intra-industry trade is defined by Grubel and Lloyd (1975) as the simultaneous export and import of goods in the same industry but at different stages of production. This results from vertical disintegration of production due to varying factor intensities within an industry. Consequently, vertical intra-industry trade is somewhat similar to inter-industry trade in the sense that both are results of delocalization of production due to differences in factor intensities.

The theoretical model in Helpman and Krugman (1985) produces both inter-industry and intra-industry trade. However, no differentiation is made between the vertical and horizontal parts of the latter. The model implies that similarity in economic sizes lead to more trade but especially more intra-industry trade, and differences in relative factor endowments increase the inter-industry trade, and decrease the intra-industry trade. Given the similarity between vertical intra-industry and inter-industry trade, it can be expected that the effect of similarity in economic sizes is larger on horizontal intra-industry trade than on vertical intra-industry trade. Furthermore,

more negative impact of differences in relative factor endowments can be expected on horizontal intra-industry trade than on vertical intra-industry trade.

Variables of the gravity model are likely to have different effects on different components of imports. This is especially true for variables that are meant to measure historical and cultural distances as well as geographical distance. Countries that are geographically or culturally close to each other share similar tastes and preferences. For geographically close countries, the transportation costs will be lower; this would make exporting of varieties of similar products possible and eventually consumers in these countries will develop a taste for each other's varieties. Consequently, one would expect to observe higher levels of horizontal intra-industry trade between countries that are geographically close than between countries that are not. Similarly, lower transportation costs between countries that are geographically close would also make it economically feasible to divide the production process into different stages, and carry out each stage in a neighboring country. This would lead to export and re-import of products in the same industry but at different stages, also known as vertical intra-industry trade. Similar arguments can also be made for countries that are culturally close as measured by a common language and/or shorter religious distance. Cultural proximity will lead to familiarity of product varieties and more horizontal intra-industry trade. It is hypothesized that past colonial relationship between trade partners will lead to more trade. Historically, the purpose of colonization has been exploitation of natural or other resources that do not exist or are scarce in the colonizing country. Given this purpose of colonization, colonial relations are expected to have a positive impact on inter-industry imports, and not much effect on intra-industry imports. These expectations can also be supported by the findings in the literature. In particular, Thoumi (1989) and Bergstrand (1985) argue that a common border is an important determinant of trade flows. The significance of a colonial relationship and cultural proximity is pointed out in Frankel *et al.* (1995).

Given these theoretical differences explaining each component and expected variations in the impact of the factors used in the gravity model on each component, there is a clear need to decompose imports. This will allow for different magnitude effects of the gravity model's variables on each component, and hence remove another often-imposed but clearly unnecessary constraint on the parameters of the model. In fact, Greenaway *et al.* (1995) demonstrate that a failure to separate horizontal and vertical imports can negatively impact the interpretation of empirical results. Different adjustment cost implications is another reason cited in the literature for decomposing trade into its intra- and inter-industry components. An extension of this reasoning is used in Kandogan (2003) for decomposing IIT into its horizontal and vertical parts, given that the latter also stems from factor intensity differences, although these are within-industry differences. Broll and Gilroy (1988) also decompose trade in analyzing the relationship between intra-industry trade and technology diffusion.

GRAVITY MODEL FOR DIFFERENT COMPONENTS OF TRADE

Decomposing Imports into its Components

One method of decomposing intra-industry imports is based on the ratio of unit values of imports of both partners in a given industry (Greenaway *et al.* 1995). If this ratio falls within a pre-specified range, usually 1 ± 0.15, it is said that the all of the trade in this industry is horizontal, otherwise it is taken as vertical. The intuition underlying this approach is that horizontal intra-industry trade is assumed to be the trade of products of similar characteristics and quality. Therefore, in such trade, the price of imports from a country to a partner should be close to the price of imports from the partner of that country. Vertical intra-industry trade involves trade of different products with significantly different prices in an industry. Schuler (1995) states that vertical intra-industry trade is often confused with intra-industry trade in vertically differentiated products with quality differentiation. This is exactly what the unit value approach does; it distinguishes between horizontal and vertical intra-industry trade on the basis of quality, a method based on the organisation of production, would better reflect the definitions of these variables.

