Intra-Industry Trade and Technological Innovation:
The Case of Belgian Manufacturing

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Abstract

In this paper, we study the determinants of intra-industry trade in the Belgian manufacturing sector. We develop a model of intra-industry trade with both horizontal and vertical product differentiation. Based on this model we study the impact of technological innovation and technological spillovers on the pattern of trade. We find that high-quality vertical intra-industry trade is driven by technological innovation and spillovers, whereas horizontal intra-industry trade and low-quality vertical intra-industry trade are driven by income and factor endowment similarity. Finally, geographical barriers reduce the importance of intra-industry trade.

1 Introduction

Empirical evidence shows economic integration leads to intra-industry trade. Especially small open advanced economies are characterised by high levels of intra-industry trade. Recent studies focus on the impact of factor endowments and technology on the level of intra-industry trade. In this paper we study the role of technological innovation on the trade structure of Belgium.

Intra-industry trade can be divided into horizontal intra-industry trade and vertical intra-industry trade. Horizontal intra-industry trade refers to trade in different varieties (Krugman (1980, 1981, 1995)), while vertical intra-industry trade to trade in products of different quality (Falvey (1981), Falvey and Kierzkowski (1987), Flam and Helpman (1987)). This distinction between horizontal and vertical intra-industry trade is important for the validity of empirical studies. The results of early studies, focusing on total intra-industry trade only, are often mixed, as they are influenced by the different determinants of horizontal and vertical intra-industry trade. Most empirical studies investigate the impact of (Heckscher-Ohlin) factor endowment differences (Tharakan (1984), Balassa and Bauwens (1987, 1988), Greenaway et al. (1994, 1995, 1997)). In particular, horizontal intra-industry trade appears to be driven by factor endowment differences, often proxied by GDP per capita. Vertical intra-industry trade, on the other hand, appears to be influenced by technological differences (Brülhart and Hine (1999), Blanes and Martin (2000)). According to Torstensson (1991, 1996), however, factor proportion differences matter for vertical intra-industry trade as well, since high capital-labour ratios improve the relative quality of exports.

We extend the existing literature on the determinants of intra-industry trade by a more detailed analysis of the impact of technology. According to Davis (1995), technological differences may be a sufficient reason for intra-industry trade. Technological differences may create comparative advantages and disadvantages between countries, which are reflected in the pattern of trade. Our contribution is original both from a theoretical and an empirical perspective. We contribute to the existing theoretical literature by developing a model of intra-industry trade that allows for horizontal and vertical product differentiation at the same time. Most other studies exclusively focus on one kind of product differentiation. In this theoretical set-up we investigate the role of technological innovation. From an empirical point of view, this paper is original in two ways. Firstly, we distinguish between input and output measures of technology. Most studies stick to one general technology indicator. Secondly, we incorporate technological spillovers in the analysis. In a small open economy like Belgium innovativeness is not only influenced by national innovation efforts. E.g., total factor productivity in small open countries is strongly stimulated by foreign R&D efforts (Coe and Helpman (1995)). Openness to trade stimulates these international technology spillovers (Keller (2002)).

We use detailed panel data in this paper. We analyse the trade structure of Belgian manufacturing at a detailed sectoral level (24 sectors) for the period 1993-2000. Total trade is split up into bilateral trade to 26 countries, including the OECD partners (excluding Luxembourg, Iceland and New Zealand), EFTA and some Central-European countries. We perform this analysis by distinguishing between horizontal and vertical intra-industry trade. Vertical intra-industry trade is further split up into high-quality and low-quality. Our research questions can be summarized in four main hypotheses:

- Hypothesis 1: Is it income similarity or technological differences that determine intra-industry trade?
- Hypothesis 2: Does technology determine trade distinguished by variety or by quality?
- Hypothesis 3: Does technology lead to exports of high-quality products?
- Hypothesis 4: Do technological spillovers influence the trade structure?

We find that technological innovation and spillovers are important determinants for high-quality vertical intra-industry trade. Horizontal and low-quality vertical intra-industry trade are mainly influenced by income and factor endowments similarity.

This paper is structured as follows. In section 2 we demonstrate a model of intra-industry trade with horizontal and vertical product differentiation and focus on the role of technological innovation. The empirical methodology and data are discussed in section 3. In section 4 we present some stylized facts about Belgian trade and technological performance. Section 5 discusses the results from estimating the empirical model. Some conclusions are formulated in section 6.

2 Model of Intra-Industry Trade

In this section we develop a model of intra-industry trade with both horizontal and vertical product differentiation within the same industry. In each country goods are produced in different varieties, but each variety belongs to one out of two quality levels, i.e. high-quality or low-quality.

This model is based on the Dixit-Stiglitz (1977) methodology in a monopolistic competition set-up. We assume that a very large number goods is manufactured, so that the product space can be represented as continuous. The model is related to Bergstrand (1989), but incorporates quality differences, similar to Gullstrand (2002).

2.1 Demand Side

A representative, average consumer maximizes the following utility function:

$$\max U = X_l^{\phi} X_h^{1-\phi} \tag{1}$$

with X_q equal to a basket of horizontally differentiated products with quality level $q = l, h$ (low and high quality respectively). Following Dixit and Stiglitz (1977), we assume that X_q can be defined by a constant-elasticity-of-substitution (CES) function:

$$X_q = \left[\int\limits_{j \in J} x_{qj}^{\theta_q} dq \right]^{\frac{1}{\theta_q}} \tag{2}$$

The parameter θ_q represents the preference intensity for variety within the quality segment q, with $0 < \theta_q < 1$. We define $\sigma_q = \frac{1}{1-\theta_q}$, equal to the elasticity of substitution between any two varieties. This elasticity of substition is constant between any two varieties within the same quality segment, but different for each quality level. We further assume that $\sigma_l > \sigma_h$ as consumers of high-quality products are less sensitive to price changes.

We assume that there are C countries $(c = 1, ..., C)$ with a similar preference structure. Consumers have preferences over all varieties, both the ones produced at home and the ones produced abroad. The "average" consumer consumes both low- and high-quality goods, e.g., because of income differences within a country[1].

Utility maximization by each individual consumer in country a implies the following minimization problem:

$$\min \int\limits_{c \in C} \int\limits_{q=l,h} \int\limits_{j \in J} x_{qj}^{ac} p_{qj}^{ac} \tau^{ac} dj dq dc \tag{3}$$

such that

[1] Gullstrand (2002) focuses on the impact of income distribution and per capita income. In this paper, we neglect the income distribution in order to simplify the analysis.

$$\int_{c\in C}\int_{q=l,h}\left(\int_{j\in J}\left(x_{qj}^{ac}\right)^{\theta_q}dj\right)^{\frac{1}{\theta_q}}dqdc=E^a \tag{4}$$

with $x_{qj}^{ac}$the import demand by a consumer in country a for a product x_{qj} produced in a country c, $p_{qj}^{ac}$the f.o.b. price for this imported good and τ^{ac} the "iceberg" transportation (and possibly trade) cost for shipping goods between countries c and a (if $c=a$, then we have domestic demand). We assume the transport cost to be identical in both trade directions and $\tau^{cc}=1$. The spending of each individual in country a on goods of quality q is denoted by E_q^a. The share of spendings on low- and high-quality in total spendings is respectively equal to ϕ and $1-\phi$. Total spendings are equal to total income.

