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Horizontal versus Vertical R&D Spillovers and Trade Flows in Differentiated Products in the Case of Tunisia

Bel Hadj Tarek*

Faculty of Economics and Management of Sfax, University of Sfax, Tunisia

Abstract

This paper aims to analyze the impact of horizontal (intra-industry) and vertical (inter-industry) R&D spillovers on trade flows in differentiated products and hence, on the pattern of international trade. We consider that such approach presents a high added value both theoretically and empirically seen that the horizontal and vertical nature of R&D spillovers has not been studied enough in the literature on the one hand, and on the other hand, the integration of product differentiation into our analysis as a potential vector of competitive advantages and generator of a favorable competitive position.

Keywords: Horizontal spillovers; Vertical spillovers; Trade flows; Product differentiation; Tunisia

Introduction

In fact, several researches on economic growth have traditionally neglected the role of technology transfer as a potential source of economic growth as a result of non-localized nature of technology and inefficient mechanisms of appropriability [1]. Otherwise, when appropriability conditions are tougher and technological change is localized, the market of technological knowledge is internationally more limited.

Despite the importance of the results of the analysis of R&D spillovers effects on economic and technological performance, many theoretical and empirical developments have not been sufficiently analyzed. Indeed, the analysis of the role assigned to R&D should firstly consider the importance of one of its faces, namely its horizontal or vertical nature, and secondly, allowing a better assessment of R&D spillovers actually transmitted, used and exploited by firms, sectors and countries.

Moreover, despite the diversity of research interested in product differentiation, including those of [2-9] Dixit and Stiglitz, Eathier, Eaton and Kierzkowski, Feenstra, Feenstra and Markusen, Jones and Funke and Ruhwedel, few of them are devoted to the study of horizontal(intra-sectoral) and vertical (inter-sectoral) R&D spillovers and this, is characteristic of all scales of analysis whether at the level of firms, industries and even country.

The underlying generic problem in our research relates to the effects of horizontal and vertical nature of R & D spillovers on trade flows in vertically and horizontally differentiated products. To this end, and given the depletion of traditional sources of competitiveness based on price, we believe by following the approach of Porter [10] that the product differentiation is a major vector of a model of the structural competitiveness generator of competitive advantages and favorable competitive position in the foreign market.

In fact, based on the literature that was focused on strategic investments, the category of spillovers that have been most eagerly analyzed is that of horizontal type between competing firms [11]. In this respect, the horizontal spillovers are synonymous with intra-industry spillovers from firms belonging to the same sector, but vertical spillovers come from different sectors and thus, of inter-industry type in the form of links between sellers and buyers [12]. Although R & D spillovers are mostly horizontally transmitted through the different transmission channels, vertical technology transfer has been proven to be much more intense. Indeed, according to Javorcik [12], increased demand for intermediate goods allows economies of scale and favors a higher productivity for local suppliers. For their part, Blalock and Gertler show that it is also possible for foreign affiliates to deliberately transfer technology to local producers and assist them in meeting quality standard [13].

Also, Alfaro and Rodriguez-Clare [14] highlighted the role of multinationals in stimulating demand for local suppliers. In their model, the entry of multinationals in downstream sectors encourages input diversification, which may impact favorably on other firms belonging to other sectors as well. Later, Keller [15] sets up a complex mechanism by which technology transfer takes place both at the intra and inter-industry level. He also distinguishes between spillovers in pecuniary externalities and pure technological transfer.

The findings of these studies are very diverse: some find positive spillovers [16-18], others find negative spillovers [11,12] while a third category reveals no significant spillover effect [19,20]. Most empirical studies converge to two conclusions.

The first one is that vertical technology transfer is more intense than horizontal transfer, due to multinationals incentives to upgrade local suppliers [12]. The second idea emphasizes the role of the firm and industry characteristics in influencing technology absorption. It is widely believed that the extent to which local firms benefit from positive spillovers depends on their absorptive capacity. Among the factors found to influence the magnitude of spillovers, the literature identifies: human capital, innovation efforts, ownership structure, technological gap, firm size or export orientation [18].