Apart from the above methodological concerns about the use of unit values, this technique has been criticized by the randomness in the choice of the threshold ratio, which is used to determine whether *all* of the intra-industry imports in an industry are vertical or horizontal.

The method used in this paper, previously used by Kandogan (2003, 2004), is developed directly from the definitions for each component of intra-industry imports. It uses values of imports at two different levels of aggregation without any need for data on the quantity of imports that the unit value method requires. The higher level of aggregation defines industries, and the lower level of aggregation defines different products in each industry. When decomposing imports into its components, the 4-digit level is used to define products, and the 2-digit level for industries: A scrutiny of category definitions in each level reveal that 5-digit level lists varieties of basically the sample product, and 3-digit level is too aggregated and includes more than one product under one category. Unlike the unit values approach, this method allows the intra-industry imports in an industry to be partly horizontal and partly vertical.

Using imports data at the higher level of aggregation, the total amount of intra-industry imports of country *i* from *j* in each industry *s* at time $t\left(IIM_{ijt}^{S}\right)$ is computed by finding the amount of imports of country *i* from $j\left(M_{ijt}^{S}\right)$ matched by imports of country *j* from $i\left(M_{jit}^{S}\right)$. The unmatched part of imports of country *i* from *j* in this industry is inter-industry imports $\left(INM_{ijt}^{S}\right)$, if there is any. Then, the sum of matched imports in each product *p* of industry $s\left(M_{ijt}^{sp}\right)$ is computed using data at the lower level aggregation. This gives the imports of similar products in a sector, i.e. horizontal intra-industry imports of country *i* from $j\left(HIIM_{ijt}^{S}\right)$. The rest of IIM_{ijt}^{S} are the imports of different products within industry *s*, i.e. vertical intra-industry imports of country *i* from *j* $\left(VIIM_{ijt}^{S}\right)$, if there is any:

$$IIM_{ijt} = \frac{1}{2}\sum_{s} IIM_{ijt}^{s} = \frac{1}{2}\sum_{s} M_{jit}^{s} + M_{ijt}^{s} - \left|M_{jit}^{s} - M_{ijt}^{s}\right| \qquad (1)$$

$$INM_{ijt} = \begin{cases} \sum_s INM^s_{ijt} = \sum_s M^s_{ijt} - IIM^s_{ijt} & \text{if positive} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

$$HIIM_{ijt} = \frac{1}{2}\sum_s HIIM^s_{ijt} = \frac{1}{2}\sum_s \sum_p M^{sp}_{jit} + M^{sp}_{ijt} - \left| M^{sp}_{jit} - M^{sp}_{ijt} \right| \tag{3}$$

$$VIIM_{ijt} = \begin{cases} \sum_s VIIM^s_{ijt} = \sum_s IIM^s_{ijt} - HIIM^s_{ijt} & \text{if positive} \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

The Model's Specifications

The discussions in earlier sections on removal of unnecessary constraints including decomposing imports into its components result in following correctly specified gravity model:

