Intra-industry trade between Brazil and OECD countries: decomposition and determinants

Abstract: We examine intra-industry trade between Brazil and OECD countries from 2000 to 2009. Specifically, we decomposed intra-industry bilateral trade (IIT) and identified its determinants. The USA and Mexico, respectively, were found to have the largest volume and IIT indices with Brazil. Additionally, vertical intra-industry trade (VIIT) was found to be larger than horizontal intra-industry trade (HIIT) and Brazilian export goods to be largely of lower quality than imports. Following the theoretical work of Falvey and Kierzkowski (1987), the effect of increasing bilateral differences in factor endowments on VIIT depends on the variety specialization in each good of the relatively better endowed country. Empirically, we specify and estimate a panel data econometric model to investigate the main determinants of VIIT. The results show that endowment differences (capital/labor ratio) had a positive effect on vertical intra-industry bilateral trade, corroborating the central hypothesis of Falvey and Kierzkowski.

Keyword: Intra-industry trade, product differentiation, quality, panel data.

JEL Classification: F10; F14; F15.

1 - Introduction

The role of product quality in international trade has historically received little attention by economists. In recent years, however, certain aspects of product quality have become recognized as important trade determinants.

Some argue that sustained success in international markets can only be reached if high productivity can be combined with high product quality. Product differentiation through intra-industry trade can be used to capture product quality in traded goods. Depending on the relative position of a country in terms of both its specialization in high or low qualities and its technology, a link between a country's endowment and its vertical intra-industry specialization should exist.

Greenaway *et al.* (1994) identify two different trade flow components: inter-industry and intra-industry trade. The former is characterized when two countries trade different types of goods; the latter when two countries simultaneously trade similar goods. Intra-industry trade is viewed as a measure of export similarity among trade partners. When this similarity occurs in horizontally differentiated goods (differentiated in variety) intra-industry trade is understood as horizontal (HIIT). When the similarity is in vertically differentiated goods (differentited by quality), the trade pattern is vertical (VIIT). HIIT is expected to occur largely among countries with similar incomes, and VIIT among countries with different incomes (Ekanayake *et al.* 2007).

Following Zhang *et al.* (2005) intra-industry studies have evolved over three phases. First, during the sixties and seventies studies were largely concerned about the identification of intra-industry trade patterns and methods of measurement. In the second phase, during the eighties, the research agenda focused on the development of theoretical models. Finally, the third phase, which started in the nineties, focused on the decomposition and the investigation of the main determinants of intra-industry trade. This paper builds upon this latter phase.

Decomposing intra-industry trade is theoretically justified. HIIT is explained by the new theory of international trade (Krugman, 1979, 1980, 1981; Lancaster, 1980; Helpman and Krugman, 1985), which predicts that intra-industry trade stems from models of monopolistic competition, horizontal differentiation, and increasing returns of scale. VIIT can be explained by traditional theories of international trade and comparative advantage (Falvey, 1981; Falvey and Kierzkowski, 1987; Flam and Helpman, 1987).

In the econometric estimation of total intra-industry trade Gullstrand (2000) identifies the likely problem of omitted variables. This problem comes from the different theoretical constructs underlying HIIT and VIIT; each have distinct determinants. Others who have investigated the determinants of HIIT and VIIT include Greenaway *et al.* (1994), Durkin and Krygier (2000), Blanes and Martin (2000), Martin and Orts (2002), Crespo and Fontoura (2004), Zhang *et al.* (2005), Baleix and Egidio (2005), Ekanayake *et al.* (2007), and Jansen and Lüthje (2009).

Intra-industry trade studies in Brazil appeared toward the end of the 1980s. Lerda (1988 *apud* Vasconcelos, 2003) computed intra-industry trade between Brazil and the rest of the world and between Brazil and Argentina. They found that intra-industry trade was 46 percent of the total trade in manufactures between Brazil and the rest of the world, but only 35 percent between Brazil and Argentina. Hidalgo (1993) also computed intra-industry trade between Brazil and the rest of the world. His results show that intra-industry trade participation in the total trade varied from 30 to 40 percent. He also found the main

determinants of intra-industry to be market size, per capita income averages, and inequality per capita income among countries.

Machado and Markwald (1997) investigate how the creation of Mercosur facilitated increased intra-industry trade between Brazil and Argentina. They concluded that the Mercosur was important to increased bilateral intra-industry trade among partners. Within Mercosur, Vasconcelos (2003) examined the contribution of intra-industry trade to Brazilian trade growth. His estimates suggest that intra-industry trade between Brazil and Mercosur grew from 48 to 64 percent from 1990 to 1998. While intra-industry trade was 43 percent of total trade from 1990 to 1992, it increased to 78 percent from 1994 to 1996, and to 89 percent from 1996 to 1998. He concluded that intra-industry trade was very important to increased trade growth between Brazil and Mercosur.

Baltar (2008) examined Brazilian exports by measuring patterns of interindustrial trade, horizontal intra-industry trade, and vertical intra-industry trade. She found an increase in intra-industry trade for intensive R&D goods and those differentiated by specialized suppliers. Evidence showed that vertical intra-industry goods exported by Brazil were of lower quality than those imported from its partners.

Curzel *et al.* (2010) measured intra-industry trade between Brazil and Mercosur. They focused on industries with large bilateral trade participation and found the plastic and vehicles industries to have the largest intra-industry trade.

Few of the above studies have investigated the determinants of the Brazilian intra-industry trade. We contribute to this knowledge gap by investigating the determinants of the intra-industry bilateral trade (IIT) between Brazil and OECD countries. We argue that intra-industry trade between Brazil and OECD countries is of a vertical nature where the quality of exported goods from Brazil is lower than those exported from OECD countries.