Therefore, we will try first to understand the concept of product differentiation by distinguishing between two types of differentiation,

***Corresponding author:** Tarek BJ, Faculty of Economics and Management of Sfax, University of Sfax, Tunisia, Tel: +216 74 242 951; E-mail: Belhaj_tarek@hotmail.fr

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vertical and horizontal. Then, after describing our methodology and model to estimate, we will discussthe results of estimates.

Pattern of International Trade and Product Differentiation

In the early 80s, several models of intra-industry trade, based on a market structure characterized by monopolistic competition [2,21-23] gave a crucial role to the economies of scale for horizontal differentiation. While [2,21,22] consider the predominance of "love of variety" approach, Lancaster [23] followed by Helpman [24] emphasize alternately the importance of the "ideal Variety" approach. These studies have classified international trade in two main types, namely inter-industry and intra-industry trade.

Regarding the inter-industry trade, the Heckscher-Ohlin provides that countries, specialized in goods intensive by abundant factors. With the opening to trade, countries will export some goods, and will import others belonging to different sectors, depending on their comparative advantages. Intra-industry trade contradicts this approach. Several theories explain why international trade can generate sectoral flows of intra-sectoral type. An interesting part of these theories are based on product differentiation, economies of scale and imperfect competition [24,25]. Intra-industry flows create links between trading partners and competitors that specialize in the production and export of similar but differentiated goods [26,27]. For three decades, several models of international trade have been developed with reference to the basic concept of monopolistic competition.

Based on these ideas, inter-industry trade is largely explained by traditional theories of intra-industry trade (Ricardo and HOS) based on specialization, a cross between two different branches and perfect competition. In contrast, intra-industry trade is cross-exchange (between two countries), an equivalent amount of products belonging to the same branch (to the same sector of activity). Furthermore, the intra-industry part is explained by modern theories that use models of imperfect competition, where economies of scale are internal to the firm. In addition, when, at the aggregate level, countries express a taste for variety, this leads to intra-industry trade in similar goods if the goods are produced with increasing returns. Indeed, the monopolistic competition market structure ensures that each country produces different varieties. Once there is a demand of all available varieties of the countries, there is then a simple explanation for the existence of intra-industry trade.

The existence of external economies of scale can explain why an inter-industry trade is possible between two similar countries, while maintaining a framework of perfect competition. However, the use of models of imperfect competition, where economies of scale are internal to the firm, is necessary when one wishes to analyze intra-industry trade.

Besides that, the synthesis developed by Helpman and Krugman [28] has emerged as a new orthodoxy. This synthesis assumes that products that are horizontally differentiated are in principle available to consumers in the form of different varieties, and given that trade openness increases the size of the market, it will stimulate the development of new varieties of goods and facilitate the achievement of economies of scale. In contrast, the concept of comparative advantage remains valid for countries with a high level of factor endowments or technological know-how. However, products are not only horizontally differentiated but can also be qualitatively (vertically) differentiated [29].

The model developed by Falvey [29] and completed by Falvey and Kierzkowski [30] is mainly the baseline of vertical differentiation. Falvey [29] attaches the product quality to the intensity of capital in production, and this in the context of the Heckscher-Ohlin-Samuelson theory, with the liberty of movement of capital between firms within a given sector rather than between sectors. If the capital/labor ratio differs within the product groups, the capital abundant countries will produce and export capital-intensive products with a high quality, while labor abundant countries will export labor-intensive products with a low quality. In an attempt to refine this reasoning, Falvey and Kierzkowski [30] show that consumers with higher incomes receive higher quality varieties and the share of vertical intra-industry trade in bilateral trade is greater, if differences in capital/labor ratios, and subsequently in the per capita income of both countries are more important.

Vertical differentiation was previously incorporated into models of intra-industry trade by Shaked and Sutton [31], in a market structure of oligopoly. They assume that the quality of a product depends on R&D embedded in fixed costs, and therefore, it is often specific to high-tech sectors.

International trade in horizontally differentiated goods implies that countries offer different consumer goods according to their tastes and preferences. At this level, the market positioning is probably more sensitive to price competition insofar consumers can direct their preferences to different producers when the price or other characteristics vary [32]. By opposition, international trade in vertically differentiated goods implies that trading partners are able to choose different positions of their goods in the quality spectrum, and the offer to consumers is conditioned by the presence of different income and diverse preferences for quality.

