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Innovativeness of Exporting firms in a Developing Country: The Case of Tunisia

Mohieddine Rahmouni
GREThA (UMR CNRS 5113) Université Montesquieu-Bordeaux IV, 33608 Pessac cedex, France,

Abstract

The relationship between exports and the propensity to innovate is an important issue for a developing economy. This article is dedicated to this question through the analysis of the first innovation survey of Tunisian firms. In particular, it distinguishes the propensity to innovate among three categories of firms: pure exporters, that only address the foreign demand, pure domestic firms, and partial exporters. We explore this relationship as it can be qualified using econometric estimation (mainly Probit models) and non-parametrical regression trees on the results of the first community innovation survey in Tunisia. We find that the innovation behavior of the three categories of firms is strongly contrasted. Our results show firms that address both the domestic and foreign demands (partial-exporters) have the highest propensity to innovate. They better benefit from external sources of knowledge, as well as a diversified demand. We find that external knowledge sources, internal R&D efforts and some types of cooperative agreements are complementary for product innovation; but the first play an essential role, in the sense that firms must benefit from, at least, one external knowledge source to reach a significant innovation propensity.

Corresponding author: Rahmouni Mohieddine, École Supérieure de Sciences Économiques et Commerciales de Tunis (ESSECT), 4 Rue Abou Zakaria El Hafsy 1089 Montfeury, Tunisia, and GREThA (UMR CNRS 5113), Université Montesquieu-Bordeaux IV, Avenue Léon Duguit, 33608 Pessac cedex, France. E-mail address: mohieddine.rahmouni@gmail.com
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Contact: Mohieddine Rahmouni - mohieddine.rahmouni@gmail.com.
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1 Introduction

This article analyses the link between exports and the propensity to innovate of firms in Tunisia. Cooper (1994) clearly explains why the shift from import-substituting industrialization to more open-economy models for development, has given a central role to the innovative activities of firms in developing countries and why innovation studies can guide the industrialization policies in developing countries. Indeed, international competition forces the domestic firms of these countries to pay a special attention to their innovative and absorptive capacities.

> "As far as import-substituting economies were concerned, the shift towards open- economy industrialization and export orientation radically changed the terms of reference for technology policies, and added new relevance to the findings of innovation studies in the industrial economies. [...] As far as industries in developing countries are concerned, the need to confront innovative competition and the capabilities required to sustain it has become more pressing because of [...] a shift away from import-substituting and other closed-economy approaches [...] towards industrialization with a more open-economy emphasis, including export promotion". p. 25, 31 in (Cooper 1994)

Moreover, these firms count on low labor costs and imitation of foreign technology to sustain their competitiveness in a strong international price competition, despite their technological disadvantage (Porter & Stern 2003). Given that developing countries try to export using relatively older products and processes, they need to seek other types of advantages in order to maintain their position in international markets. Strategies based on cost reduction and niche-market exploitation are not sufficient for maintaining their competitiveness since many countries are competing now in these niches, where the residual demand for rather old products is already weak. The access to foreign markets indeed constitutes an important demand source for firms, especially in developing countries where the domestic purchasing power and demand can be considerably weak and fragile in comparison with the markets for exports (notably the demand from the consumers of industrialized countries). Yet, another ability, which is the capacity to serve a heterogeneous demand, can also constitute an important impulse to innovate: in process for coping with the lower domestic purchasing power and higher quality standards of foreign markets; in products for adapting to the specific needs of the domestic market, and demands of foreign markets. Consequently, firms serving both foreign and domestic markets can have motivation different than the ones of the firms exclusively dedicated to exports. The analysis of this potential heterogeneity in behavior will be a central issue in this article.

We must also take into account, in our approach, that analyzing the relationship between innovation and exports can be quite complex, since the results can suffer from a self-selection bias due to the fact that innovating firms can more easily face international competition[1]. More specifically, for the case of Tunisia, the issue of innovation and exports is particularly important. The Tunisian public policies in the recent period have been quite remarkable in their ambition to increase the innovative capacity and the competitiveness of domestic firms, while they opened the domestic market to foreign firms, mainly through the accession to the GATT, and the establishment of the free trade union with European Union (1995). Another important dimension of these policies is the international subcontracting activities that constitute a central component of the export-oriented development strategy adopted in Tunisia. The expansion of subcontracting in Tunisia is mainly characterized by the creation of plants with low-technical progress, and the exploitation of advantages related to low labor costs. These strategies do not seem very favorable to the technical independence of domestic firms[2]. Consequently, the final effect on the innovativeness

[1] Any result on this connection must be taken with some caution, especially because of the simultaneity of the answers in the surveys on these points (Mohnen et al. 2006).

[2] The indicator of technological development defined according to the classification of the United Nations

of the exporting firms deserves a careful statistical and econometric analysis that we propose to carry out in this article.

The paper is structured as follows. Section 2 discusses the main results obtained in the recent literature on the links between exports and innovativeness. This literature seems to indicate a rather robust positive link between these activities. Section 3 presents the data set used in this work, and our research methodology. Section 4 studies the relationship between exports and innovativeness of firms. First, we distinguish innovative behavior of three sets of firms: firms that export the totality of their production; firms that serve only the domestic market; firms that serve both foreign and domestic markets. We also distinguish product and process innovation behaviors. Our results show that the firms serving both markets have the highest propensity to innovate. We analyze the determinants of this result that is rather paradoxical in comparison with the conclusions of the literature discussed in the second section. The last section concludes the paper.