The typical Dixit-Stiglitz minimization problem yields the following import demand:

$$x_{qj}^{ac}=\frac{\left(p_{qj}^{ac}\tau^{ac}\right)^{-\sigma_q}}{\int_{c\in C}\int_{j\in J}\left(p_{qj'}^{ac}\right)^{1-\sigma_q}dj'}E_q^a \tag{5}$$

We can define a price index $G_q=\left(\int_{c\in C}\int_{j\in J}p_{qj}^{1-\sigma_q}dj\right)^{\frac{1}{1-\sigma_q}}$, so we can rewrite (5) as

$$x_{qj}^{ac}=\left(\frac{\left(p_{qj}^{ac}\tau^{ac}\right)}{G_q}\right)^{1-\sigma_q}E_q^a \tag{6}$$

The import demand for each variety of a given quality depends on the price of this good, relative to the price of the other varieties of the same quality, on the transportation cost and on spendings (income).

2.2 Supply Side

The market is characterised by monopolisitic competition. All firms within the same quality segment have a similar production technology. Each of them produces one variety. The firms maximize their profits, but there is free entry and exit. Hence, profits are driven to zero. The number of firms is determined endogenously.

There are two factors of production (f): K (capital) and L (labour). The production technology is defined as input requirements for each production factor. These production technologies are different for each quality.

$$D^a_{fq} = \alpha_{fq} + \beta_f x^a_{jh} \tag{7}$$

D^a_{fq} is the required amount of factor f in country a to produce varieties of quality q. There is a fixed requirement α_{fq} and a per-unit (marginal) requirement β_f. The former is different for each quality segment, whereas the latter is assumed to be identical for both qualities. We make the following assumptions regarding the fixed input requirements:

$$\alpha_{Kh} > \alpha_{Kl} \tag{8}$$

$$\alpha_{Lh} < \alpha_{Ll} \tag{9}$$

High-quality goods have a larger fixed capital input requirement, whereas low-quality goods require a higher fixed labour input in the production process. In country c, the per-unit compensation of factor L is denoted by w^c (wages), the one of factor K by r^c (interest rate) respectively.

Similar to Bergstrand (1989) total output of a variety j in country a is a constant-elasticity-of-transformation (CET) function of all its exports:

$$x^a_{qj} = \left[\int\limits_{c \in C} \left(x^{ca}_{qj} \right)^{\frac{\lambda+1}{\lambda}} \right]^{\frac{\lambda}{\lambda+1}}, \lambda > 0 \tag{10}$$

Firms maximize their profits, given their domestic sales and exports, as well as the cost functions associated with the input requirements. Hence, firms maximize

$$\Pi_{qj}^{a} = \int p_{qj}^{ca} x_{qj}^{ca} - (\alpha_{Lq} w^{a} + \alpha_{Kq} r^{a}) - (\beta_{Lq} w^{a} + \beta_{Kq} r^{a}) x_{qj}^{a} \tag{11}$$

For notational simplicity, we define $(\alpha_{Lq} w^{a} + \alpha_{Kq} r^{a}) = FC_{q}^{a}$ and $(\beta_{L} w^{a} + \beta_{K} r^{a}) = MC^{a}$. From the first order condition of the profit maximization problem we get

$$p_{qj}^{ac} = \frac{\sigma_q}{\sigma_q - 1} MC^{a} \left(\frac{x_{qj}^{ca}}{x_{qj}^{a}} \right)^{\frac{1}{\lambda}} \tag{12}$$

Finally, putting (11) equal to zero and filling in (12) yields

$$x_{qj}^{a} = (\sigma_q - 1) \frac{FC_{q}^{a}}{MC^{a}} \tag{13}$$

2.3 The Number of Firms and the Role of Technological Innovation

In order to determine the produced number of varieties of each quality, we assume that there is perfect competition in the factor markets. Consequently, total factor supply equals total factor requirements. Each firm within a quality segment has the same factor demand. The total number of firms producing low-quality and high-quality varieties is respectively denoted by n_l and n_h. This implies that in each country it holds that

$$L^{S} = n_l D_{Ll} + n_h D_{Lh} \tag{14}$$

$$K^{S} = n_l D_{Kl} + n_h D_{Kh} \tag{15}$$

This is a set of two equations with two unkowns (n_l and n_h). We can solve for these unknowns by filling in successively (7) and (13) into (14) and (15). After computations and rearrangements we find that

$$n_h = K^S \frac{(MC.\alpha_{Ll} + \beta_L (\sigma_l - 1) FC_l)}{N} - L^S \frac{(MC.\alpha_{Kl} + \beta_K(\sigma_l - 1)FC_l)}{N} \tag{16}$$

$$n_l = L^S \frac{(MC.\alpha_{Kh} + \beta_K (\sigma_h - 1) FC_h)}{N} - K^S \frac{(MC.\alpha_{Lh} + \beta_L (\sigma_h - 1) FC_h)}{N} \tag{17}$$

with

$$\begin{aligned} N \;&=\; (MC.\alpha_{Kh} + \beta_K (\sigma_h - 1) FC_h) (MC.\alpha_{Ll} + \beta_L (\sigma_l - 1) FC_l) - \\ &\quad\; (MC.\alpha_{Lh} + \beta_L (\sigma_h - 1) FC_h) (MC\alpha_{Kl} + \beta_K (\sigma_l - 1) FC_l) \end{aligned}$$

K^S and L^S affect n_h and n_l in opposing ways. Since the nominators of the arguments associated with K^S and L^S are always positive, the sign of the denominator N determines whether K and L have a positive or negative impact on the number of low- and high-quality varieties produced. In the event of $N > 0$, a larger labour (capital) supply lowers (increases) the number of high-quality varieties and increases (lowers) the number of low-quality varieties. In the event of $N < 0$, the opposite holds[2].

Now we define the role of technological innovation. We do this in an exogenous way, although it could have been the endogenous result of a product cycle model (e.g., Dollar (1986)). We assume that domestic technological innovation lowers the fixed capital input requirements of the high-quality sector in the innovating country, relative to the fixed capital input requirement of the low-quality sector abroad. In a two-country model (with countries A and C), this implies:

$$\frac{\alpha^A_{Kh}}{\alpha^B_{Kl}} = \frac{T_B^{\delta_1}}{T_A^{\delta_2}}, \qquad \delta_1, \delta_2 > 0 \tag{18}$$

[2] Given assumptions (8) and (9), N is definitely larger than 0 if it holds that $\frac{\alpha_{Kh}}{\beta_K} > \frac{\alpha_{Lh}}{\beta_L}$ and $\frac{\alpha_{Ll}}{\beta_L} > \frac{\alpha_{Kl}}{\beta_K}$.