The concept of horizontal differentiation was introduced in models of endogenous growth based on the principle of preference for variety. Such a representation is rooted in the research of Dixit and Stiglit [2]. According to Lancaster [33], the products with the same set of features, form a sector. If they have a different proportion of features, and none of them is extensively marked by a characteristic, they are horizontally differentiated or similar. The latter type (horizontally differentiated goods) reflects the existence of different varieties for a given level of quality and shows a preference for diversity.

For against, in the case where a product is largely characterized by certain features in comparison with the other products, it is of better quality compared to others and vice versa. This is the case of the vertical differentiation where goods present more differences in its prices compared to horizontally differentiated goods. In such a situation, this type of differentiation results from preference of individuals to improve the quality of goods in a given variety.

Thus, goods are vertically differentiated when consumers are unanimous in their rankings of those goods. This form of differentiation is due to differences in the quality of goods: with identical prices, all consumers prefer products with much higher quality than a good with inferior quality. Under these conditions, vertically differentiated vertically differentiated products coexist in a market, and it is necessary that products with lower quality are sold cheaper than products of better quality.

In the case of a horizontal differentiation, firms offer the same quality of products but with different characteristics.

Also, if the vertical differentiation is explained by differences in consumer income, horizontal differentiation is rather explained by differences in tastes.

In this paper, we measure the extent of product differentiation, whether horizontal or vertical based on the international trade indicators, particularly the degree of overlap between exports and imports. This approach can diagnose the extent of product differentiation for the foreign market, and it will be treated exhaustively in the following paragraph.

Research Methodology

An ascending number of empirical researches distribute flows of intra-industry trade to horizontal and vertical parts. Abd-El-Rahman [34] uses a technique that has since been very common, and attempts to separate the two parts of intra-industry trade based on the ratio of unit values of exports and imports /ton. If the ratio is outside a pre-specified row, the flow of trade is defined as of different qualities.

However, it is necessary to refer to a relatively low level of aggregation in order to separate the flow of trade explained by comparative advantages[1]. At a macro level, the empirical researches have used several indices to measure the differentiation ofinternational trade. A significant number of these studies have used the methodology developed by Abd-El-Rahman and Freudenberg and Muller [35,36]. This methodology is based on an "overlap index" which is formulated as follows:

$$\text{Overlap Index} = \frac{MIN\ (XN_{k,p,t}, MN_{k,p,t})}{MAX\ (XN_{k,p,t}, MN_{k,p,t})}$$

Where k is trade partner, p is a product, and t is the time. The overlap index is designed to reconcile between two incompatible paradigms for the two types of international trade based on imperfect competition on the one hand, and perfect competition on the other. This last indicator measures the extent of overlap between imports (MN) and exports (XN) of the two countries in their structures of international trade. If it is of high value, this is equivalent to a significant overlap. In the latter case, we consider that the overlap is a structural feature of international trade and the flow is considered as intra-industry trade. Otherwise, the overlap cannot be described as structural. This is the case of inter-industry trade. The existence of intra-industry flow is an indicator of product differentiation (horizontal and vertical).

Generally, if the overlap index exceeds a certain threshold arbitrarily set, the total trade in the product is treated as a flow of intra-industry. A change of this threshold implies a change in the extent of inter and intra-industry specialization. A lower threshold value reduces the importance of industrial specialization.

To do this, we refer to Freudenberg [27] to select a threshold of 10% in order to distinguish between intra-industry flow and inter-industry flow of international trade. The choice of this value is explained by the fact that the first commercial partners of Tunisia are part of the European Union, which was retained in the analysis of Freudenberg and [27] as the most important part of the sample. Furthermore, given the geographical proximity of Tunisia with respect to these countries (and the inclusion of transportation costs), we consider that this threshold seems adequate for the distinction between the two types of trade flows. In this way, if the overlap is more than 10%, it is a flow in differentiated products, otherwise, they are homogeneous. Regarding the types of differentiation, and reasoning at a sufficiently disaggregated sectoral level, qualitatively differentiated goods should reveal an increased difference in price, unlike other goods.