In the the present study we find the USA and Mexico to be the two main OECD countries that have intra-industry trade with Brazil. We also found that VIIT is larger than HIIT, and that Brazilian exports are of lower quality than imports. Specifying a panel data econometric model, we verify the importance of factor endowment differences in explaining VIIT. We find that differences in factor endowments have a positive effect on vertical intra-industry trade at more aggregated levels, confirming the theoretical findings of Falvey and Kierzkowski (1987).

In the next section the theoretical model of Falvey and Kierzkowski (1987) is presented. Following this we describe our approach to measure and decompose intra-industry trade. We continue with the measurement and decomposition of intra-industry trade between Brazil and the selected OECD countries. This is followed by a discussion of our empirical estimations. In the final section we provide some concluding remarks.

2 - Theoretical Background

Quality and Intra-Industry trade

Linder (1961) was the first to stress the importance of quality in trade. He argues that consumers in rich countries typically spend more on high quality products than consumers in poor countries. Rich countries have a comparative advantage in producing high quality products; hence, countries with similar per capita income levels trade more with each other. This contribution has become known as the Linder Hypothesis, which differs from

Heckscher-Ohlin. Alchian and Allen (1964) put forth the hypothesis that per unit trade costs shift demand toward high-quality goods, which became known as the "shipping the good apples out" hypothesis. This means that higher per unit costs increase the price of cheap goods relative to more expensive goods. In general, goods of higher quality (price) are the ones that have larger share on trade. Vertical product differentiation in international trade subsequently emerged as a tool to describe quality of goods, since it represents firm behavior in producing goods of different quality and price.

Our study is based on the contributions of Falvey (1981), Falvey and Kierzkowski (1987), Flam and Helpman (1987), who look at the quality dimension of international trade. These investigators recognize that countries differ in capital and labor endowments in that the production of higher quality goods uses relatively more capital than labor, leading to production specialization. So, the more capital abundant country will produce and export higher quality goods, and import labor-intensive (lower quality) goods. Therefore, factor endowment differences result in intra-industry trade of different vertical varieties.

Two different groupings of theoretical models can help explain intra-industry trade (IIT). First the monopolistically competitive models of Krugman (1979, 1980, 1981), Lancaster (1980), Helpman (1981) and Markusen (1986) consider not only the presence of scale economies, but also that trade in horizontally differentiated goods is due to varieties of a similar quality but different attributes. These models are justified under the "preference for variety" or preference for an "ideal variety". Bergstrand's (1990) theoretical extensions show the share of IIT in total trade as a function of differences in capital/labor endowment ratios, per capita incomes, market sizes and tariff levels. Empirical studies of these models provide some support for both country and industry determinants of IIT.

The second group is based on Falvey (1981), Falvey and Kierzkowski (1987), and Flam and Helpman (1987). Again, these models consider trade in vertically differentiated goods that are made up of varieties of different qualities (prices) offering different levels of service. IIT in vertically differentiated goods is due to differences in relative factor endowments, demand for different perceived qualities of the same good and the degree of vertical differentiation. Thus, IIT is in fact determined by comparative advantage as in Heckscher-Ohlin since the larger the differences in endowments, the larger is the IIT between countries. However, unlike Heckscher-Ohlin, in these trade models there are different varieties of a good, rather than different goods. These theoretical contributions have stimulated empirical studies separating IIT into horizontal and vertical IIT. The assumption is that quality is reflected in price and price is proxied by unit values (Abd-el-Rahman, 1991; Greenaway *et al.,* 1994, 1995). There is growing empirical support that quality plays an important role in explaining international trade patterns (Schott 2004; Hummels and Klenow 2005; Hallak 2006).

A model for intra-industry trade

To assess intra-industry trade (IIT) Falvey and Kierzkowski (1987) specify a 2x2x2 model where there are two countries, N (North) and S (South), two factors of productions, capital (K) and labor (L), and two goods, a homogenous good and a differentiated good, where the quality (s) of the differentiated good is determined in the interval . Labor (L) is used in the production of both types of goods, while capital (K) is used only in the production of the differentiated good. The production of one unit of the homogeneous good demands *b* units of labor, and the production of one unit of differentiated good, of quality *s*, demands one

unit of labor and *s* units of capital. Therefore, the quality of differentiated good is directly proportional to the quantity of capital used in production.

Under the assumption of perfect competition, and considering the homogeneous good as the *numéraire*, the price of the differentiated good of quality *s* is determined as , where is the labor cost and *r* is the capital rent. Further, countries have different factor endowments in terms of capital/labor ratio. Hence, if country N has a larger capital/labor ratio than country S, , and , for the case when both countries produce the homogeneous good under free trade. In order for intra-industry trade to occur it is necessary that the capital rent in N is less than in S, that is, .

If and are the production costs of the good of quality *s* in N and S, respectively, the marginal quality s_m becomes

Since N has more than enough physical capital it can produce goods with varieties of quality larger than s_m because of its lower production cost; N has a comparative advantage in producing varieties of high quality goods. For country S capital is scarce, and therefore it produces lower quality goods than s_m, meaning that S has a comparative advantage in producing varieties of lower quality goods.

In order to observe intra-industry trade, we assume income is unequally distributed in both countries. Therefore, low income consumers in both countries will demand lower quality goods produced in S, and high income consumers in both countries will demand higher quality goods produced in N. This could lead to closure of firms in country S, and increase in poverty and income inequality. So lower prices and access to higher-quality varieties could compensate for the negative welfare effects of trade.

Due to differences in capital/labor ratios, we test the hypothesis that intra-industry bilateral trade between Brazil and OECD countries occurs mainly in vertically differentiated goods. Because Brazil has a smaller capital/labor ratio in comparison to most of OECD countries, the quality of most Brazilian exported goods is inferior to the quality of the goods exported by OECD countries.

3 - Intra-Industry Trade: Measurement and Decomposition

To measure and decompose bilateral intra-industry trade (IIT) we use the methodology of Greenaway *et al.* (1994). The total trade volume (TTk_{ijt}) between countries i and j in year t, is equal to the sum of the inter-industry trade (EIT_{kijt}) and intra-industry trade (IIT_{kijt}). For the good k, this is

[1]

where:

[2]

[3]

From [2] and [3] intra-industry trade (IIT_{kijt}) is:

[4]

X_{kijt} and M_{kijt} are respectively, the monetary value of exports and imports of good k traded between countries i and j in year t.