$$\begin{aligned}
\left\{ \begin{matrix} INM_{ijt} \\ VIIM_{ijt} \\ HIIM_{ijt} \end{matrix} \right\} &= \alpha_i + \gamma_j + \lambda_t + \delta_{ij} + u_{ijt} \\
&\mu^{INM} + \beta^{\text{INM}}_1 d_{ij} + \beta^{INM}_{2i} Y_{it} + \beta^{INM}_{2j} Y_{jt} + \beta^{INM}_{3i} y_{it} + \beta^{INM}_{3j} y_{jt} + \\
&\beta^{INM}_4 SIM_{ijt} + \beta^{INM}_5 RF_{ijt} + \\
&\beta^{INM}_6 CR_{ij} + \beta^{INM}_7 C_{ij} + \beta^{INM}_8 L_{ij} + \beta^{INM}_9 d^r_{ij} + \\
&\left(\begin{matrix} \mu^{IIM} + \beta^{\text{IIM}}_1 d_{ij} + \beta^{IIM}_{2i} Y_{it} + \beta^{IIM}_{2j} Y_{jt} + \beta^{IIM}_{3i} y_{it} + \beta^{IIM}_{3j} y_{jt} + \\ \beta^{IIM}_4 SIM_{ijt} + \beta^{IIM}_5 RF_{ijt} + \\ \beta^{IIM}_6 CR_{ij} + \beta^{IIM}_7 C_{ij} + \beta^{IIM}_8 L_{ij} + \beta^{IIM}_9 d^r_{ij} \end{matrix} \right) .D^{IIM}_{ijt} + \\
&\left(\begin{matrix} \mu^{HIIM} + \beta^{\text{HIIM}}_1 d_{ij} + \beta^{HIIM}_{2i} Y_{it} + \beta^{HIIM}_{2j} Y_{jt} + \beta^{HIIM}_{3i} y_{it} + \beta^{HIIM}_{3j} y_{jt} + \\ \beta^{HIIM}_4 SIM_{ijt} + \beta^{HIIM}_5 RF_{ijt} + \\ \beta^{HIIM}_6 CR_{ij} + \beta^{HIIM}_7 C_{ij} + \beta^{HIIM}_8 L_{ij} + \beta^{HIIM}_9 d^r_{ij} \end{matrix} \right) .D^{HIIM}_{ijt}
\end{aligned} \tag{5}$$

where α_i, γ_j, λ_t, and δ_{ij} are the country fixed effects, year fixed effects, and the bilateral interaction fixed effects, respectively. μ^{INM}, μ^{IIM}, and μ^{HIIM} are constants for inter-industry, vertical and horizontal intra-industry components of imports, respectively. The latter two and the explanatory factors of the equation are interacted with D^{IIM}_{ijt}, the dummy variable for intra-industry imports, and, D^{HIIM}_{ijt}, another for horizontal intra-industry imports. The term D^{IIM}_{ijt} takes the value of 1 for both components of intra-industry imports of country i from j at time t, and D_{ijt}^{HIIM} is set equal to 1 for the horizontal part. Hence, the coefficients of interaction variables with D_{ijt}^{IIM} show how different the effects of the model's variables are on intra-industry trade relative to inter-industry trade. Similarly, the coefficients of interaction variables with D_{ijt}^{HIIM} capture the difference in effects on horizontal intra-industry trade relative to its vertical part.

Note that there are now potentially six observations for each country pair per year. This allows differentiation between exporter and importer country fixed effects, which was not possible in a model of total trade. Since the dependent variable of imports is decomposed into its components, varying effects of all of the explanatory factors on the right hand side is possible for each. In other words, geographical distance, d_{ij}, GDPs of importer and exporter countries, Y_{it} and Y_{jt}, their per capita GDPs, y_{it} and y_{jt}, can assume different coefficients for different components of imports. This is also true for variables coming from main trade theories: similarity in economic size of trade partners, SIM_{ijt}, and difference in relative factor endowments, RF_{ijt}. The model also includes variables that capture the past colonial relations, CR_{ij} and C_{ij}, cultural proximity such as common language, L_{ij}, and religious distance, d_{ij}^{r}. After decomposing imports into its parts, if zero values result for some components, instead of omitting these zero observations, they are replaced by 0.5 before taking the natural logarithm, since they provide useful information.