Compared to our level of disaggregation, the unit value indices represent reliable "proxies" of commodity prices, and hence we can use the quality index to measure quality differences between the imported goods and domestic goods. In other words, the distinction between the two types of differentiation, horizontal and vertical, refers to the criterion of similarity of products, based in turn, on the ratio of the unit value of exports (VU (XN)) and unit value of imports (VU (MN) This criterion can be expressed analytically as follows.:

$$\text{Quality Index} = \frac{VU(XN)}{VU(MN)}$$

If the quality index is very high or very low, the price differences indicate differences in quality between the imported goods and domestic goods. If it is close to unity, this is an indication of the qualitative similarity. To do this, we followed the literature [27] and we used a certain range determined exogenously, with values $[\frac{1}{1+\alpha}, 1+\alpha]$[2]. Thus, if the quality index is outside this range, the flow refers to goods qualitatively differentiated. Otherwise, the flow refers to horizontally differentiated goods.

Regarding vertical differentiation, there are two types of cases: It is considered superiorly vertical if the quality index is in the range of [1+α, +∞], and inferiorly vertical if this index belongs to the interval $[0, [\frac{1}{1+\alpha}]]$.

The parameter α is a factor of dispersion. In general, α is set at 0.15[3]. Given the geographical proximity between Tunisia and the majority of countries in our sample (see appendix), we will use the later value α in the analysis of product differentiation in the case of Tunisia. Following Abd-El-Rahman [34], Greenaway, Hine and Milner also used the 15% (as well as a 25%) threshold to distinguish between similar products and vertically differentiated products, despite a more limited degree of classification disaggregation. The latter authors apply a dispersion factor with an interval [1-α, 1+α].

To us the left side of this condition is incoherent with the right side, and this incoherence increases with the value of α. For example, the threshold of 25% means that export unit values can be 1.25 times higher than those for imports to fulfill the similarity condition. The lower limit in that case is 0.75: import unit values need to represent at least 75% of export unit values. But this last statement can be formulated in a different way: export unit values can be 1.33 (1/0.75) times higher than import unit values, a condition which is incompatible with the condition on the right.

If the quality index shows that the quality of exports is higher than that of imports, this reflects a better position in the global market relative to trading partners, and domestic industries are protected against the price competition. Otherwise, a qualitatively disadvantaged position implies that domestic exports may be adversely affected by competition with the emergence of producers adopting strategies of low price and low quality.

[1]In this case, as the level of aggregation is weakened, the variation in the content of factors decreases.

[2]This interval appears much more stringent than that traditionally used in the literature set at [1-α, 1+α].

[3]Fixing parameter α at this value, reflects that in the case of intra-industry trade, transport costs are implausibly incorporated into the prices of products, to measure the difference between the unit values of exports and imports with a variation limited to ± 15%.

The basic assumption of criterion mentioned above is that prices (unit values) are considered to be reliable indicators of quality of goods. This positive relationship between price and quality reflects that in the context of perfect information, a given product variety can be sold at a higher price if it has a superior quality.

In fact, the unit value indices are not price indices in the strict sense, but average value indices reflecting the evolution of the ratio value per quantity traded. This methodology, in calculating the price of traded goods has advantages and disadvantages. Indeed, one of the main advantages of using unit values for the calculation of international trade indices is that it does not require an additional collection of data from companies. Unit values are fully determined from customs declarations. In addition, the use of unit values allows a comprehensive picture of foreign trade. Indeed, unit values are calculated on all transactions that are part of foreign trade. However, these advantages sometimes thwarted by a set of drawbacks due to the volatility of unit values compared to actual prices. Another disadvantage of the use of unit values is explained by the fact that the change of the unit values may not reflect the actual change of the price. Indeed, it may reflect other factors, other than price, such as a change in the composition of a heterogeneous custom position; product miniaturization caused by technological change; packaging changes or the quality changes.

Despite criticism of proxies based on the unit value (in the short term, consumers can buy a more expensive product for reasons other than quality), this approach has been widely used by an attractive branch of research [27]. This branch of literature assumes that at least at a sufficiently disaggregated level, relative prices may reflect the relative qualities.

