Bilateral export trade and income similarity: Does the Linder hypothesis hold for agricultural and food trade?

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ABSTRACT

In this paper we investigate the Linder hypothesis for bilateral export trade in agricultural and food products by utilizing the sectoral gravity equation derived in Hallak (2010). Based on a sample of 152 countries, we study the relationship for 737 agricultural and food products at the 6-digit HS code level, using trade data for 1995-2012. We estimate the gravity equation year by and year and sector by sector, analyzing the estimates of Linder's term for two specifications of the similarity index. We compare a theoretically justified definition of the index with an adjusted definition that takes into account relative prices. We show that similar demand structures determine bilateral export trade. Accounting for relative prices, we find that the Linder term is more pronounced. Our findings show that the similarity effect is strongest for processed products and weakest for bulk products. From those results we come to the conclusion that similar aggregate preferences are a major driver of export trade in final consumption goods.

Keywords: Product quality, Linder effect, sectoral gravity model

1 Introduction

This paper empirically investigates the Linder hypothesis for bilateral export trade in agricultural and food products. The hypothesis states that countries with similar aggregate preferences trade more intensively with each other than with other countries. Although this hypothesis has attracted substantial research attention, little empirical evidence has been provided in its support. Our benchmark framework to study the validity of Linder's theory for bilateral export trade in agricultural and food products is the gravity equation. The equation has been shown to hold under various theories, including perfect competition, Bertrand competition, monopolistic competition with homogenous firms, and monopolistic competition with heterogeneous firms. Gravity will arise whenever preferences are represented by a constant elasticity of substitution (CES) utility function, trade costs are of the iceberg form, and the decision to consume/produce a good is separable from the decision about where to buy/sell it.

Our paper utilizes the theoretical framework for the gravity equation derived in Hallak (2010), capturing the essential aspects of Linder's theory by postulating a systematic relation between the income per capita and the supply of and demand for quality. This gravity equation is only valid when formulated at the sectoral level. Based on a sample of 152 countries for 1995-2012, we investigate the Linder hypothesis for 737 agricultural and food products at the 6-digit Harmonized System (HS) code level. According to Hallak (2010), we define the Linder term as the squared difference between the log of the income in home and that in foreign. Our specifications include time-varying fixed effects for importer and exporter to account for the multilateral resistance terms. To approximate the trade cost function accurately, we follow the literature and include the following control variables: distance, shared border, common language, common ethnicity, common colonizer, colony, multilateral trade integration and bilateral trade integration. Because of its advantages over more traditional estimation strategies, we utilize the Poisson pseudo-maximum-likelihood (Poisson PML) estimator to identify the parameters of the gravity equation. Poisson PML allows for modeling zero trade flows precisely. In general, trade flows include a large portion of zeros and excluding them would bias the parameter estimates. Moreover, the Poisson PML allows us to handle heteroskedasticity with a robust covariance matrix. We estimate the gravity equation sector by sector and analyze the estimates of Linder's term for two specifications of the income per capita. We compare the parameter estimates for the nominal gross domestic product (GDP) per capita with that of the GDP per capita adjusted by purchasing power parity (PPP).

Our results show that similar aggregate preferences determine bilateral export trade in agricultural and food products. We find that countries with similar income per capita trade more intensively with each other. Overall, our findings are robust, which is indicate by the good fit of the regression specifications. Accounting for the relative cost of living and inflation rates, we find that the Linder term is more expressed. We use the definition of agricultural and food products by Regmi et al. (2005) to group the parameter estimates in five categories: aquaculture, bulk, horticulture/produce, semi-processed and processed. Our findings show that the Linder term is strongest for processed products and weakest for bulk products. From those results we conclude that similar aggregate preferences are determine bilateral export trade.

The remainder of this paper is organized as follows. Section 2 presents the methodology. We introduce the empirical model, provide an overview on the data and discuss econometric issues. Section 3 deals with our estimation results. We summarize the results and illustrate the sectoral estimation results for the two specifications of the similarity index. This section is also concerned with the validity of Linder's hypothesis for different agricultural and food products. We compare the estimates for for five agricultural and food sectors. Section 4 concludes with a summary and discussion of our major findings.