Let's next elaborate on the source of data for these variables, and how they are measured. The great-circle formula is used to obtain the geographic distance between trade partners' economic centers. This is defined as the shortest distance between two locations on the surface of a sphere measured along a path on its surface. The data needed is obtained from US Census Bureau of Geographic Information Systems. Note that distance, d_{ij}, is kept in the model since it is a standard factor in gravity models, despite the bilateral fixed effects in the model that could pick its impact as well. This is also true for some of the other bilateral explanatory variables in the model. The GDP and per capita GDP of trade partners are measured at current prices. Baldwin (1994) used GDP-PPP to estimate the trading potential of Central and Eastern European countries. However, this approach has been criticized since GDP-PPP measures how well people live and is a poor proxy for export supply and import demand potential of a country (Gros and Gonciarz, 1996).

The data for these variables is obtained from World Bank's World Development Indicators.

The World Bank's World Development Indicator is used to obtain the data needed for computing the similarity in economic sizes, and the difference in relative factor endowments.

$$SIM_{ijt} = \ln\left(1 - \left(\frac{Y_{it}}{Y_{it} + Y_{jt}}\right)^2 - \left(\frac{Y_{jt}}{Y_{it} + Y_{jt}}\right)^2\right)$$

captures the similarity in size of countries i and j at time t in terms of their GDP, Y_{it} and Y_{jt}, respectively. When the two countries are of equal size, the term inside the parentheses takes the value of 0.5, and it decreases as countries diverge in size.

$$RF_{ijt} = \left| \ln\left(\frac{K_{it}}{L_{it}}\right) - \ln\left(\frac{K_{jt}}{L_{jt}}\right) \right|$$

measures the distance between the partner countries in terms of relative factor endowments. K_{it} and L_{it} denote the capital stock and the labor force for country *i* at time *t*, respectively. When countries *i* and *j* have the same factor endowment ratios, this measure takes the value of zero, and it increases as the difference widens.

Capital stocks needed for the above measure can be obtained using the perpetual inventory method as follows:

$$K_{i1} = 5\left(GFCF_{i0} + GFCF_{i1}\right) \tag{8}$$

$$K_{it} = 0.9K_{it-1} + GFCF_{it} \tag{9}$$

where $GFCF_{it}$ is the gross fixed capital formation in country *i* at time *t*. Note that capital stocks are assumed to depreciate at a constant rate of 10%.

Colonial relations are defined loosely to include country pairs where one was part of the other in the past or was governed by the other for an extended period of time. The reason for such a loose definition is to include all possible cases that would lead to commonality of laws that was addressed in Rauch (1999). Data on colonial relations defined this way is obtained from the historical background section of the CIA World Factbook. Two separate dummy variables are used to fully capture the effect of colonial relations: CR_{ij} is set equal to 1 if there is a colonial relationship between countries *i* and *j*. C_{ij} is set equal to 1 if importer country *i* was a colony of the exporter country *j*. The latter is meant to capture how a colony's trade with its colonizer is different than the trade between two countries that had a colonial relationship.

Two aspects of cultural proximity are considered: Commonality of language and religion. Both of these are expected to promote trade, however, their impact on different components of trade is expected to vary. In particular, the impact on intra-industry imports, especially its horizontal component, is expected to be greater if the trading partners are culturally close. In trade of differentiated products, consumers' preferences play an important role. Therefore, it is intuitive to expect that they will prefer varieties produced by countries with similar cultures.

The source for languages spoken and religions is the CIA's World Factbook. 15 languages and 5 major religions and their main denominations are considered. A dummy variable is used to capture the effect of common language between countries *i* and *j*, L_{ij}. Separate dummy variables for each language are also added to see if there are differences in impacts across these languages.