The application of the above two indices consisting of the overlap index and quality index, allows the classification of each trade flows, and subsequently, the degree and nature of product differentiation at a fairly high level of disaggregation to avoid aggregation bias whether geographical or industrial.

Furthermore, the procedure adopted by Tunisia for product classification is based on the harmonized system. To ensure consistency between the international standard classification of industry and the harmonized system we relied on the table of correspondence developed by the United Nations.

In addition, to better understand the structure of the sectoral share of product differentiation of Tunisia, we have focused our analysis on the following eight sectors: agriculture, hunting, forestry and fishing; Food, beverages and tobacco; mining, quarrying and oil; chemicals; wood, paper and printing; textiles, clothing, leather and footwear; basic metals and articles made of metals and electrical machinery and apparatus.

Model Specification

The originality of our econometric approach is the integration in our model an important aspect of the explanatory variables related to the pattern of international trade i.e. factors apprehended from the demand side and those apprehended from the supply side.

In terms of demand, the first causal relationship can spend from per capita income to product differentiation. Indeed, the reasoning oriented from the demand side suggests that in high-income economies, consumers demand not only more consumption, but also a wider range and more refined quality of goods.

An additional link on the side of demand between product differentiation and income per capita is based on the importance of the increase in exports, which can induce an increase in per capita income. This mechanism is mainly caused by the emergence along export, products that are both new and better. Indeed, the richest economies export more in nominal terms than poor countries and by exposing in the global market, larger quantities of each product and a much larger variety.

We will include in our model an additional variable apprehended from the demand side, that relating to the real effective exchange rate in so far as the variable of product differentiation is measured in our research by indicators of international trade. In addition, intra-industry in vertically differentiated products creates a specialization in the quality spectrum, as a result of expenditure on R&D and endowmentsof human capital. Therefore, the reasoning from the supply side requires integration in our model all forms of R&D (domestic or foreign) and, therefore, national technology innovation, domestic and foreign R&D spillovers.

In fact, we will focus in what follows on the effects of vertical and horizontal R&D spilloverson the pattern of international trade of Tunisia at eight sectors and during the period 1988-2012. Therefore, we will try to validate the following two central assumptions:

A.1:*Horizontal R&D spillovers condition significantly the pattern of international trade;*

A.2:*Vertical R&D spillovers significantly affect the pattern of international trade.*

In addition, a series of axial assumptions can be derived from our central assumptions and they are formulated as follows:

A.1.1:*Horizontal R&D spillovers significantly stimulate intra-industry trade in horizontally differentiated products;*

A.1.2: *Horizontal R&D spillovers significantly stimulate the intra-industry trade in vertically differentiated products;*

A.2.1: *The intra-industry trade in horizontally differentiated products is positively and significantly dependent on vertical R&D spillovers;*

A.2.2: *The intra-industry trade in vertically differentiated products is positively and significantly dependent on vertical R&D spillovers.*

The validation of these assumptions arises as a supporter to the hypothesis of endogenous growth, reflecting the importance attributed to R&D as a stimulus for product differentiation (specifically intermediate goods and capital goods).

$$TS_{it} = \alpha_0 + \alpha_1 INV_{it} + \alpha_2 DS_{it} + \alpha_3 FS_{it}{}^{H} + \alpha_4 FS_{it}{}^{V} + \alpha_5 TER_t + \alpha_6 OC_t + \alpha_7 GDP_t + \xi_{it} \quad (1)$$

With TS_{it} is a qualitative variable related to the pattern of international trade in sector i; It takes the value 0 if the international trade in this sector is of inter-industry type and 1 if it is of intra-industry type; INV_{it} is the national technological innovation in sector i; DS_{it} is the pool of domestic technological spillovers from the sector i; $FS_{it}{}^{H}$ is the pool of foreign horizontal R&D spillovers from the same sector i; $FS_{it}{}^{V}$ is the pool of foreign vertical R&D spillovers from sectors other than the sector i; TER_t is the real effective exchange rate; OCt is per capita income of trade partner, GDP is gross domestic product, which is integrated as a control variable; ξ is the error term, and t is time.