To convert the intra-industry trade volume (IIT_{kijt}) to an index we divide equation [4] by [2]:

[5]

Equation [5] is the Grubel and Lloyd (1975) index (GL). The GL index is defined in the interval (0,1); the closer the index is to 1.0, the larger the IIT in the total trade.

We use the similarity criterion based on Crespo and Fontoura (2004) to decompose intra-industry trade (IIT) in horizontal (HIIT) and vertical (VIIT). This criterion defines a pattern of goods differentiation from a ratio (λ) between the unit value of an exported good k (VUX_{kijt}) and its imported unit value (VUM_{kijt}) between countries i and j in year t, that is: $\lambda = VUX_{kijt}/VUM_{kijt}$[1].When the ratio approaches 1.0 traded goods are horizontally differentiated, that is, there is a horizontal intra-industry trade (HIIT). Otherwise, vertical intra-industry trade (VIIT) occurs.

How close λ is to zero or one is based on a dispersion interval, defined by: [(1-α); (1+α)]. Hence, when λ is within this interval the goods traded are horizontally differentiated, otherwise they are vertically differentiated. If the unit value of an export flow exceeds the range, we consider it as quality trade. Following Greenaway *et al.* (1994) and Fontagné and Freudenberg (1997), we use two different factors of dispersion, α = 15% and α = 25%. So we define our two intervals as: [0,85; 1,15] and [0,75; 1,25].

For vertically differentiated goods defined from the viewpoint of the exporter country as vertical inferior ($VIIT^{INF}$) or vertical superior ($VIIT^{SUP}$), when $\lambda < (1- \alpha)$ or $\lambda > (1+ \alpha)$, respectively. In the first case, the goods from the exporter country have lower quality than those imported, and the opposite occurs in the second situation.

The similarity criterion departs from the assumption that the unit value is a good *proxy* for quality. According to Greenaway *et al.* (1994) consumers have perfect information and are capable to distinguish quality, where better quality goods have higher prices. Stiglitz (1987) also argues that the unit value reflects quality even when the consumer lacks perfect information. However, Fontagné *et al.* (2007) recognize that even a direct association between the unit value of a good and its quality has some limitations. Other factors, such as market structure, cost differences, and differences in technology, can affect the unit value of a good, which might lead to mistaken interpretations about its quality. Others argue that such factors are extremely dificult to measure, making plausible the assumption that the unit value is a good proxy for quality.

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[1]As commonly done in the literature on quality trade, where unit values provide a good measurement of vertical differentiation. According to Greenaway *et al.* (1994), Fontagné and Freudenbrg (1997), and Schott (2004), the unit value of a good will be calculated using a ratio between the monetary value and the traded quantity: VU = V/Q. Gullstrand (2000) says that the use of the unit value as *proxy* of quality needs the assumption that there is no correlation between quality and the good's weight, otherwise the unit value calculation would be biased. Greenaway (1995) has a detailed discussion on the use of unit values as a measure of quality.

To measure and decompose intra-industry trade (IIT) between Brazil and OECD countries we use the BACI data base which reports bilateral trade in the Harmonized System (HS) at the 6-digit disaggregation level[2]. It is important to note that our disaggregation level is higher than those used in previous studies. For example, Vasconcelos (2003)[3] uses the 3-digit level.

4 - Intra-Industry Trade between Brazil and the Main OECD Countries

Table 1 shows the average (2000-2009) intra-industry bilateral trade (IIT) between Brazil and selected OECD countries. Total IIT was near US$ 13 billion with some differences between HIIT and VIIT, depending on the dispersion level used (α = 15% or α = 25%). In both cases VIIT was larger than HIIT. The countries with the largest proportion of IIT trade with Brazil are the USA (US$ 6,309), Germany (US$ 1,971) and Mexico (US$ 1,030). All bilateral trade relations showed VIIT larger than HIIT regardless the dispersion level adopted.

Increased globalization and trade liberalization in most of developing countries, can explain such a large intra-industry trade for Brazil (Fontagné and Freudenberg 2006).

TABLE 1 – Total intra-industry trade (IIT), horizontal intra-industry trade (HIIT) and vertical intra-industry trade (VIIT), between Brazil and main OECD countries, average for 2000/2009 (in millions of US$).

Country	IIT	α = 15%		α = 25%	
		HIIT	VIIT	HIIT	VIIT
Canada	187,8	29,6	158,2	47,3	140,5
France	701,4	85,1	616,3	175,7	525,7
Germany	1.971,0	534,8	1.436,2	804,2	1.166,8
Netherlands	258,5	26,5	232,0	40,5	218,0
Italy	622,3	77,8	544,5	133,9	488,5
Japan	210,0	25,9	184,1	43,3	166,7
Mexico	1.030,8	133,7	897,1	293,6	737,2
Spain	288,1	35,3	252,8	65,1	223,0
UK	394,5	46,0	348,6	72,7	321,8
USA	6.309,6	972,0	5.337,6	1.548,3	4.761,3
Total (all OECD countries)	12.948,8	2.095,7	10.853,1	3.440.1	9.508.6

Source: BACI data base. Authors' calculations.

[2] BACI is published by CEPII, and it is available from: *http://www.cepii.fr/anglaisgraph/bdd/baci.htm*. For more details on this data base, see Gaulier and Zignago (2010).

[3] The IIT measurement with more aggregated data tends to overestimate the GL index. Finger (1975) calls it "cathegoric bias". Therefore, the use of more disaggregated data helps to mitigate this bias and makes the results more reliable.