T_c denotes the technological innovation of country c. If the technological innovation of country A increases (or if it increases more than the technological innovation of country B), then α^A_{Kh} goes down and α^B_{Kl} increases. We measure the impact of this event on the number of varieties produced in the low- and high-quality segments of both countries. Assuming that $\frac{\alpha_{Kl}}{\alpha_{Ll}} < \frac{K^S}{L^S}$, $\frac{\alpha_{Kh}}{\alpha_{Lh}} < \frac{K^S}{L^S}$, and that $\frac{\beta_K}{\beta_L} < \frac{K^S}{L^S}$, we find that

$$\frac{\partial n^A_h}{\partial \alpha^A_{Kh}} > 0 \tag{19}$$

$$\frac{\partial n^B_l}{\partial \alpha^B_{Kl}} < 0 \tag{20}$$

Hence, an increase in the relatively good innovation performance in country A increases both the number of high-quality goods produced by country A and the number of low-quality goods produced by firms in country B[3]. We can attribute a similar effect to technological spillovers by changing (18) into

$$\frac{\alpha^A_{Kh}}{\alpha^B_{Kl}} = \frac{T_B^{\delta_1}}{T_A^{\delta_2} T_{world}^{\delta_3}}, \qquad \delta_1, \delta_2, \delta_3 > 0 \tag{18'}$$

Where T_{world} is the innovation by other countries in the world, which spills over internationally (see empirical part).

2.4 The Pattern of Bilateral Trade

Finally, we turn to the pattern of bilateral trade. We calculate the value of bilateral trade between two countries A and B by putting (13) into (12). Hence we are able to compute the volume and price of a single firm's exports from A to B. The product of both gives us the value of exports. Total bilateral exports are equal to the value of exports by a single firm, multiplied by the number of firms producing varieties in that quality segment in country A. Hence we find that total exports from A to B are equal to

[3] Note that this holds regardless of the sign of N.

$$
\begin{aligned}
EX_{qj}^{BA} &= n_q^A.p_{qj}^{BA}.q_{qj}^{BA} \\
&= n_q^A.\sigma_q^{\frac{2-\sigma_q}{\sigma_q}} \left(\sigma_q - 1\right)^{\frac{(1+\lambda)(\sigma_q-2)}{\lambda\sigma_q}} \left(FC_q^a\right)^{\frac{2-\sigma_q}{\lambda\sigma_q}} \left(\tau^{AB}\right)^{\frac{2(1-\sigma_q)}{\sigma_q}}. \\
& E^{\frac{2}{\sigma_q}} \left(MC^a\right)^{\frac{(2-\sigma_q)(\lambda+1)}{\lambda\sigma_q}}
\end{aligned} \tag{21}
$$

In a similar way we can compute imports (IM).From (21) we learn that exports are positively influenced by the number of firms, by the elasticity of substitution and the income level. The impact of fixed and marginal costs depends on the exact value of the parameters. Transport costs have a negative impact on total trade.

2.5 Measurement of Intra-Industry Trade

We are now able to calculate the pattern and importance of intra-industry trade. We use the most popular and widespread index of intra-industry trade, developed by Grubel and Lloyd (1975). This GL-index is equal to

$$
\begin{aligned}
GL^{BA} &= \frac{\left(EX^{BA} + IM^{BA}\right) - \left|EX^{BA} - IM^{BA}\right|}{EX^{BA} + IM^{BA}} \\
&= 2\min\left(EX^{BA}, IM^{BA}\right) \\
&= 2\min\left(EX_h^{BA} + EX_l^{BA}, IM_h^{BA} + IM_l^{BA}\right)
\end{aligned} \tag{22}
$$

Total intra-industry trade is typically split up into horizontal and vertical intra-industry trade, in order to measure the relative impact of horizontal and vertical product differentiation. Vertical intra-industry trade is further split up into high-quality and low-quality vertical intra-industry trade (see empirical calculation for more details). These definitions allow us to define:

$$HIIT^{BA} = 2(\min(IM_l^{BA}, EX_l^{BA}) + \min(IM_h^{BA}, EX_h^{BA}) \tag{23}$$

$$VIIT_{high}^{BA} = 2\min(EX_h^{BA}, EX_l^{AB}) \tag{24}$$

$$VIIT_{low}^{BA} = 2\min(EX_h^{AB}, EX_l^{BA}) \tag{25}$$

Based on From (22)-(24) and (21) we know the determinants of the pattern of intra-industry trade. In particular, it is straightforward that high-quality VIIT by country A increases if country A performs relatively well in terms of technological innovation. Low-quality VIIT by country A will be important if a sector (or the entire economy) is technologically dominated by the trading partner. Technological spillovers that benefit the exporter's market trigger a similar positive effect on high-quality VIIT as domestic innovation.We will test these theoretical hypotheses in the empirical part of this paper.

3 Methodology and Data

3.1 Empirical Model

In order to study the determinants of each kind of intra-industry trade, we estimate an empirical model for bilateral trade between Belgium and its main trading partners.

$$\begin{aligned} GL_{ikt}^{z} &= \alpha + \beta_1 IS_{kt} + \beta_2 \ln(DIST_k) + \beta_3 \ln(SCALE_{kt}) \\ &\quad + \beta_4 \ln(RTP_{ikt}) + \beta_5 \ln(GTS_{ikt}) + \mu_{ikt} \end{aligned} \tag{26}$$

with

GL^z_{ikt}	Grubel-Lloyd Index with z denoting Total IIT, Horizontal IIT, High-quality Vertical IIT and Low-qualityIIT subsequently
IS_{kt}	Income Similarity between Belgium and its trading partner k at time t
$DIST_k$	Distance between Belgium and its trading partner k
$SCALE_{ik}$	Relative scale of trading partner k to Belgium in sector i (measured by relative sectoral employment, averaged over time)
RTP_{ikt}	Relative Technological Performance of coutry k to Belgium in sector i at time t (several indicators: see below)
GTS_{ikt}	Global Technology Spillovers in sector i between country k and Belgium at time t
μ_{ikt}	Error Term
α	Constant Term

We estimate equation (26) separately for total intra-industry trade ($TIIT$), horizontal intra-industry trade (*HIIT*), low-quality vertical intra-industry trade (*low-quality VIIT*) and high-quality vertical intra-industry trade (*high-quality VIIT*). For each kind of intra-industry trade we compute the Grubel-Lloyd (1975) index as follows:

$$GL_{ikt} = \frac{\sum_{j\in i} X_j + M_j - \sum_{j\in i} |X_j - M_j|}{\sum_{j\in i} (X_j + M_j)} * 100$$

This GL-index is equal to the share of intra-industry trade in total trade between Belgium and country k in year t in industry i. We use detailed sectoral trade flows in order to compute this index. The final outcome is an aggregate of all intra-industry trade in sub-sectors j that all belong to industry i. Therefore both intra-industry trade and total trade are aggregated at each industry level in order to compute this GL-index. GL takes values between 0 and 100, where the former indicates complete inter-industry trade and the latter complete intra-industry trade.