Euclidean distance is assumed in finding the religious distance between trading partners. This is based on the square root of the sum of squared differences in proportions of populations for each religion. A nested structure is assumed for Christianity and Islam to take into account different denominations within these religions. In other words, squared differences in proportions of populations with these religions are weighted by square root of the sum of squared differences in proportions of populations for each denomination within these religions. This formulation results in a measure that recognizes that two predominantly Christian countries are closer to each other, even if they have different denominations relative to other non-Christian countries. At the same time the measure recognizes the difference in denominations in comparisons with other predominantly Christian countries. The resulting religious distance between countries *i* and *j*, d_{ij}^{r}, is given as follows:

$$d_{ij}^{r} = \sqrt{\sum_{r}(p_i^r - p_j^r)^2 \sum_{d}\left(p_i^{rd} - p_j^{rd}\right)^2} \tag{10}$$

where p_i^{rd} and p_j^{rd} are the proportion of population in countries, *i* and *j*, respectively that belong to the denomination *d* of religion *r*. The terms p_i^r and p_j^r are proportions that belong to religion *r* irrespective of denominations, in countries *i* and *j*, respectively. Note that summation is first carried out for each religion at the denomination level, and these are used as weights for the squared differences at the religion level. Separate dummy variables for the commonality of each religion are also added to the gravity model.

RESULTS AND DISCUSSION

The parameters of the fixed effects model in equation (5) are estimated using the Ordinary Least Square (OLS) technique. Feenstra (2002) argues that this approach consistently estimates the parameters of the gravity equation without the complexity of other estimation methods that produce similar results such as the one suggested by Anderson and van Wincoop (2003). The coefficients of the model as well as the statistics for the usual tests for OLS can be found in Table 1. Multicollinearity is tested using Variance Inflation Factors (VIF). This statistic shows how much the variance of the coefficient estimate for each variable is inflated by its potential presence. The commonly used heuristic is that VIF statistics higher than 5 suggest multicollinearity. In this model, there appears to be no reason for concern. Also, the Goldfeld-Quant test for heteroskedasticity produces F statistics that are close to 1 suggesting the validity of the assumption of constant variance in error terms. Furthermore, the Durbin-Watson test statistic of 1.9896 suggests no risk of either positive of negative autocorrelation. Lastly, the value of the adjusted R^2 and the F statistic indicate that the model's parameters are highly significant overall in explaining the variation in the different components of imports.

The coefficients of the variables in the first row of the table reflect their effect on the inter-industry component of imports. Since the dependent variables and most of the independent variables are in natural logs, with the exception of dummy variables, the coefficients can be interpreted as elasticity. Most variables have the expected sign and are statistically significant. Accordingly, a 1% increase in distance reduces the volume of inter-industry imports by 1.24%. While increases in per capita income of both importer and exporter increase the volume, increases in their economic size as measured by GDP decreases it contrary to expectations. This is probably due to the fact that the country fixed effects already partly control for each partner's GDP. It is noteworthy that the GDP and per capita GDP of the importer country *i* are more crucial factors

Table 1
Regressions Results Total Trade, Imports, and Types of Imports

	Const.	d_{ij}	Y_{it}	Y_{jt}	y_{it}	y_{jt}	SIM_{ijt}	RF_{ijt}	CR_{ij}	C_{ij}	L_{ij}	d_{ij}^{r}
INM_{ijt}	84.8	-1.24	-1.99	-1.82	1.87	1.70	0.28	0.16	1.07	-0.62	0.69	-0.55
	(14.1)	(-100)	(-8.15)	(-7.45)	(7.60)	(6.91)	(34.1)	(18.9)	(13.3)	(-5.51)	(24.3)	(-16.3)
IIM_{ijt}	-13.3	-0.76	0.47	0.04	0.16	0.25	0.10	-0.17	0.07	0.83	0.48	0.09
	(-46.4)	(-48.7)	(55.9)	(4.64)	(13.8)	(22.1)	(10.6)	(-15.4)	(0.64)**	(5.41)	(12.9)	(2.19)
$HIIM_{ijt}$	1.22	-0.16	-0.04	-0.04	0.09	0.09	0.01	-0.08	0.01	-0.00	0.17	-0.08
	(4.26)	(-10.2)	(-5.02)	(-5.02)	(8.27)	(8.27)	(1.34)**	(-7.15)	(0.04)**	(0.00)**	(4.43)	(-1.90)**
VIF		1.07	1.67	1.67	1.64	1.64	1.17	1.19	2.10	2.06	1.11	1.11
Goldfeld-Quant		1.02	1.16	1.57	1.23	1.42	1.18	1.03	1.01	1.00	1.05	1.01
Durbin-Watson		1.9896										
n	155,034											
Adj.R^2	0.819											
F	3,155											