Furthermore, we chose to approximate the R&D spillovers by

	Value of Chi² (p-value)	Value of F (p-value)
Test of Fisher		F(7, 193) =85.44 p-value=0.000
Test of Hausman	Chi² (7)=0.74 (p-value=0.981)	
Test of Breush- Pagan	Chi² (1)=674.49 (p-value=0.000)	
Number of observations	200	

Table 1: Specification tests of the individual effects, Number of sectors: 8, Period: 1988-2012.

interacting internal expenses of R&D of firms (DIRDE) with the flow of imports. So, variables related to horizontal and vertical R&D spillovers are respectively formulated and approximated as follows:

$$FS_{it}^{H} = m_{it} DIRDE_{it} \qquad i \neq j$$

$$FS_{it}^{V} = m_{jt} DIRDE_{jt}$$

mit is the share of imports in total imports of sector i; i and j are sector indices with i ≠ j and t is the time index.

Regarding domestic technological innovation (INV) and the domestic R&D spillovers (DS), given the unavailability of sectoral data on R&D expenditures, we had to use the sectoral distribution of patents as an output indicator of R&D instead of using inputs.

Moreover, in order to assess the effects of the list of explanatory variables in the model (I), especially those relating to R&D spillovers whether national or foreign, horizontal or vertical we opted for the model (II) which the dependent variable, denoted TSD is intra-industry trade in differentiated products.

$$TSD_{it} = \alpha_0 + \alpha_1 TSD_{it-1} + \alpha_2 INV_{it} + \alpha_3 DS_{it} + \alpha_4 FS_{it}{}^{H} + \alpha_5 FS_{it}{}^{V} + \alpha_6 TER_t + \alpha_7 OC_t + \ + \alpha_7 GDP_t + \xi_i t \qquad (2)$$

With TSD_{it-1} is the initial level of intra-industry trade in horizontally and vertically differentiated products.

Estimation Results and Discussion

Our first step is to verify the presence of individual effects in our data. In this regard, the test of the existence of the individual specificities based on Fisher statistic indicates the existence of homogeneous coefficients of the model (I). The use of panel techniques can be justified. The Fisher's test also showed the presence of significant individual effects.

In order to determine the nature of the individual effects, we used the Hausman test that tests whether the coefficients of the two estimates (fixed and random) are statistically different. Our results presented in Table 1 show that the probability of the Chi2 test is greater than 10% (p-value=0.981), which shows that we cannot reject the null assumption of no correlation between individual effects and the explanatory variables. In other words, the model (I) can be specified with random individual effects.

In the model (I) the dependent variable takes the value 0 and 1 respectively in the case of inter-industry trade and intra-industry trade and therefore, the linear estimation is not quite appropriate because the predicted values may be below 0, above 1 or between the two. In this regard, the variable related to the pattern of international trade takes the value 1 if the overlap index is greater than 10%, and 0 otherwise. The results of the estimate by the Probit method are summarized in Table 2.

Our estimation results show significant positive effects of domestic technological innovation and domestic R&D spillovers on the pattern of international trade, and therefore these variables positively affect the intra-industry trade in differentiated products. In addition, the same positive effects are exerted by the vertical R&D spillovers although they are hampered by significant negative effects of horizontal R&D spillovers. These results reflect that the international competitiveness of Tunisia based on product differentiation is strongly and positively influenced by the national innovation and foreign R&D from other sectors. In contrast, foreign R&D realized in the same sector pushes Tunisia to remain captive in its traditional specialization and thus, strengthening inter-industry trade at the expense of intra-industry trade. These results confirm our central assumptions A.1 and A.2 under which R&D spillovers they are horizontal or vertical condition significantly the pattern of international trade.

Regarding the factors apprehended from the demand side, our results show significant positive effects of variables related to per capita income of trade partner and gross domestic product on the pattern of international trade unlike significantly negative effects exerted by the real effective exchange rate.

Furthermore, the model (II) described above takes the form of a dynamic panel model in which a delay of the variable related to international trade in differentiated products is an explanatory variable. At this level, the standard econometric techniques do not lead to unbiased results. Therefore, we used the generalized method of moments (GMM) which controls the individual and time specific effects and mitigate the endogeneity of variables.