We take a logarithmic transformation of the independent variables, but not for the dependent variable. Hence we estimate a so-called "level-log-model". The interpretation of the coefficients is nevertheless parsimonious. As the dependent variable is in all cases an index ranging between 0 and 100, the coefficient β in $y = \alpha + \beta.\ ln\ x$ can be interpreted as the absolute increase in y in case x goes up by 1 %. This absolute increase is nevertheless equal to the percentage increase in intra-industry trade. Hence y will go up by β %[4].

3.2 Splitting up Intra-Industry Trade

After computing total intra-industry trade we fine-tune our analysis. Similar to most recent studies we follow Abd-el Rahman (1986, 1991) and Greenaway et al. (1994) and split up total intra-industry trade based on relative unit values of sectoral exports and imports. Using this methodology we compute the relative unit values of bilateral export over bilateral imports as

$$\frac{UV_{jikt}^{EX}}{UV_{jikt}^{IM}}$$

This "price ratio" is interpreted as an indicator of quality. If export and import prices at a very detailed level, namely at sub-sector j belonging to industry i, are almost equal, than this reflects similar quality of differentiated products. In this case we consider the total amount of intra-industry trade in this sector as horizontal intra-industry trade, based on two-way trade in different varieties of the same good. In the other case, namely that these unit values differ by 15 % or more from each other, we call it vertical intra-industry trade. Important assumption in this approach is of course that prices reflect quality[5].

We take a step further by defining *high-quality* versus *low-quality* vertical intra-industry trade. This distinction is relevant as the role of technology may be very different in both cases. *High-quality* (*low-quality*) vertical intra-industry trade is defined as intra-industry trade where Belgium exchanges *high-quality* (*low-quality*) products for *low-quality* (*high-quality*) products made by its bilateral trading partner within the same industry. The "price

[4]For similar reasons we do not take a logarithmic transformation of the income similarity indicator.

[5]In the literature one mostly uses either 15 % or 25 %. This choice is arbitrary. For the paper we did not find much difference in the computed GL-indices based on both cut-off levels. We only report the empirical evidence based on the 15 % criterium. The other results are available upon request.

ratio" can be used to determine high and low quality too. If the "price ratio" is larger than 1+0.15, then Belgian export products are priced at least 15 % higher than Belgian imports in the same subsector. As we assume that prices reflect quality, we call this vertical intra-industry trade *high-quality*. So in our definition we always take the Belgian perspective. We speak about *low-quality* vertical intra-industry trade once Belgian export prices are at least 15 % lower than the import prices. Once we have determined the kind of trade at each sub-sector j, we aggregate all computed horizontal, vertical *high-quality* and vertical *low-quality* intra-industry trade at each industry level. We express each kind of intra-industry trade as a percentage of total sectoral trade.

3.3 Overview of the Independent Variables

In our empirical model we study the determinants of total, horizontal and vertical intra-industry trade. We test for the importance of technological performance and technological spillovers, apart from the importance of other determinants that have been studied in the literature. We do not stick to a partial analysis of the role of technology only as this might cause measurement errors as argued by Leamer and Levinsohn (1995). For convenience as well as to investigate the heterogeneous impact on the different dependent variables, we use the same set of independent variables for each kind of intra-industry trade. We are mainly concerned about the role of technological innovation and spillovers, versus factor endowments, as determinants of (different categories of) intra-industry trade.

3.3.1 Income Similarity and Endowments

Similarity in income or endowments is traditionally considered as the main determinant of intra-industry trade. We use the following measure of income similarity:

$$1 - \frac{|GDP/POP_{partner} - GDP/POP_{Bel}|}{[GDP/POP_{partner} + GDP/POP_{Bel}]} * 100$$

This index ranges between 0 and 100. 0 corresponds to very different countries, whereas 100 indicates countries with identical GDP per capita[6]. This index is at the same time a proxy for relative endowment differences, as countries with similar incomes are assumed to have similar capital-labour ratios.

3.3.2 Scale

Another traditional argument for the explanation of intra-industry trade is the scale of the sector (Helpman (1981)). Countries tend to specialize in the production of one good in order to benefit from increasing returns to scale (Harrigan 1991). These increasing returns to scale create a competitive advantage for the larger country in a particular sector. Hence we expect to observe a large export flow by this country in that sector.

The impact of the resulting specialization pattern between countries on intra-industry trade is ambiguous. The exact outcome depends however on whether we deal with small open economy or not.

Generally speaking, we expect to find a negative effect on intra-industry trade if the trading partner is relatively large. In this case this trading partner benefits from its scale effects and is able to produce more efficiently. Hence he has comparative advantage on the export market.

However, *for small open economies* this need not be the case. A small country that acts as a supplier to a larger country, may actually benefit from these foreign scale effects. Either it may deliver more goods for the production process abroad, while importing more of the finalized goods; or it may manufacture final goods by using imported unfinished products. Hence we expect higher intra-industry trade in the event of a larger trading partner in the sector.

In order to test this scale effects at the sectoral level, we add a variable measuring sectoral employment by the partner country relative to Belgian employment. If we find a positive relationship, then a larger partner in that sector leads to more intra-industry trade. Due to data limitations we take an average over time for this measure.

[6] This index resembles to the GL-index. Therefore, as an exception we do not take its logarithmic form, as a level-to-level interpretation is more useful in this case.

3.3.3 Geographical Distance and Trade Barriers

Distance, like in the gravity model, can be interpreted as transportation and transaction costs. One assumes a positive relationship between geographical distance and the degree of trade barriers. Therefore we add the distance between the capital cities of the trading partners as variable in our model. In terms of intra-industry trade, the barriers may induce substitution of production by domestic firms and hence intra-industry trade will drop. The latter finding is very robust in the literature (for an overview and discussion, see Amiti and Venables (2001)).

3.3.4 Technological Innovation

We define several measures of technological innovation. We make a distinction between three kinds of variables, namely *technology-input*, *technology-output* and *technology-spillover* measures. We define technology as the technological performance of the trading partner relative to Belgium.

For the *technology-input* measure we use the relative performance of the trading partner to Belgium in terms of two alternative indicators: R&D expenditures and value added per worker. We take an average over time for both (because of data limitations). USPTO patent data are used as an indicator of *technological output* performance. We calculate the relative number of patents granted in the US market (fractional data). However as this latter measure is undoubtedly influenced by country size, we scale this variable.

3.3.5 Technology Spillovers

In order to investigate the impact of technological spillovers, we compute a weighted technology measure, in which we add up all patents granted in the USA to each trading partner under observation. We refer to this variable as global technology spillovers, recognizing the role of trade as transmission channel for technological diffusion (e.g., Keller (2002)). "Global" simply refers to all countries in our sample. We use the relative import share in total Belgian imports as weights. Hence we have a measure of intra-sectoral technological spillover-effects. We expect to find a positive effect on intra-industry trade, in particular on vertical high-quality intra-industry trade.

Our expectations are supported by the positive effect of international innovation on productivity and growth in small open economies.