2 Methodology

2.1 Empirical model

The gravity equation has been used to analyze the determinants of bilateral trade flows since Tinbergen (1962). It is one of the most successful empirical models in international economics and its accuracy of fit for bilateral trade flows has long been recognized. For the empirical model, we rely on the sectoral gravity equation derived by Hallak (2010), which can be expressed as follows:

$$X^s_{ij} = \text{exp}(e^s_i - \theta \log \tau^s_{ij} + m^s_j) + \epsilon^s_{ij} \tag{1}$$

, where X^s_{ij} are bilateral export flows of product s from country i to country j in year t. The index for t is omitted for simplification. We denote sector-specific exporter fixed effects by e^s_i and the corresponding fixed effects for importers by m^s_j. The fixed effects are included to account for multilateral trade resistances. The trade cost function is denoted by τ^s_{ij}. We assume that trade costs are symmetric and of the iceberg form. We discuss variables included in the trade cost function in the following section. Lastly, the error term is denoted by ϵ^s_{ij}. Because we estimate the sectoral gravity equation separately for each sector and year, the fixed effects can be different in each specification, which allows us to comply with the theoretical assumption of the sectoral gravity equation (Hallak, 2010).

2.2 Data

Trade data and definition of agricultural and food products

Estimating Equation 1 requires information on bilateral trade flows at the sectoral level. We obtained these data from the BACI trade database (CEPII, 2015). This dataset breaks down trade flows at the 6-digit HS code level. It has the advantage that the trade declarations of exporters and importers are reconciled, which considerably expands the number of countries for which information is available. We are able to include 152 countries in the analysis, allowing us to address the selection bias present in earlier studies. Bilateral export trade is defined as the sum of export flows in millions of current US$. We rely on the definition introduced by Regmi et al. (2005) to define agricultural and food products and group them into five categories: aquaculture, bulk, horticulture, semi-processed and processed. Our study includes 737 agricultural and food products of the HS-92 code system.

Trade cost variables

A descriptive statistics of the included trade cost variables is provided in Table 1. These data were obtained from three sources. To calculate the similarity index, we use data from the World Development Indicators Database (World Bank, 2015). The similarity index is defined according to Hallak (2010) as follows:

$$s_{ij} = (\ln y_i - \ln y_j)^2, \tag{2}$$

where s_{ij} stands for the similarity index, y_i is the income per capita in the exporting country and y_j is that in the importing country. We compare two definitions of the similarity index. First, we follow Hallak (2010) and calculate the similarity index based on data on the GDP per capita. Second, we define an adjusted similarity index, which allows us to consider the relative value of different currencies. For this index, we use data on the GDP per capita adjusted by PPP.

Table 1: Descriptive statistics of trade cost variables

Variables	Mean	Standard deviation	Minimum	Maximum
Theoretical similarity index	4.999	5.880	0.002	35.300
Adjusted similarity index	3.270	3.950	0.000	27.267
Weighted distance	8.692	0.790	3.572	9.886
Shared border	0.019	0.135	0.000	1.000
Economic integration	0.231	0.388	0.000	1.000
WTO membership	0.623	0.424	0.000	1.000
Common language	0.145	0.352	0.000	1.000
Common legacy	0.010	0.097	0.000	1.000
Colonial link	0.013	0.112	0.000	1.000
Common colonizer	0.096	0.295	0.000	1.000

Notes: The descriptive statistics are based on the mean for each variable by country pair for 1995-2012. Only statistics for the trade cost variables are presented.

Our specification of the trade cost function includes further variables that are regularly used in the gravity literature. The first set of variables was obtained from the *Centre d'Etudes Prospectives et d'Informations Internationales* (CEPII) gravity database (CEPII, 2015). It includes information on the distance between trading partners, shared border, common language, common legacy, colonial link and common colonizer. The second set of variables relates to the stage of economic integration between countries. We constructed the multilateral trade integration variable from membership information provided by the World Trade Organization (WTO) webpage. The bilateral economic integration variable is based on the NSF-Kellogg Institute dataset on Economic Integration Agreements (EIA).