Notes: Numbers in parentheses are t statistics. Those marked with * or ** are insignificant at 95% or 90% level, respectively. All others are significant. Second and third rows list the coefficients of interaction terms with D_{ift}^{IIM} and D_{ift}^{HIIM}.

in determining the imports than those of the exporter country *j*. The elasticities for both are higher for the importer country than the exporter country. The results also show that an increase in the similarity of the economic sizes increases the volume of imports, in support of the Increasing Returns Theory, as does the difference in relative factor endowments, providing evidence for the Heckscher-Ohlin Theory. To test for sensitivity of results, similarity in relative factor endowments is replaced with similarity in income levels in the regressions. The results show that this decreases total trade, also in support of the Heckscher-Ohlin Theory.

The rest of the variables in the model, except religious distance, are binary and their coefficients cannot be interpreted as elasticity. Instead, the exponential of the coefficients would indicate the relative size of imports when these dummy variables take the value of one to that when they are zero. Accordingly, if the importer is the colonizer of the exporter, its inter-industry imports are 191% (exponential of 1.07) higher. Similarly, if the importer is a former colony of the exporter, its inter-industry imports are 57% (exponential of 1.07-0.62) higher than having no colonial relationship between the two. This result supports the view that a colonizer takes advantage of the differences in factor abundances, by probably continuing to import their former colonies' natural resources, whereas the reverse relationship is not as strong. Further emphasizing the role of a historical link, sharing a common language increases inter-industry imports by an additional 100% (exponential of 0.69). The last variable measuring cultural or historical proximity is the religious distance. Its negative coefficient suggests that the volume of inter-industry imports from a religiously distant exporter is lower than one that shares the same religion as the importer, further supporting the hypothesis that culturally closer countries trade more with each other.

The coefficients in the second row of the table capture the changes in the effect of the model's variables on intra-industry imports relative to inter-industry imports. Those in the third row show how the effects are different for horizontal as opposed to vertical intra-industry imports. Accordingly, relative to inter-industry imports, geographical distance has a stronger dampening impact on vertical intra-industry imports, and even slightly stronger impact on its horizontal component. A 1% increase in distance leads to a 2% decrease in vertical, and a 2.16% decrease in horizontal intra-industry imports, as opposed to a 1.24% for the inter-industry component. This may be partly explained by feasibility of the former two types of trades only for closer countries. Goods at different stages of production need to be transported twice for the vertical component. In other words, due to implied costs of production, geographically closer countries tend to disintegrate production of goods among themselves. For the horizontal component to occur, a variety transported from one country needs to be matched by another variety transported from the other country, again making the geographical distance a more important factor. Another interpretation could be that trade of similar products, as captured by the horizontal component, is higher for countries in close proximity since such countries are more likely to have a taste for each other's differentiated products. This may be due to familiarity or cultural proximity not captured by the last four factors of the model.

While the international trade theory does not have any predictions about different impact of economic sizes on various components of imports, it appears that they have a less negative impact intra-industry imports, especially the importer's size. The only interpretation would be that the positive coefficients for GDPs out the role of economies of scale for intra-industry imports. Note that the effect on the horizontal component is slightly more negative than the vertical component. This said, the coefficients of per capita incomes for intra-industry components are in line with the literature's findings: Richer countries tend to engage in more intra-industry trade, especially more of its horizontal component. Their technology allows disintegration of production according to factor intensities involved at different stages in production, and more importantly they tend to have a more developed taste for differentiated goods. In particular, 1% increase capita income of the importer leads to 2.03% increase in vertical intra-industry imports, and 2.12% increase in its horizontal component. The figures for the exporter are 1.95% increase in the vertical and 2.04% in the horizontal components in comparison to 1.70% in inter-industry component.