Table 2 shows IIT between Brazil and main OECD countries as a GL index. The GL index was around 0.12. The GL-H and GL-V indices were, respectively 0.02 and 0.10, for α = 15%, and 0.03 and 0.09 for α = 25%. Countries with the greatest intra-industry trade with Brazil are Mexico (0.21), USA (0.18) and Germany (0.15). Although Mexico is the third largest trading partner of Brazil in terms of total intra-industry trade it is the most important in terms of GL index.

TABLE 2 – Intra-industry trade index (GL), horizontal intra-industry trade index (GL-H) and vertical intra-industry index (GL-V), between Brazil and main OECD countries, in bilateral trade (average for 2000/2009).

Country	GL	α = 15%		α = 25%	
		GL-H	GL-V	GL-H	GL-V
Canada	0,06	0,01	0,05	0,02	0,05
France	0,12	0,01	0,11	0,03	0,09
Germany	0,15	0,04	0,11	0,06	0,09
Netherlands	0,04	0,00	0,04	0,01	0,03
Italy	0,10	0,01	0,09	0,02	0,08
Japan	0,03	0,00	0,03	0,01	0,02
Mexico	0,21	0,03	0,19	0,06	0,15
Spain	0,08	0,01	0,07	0,02	0,06
UK	0,09	0,01	0,08	0,02	0,07
USA	0,18	0,03	0,15	0,04	0,13
Total (all OECD countries)	0,12	0,02	0,10	0,03	0,09

Source: BACI data base. Authors' calculations.

The largest part of intra-industry bilateral trade between Brazil and OECD countries occurs in vertically differentiated products. Therefore, we investigate if the quality of Brazilian exported goods are larger or lower than those imported. Table 3 shows the decomposition of the vertical intra-industry trade (VIIT) in vertical inferior ($VIIT^{INF}$) and vertical superior ($VIIT^{SUP}$). Here we see that the majority of Brazilian exported goods are of lower quality than those imported from OECD countries[4], as $VIIT^{INF}$ is larger than $VIIT^{SUP}$. These results are robust with respect to the dispersion level adopted (α). Figure 1 shows the same results for each year of our sample. The gap between the two types of vertical IIT was

[4] It is interesting to say that $VIIT^{SUP}$ was larger than $VIIT^{INF}$ for other OECD countries that are not in Table 3: South Korea, Finland, Hungary, Czech Republic, Ireland and Turkey. However, a more detailed investigation of these situations is not in the scope of this study.

smaller in 2003, 2004 and 2009. In these years some $VIIT^{Sup}$ flows were larger than the $VIIT^{Inf}$ for France, Germany, Canada, Spain, the Netherlands and Mexico[5].

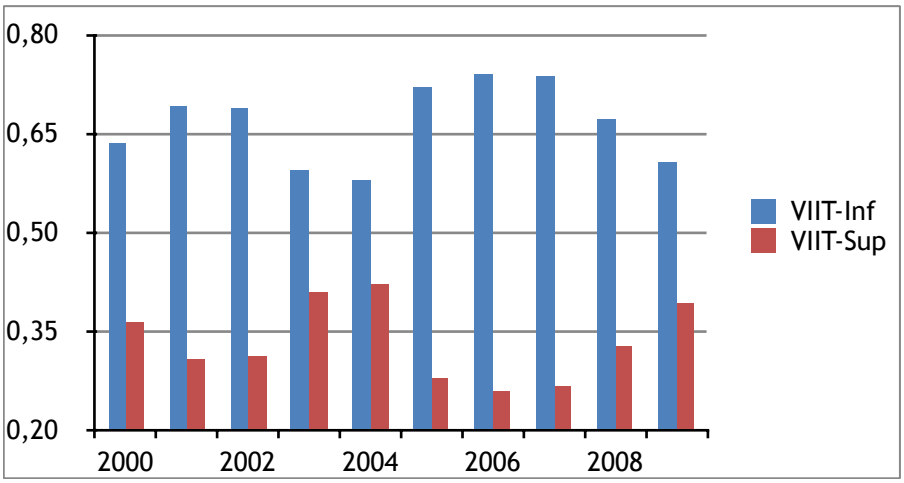
TABLE 3 – Decomposition of the vertical intra-industry trade (VIIT)
in vertical inferior (VIIT
($VIIT^{SUP}$

Country	α = 15%		α = 25%	
	VIIT	VIIT	VIIT	VIIT
Canada	57,0	43,0	57,7	42,3
France	62,3	37,7	60,5	39,5
Germany	61,6	38,4	60,7	39,3
Netherlands	74,9	25,1	75,3	24,7
Italy	69,8	30,2	71,0	29,0
Japan	73,1	26,9	72,9	27,1
Mexico	68,5	31,5	65,9	34,1
Spain	52,6	47,4	54,1	45,9
UK	73,8	26,2	73,8	26,2
USA	69,0	31,0	69,3	30,7
Total (all OECD countries)	67,2	33,0	66,3	33,7

Source: BACI data base. Authors' calculations.

[5] Detailed results at sectoral level were omitted due to space constraints, but they can be made available upon request from the authors.

FIGURE 1 – Relative changes in vertical inferior intra-industry trade ($VIIT^{INF}$) and vertical superior intra-industry trade ($VIIT^{SUP}$) between Brazil and main OECD countries from 2000 to 2009 (in %).



Source: BACI data base. Authors'calculations.

At the sectoral level most of the VIIT is inferior over time. However, in Table 4 for some sectors and countries Brazilian exports are of better quality. The relative quality improvement of the Brazilian exports to Mexico, as seen for capital goods, consumer goods and industrial supplies, was mainly due to the exports from 2009, probably as a consequence of the 2008 financial crisis[6].

TABLE 4 – Sectors and countries where the Brazilian VIIT larger, average 2000 to 2009.

Sector	Country	Average VIIT (in %)
Fuel and lubricants	France	55.6
Capital goods	Canada	54.9
	Mexico	50.6
Transport equipment	Germany	50.2
	Spain	66.0
Consumer goods	Germany	51.8
	Mexico	79.5

[6] Once again, the detailed results at sectoral level are not reported here due to space constraints.