2.3 Estimation issues

Equation 1 predicts bilateral export trade flows at the sectoral level. Such trade flows include a large portion of zeros. We estimate the gravity equation by Poisson PML. The estimator allows incorporating zeros by estimating the gravity equation in levels instead of logs. Heteroskedasticity typically arises with this approach due to large variation in production and consumption across countries. The Poisson PML allows handling heteroskedasticity with a robust covariance matrix. It is the only consistent and efficient one-stage estimator of the gravity equation when zeros are present in the data (Santos Silva and Tenreyro, 2006). Moreover, over-dispersion is not an issue with Poisson PML because the variance is estimated with a non-parametric Sandwich estimator that produces cluster-robust standard errors. Lastly, the estimator solves the adding up problem, which is an issue with most other estimators of the gravity equation (Arvis and Shepherd, 2013).

3 Results and discussion

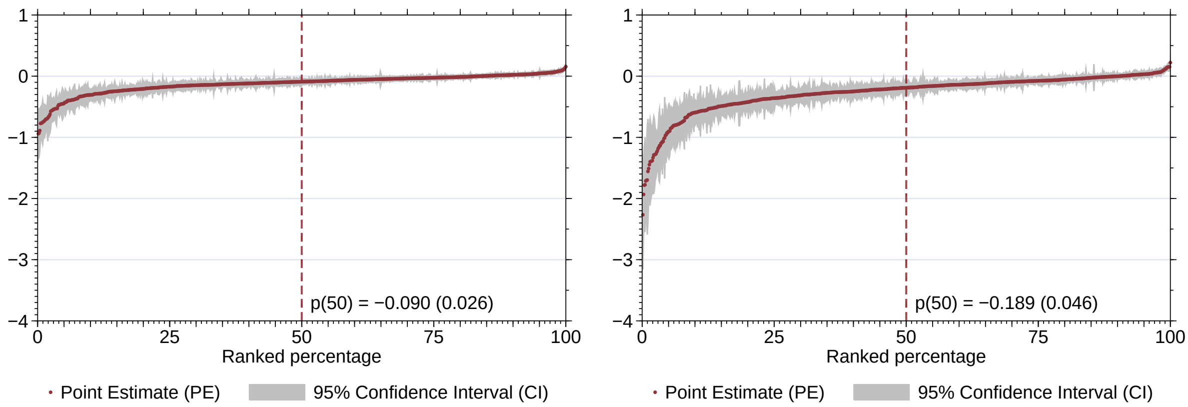
Equation 1 was estimated by Poisson PML separately for each of the 737 agricultural and food sectors and for each year of the observation period. We calculated the mean for each sector over the observation period and present these results in Table 2. The first two columns provide a breakdown of the parameter estimates by sign. We find that the similarity index has a negative sign for 83.5% of the sectors. Only 6.3% of all parameter estimates have a positive sign and are significant at the 10% level. On the other hand, 57.1% of the estimates have a negative sign and are significant. The other trade cost variables have the expected sign and magnitude and the overall fit of the regression equations is high, which means that our model mimics the data-generating process well. This allows us to conclude that our results support the empirical validity of the Linder hypothesis.

Table 2: Median parameter estimates of the sectoral gravity model

	Sign			Significance (10%)	
Variables	Positive	Negative	Median effect	Significant	Not significant
Similarity index	120	606	−0.090 (0.026)	−0.141 (0.031)	−0.024 (0.021)
Weighted distance	170	556	−0.539 (0.281)	−0.928 (0.244)	−0.162 (0.312)
Shared border	690	36	1.443 (0.413)	1.635 (0.374)	0.728 (0.520)
Economic integration	688	38	1.051 (0.272)	1.230 (0.251)	0.425 (0.315)
WTO membership	705	21	1.796 (0.332)	1.954 (0.334)	0.710 (0.325)
Common language	467	259	0.244 (0.281)	0.844 (0.265)	0.074 (0.293)
Common legacy	47	679	−1.946 (0.736)	−2.591 (0.708)	−0.989 (0.780)
Colonial link	604	122	0.842 (0.463)	1.627 (0.374)	0.453 (0.527)
Common colonizer	28	698	−2.951 (0.574)	−3.222 (0.593)	−0.709 (0.490)

Notes: The summary statistics are based on the mean parameter estimates for 1995-2012. Only results for the theoretically justified similarity index are displayed in the table. Column 1 and 2 break down the parameter estimates by sign. Column 3 reports the median size of the parameter estimate and columns 4-5 provide a breakdown by significance. The corresponding median standard error is reported in parenthesis. Standard errors are robust to heteroskedasticity and clustered by country pair.