3.4 Data Description

All trade data are taken from the OECD Trade and Commodity Statistics. We use SITC rev.3 (5-digits) as classification for the sub-sectors j. We calculate the indices and convert them to the ISIC rev.3 (2-digit) classification. All other data are also collected or converted to ISIC rev.3 . Data on value added, production, employment and R&D expenditures are taken from OECD (STAN database and SSIS for missing values, ANBERD and OFFBERD for missing values). Sectoral patent data are from USPTO (conversion from USSIC). GDP and Population data are from IMF – Financial Statistics[7].

We use data for 8 years (1993-2000) for 26 Belgian trading partners: OECD-countries (except Luxembourg, Iceland and New Zealand), EFTA-countries and Poland, Hungary, Slovak Republic and Czech Republic. The ISIC-classification contains 24 manufacturing sectors. There are of course missing values in our dataset. Therefore estimation results are not based on a fully balanced and complete dataset.

We opt for using panel data to investigate the impact of technology on intra-industry trade, as Hummels and Levinssohn (1995) show that the determinants of intra-industry trade are not always stable over time. Greenaway and Torstensson (1997) call the use of panel data one of the most promising extensions of empirical analysis in intra-industry trade. We use data for a relatively short period of time (8 years). Therefore we focus in our analysis on the cross-sectional and cross-country variation. For this kind of analysis, the between-effects-estimator (BE-estimator, regression on the group means) is prefered. By using the BE-estimator, we measure the impact of cross-country cross-sectional variation in e.g., technology indicators on variation in the level of intra-industry trade. By doing so, we give in to the remarks formulated by Menon and Dixon (1996), who formally prove that the interpretation of GL-indices over time may be misleading. An increase in the GL-index merely indicates a higher share of intra-industry trade in total trade. Growth of inter-industry trade possibly exceeds growth of intra-industry trade. Under

[7] More information regarding the conversion methodologies are available upon request.

particular conditions, inter-industry trade might have grown relative to intra-industry trade. As Brülhart (2002) argues it is justified to use the GL-index as long as one is interested in a comparison of the pattern of trade at different points in time. Deriving dynamic or adjustment conclusions based on the GL-evolution, however, is not an adequate methodology. Consequently, the BE-estiamtor should be taken instead of e.g., a random-effects or fixed-effects estimator.Moreover, the fixed-effects estimator cannot be used easily in the model as some of our independent variables do not change over time (like e.g., distance). Hence, multicollinearity problems would arise, if we estimate the coefficients by a fixed-effects estimator.

4 Stylized Facts about Belgian Trade and Technology

Belgium is a small open economy at the heart of Western Europe. In this section we give an overview of the innovativeness and competitiveness of the Belgian manufacturing sector. We do this by comparing technological performance in Belgium and the other countries in our data for the 24 manufacturing sectors under study. Next, we examine the importance of intra-industry trade in total Belgian trade. We do this again for 24 manufacturing sectors. Additionally we compare Belgian intra-industry trade bilaterally with the 26 countries mentioned above.

4.1 The Relative Innovativeness of the Belgian Economy

In Table 1 we compare technological innovation in manufacturing in Belgium with its 26 trading partners. We define technology both as output and input variable. *Sectoral Technology-Intensity* is measured as the ratio of the sectoral number of patents (respectively business R&D expenditures) over the total number of manufacturing patents (respectively business R&D expenditures). We calculate one figure for all trading partners jointly (including Belgium) and compare this to the Belgian sectoral technology-intensity.

From Table 1 we learn that a ranking of technology-intensity of sectors depends on the technology measure (input/output) used. If we focus on technology output, Machinery, Medical and Precision Instruments, Electrical Machinery and Chemistry represent the highest shares in the total number of patents granted to manufacturing sectors. We find the highest R&D spending in Communication, Motor Vehicles, Pharmacy, Other Transport and Chemistry. In general, Belgium has a similar technology-intensity pattern as its trading partners. Nevertheless some interesting deviations appear:

1. Belgium does not perform well in high-tech sectors, generally speaking. Notable exceptions are Chemistry and Pharmacy. This can be explained by some large and important Belgian companies active in these sectors.
2. Generally speaking again, Belgium performs relatively well in low-tech sectors, both in terms of R&D spendings and in terms of patent grants. Striking examples are Food, Textiles and Energy.
3. Also striking are the relatively large R&D spendings in the Metal Sector (Iron and Steel, Non-Ferrous Metals, Metal Products). This clearly contrasts the low performance in terms of patent grants.

[*insert figure 1*]

4.2 The Structure of Belgian Sectoral and Bilateral Trade

We now turn to the measures of intra-industry trade. We first look at the sectoral variation in intra-industry trade.

We compute the GL-index for total Belgian trade (world trade) for 24 manufacturing sectors. Table 2 shows our findings for Total intra-industry trade (TIIT). We also compute separate GL-values for horizontal (HIIT) and vertical intra-industry trade (VIIT) based on the price ratio. The sum of both of them adds up to the GL-value of TIIT. Vertical intra-industry trade is further decomposed into high-quality and low-quality vertical intra-industry trade (VIIThigh and VIITlow). Again, the sum of both of them adds up to the GL-value of VIIT.

Table 2 shows that in all Belgian manufacturing sectors total intra-industry trade (TIIT) exceeds 50 % of total trade (exports plus imports). More interestingly is the composition of intra-industry trade. In terms of the number of sectors vertical intra-industry trade dominates horizontal intra-industry trade. By contrast, in some important sectors (for Belgium) like Motor Vehicles and Iron and Steel horizontal intra-industry trade dominates.

When we compare high and low quality vertical intra-industry trade (resp. VIIThigh and VIITlow), high quality exceeds low quality except for Food and Printing.

[*insert figure 2*]

Apart from examining the sectoral variation of intra-industry trade, we also look at the geographical variation. Table 3 shows intra-industry calculations similar to Table 2, but this time for all countries under study separately. The intra-industry trade in each sector has been added up and weighted by its share in total manufacturing trade (exports plus imports). The final two columns give respectively the ratio of HIIT over VIIT and VIIThigh over VIITlow.

Total intra-industry trade is highest for Belgium's main trading partners. For all trading partners vertical intra-industry trade exceeds horizontal intra-industry trade. Vertical intra-industry trade seems relatively more important for very distant trading partners. The picture for the relative importance of high-quality vertical intra-industry trade is very heterogeneous.

[*insert figure 3*]

The computed levels for GL in Table 3 are relatively low compared to other studies. They seem not to confirm the general view that a small open economy like Belgium is characterised by high levels of intra-industry trade. However these lower values are exactly the result of our large geographical (and sectoral) disaggregation. This structure of trade is typical of a small economy with a high openness to trade in several industries and with a lot of trading partners. By using this approach we tackle the criticism on the GL-index about aggregation bias.

5 Empirical Results

We report both the results from the OLS-estimator and the BE-estimator. We successively discuss the empirical results for total, horizontal and vertical intra-industry trade. We focus on the BE-estimator as this estimator is prefered for reasons stated above.

5.1 Determinants of Total Intra-industry Trade

[*insert figure 4*]

From table 4 we learn that our main theoretical expectations are confirmed for total intra-industry trade. The model is able to explain 50-60 % of the variance in the data.The F-test reject the hypothesis that all coefficients are jointly equal to zero. Most estimated coefficients are significantly different from zero.