Two tests are associated with the GMM estimator in dynamic panel: The over-identification test of Sargan/Hansen for testing the validity of lagged variables as instruments and Arellano and Bond autocorrelation test where the null assumption is the absence of second order autocorrelation of the errors of the equation in differences.

In addition, we relied on the system GMM estimator of Blundel and Bond, which combines between the equation in first differences and the level equation of the model (II) in which the variables are instrumented by its first differences.

In this respect, the system GMM estimator overcomes the limitations which characterize the differences estimator including: The lagged values of the explanatory variables are weak instruments for the equation in first differences. The differentiation of the level equation eliminates inter-individual variability and takes into account intra-

	Coefficient
INV	0.105***
DS	0.352**
FS^H	-4.621**
FS^V	6.325***
TER	-0.087*
OC	10.924***
GDP	8.423*
constant	0.825**
Wald chi2(7) Prob > chi2	8.87 0.0514
(***) Significant at 1%; Significant at 5%; (*) Significant at 10%.	

Table 2: Results of the estimates by the Probit method, Dependent variable: Structure of international trade, Number of observations: 200, Number of sectors: 8.

individual variations. Therefore, the equation in first differences is estimated simultaneously in level by the GMM.

In the level equation, the variables are instrumented by its first differences. To do this, we used one-year lagged values of the variables related to horizontal R&D spillovers (FS^H) and vertical R&D spillovers (FS^V) as instruments. In addition, we will try through this model to assess the effects of the series of explanatory variables previously selected on two types of intra-industry trade: Intra-industry trade in vertically differentiated products and intra-industry trade in horizontally differentiated products (Table 3).

Our empirical results show that the Hansen test (p-value=1.00) and the Sargan test (p-value=0.481 and p-value=0.574) did not reject the assumption of validity of the lagged variables in level and differences as instruments. In addition, the second order autocorrelation test of Arellano and Bond (p-value=0.516 and p-value=0.509) shows the absence of second order autocorrelation.

As shown in Table 3, our estimation reveals the positive impact of national innovation efforts undertaken in the same sector on intra-industry trade in both vertically and horizontally differentiated products. For this purpose, an increase of national technological innovation by10% leads to 4.23 and 3.94 percentage points of the vertical and horizontal differentiation respectively. These results reinforce our estimation results of Probit model previously found. Domestic technological spillovers have positive and significant effects on intra-industry trade in horizontally differentiated products.

	Intra-industry trade in vertically differentiated products	intra-industry trade in horizontally differentiated products
	Coefficient (t-Student)	Coefficient (t-Student)
TSD_{t-1}	-0.488** (-0.877)	-0.511* (-0.844)
INV	0.423** (0.277)	0.394*** (0.158)
DS	0.113 (0.71)	0.299** (2.94)
FS^H	-0.039*** (-1.01)	0.111 (0.87)
FS^V	8.519** (1.28)	4.957*** (2.86)
TER	-4.333** (-1.228)	-5.23** (-3.08)
OC	0.003** (0.124)	0.109** (0.87)
GDP	9.125 (2.87)	6.357* (2.57)
Constant	-19.663** (-2.48)	-48.258*** (-5.17)
Hansen test of validity of instruments	$chi^2(198)$=0.00 p-value=1.000	$chi^2(198)$=0.00 p-value=1.000
Sargan test of validity of instruments	$chi^2(198)$ =144.96 p-value= 0.481	$chi^2(198)$=151.22 p-value=0.574
Arellano-Bond test for AR (1) in first differences	z=-2.12 p-value=0.035	z= -2.65 p-value= 0.041
Arellano-Bond test for AR (2) in first differences	z=0.67 p-value= 0.516	z=0.71 p-value=0.509

Table 3: Estimation results by the system GMM method, Dependent variable: Intra-industry trade in differentiated products, Number of observations: 200, Number of sectors: 8