The distribution of the average effect for the two specification of the similarity index is presented in Figure 1. In both graphs, the agricultural and food sectors are arranged in ascending order along the horizontal axis according to the magnitude of the estimated effect. The point estimates are represented by the dotted line and the corresponding 95% confidence level is depict by the grey area in the background. The left hand panel illustrates the distribution of the theoretically justified similarity index and the right hand panel that for the adjusted similarity index. Both specification convey the same message, which is that bilateral export trade of agricultural and food products is driven by similar demand structures. In comparison to the theoretically justified index, we find for the adjusted similarity index that the effect is stronger when relative prices are taken into account.



(a) Theoretical similarity index

(b) Adjusted similarity index

Figure 1: Parameter estimates for the sectoral similarity indexes sorted by magnitude

Notes: The illustration is based on the mean parameter estimates for 1995-2012. The point estimates and the corresponding 95% confidence intervals are ranked according to the effect size and the median effect is denoted by p(50). The corresponding standard error is given in parenthesis. Standard errors are robust to heteroskedasticity and clustered by country pair.

We compare the parameter estimates for the theoretically justified similarity index for different types of agricultural and food products in Table 3. The first two columns breaks down the parameter estimates by sign and type. Our findings show that most of the parameter estimates have a negative sign. We sorted the estimates by significance level and sign in columns 3 to 5. The share of significant and positive parameter estimates is small for all types of agricultural and food products. The highest share of significant estimates with a negative sign is found for processed products, which usually have a higher per unit value and are of better quality. The median effect for the similarity index is reported in the last column. We find that the similarity effect is strongest for processed products, followed by products that are semi-processed or from aqua-farming. The similarity index is weakest for bulk products, which strongly supports our hypothesis that similar demand structures are a major driver of trade patterns.

Table 3: Median parameter estimates of the sectoral gravity model for different categories of agricultural and food products

	Sign		Significance (10%)			
Sectors	Positive	Negative	Positive	Insignificant	Negative	Median effect
Aquaculture	19	82	5	50	46	$-0.073\,(0.032)$
Bulk	15	38	7	25	21	$-0.041\,(0.019)$
Horticulture	42	173	14	96	105	$-0.060\,(0.024)$
Semi-processed	28	87	9	40	66	$-0.088\,(0.025)$
Processed	16	226	8	58	176	$-0.127\,(0.030)$

Notes: The summary statistics are based on the mean parameter estimates for 1995-2012. Only results for the theoretically justified similarity index are displayed in the table. Column 1 and 2 provide a breakdown of parameter signs by sector. Column 3 to 5 provide a breakdown by sector, sign and significance and column 6 reports the median size of the parameter estimate. The corresponding median standard error is reported in parenthesis. Standard errors are robust to heteroskedasticity and clustered by country pair.

4 Conclusion

In this paper we empirically investigate the Linder hypothesis for bilateral export trade in agricultural and food products. We utilize the theoretical framework proposed in Hallak (2010) to study the validity of Linder's theory for bilateral export trade in agricultural and food products. His model captures the essential aspects of Linder's theory by postulating a systematic relation between the income per capita and the supply of and demand for quality. Based on a sample of 152 countries, we investigate the Linder hypothesis for 737 agricultural and food products at the 6-digit HS code level, using trade data for 1995-2012. Our specification of the gravity equation include time-varying fixed effects for importer and exporter. We estimate the gravity equation sector by sector and analyze the estimates for two specifications of the similarity index, using a theoretically justified definition of the similarity index and comparing it with an adjusted index that takes into account relative prices. Our results show that similar aggregate preferences are an important determinant of bilateral export trade in agricultural and food products. Accounting for relative prices, we find that the Linder term is more expressed. Moreover, our findings show that the similarity effect is strongest for processed products and weakest for bulk products. From those results we conclude that similar aggregate preferences are a strong driver of export trade in final consumption goods.

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