Total intra-industry trade is positively influenced by income similarity. A 1% decrease in income differences between trading partners result in a 0.19 % increase in intra-industry trade. This effect is small, but very significant. Geographical distance has a large and very significant negative effect on total intra-industry trade. To the contrary, relative scale has a very positive effect. This latter finding confirms are expectations about the role of relative scale in case of small open economies.

The impact of relative technological performance depends on the indicator we look at. Relative performance in terms of technology output (patents) has no significant impact on intra-industry trade, whereas relative performance in terms of technology input (R&D expenditures) does have a significant positive impact. Finally, the indicator based on value added per worker is insignificant. Surprisingly maybe, global technological spillovers have a positive and significant impact on total intra-industry trade.

We report these results for intra-industry trade in order to compare them to the results that we obtain for horizontal and vertical intra-industry trade separately. We are aware that attempts to interprete the results for total intra-industry trade may be misleading, as they are the combinations of different channels through which intra-industry trade is affected.

5.2 Determinants of Horizontal Intra-industry Trade

[*insert figure 5*]

Compared to the findings for total intra-industry trade, the estimated coefficients for horizontal intra-industry trade are smaller and several of them are insignificant.

Income similarity still has a significantly positive impact on horizontal intra-industry trade, as theoretically predicted. Although the coefficient is significant and it has the expected sign, the size of the coefficient is rather small. Distance and Scale maintain respectively their significant negative and positive impact on horizontal intra-industry trade, but again the significance and the size of the coefficient have decreased compared to the case of total intra-industry trade.

Clearly, the impact of technological performance and spillovers is very limited. We do not find a significant impact on horizontal intra-industry trade, except for a small positive impact of relative R&D expenditures.

5.3 Determinants of Vertical Intra-industry Trade

[*insert figure 6*]

[*insert figure 7*]

The results for low-quality vertical intra-industry trade are very similar to the results for horizontal intra-industry trade. The impact of income similarity, distance and scale increase again. Technological differences and spillovers have no significant impact at all.

The findings for low-quality vertical intra-industry trade are completely different from the results for high-quality vertical intra-industry trade. The positive effect of income similarity is maintained, but is smaller than in the other cases. The impact of distance is softened as well. Scale still has a very positive and significant effect on high-quality vertical intra-industry trade.

Most interestingly, technological differences and spillovers play a major role as determinants of high-quality vertical intra-industry trade. We find however opposing effects from the technology input indicator and the technology output indicator. On the one hand, if the Belgian trading partner has obtained a higher number of patents in the sector, then high-quality vertical intra-industry trade is smaller. On the other hand, higher R&D expenditures abroad has a positive effect on high-quality vertical intra-industry trade. This implies that the foreign innovation efforts benefit (or have a similar effect on) the export performance of the domestic economy, whereas successful foreign innovation creates a competitive disadvantage for the domestic economy.

Finally, global technological spillovers have a large, positive and significant impact on high-quality vertical intra-industry trade. This confirms our hypothesis that a small open economy like Belgium benefits from the research efforts undertaken by its trading partners, which leads to an increase in Belgian exports of high-quality products in exchange for imports of low-quality products.

6 Conclusion

We started this paper by posing some hypotheses regarding the determinants of intra-industry trade. As a small open economy, like Belgium, is particularly influenced by events in the international economy, we examine the link between two well-known phenomena. On the one hand, small open economies are characterised by high levels of intra-industry trade. On the other hand, in order to remain competitive, continued technological innovation takes place by all players in the world. Even if a small economy chooses a policy that is directly focusing on substantial investments in R&D and innovation, it will at all time be confronted with large trading partners who have a much more influential position in international innovation. However, as technology has some characteristics of a public good, technological spillovers may compensate for the disadvantages of a smaller size.

This paper investigated the role of technological innovation and technological spillovers in shaping the trade structure of a small open economy, namely Belgium. We developed a theoretical model of intra-industry allowing for both horizontal and vertical product differentiation. Based on this model we predicted a positive effect of domestic technological innovation and technological spillovers on the importance of (vertical) intra-industry trade. Our empirical study confirmed these predictions. The role of technology becomes more clear if investigated for all kinds of intra-industry separately. We confirm the theoretical prediction that relative technological performance matters more for high-quality vertical intra-industry trade than for horizontal intra-industry trade.

In addition, we tested the hypothesis that relative factor endowments are a crucial determinant of intra-industry trade. We find that this is indeed so, but mainly for horizontal intra-industry trade, and also for low-quality vertical intra-industry trade. But endowments do not explain everything. We find that trade barriers hamper all kinds of intra-industry trade and that relative production scale is relevant, especially for vertical intra-industry trade.

This research is a first attempt to analyse the impact of technological spillovers, apart from technological innovation, on intra-industry trade. Many interesting extensions are possible. In particular the channels through which these spillovers benefit the economy are worth further theoretical and empirical research.

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		Technology Output (a)				Technology Input (b)		
Sector	Sector Name	Partners	Belgium	Compare		Partners	Belgium	Compare
15	Food	1.36	2.08	BEL high		0.85	3.15	BEL high
16	Tobacco	0.00	0.00	IDEM		0.04	0.05	BEL high
17	Textiles	1.55	2.39	BEL high		0.23	1.42	BEL high
18	Wearing Apparel	0.56	0.64	BEL high		0.12	0.07	BEL low
19	Leather	0.93	1.40	BEL high		0.03	0.08	BEL high
20	Wood	0.15	0.24	BEL high		0.18	0.07	BEL low
21	Paper	0.00	0.00	IDEM		0.19	0.41	BEL high
22	Printing	0.90	0.57	BEL low		0.04	0.71	BEL high
23	Energy	0.98	1.29	BEL high		1.09	2.89	BEL high
24	Chemistry	10.04	23.57	BEL high		8.53	23.41	BEL high
2423	Pharmacy	5.21	8.53	BEL high		9.56	18.91	BEL high
25	Rubber	2.29	4.16	BEL high		1.88	2.89	BEL high
26	Minerals	2.60	2.88	BEL high		1.15	2.27	BEL high
271+2731	Iron and Steel	0.57	0.29	BEL low		1.12	3.15	BEL high
272+2732	Non-Ferrous Metals	0.72	0.69	BEL low		0.76	1.32	BEL high
28	Metal Products	4.95	3.26	BEL low		1.38	1.67	BEL high
29	Machinery	16.85	13.73	BEL low		7.34	6.43	BEL low
30	Office	6.69	3.19	BEL low		7.71	0.27	BEL low
31	Electrical Machinery	11.42	6.42	BEL low		5.75	4.33	BEL low
32	Communication	9.29	4.87	BEL low		16.83	17.91	BEL high
33	Medical, Precision Instruments	14.23	13.00	BEL low		7.66	2.31	BEL low
34	Motor Vehicles	2.76	1.44	BEL low		14.39	3.39	BEL low
35	Other Transport	3.47	2.52	BEL low		8.70	1.81	BEL low
36	Furniture	2.35	2.57	BEL high		0.75	1.03	BEL high
		(a) Technology Output is measured as the share of the sectoral number of patents granted (fractional) in total manufacturing, in all in-sample countries jointly in the US market (source: USPTO)				(b) Technology Input is measured as the share of sectoral Business R&D expenditures in total manufacturing in all in-sample countries jointly (source: OECD, STAN)		