Industrial supplies	Mexico	55.8

Source: BACI data base. Authors'calculations.

The above results suggest that there is intra-good differentiation, where Brazil seems to be a net exporter of lower quality variety of goods, and a net importer of higher quality goods from OECD countries[7]. These results might suggest that the intra-industry trade between Brazil and OECD countries is determined by comparative advantage, as Falvey and Kierzkowski (1987) predict.

5 - Model Estimation and Main Results

The descriptive statistics suggest that intra-industry trade between Brazil and main OECD partners is dominated by vertically differentiated goods. We now empirically investigate if differences in fator endowments contribute to increased vertical intra-industry trade, as predicted by the theoretical work of Falvey and Kierzkowski (1987).

Econometric model

To test the Falvey and Kierzkowski hypothesis we specify an econometric gravity trade model[8]:

[6]

where, $VIIT_{ijt}$ is total vertical intra-industry trade between Brazil and country j in year t; PIB_{ijt} is the product of GDPs of Brazil and country j in year t; $DIST_{ij}$ is the distance between Brazil and country j; DIF_{ijt} is the difference in factors endowment between Brazil and country j in year t; α_0 is the intercept, common for all years and bilateral trade relations; α_t is the time intercept; θ_{ij} is a unobservable heterogeneity present in bilateral trade relations, which is time invariant; and u_{ijt} is the error term.

Ekanayake et al (2007) and Jansen and Lüthje (2009) use an intra-industry index instead of volume of intra-industry trade as dependent variable in [6]. However, Nilsson (1999) criticizes the use of GL index as the dependent variable because it lacks scale. It is possible that bilateral trade could have a large intra-industry trade index, but low volume of trade. We saw this possibility earlier where Mexico had a large intra-industry trade index with Brazil but the largest intra-industry trade volume was with the USA[9]. Therefore, following Baleix and Egidio (2005), and Emirhan (2005), our econometric model specifies VIIT as the dependent variable, as calculated above.

GDP is used as proxy for the consumer market size. Greenaway et al. (1994) and Torstensson (1996) purport that the production of vertically differentiated goods has high fixed costs, implying that consumer market is important and relevant in the production and commercialization of these type of goods. Further, Crespo and Fontoura (2004), Baleix and

[7] Additional information of VIIT at country level over time can be found in the Appendix Figures 2 and 3.

[8] This empirical model is similar to the one used in Emirhan (2005).

[9] Table 1 and Figures 2 and 3 in Appendix are also useful to illustrate this issue.

Egidio (2005), Jansen and Lüthje (2009) provide empirical evidence about the positive effect that the consumer market has in the VIIT, so we expect that $\beta_1 > 0$.

Geographical distance (DIST) is a *proxy* for transportation cost (Nilsson 1999). The trade of differentiated goods tends to be more sensitive to distance than the trade of homogeneous goods. According to Rauch (1999), homogeneous goods are traded in organized markets, where price and characteristics of the goods are known for all agents. However, the trade of differentiated goods does not occur in organized markets. Characteristics and prices of such goods are not completely known, hence the reason for the presence of information asymmetries in the trade of manufactured goods. Many studies show a negative influence of the distance in the VIIT, such as Durkin and Krygier (2000), Crespo and Fontoura (2004), Baleix and Egidio (2005), Ekanayake *et al.* (2007), Jansen and Lüthje (2009), so we expect that $\beta_2 < 0$.

According to Falvey and Kierzkowski (1987), vertical intra-industry trade largely occurs between partners with different factors specializing their production and exports on higher quality goods; the opposite is expected to occur in less developed countries. Therefore, the DIF variable in [6] has the role to identify the factor endowment differences among trade partners. Helpman (1987) and Hallak (2006) consider that per capita income can be a good proxy for country factor endowments, due to the positive correlation between capital/labor ratio and per capita income[10]. Thus, the absolute difference in per capita GDP will be used as proxy for factor endowment (DIF) differences between countries. According to Falvey and Kierzkowski (1987), we expect that $\beta_3 > 0$[11].

Estimation strategy

Our sectoral-aggregated data base has 1,500 observations. They represent ten bilateral trade relations beween Brazil and main OECD countries[12] from 2000 to 2009 and 15 sectors[13]. The sectoral-disaggregated data has 460,431 observations, from which 119,032 observations have positive VIIT[14] when using $\alpha = 15$ %.

Panel data econometrics is used to estimate [6] for both data sets. We control for unobserved heterogeneity (θ_{ij}) typical in bilateral trade data[15]. In the case where θ_{ij} is not correlated to the explanatory variables of the model Pooled Ordinary Least Squares (Pooled OLS) can give unbiased and consistent parameter estimates (Wooldridge 2002). However,

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[10] The logic to use per capita GDP as *proxy* for the capital/labor ratio is as follows: consider that Y = F(K, L), where Y denotes the GDP, K is the quantity of phisical capital, L denotes the number of workers and F(.) is a homogeneous function of degree one. If we divide both sides by L we have: y = f(k); where y = Y/L and k = K/L.

[11] The main descriptive statistics for the variables used in [6] are available in Appendix (Table 7). The variables used are from different sources: trade flows are from BACI data base; GDP and per capita GDP are measured in tems of Power Parity of Purchase (PPP) and both are from IMF. The distance is from CEPII data base.

[12] The main OECD partners considered are the same ten countries from Table 1.

[13] Description of all sectors can be found in Table 8 from Appendix.

[14] For the sample considering $\alpha = 25$ % we have 87,994 observations.