The coefficients of the similarity in size and differences in relative factor endowments are also as the Increasing Returns and the Heckscher-Ohlin Theories suggest, respectively. The similarity in economic size increases the intra-industry imports more significantly than inter-industry imports. The coefficient of this parameter in the third row of the table suggests that there is no statistically significant difference in its impact on horizontal or vertical component, though. This finding is in support of the Increasing Returns Theory. The support for the Heckscher-Ohlin Theory comes from the coefficients of the differences in relative factor endowments. As predicted, while such differences increase inter-industry imports, they tend to decrease the intra-industry imports, especially the horizontal part. In particular, a 1% increase in distance between importer and exporter's relative factor endowments increases inter-industry imports by 0.16%, whereas it decreases vertical intra-industry imports by 0.01%, and the horizontal part by another 0.08%. The same model is applied to the data after replacing this variable by similarity in per capita incomes, and the results are not sensitive to the choice of variable used. Not only did the signs and significance of other variables in the model remain the same, but also the coefficients of this variable remained in support of the Heckscher-Ohlin Theory. In particular, similarity in income levels reduced the inter-industry imports, but increased intra-industry imports, especially the horizontal component. Since, the Increasing Returns Theory also predicts increased intra-industry imports with similarity in income levels, this result also supports this theory.

The effects of individual colonial relations, languages and religions on vertical and horizontal intra-industry imports are given in last four columns of the second and third rows, respectively. The results are as expected: A colonial relationship only increases inter-industry imports, with positive but insignificant additional impact on vertical and horizontal components of intra-industry imports. But interestingly, colonies tend to import significantly more products at different levels of production from their colonizer, as shown by the significant positive coefficient of C_{ij} on the second row. This is also true for product varieties, as reflected in horizontal intra-industry trade, but the insignificant coefficient on the third row suggests no significant difference between the horizontal and vertical components. Cultural proximity, measured by either commonality of language or religion promotes intra-industry imports, especially the horizontal component. This is evident from positive coefficients for L_{ij} in the second and third rows of the table. Likewise, religious distance reduces inter-industry imports, but and has less of a negative impact on both vertical and horizontal components of intra-industry imports, consistent with the implications of other cultural variables. Furthermore, there does not seem to be a significant difference in impact of religious distance between the two components. In contrast, Hutchinson (2002) found that the proportion of the population that speak English does not have a differential effect for differentiated products.

Differences across particular colonizers, languages and religions are explored further with the additions of dummy variables representing each to the model. The results for each are presented in Table 2. Relatively speaking, colonies' trade relations seem stronger than the colonizer countries' relations with their colonies, as reflected by mostly negative coefficients for CR_{ij} and mostly positive and significant coefficients for C_{ij}. This is true for all colonies except the British, French, Russian, Danish and Norwegian colonies for each the relationship promotes trade both ways, although insignificantly most of the cases, but consistent with earlier observation there are stronger tendencies to import for their colonies from their colonizers. Furthermore, the Russian, Turkish, Arabic and Spanish speaking countries are found to trade more with each other. These results suggest a lingering effect of the distribution and transportation systems from the socialist era, as well as a common religion shared by these countries that also speak the same language. It is also noteworthy that among religions, Hinduism, followed by Islam promotes trade with other countries sharing the same religion, whereas Christianity and Buddhism seem to have a negative impact in trade with other countries with same religions.