Figure 1: Sectoral Technology-Intensity of Belgium and its Main Trading Partners (Average 1993-2000)

Sector	Sector Name	TIIT	HIIT	VIIT	*VIIThigh*	*VIITlow*
36	Furniture	82.63	11.93	70.7	*54.63*	*16.07*
30	Office	81.67	33.6	48.07	*31.23*	*16.84*
18	Wearing Apparel	78.41	35.08	43.33	*38.88*	*4.45*
33	Medical, Precision Instruments	76.27	32.78	43.49	*30.65*	*12.84*
2423	Pharmacy	75.54	27.29	48.25	*36.91*	*11.34*
32	Communication	74.95	15.96	58.99	*49.43*	*9.56*
25	Rubber	74.14	28.98	45.16	*34.05*	*11.11*
22	Printing	73.19	16.46	56.74	*15.92*	*40.81*
19	Leather	70.1	8.3	61.8	*50.83*	*10.97*
21	Paper	70.1	47.96	22.14	*13.89*	*8.25*
28	Metal Products	68.88	23.16	45.72	*28.36*	*17.36*
29	Machinery	68.74	19.5	49.23	*35.03*	*14.2*
31	Electrical Machinery	66.46	21.57	44.9	*37.59*	*7.31*
24	Chemistry	65.94	29.79	36.15	*22.57*	*13.59*
20	Wood	65.05	34.96	30.1	*22.04*	*8.05*
35	Other Transport	64.51	12.86	51.65	*40.01*	*11.63*
34	Motor Vehicles	63.95	50.53	13.42	*12.54*	*0.88*
16	Tobacco	63.82	21.79	42.03	*34.43*	*7.6*
15	Food	60.66	29.28	31.37	*14.95*	*16.42*
17	Textiles	59.99	22.94	37.05	*28.66*	*8.38*
26	Minerals	59.12	19.79	39.33	*24.13*	*15.2*
271+2731	Iron and Steel	52.76	37.32	15.44	*10.35*	*5.09*
272+2732	Non-Ferrous Metals	52.7	34.93	17.76	*14.98*	*2.79*
23	Energy	51.12	34.12	17	*13.72*	*3.28*

Figure 2: Relative Share of Total, Horizontal and Vertical Intra-Industry Trade in Total Belgian Trade (World, Average 1993-2000); own computations based on OECD International Trade Statistics, with Conversion to ISIC rev.3

	TIIT	HIIT	VIIT	VIIThigh	VIITlow		HIIT/VIIT	VIIThigh/ VIITlow
Norway	5.97	1.72	4.25	1.94	2.31		40.49	83.64
Australia	6	0.37	5.63	1.5	4.13		6.54	36.25
Mexico	7.13	0.7	6.43	4.49	1.94		10.96	231.08
Korea	7.87	1	6.87	5.42	1.45		14.63	374.18
Turkey	8.08	1.99	6.09	4.95	1.15		32.64	431.36
Canada	8.39	0.9	7.49	3.67	3.81		12.08	96.22
Greece	9.86	1.63	8.23	4.41	3.82		19.86	115.58
Finland	12.61	3.06	9.55	6.06	3.49		32.08	173.88
Hungary	14.39	2.19	12.19	7.8	4.39		17.99	177.69
Ireland	15.88	3.84	12.04	4.4	7.63		31.94	57.7
Slovak Republic	16.96	4.94	12.01	5.76	6.25		41.12	92.16
Poland	18.58	6.33	12.26	6.81	5.45		51.63	124.86
Japan	19.25	1.61	17.64	13.55	4.09		9.15	330.79
Portugal	20.76	5.38	15.38	8.23	7.16		34.97	115
Czech Republic	22.56	5.91	16.65	11.77	4.88		35.52	241.3
Austria	23.61	5.1	18.52	8	10.51		27.52	76.13
Denmark	25.19	5.35	19.84	9.62	10.22		26.97	94.09
Sweden	25.83	4.72	21.11	7.7	13.41		22.37	57.4
Spain	31.78	12.03	19.75	12.69	7.07		60.88	179.45
USA	33.25	5.13	28.13	19.78	8.35		18.23	236.84
Switzerland	33.76	8.82	24.94	12.43	12.51		35.35	99.35
Italy	35.54	9.15	26.4	18.08	8.32		34.64	217.35
UK	39.85	9.9	29.95	20.38	9.56		33.07	213.13
Germany	50.94	14.83	36.11	14.96	21.15		41.08	70.74
France	51.6	18.59	33.01	14.3	18.71		56.32	76.42
Netherlands	52.61	17.14	35.48	17.84	17.63		48.3	101.16
World	61.21	27.12	34.09	24.62	9.47		79.57	259.99

Figure 3: The Bilateral Belgian Trade Structure (Sector-weighted, Average 1993-2000); own computations based on OECD, International Trade Statistics

Total IIT														
OLS														
	coef.	**s.e.**	**t**			**coef.**	**s.e.**	**t**			**coef.**	**s.e.**	**t**	
Income Similarity	0.19	0.01	16.09	*		0.17	0.01	11.84	*		0.13	0.02	6.32	*
Distance	-8.19	0.23	-35.24	*		-8.16	0.23	-35.00	*		-9.80	0.28	-34.5	*
Scale - Employment (av.)	4.56	0.16	27.89	*		4.38	0.16	27.30	*		2.77	0.35	7.91	*
Relative Number of Patents	-0.44	0.25	-1.78	***										
Global Tech Spillovers	1.34	0.16	8.44	*		1.27	0.15	8.20	*		1.73	0.20	8.85	*
Relative VA/worker (av.)						0.03	0.45	0.07						
Relative R&D Expenditures (av.)											1.72	0.29	5.88	*
Constant	39.10	2.38	16.44	*		41.90	2.49	16.82	*		56.27	3.58	15.73	*
R^2 adj.	0.43					0.42					0.50			
F	475.29					474.03					414.63			
Panel Between-Effects														
Income Similarity	0.19	0.03	6.90	*		0.15	0.04	4.01	*		0.14	0.05	2.63	*
Distance	-8.18	0.56	-14.65	*		-8.21	0.56	-14.66	*		-9.75	0.70	-13.94	*
Scale - Employment (av.)	4.56	0.39	11.72	*		4.38	0.38	11.44	*		2.83	0.86	3.28	*
Relative Number of Patents	-0.87	0.76	-1.15											
Global Tech Spillovers	1.31	0.38	3.47	*		1.25	0.37	3.34	*		1.72	0.48	3.57	*
Relative VA/worker (av.)						0.83	1.29	0.64						
Relative R&D Expenditures (av.)											1.67	0.72	2.32	*
Constant	39.15	5.66	6.91	*		43.82	6.32	6.94	*		55.14	9.01	6.12	*
R^2 between	0.51					0.50					0.58			
F	85.08					83.18					69.56			

Figure 4: Regression Results for Total Intra-Industry Trade: *, ** and *** indicate that the estimated coefficient is significantly different from zero at respectively the 1 %, 5 % and 10 % level.