[15] According to Cheng and Wall (2005): "*With such heterogeneity, a country would export different amounts to two countries, even though the two export markets have the same GDPs and are equidistant from the exporter. This can be because there are historical, cultural, ethnic, political, or geographic factors that affect the level of trade and are correlated with the gravity variables*".

more efficient estimates can be obtained through the use of Random Effects model (RE). In the likely case that θ_{ij} is correlated with the regressors both Pooled OLS and RE are biased and inconsistent; a Fixed Effects model (FE) is not. However, for comparison we estimate different specifications of Pooled OLS, FE and RE models for each set of data (aggregated and disaggregated). To deal with different heterogeneity issues, we use different combinations of fixed effects dummy variables, interaction terms between each sector, and bilateral differences in factor endowment.

Results and Discussion

The estimation results are presented in Table 5. All estimations have Huber/White/ Sandwich robust variances (HUBER 1967). Some specifications include sector dummies, time dummies, country dummies and also interaction terms between difference in factors endowments (DIF) and the sector dummies. The latter can be important in identifying the presence of influence from DIF on VIIT, since these dummies control for fixed characteristics of exporters in specific sectors, such as geographical distance from exporter to main buyers of a given good, or different degrees of competition in given sectors across different exporters.

Most of estimated coefficients have expected signs and are statistically significant. The first three columns show the results from the Pooled OLS model. Here GDP and distance (DIST) are statistically significant at the 1 percent. Many of the coefficient for the differences in factors endowment (DIF) were not different than zero, except in the first specification. In specifications (2) and (3) the model results confirm that differences in factors endowment improve VIIT.

Columns (4) to (7) show the results from FE model. The coefficients for GDP were not significantly different to previous estimations; the main difference was the magnitude and the statistical significance of DIF. Specifications (6) and (7) were performed using sectors as the cross-section specification, while in all previous estimations country pairs was the cross-section unit. In column (7) we added country dummies to control for country characteristics, such as geographic location, institutions, openness to trade, which may affect average price of exports and, at same time may be correlated with differences in factor endowments. The fixed effects estimations showed expected coefficient signs and statistical significance; the only exception was in (5) where the coefficient of DIF was not significant.

For the RE estimates in columns (8) to (11) PIB and DIST have, respectively, positive and negative impacts on the vertical intra-industry bilateral trade.This means that Brazil had on average larger volumes of VIIT with partners of larger economic size and geographically closer (exception is in the last specification where the distance coefficient was positive, but not significant). The difference in factors endowment (DIF) in terms of capital/labor ratios also had a positive impact on the VIIT, following specifications (8) and (9). According to the Hausman test, the preferred results for different specifications are based FE models columns (6) and (7) and RE models (8) and (9). Due to the sign and significance of the DIF estimated coefficient, these estimations corroborate the main hypothesis of Falvey and Kierzkowski (1987)[16].

[16] Similar results were obtained considering a dispersion level of $\alpha = 25\%$.

TABLE 5 – Results of the econometric estimations for VIIT as dependent variable (α = 15%), from 2000 to 2009

Variables	Pooled OLS			Fixed Effects				Random Effects			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Constant	15.53*	13.47*	-3.48*	-24.26**	-40.30**	14.63*	-4.53	-3.59	-3.98	15.35*	-40.46
Ln GDP	1.080*	1.080*	1.078*	1.188*	2.911**	1.069*	1.188*	1.057*	1.137*	1.078*	1.156*
Ln Distance	-2.651*	-2.671*	-2.651*	-	-	-	-	-2.554*	-2.603*	-2.666*	3.81
Ln Dif	0.153	0.197*	1.89*	1.361**	0.456	1.873*	1.361**	1.827*	1.806*	0.005	-0.408
Interactions Dif*Sector	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	No	Yes	Yes	No	Yes	No	No	No	Yes	No	No
Country Dummies	No	No	No	No	No	No	Yes	No	No	No	Yes
Sector Dummies	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No
Observs.	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
R^2	0.20	0.74	0.76	0.74	0.75	0.48	0.58	0.74	0.75	0.42	0.52
Hausman test	-	-	-	-	-	-	-	0.95	3.08	142.68	181.85

Source: BACI data base. Authors' estimations.
Notes: i) (*),(**),(***) denote, respectively, 1%, 5% e 10% statistical significance level; the intercepts α_i were excluded due to space constraint.

The type of good traded is important for a country's participation in international trade and development. Fontagné and Freudenberg (2002) point out that trade in high quality goods provides the opportunity for a country to increase its participation in world trade, since these goods generally have higher income and lower price elasticities than lower quality goods.

The results so far are from the sectoral-agreggated data set. In order to verify if such results are largely driven by specific sectors, and product aggregation, we disaggregated our data set of HS 6-digit product data in 15 sectors. So we generated 15 data sets with thousands of different products for each sector. We followed the same aggregation procedure used at 2-digit level in the previous analysis, as we can see in Table 8 (Appendix). Our estimated different panel specifications for each sector are reported in Table 6. In this sample (different from the previous one) we also have cross-section information of the products for every sector, country, and year. Therefore, we included other fixed effects dummies related to the products which vary by sector.

Results show that the impact of income and distance vary across sectors but most coefficients are significant with expected signs. The main difference across estimations is related to the coefficient of the factors endowment differences (DIF). For most estimations this coefficient was positive, but it was only statistically significant for five sectors: (i) animal

and animal products, (ii) vegetable products, (iii) plastic and rubbers, (iv) skin, leathers and furs, (v) textiles, and (vi) metals[17].

Distance and income levels are important determinants of VIIT between Brazil and OECD countries. Although the main hypothesis of Falvey and Kierzkowski (1987) seems to support the Brazilian VIIT in many sectors, the results might illustrate the need to improve productivity and the quality of traded goods in many sectors in the country. Accordingly, policies aimed to reduce endowment differences between Brazil and OECD countries can be important to improve the relative quality of Brazilian traded goods.

[17] When $\alpha = 25\%$, the DIF coefficients were also positive and significant for the following sectors: Wood and Wood Products, and Stone and Glass.