CONCLUSIONS

Although gravity models were quite successful even in their simplest form, that did not stop researchers from trying to improve it. It was first augmented by variables showing some form of historical or cultural commonality between the trade partners, and later by variables from the

Table 2
Effects of Different Colonies, Languages and Religions

Colony	CR_{ij}	C_{ij}	*Language*	L_{ij}	*Religion*	R_{ij}
British	0.05	0.92	English	-0.48	Christianity	-0.33
	(0.20)**	(2.40)		(-2.50)		(-9.54)
French	0.16	0.75	French	-0.16	Islam	0.41
	(0.62)**	(1.87)*		(-0.84)**		(8.12)
Dutch	-1.72	0.89	Dutch	-6.25	Hinduism	1.87
	(-5.71)	(1.96)		(-16.2)		(4.70)
Spanish	-0.60	1.13	Spanish	0.42	Buddhism	-0.85
	(-2.38)	(2.89)		(2.16)		(-10.8)
Portuguese	-1.23	0.96	Portuguese	-0.91		
	(-3.89)	(2.02)		(-2.48)		
German	-2.00	0.90	German	-2.55		
	(-5.08)	(1.55)**		(-9.63)		
Russian	1.49	1.23	Russian	3.04		
	(6.03)	(3.19)		(14.7)		
Turkish	-0.42	0.85	Turkish	3.91		
	(-1.59)**	(2.06)		(10.1)		
Swedish	-1.00	0.63	Swedish	-2.65		
	(-3.29)	(1.35)**		(-7.22)		
Danish	0.95	0.44	Chinese	-0.69		
	(1.80)*	(0.58)**		(-2.89)		
Norwegian	2.44	1.06	Malay	-3.10		
	(4.92)	(1.47)**		(-7.92)		
Austrian	-2.15	1.19	Arabic	1.39		
	(-6.75)	(2.47)		(5.78)		
Japanese	-4.94	1.56				
	(-9.95)	(2.19)				
American	-1.54	1.18				
	(-4.82)	(2.21)				

Notes: Due to high correlation, these coefficients are obtained from three different regressions where colonial relationship, language, and religion dummy variables are added to the model separately to avoid potential multicollinearity. The coefficients for colonial relationships or languages are relative to colonial relationships of Hungary or Hungarian language. The coefficients for religions are relative countries with no significant populations (>30%) with a common religion. Judaism is omitted since there are no two countries with significant Jewish populations.

Increasing Returns and the Heckscher-Ohlin Theories. Questions about the specification of the model led to efforts in removing unnecessary constraints on the parameters of the model, by first using as imports as the dependent variable and then by adding year exporter, importer, and bilateral interaction fixed effects.

Within this theme of correcting the specification of the gravity model, this paper argue that imports should be decomposed to its inter-industry, horizontal and vertical intra-industry components, and these should be used as the dependent variables in the model. Since these components are explained by different trade theories, it is expected that independent variables included in the gravity model will have different impact on each component. Hence, such a model will remove another unnecessary but often-imposed constraint.

The results of a correctly specified model for different components of imports applied to bilateral trade of more than 90 countries give support this expectation. In particular, it is observed that every independent variable considered had a statistically significant different impact on inter- and intra-industry components of imports. Most also had such significant difference even for the vertical and horizontal components.

As various trade theories imply, each country's composition of its trade in terms of its components are different depending of their level of economic development, and their trade partners. Significantly different effects of each determinant of trade on each component, as demonstrated in this paper, have important implications for policy makers. As gravity models are typically used to compute trade potential, policy makers should recognize and take into account the different potential trade that can be created with trade partners that they may consider for trade liberalization agreements. Sharing the same language or religion, or having a common colonial history, or resembling to each other in terms of factor endowments or economic size creates different amounts of various components of trade. These need to be taken into account in assessing the trade potential with future potential trade partners.

Furthermore, as demonstrated in the literature, each of these components of trade has different adjustment cost implications. The literature shows that adjustment costs associated with inter-industry trade is much higher than vertical intra-industry trade, which is in turn higher than horizontal intra-industry trade. Thus having an idea about how much adjustment costs are associated with a potential trade partner in advance, would be useful for policy makers in assessing how much opposition they will face against a particular potential trade agreement, and help them determine the extent of assistance that will be given to industries and labor groups that will be facing significant foreign competition in domestic markets.

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