Horizontal IIT														
OLS														
	coef.	**s.e.**	**t**			**coef.**	**s.e.**	**t**			**coef.**	**s.e.**	**t**	
Income Similarity	0.05	0.01	6.28	*		0.04	0.01	4.21	*		0.03	0.01	2.53	**
Distance	-2.03	0.15	-13.70	*		-1.98	0.15	-13.31	*		-2.38	0.19	-12.25	*
Scale - Employment (av.)	0.62	0.10	5.99	*		0.57	0.10	5.55	*		0.14	0.24	0.58	
Relative Number of Patents	-0.06	0.16	-0.38											
Global Tech Spillovers	-0.14	0.10	-1.38			-0.11	0.10	-1.14			-0.23	0.13	-1.7	***
Relative VA/worker (av.)						0.20	0.28	0.72						
Relative R&D Expenditures (av.)											0.53	0.20	2.64	*
Constant	14.16	1.52	9.35	*		14.71	1.59	9.25	*		18.81	2.45	7.68	*
R^2 adj.	0.08					0.08					0.10			
F	59.57					56.24					47.12			
Panel Between-Effects														
Income Similarity	0.04	0.01	3.62	*		0.04	0.01	2.70	*		0.04	0.02	1.61	
Distance	-2.10	0.22	-9.63	*		-1.98	0.21	-9.22	*		-2.38	0.30	-8.02	*
Scale - Employment (av.)	0.62	0.15	4.07	*		0.57	0.15	3.88	*		0.14	0.37	0.39	
Relative Number of Patents	0.41	0.30	1.38											
Global Tech Spillovers	-0.16	0.15	-1.10			-0.10	0.14	-0.72			-0.24	0.20	-1.17	
Relative VA/worker (av.)						0.20	0.49	0.40						
Relative R&D Expenditures (av.)											0.53	0.30	1.73	***
Constant	15.55	2.21	7.04	*		14.52	2.42	6.01	*		18.82	3.82	4.92	*
R^2 between	0.26					0.25					0.29			
F	28.62					27.66					20.62			

Figure 5: Regression Results for Horizontal Intra-Industry Trade: *, ** and *** indicate that the estimated coefficient is significantly different from zero at respectively the 1 %, 5 % and 10 % level.

Low-Quality Vertical IIT														
OLS														
	coef.	s.e.	t			coef.	s.e.	t			coef.	s.e.	t	
Income Similarity	0.07	0.01	6.62	*		0.05	0.01	3.95	*		0.07	0.02	4.24	*
Distance	-2.33	0.21	-10.99	*		-2.40	0.21	-11.23	*		-2.29	0.24	-9.35	*
Scale - Employment (av.)	0.99	0.15	6.63	*		0.96	0.15	6.54	*		1.37	0.30	4.54	*
Relative Number of Patents	0.16	0.22	0.71											
Global Tech Spillovers	-0.24	0.14	-1.65	***		-0.20	0.14	-1.44			0.13	0.17	0.80	
Relative VA/worker (av.)						0.98	0.41	2.41	**					
Relative R&D Expenditures (av.)											-0.35	0.25	-1.38	
Constant	18.40	2.17	8.47	*		20.71	2.28	9.09	*		14.74	3.09	4.78	*
R^2 adj.	0.07					0.07					0.08			
F	47.21					50.48					36.73			
Panel Between-Effects														
Income Similarity	0.08	0.02	4.83	*		0.05	0.02	2.15	**		0.08	0.03	2.68	*
Distance	-2.25	0.36	-6.29	*		-2.38	0.36	-6.63	*		-2.23	0.42	-5.29	*
Scale - Employment (av.)	1.00	0.25	4.02	*		0.96	0.25	3.90	*		1.44	0.52	2.77	*
Relative Number of Patents	-0.24	0.49	-0.49											
Global Tech Spillovers	-0.12	0.24	-0.48			-0.17	0.24	-0.70			0.16	0.29	0.53	
Relative VA/worker (av.)						1.10	0.83	1.33						
Relative R&D Expenditures (av.)											-0.41	0.43	-0.95	
Constant	15.91	3.63	4.39	*		20.39	4.06	5.03	*		13.29	5.44	2.44	**
R^2 between	0.18					0.18					0.20			
F	18.32					18.31					12.78			

Figure 6: Regression Results for Low-Quality Vertical Intra-Industry Trade: *, ** and *** indicate that the estimated coefficient is significantly different from zero at respectively the 1 %, 5 % and 10 % level.

High-Quality Vertical IIT														
OLS														
	coef.	**s.e.**	**t**			**coef.**	**s.e.**	**t**			**coef.**	**s.e.**	**t**	
Income Similarity	0.01	0.01	0.87			-0.01	0.02	-0.75			-0.05	0.02	-2.15	**
Distance	-1.79	0.24	-7.40	*		-1.86	0.25	-7.48	*		-2.67	0.30	-8.89	*
Scale - Employment (av.)	1.92	0.17	11.32	*		1.83	0.17	10.72	*		0.48	0.37	1.29	
Relative Number of Patents	-0.56	0.26	-2.18	**										
Global Tech Spillovers	1.41	0.16	8.57	*		1.26	0.16	7.64	*		1.62	0.21	7.82	*
Relative VA/worker (av.)						0.05	0.47	0.11						
Relative R&D Expenditures (av.)											1.30	0.31	4.21	*
Constant	7.05	2.47	2.85	*		10.82	2.65	4.08	*		19.67	3.79	5.19	*
R^2 adj.	0.07					0.06					0.09			
F	48.09					42.06					43.21			
Panel Between-Effects														
Income Similarity	0.03	0.02	1.49			0.02	0.02	0.77			-0.04	0.03	-1.28	
Distance	-1.76	0.36	-4.91	*		-1.74	0.36	-4.84	*		-2.67	0.46	-5.80	*
Scale - Employment (av.)	1.94	0.25	7.76	*		1.83	0.24	7.46	*		0.51	0.57	0.90	
Relative Number of Patents	-0.93	0.49	-1.90	***										
Global Tech Spillovers	1.57	0.24	6.48	*		1.40	0.24	5.89	*		1.83	0.32	5.76	*
Relative VA/worker (av.)						-1.02	0.82	-1.24						
Relative R&D Expenditures (av.)											1.26	0.47	2.65	*
Constant	4.73	3.63	1.30			6.51	4.04	1.61			18.39	5.94	3.09	*
R^2 between	0.23					0.21					0.29			
F	24.61					22.18					20.01			

Figure 7: Regression Results for High-Quality Vertical Intra-Industry Trade: *, ** and *** indicate that the estimated coefficient is significantly different from zero at respectively the 1 %, 5 % and 10 % level.