TABLE 6 – Results of the econometric estimations for VIIT as dependent variable (α = 15%) for 15 sectors[18] (HS-6 digit), from 2000 to 2009

Variable	Animal and Animal Products	Vegetable Products	Foodstuff	Mineral Products	Chem. & Allied Ind.	Plastic & Rubbers	Skin, Leath & Furs
Ln GDP	0.420 (3.384)	0.235* (0.063)	0.747 (1.281)	0.437* (0.118)	0.727* (0.203)	0.967* (0.042)	0.406* (0.052)
Ln DIST	-	-0.780* (0.279)	-	-0.889 (0.579)	-0.794* (0.087)	-2.422* (0.164)	-1.188* (0.221)
Ln DIF	5.075* (2.315)	0.516* (0.154)	2.109 (3.559)	0.135 (0.245)	0.021 (0.031)	0.351* (0.070)	0.186*** (0.108)
Observations	*761*	*2,426*	*3,068*	*1,210*	*12,514*	*7,309*	*1,596*
R	0.21	0.40	0.15	0.06	0.36	0.47	0.36

Variable	Wood & Wood Prod.	Textiles	Footwear	Stone & Glass	Metals	Machinery & Electrical	Transport.	Miscellan.
Ln PIB	0.644* (0.044)	0.301* (0.019)	0.351* (0.086)	1.970** (0.938)	0.490* (0.034)	0.720* (0.023)	2.607* (1.373)	0.796* (0.028)
Ln DIST	-1.618* (0.198)	-1.562* (0.106)	-1.570* (0.356)	-	-1.163* (0.145)	-1.401* (0.118)	-	-1.176* (0.113)
Ln DIF	-0.061 (0.137)	0.093** (0.041)	-0.151 (0.173)	2.330 (5.259)	0.130* (0.054)	-0.011 (0.045)	-16.974 (17.536)	0.058 (0.055)
Observations	*4,543*	*9,364*	*1,147*	*4,841*	*13,872*	*28,398*	*3,089*	*11,053*
R	0.43	0.35	0.31	0.12	0.41	0.49	0.14	0.45

Source: BACI data base. Author's calculations.
Obs: Robust absolute standard errors clustered at the exporter level reported in parentheses; reported results are only for the model that passed Hausman test; all estimations include constant, time dummies, and product FEs; (*), (**), (***) denote, respectively, 1%, 5% e 10% statistical significance level.

With regard to bilateral trade between Brazil and main OECD countries, our results show evidence of production specialization in intra-industry trade, where Brazil is a net exporter of lower quality goods and net importer of higher quality goods. In other words, production specialization in international trade can occur not only in inter-industry trade (the trade of homogeneous goods) but also in intra-industry trade (where the goods are differentiated according to their intrinsic qualities). In both situations comparative advantage is the main determinant.

6 – Final Remarks

[18] Similar results were obtained considering a dispersion level of α = 25%.

Intra-industry trade (IIT) occurs when two trade partners simultaneously trade goods from the same industrial origin. When traded goods are horizontally differentiated, the intra-industry is called horizontal (HIIT) but when the goods are vertically differentiated we observe vertical intra-industry trade (VIIT). It is important to make this distinction because these two types of trade have different theoretical structures. HIIT can be explained by models of monopolistic competition and VIIT can be explained by comparative advantage theory. In principle, HIIT can be expected to occur between countries with similar income levels and VIIT between countries with different levels of income and/or development.

The main goal of this paper was to analyze IIT between Brazil and its main trade partners from OECD over the period 2000 to 2009. We decompose intra-industry trade and investigate the main determinants of the VIIT, paying special attention to the impacts of differences in factor endowments as a source of comparative advantage.

We applied conventional methodology to measure and decompose bilateral intra-industry trade. The USA and Mexico were found to be the main Brazilian trade partners among the OECD countries. Considering all bilateral relations VIIT was found to be larger than HIIT and Brazilian exported goods to be of lower quality than those imported.

A gravity type model was estimated in order to investigate the main determinants of the VIIT. The estimation results showed that market size and geographical distance had positive and negative effects respectively, in the VIIT. We further verified that differences in factor endowments, in terms of capital/labor ratio, had a positive impact on VIIT. Our general results corroborated the Falvey and Kierzkowski (1987) factor endowment difference hypothesis for most of the estimations.

Hummels and Klenow (2005) show a positive relationship between trade on high quality goods and growth in per capita income. Our results show that policies targeted to improve the quality of Brazilian export goods would contribute to increased participation in international markets. At sectoral and disaggregated level however there are some sectors (or industries) where vertical intra-industry trade might be determined by factors not considered in this paper.

A main limitation of this study could be the use of per capita GDP as proxy for capital/labor ratio. Even though it is common in the literature, we believe that the use of other proxies such as stocks of physical and human capital could bring new insights. Another limitation, which is also standard in the literature, is the lack of a better measure of trade costs, since they can be very important (Anderson and Van Wincoop 2004). Further, Bergstrand and Egger (2006) find that differences in trade costs between homogeneous and differentiated goods can affect the GL index, and that these effects are sensitive to differences in factor endowments.

A final but not least important limitation is related to the trade decomposition used, in order to avoid what Azhar and Elliot (2006) called “proportionality effect” due to the consequences that data scaling can have in the asymmetric effects in unit values of exports and imports. In order to avoid such a problem, Azhar and Elliot (2006) suggest the use of a modified GL index, a logical extension of this paper.