	Intra-industry trade in vertically and inferiorly differentiated products	Intra-industry trade in vertically and superiorly differentiated products
	Coefficient (t-Student)	Coefficient (t-Student)
TSD_{t-1}	0.190* (0.148)	-0.588* (-0.395)
INV	0.257* (0.132)	0.287** (0.111)
DS	0.233 (1.157)	0.291*** (2.011)
FS^H	0.627*** (1.08)	-0.387*** (-0.471)
FS^V	-7.925* (1.22)	6.087*** (2.45)
TER	-4.057** (-4.389)	-9.11** (-4.101)
OC	0.046 (0.149)	0.369** (0.804)
GDP	8.548 (2.33)	5.111 (2.32)
Constant	-14.254** (-2.87)	-34.81*** (-3.74)
Hansen test of validity of instruments	$chi^2(198)$ = 0.00 p-value= 1.000	$chi^2(198)$ = 0.00 p-value= 1.000
Sargan test of validity of instruments	$chi^2(198)$ =152.35 p-value= 0.447	$chi^2(198)$ =155.11 p-value= 0.391
Arellano-Bond test for AR (1) in first differences	z= -2.75 p-value= 0.039	z= -2.87 p-value= 0.049
Arellano-Bond test for AR (2) in first differences	z= 0.64 p-value= 0.417	z= 0.61 p-value= 0.401
(***) Significant at 1%; (**) Significant at 5%; (*) Significant at 10%.		

Table 4: Estimation results by the system GMM method, Dependent variable: Intra-industry trade in vertically differentiated products, Number of observations: 200, Number of sectors: 8.

Moreover, horizontal R&D spillovers exert no significant effect on intra-industry trade in horizontally differentiated products and negatively affect intra-industry trade in vertically differentiated products based on the quality spectrum. This result, rejects our assumptions A.1.1 and A.1.2 and reflects the inability of Tunisia to fight against the fierce competition launched with the entry of better products with lower prices.

That is why Tunisia is seeking to locate in new markets by producing new varieties of products and, benefiting from vertical R&D spillovers which, as shown by our result of estimates, significantly condition the extent of horizontal differentiation of products. In addition, the same type of R&D spillovers positively affects the competitive position of Tunisia based on vertical differentiation thereby mitigate negative effects of horizontal R&D spillovers on intra-industry trade in differentiated products.

Based on these results, it appears that product differentiation as a key contributor to the international competitiveness is positively reinforced by foreign R&D spillovers from other sectors, which validates our assumptions A.2.2 and A.2.1.

To better assess the effects of R&D spillovers on the competitive position of Tunisia based on product quality, we used two forms of vertical differentiation included in the intra-industry trade which are inferiorly and superiorly vertical differentiation.

To this end, our estimation results presented in Table 4 show that horizontal R&D spillovers exert significant and positive effects on intra-industry trade in vertically and inferiorly differentiated products and significant and negative effects on intra-industry trade in vertically and superiorly differentiated products.

These results reflect that the goal pulled from horizontal R&D spillovers is the import of quality. By opposition, these effects are reversed when it concerns vertical R&D spillovers on the intra-industry trade in vertically differentiated products as a dependent variable. Therefore, Tunisia is better protected against competition thanks to foreign vertical R&D spillovers.

Concluding Remarks

It is clear from our empirical analysis that vertical R&D spillovers are expected to have a positive impact on the pattern of international trade in horizontally differentiated products and on vertically and superiorly differentiated products. By opposition, the international competitiveness of Tunisia based on vertically differentiated products is adversely affected by horizontal spillovers from the same sector. In other words, the competitive position of Tunisia based on product differentiation is enhanced by international cross-sectoral spillovers. It is through its positive effects that Tunisian products are more protected against foreign competition and from which Tunisia could export quality of products and have a greater ability to escape against competitive pressures by producing new varieties of products. The originality of our approach lies, first, in the choice of the non-price competitiveness based on product differentiation, vertical or horizontal, as a potential vehicle for international competitiveness. Then, we rely on a rather low level of aggregation in the choice of the variables related to the pattern of international trade and the various forms of R&D spillovers. However, the contributions of our research do not prevent the presence of some gaps, especially in the construction of the variables of our model. At this level, the approximation of the domestic technological innovation by the number of patents, poses problems concerning its reliability and relevance. In this case, the use of inputs approach based on sectoral data of internal R&D seems more rational than the adoption of the approach based on outputs.

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