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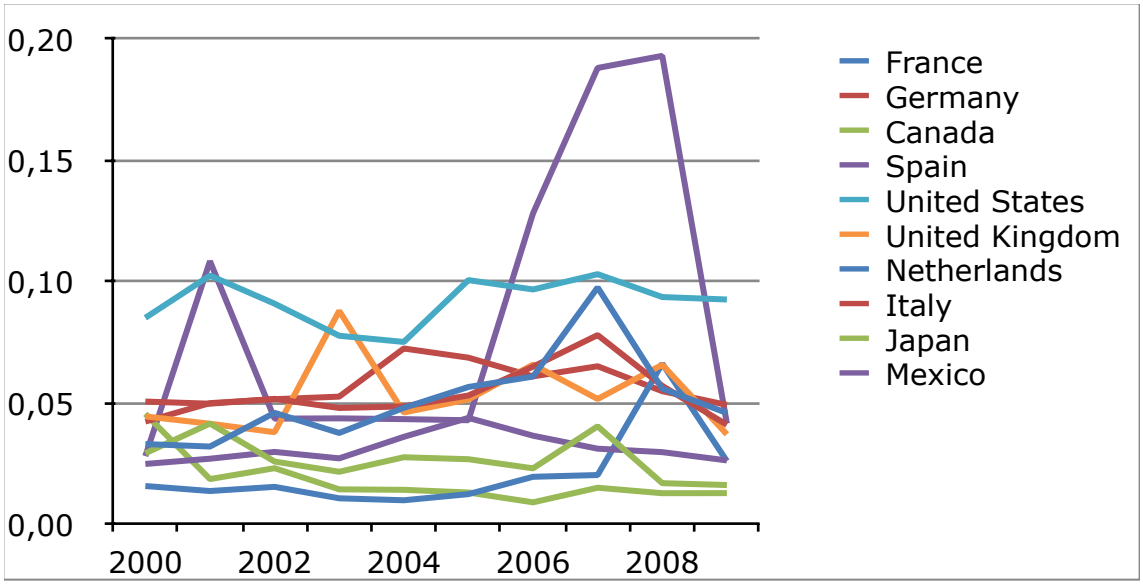
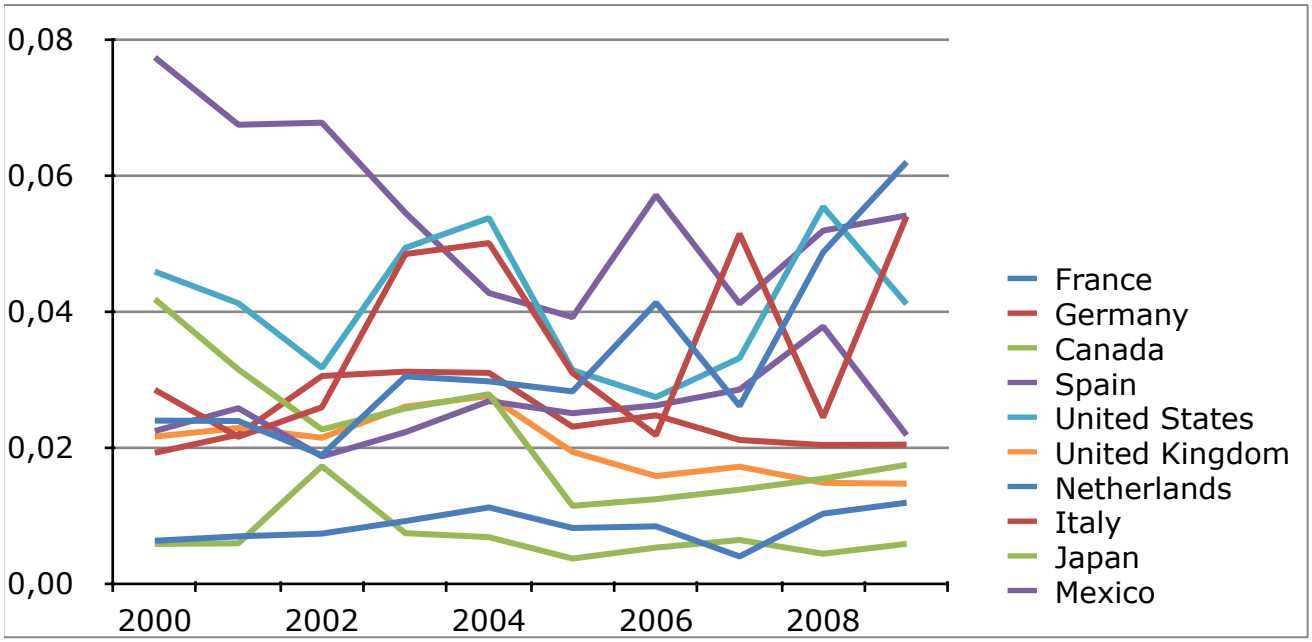
APPENDIX

FIGURE 2 – Shares of vertical inferior intra-industry trade ($VIIT^{Inf}$) between Brazil and main OECD countries from 2000 to 2009.



Source: BACI data base. Authors' calculations.

FIGURE 3 – Shares of vertical superior intra-industry trade ($VIIT^{Sup}$) between Brazil and main OECD countries from 2000 to 2009.



Source: BACI data base. Authors' calculations.

TABLE 7 - Descriptive statistics of the used variables

Variable	Obs.	Mean	Standard Deviation	Minimum	Maximum
Ln VIIT (α = 15%)	95,829	4.005	2.104	0.693	14.036
Ln VIIT (α = 25%)	87,994	3.963	2.089	0.693	14.036
Ln GDP	460,431	14.906	0.836	13.278	17.171
Ln DIST	460,431	9.128	0.232	8.938	9.797
Ln DIF	460,431	9.854	0.575	8.100	10.500

Source: BACI data base. Authors' calculations.

TABLE 8 – Product (Sector) Groups (HS Classification Codes)

HS Product (Sector) Group Description	HS Product (Sector) Group Description
01-05 Animal & Animal Products	50-63 Textiles
06-15 Vegetable Products	64-67 Footwear/Headgear
16-24 Foodstuffs	68-71 Stone/Glass
25-27 Mineral Products	72-83 Metals
28-38 Chemicals & Allied Industries	84-85 Machinery/Electrical
39-40 Plastics/Rubbers	86-89 Transportation
41-43 Raw Hides, Skins, Leathers, & Furs	90-97 Miscellaneous
44-49 Wood & Wood Products	-

Source: http://www.foreign-trade.com/reference/hscode.htm