2 Discussion of the literature

The relationship between exports and innovation activities has been widely studied by the endogenous growth and the new trade theories which distinguish between the role of knowledge spillovers generated either by the interactions with foreign agents (Grossman & Helpman 1991, Rivera-Batiz & Romer 1991*a,b*), or by the use of the intermediate goods (Rivera-Batiz & Romer 1991*a,b*, Coe & Helpman 1995). Another channel analyzed in the literature concerns the role of the international trade on incentives to invest in R&D and innovation activities (Aghion & Howitt 1998). The theory of internalization asserts that firms may acquire technologies and increase their innovative capacities through their access to foreign markets. Exports are indeed considered as the most prevalent form of international expansion. However, the analyses are carried out mainly at the macroeconomic level, and they do not help to explain heterogeneity in firms behavior. The relationship between exports and innovation may also be affected by the degree of market competition that the firms face. Aghion et al. (2005) show an inverted-U shaped link between competition and innovation. Two tendencies interact to form the shape of this link. On one hand, product differentiation and innovation increase with competition (Shaked & Sutton 1987). On the other hand, innovation may decline with competition, because the later reduces monopoly rents that motivate the innovation (Aghion & Howitt 1992). As a consequence, the role of foreign competition is not clear-cut (see also Piva & Vivarelli (2007)).

Previous empirical studies have tested the demand-pull hypothesis and found that innovation may indeed be driven by output (Piva & Vivarelli 2007) and by changes in market conditions (Nemet 2009). They have also established that geographic differences in the acceptance of products, and in the composition of demand (Griliches 1957, 1960), shifts in relative factor prices (Hicks 1932), and, finally, potential new markets (Vernon 1966) may largely influence the innovative behavior of firms. The openness consequently reinforces the need for process innovation, and for a better adaptation of products to foreign and domestic demands (Piva & Vivarelli 2007).

Theoretical literature seems to point to a positive link between exports and innovativeness of firms. We can confront these results to the existing empirical literature. Although several empirical micro-level studies emphasized the selection effects of more productive firms into export markets, recent studies assert that access to foreign markets is positively related with innovativeness (Harris (1991), Alvarez & Lopez (2005), Costantini & Melitz (2008)). They also recognize that firms jointly make innovation and export market participation decisions (Aw et al.

Development Program (UNDP 2001) shows that Tunisian exports are characterized by low- technology contents (52% of exports of goods). But, the technology achievement index (TAI) shows that Tunisia is among dynamic adopters of new technologies (World report (UNDP 2001)).

2007, Bustos 2010, 2007, Verhoogen 2008).

Another channel considered by several studies is the ability of the exporters to tap foreign knowledge bases. Exporting may hence induce a flow of information and knowledge through interactions with foreign parties such as buyers, suppliers, intermediaries and competitors (Bratti & Felice 2009). This acquired knowledge may then spill back on the local firms (Learning by exporting, Salomon & Shaver (2005)). Salomon (2006) concludes that exports provide Spanish firms with exposure to diversified knowledge inputs located in foreign markets, with an emphasis on developed countries. Firms can also acquire new knowledge through export intermediaries, joint-venture partners and trade associations (Kogut & Chang (1991)), or directly from customers who suggest specific improvements that stimulate innovation (von Hippel (1988)). Indeed, customers from different nations do not share identical tastes. The products desired by foreign customers may thus differ from those offered in domestic market, leading firms in developing countries to upgrade their technologies.

Only a small subset of studies that use micro level data explore the relationship between openness and technological innovation in developing countries (see, for example, Alvarez & Robertson (2004)). For Alvarez (2001), Alvarez & Robertson (2004), Alvarez & Lopez (2005), exports are the most significant external source that significantly increases technological innovation. For Brazilian firms, Braga & Larry (1991) find that the effect of the exports are highly significant and quite large, indicating that the competitive pressure of producing for foreign markets demands greater access to imported technology, encourages technological effort. Almeida & Fernandes (2008) find, for 43 developing countries, a strong positive correlation between trade and technological innovation. The exposure to foreign markets promotes technology adoption, and exporters have a higher likelihood of adopting new technologies than firms oriented exclusively to the domestic market. Trade liberalization also seems to increase exporting revenues, inducing more firms to enter the export markets and to adopt skill-biased new technologies (Bustos 2010, 2007). It may positively affect firm efficiency by stimulating process innovation which make a case in favor of the learning by exporting hypothesis (Damijan et al. 2010).

3 Dataset, model and methodology

We first present the dataset we use in this article. The discussion of the methodology we have adopted is presented in a second paragraph.

3.1 Overview of the dataset

The analysis is based on micro data from the Innovation Survey provided by MSRTCD5[3] which surveyed firms about various aspects of their innovation activity from 2002 to 2004. Following the Oslo Manual, a harmonized questionnaire inspired from the Community Innovation Survey (CIS) was used to collect the data.

This survey has many shortcomings. It shares the common deficiencies of the CIS inspired surveys (many qualitative variables, subjective questions difficult to interpret, etc. *see* Mohnen & Mairesse (2010)). But, it also has some specific shortcomings: it does not constitutes a dynamic dimension that would allow panel data analysis; some questions propose items difficult to interpret by the respondents or items that do not belong to the same level of causality (like mixing mid-term strategic dimensions with immediate consequences of decisions). Nevertheless, this survey is precious since it allows an outlook to the innovation process of Tunisian firms. Tables 1 and 2 respectively give the description of the variables used in this article and their descriptive statistics (the mean and the standard deviation). We also indicate the type of each

[3] MSRTCD: Ministry of Scientific Research, Technology and Competency Development in 2005.

variable: binary or continuous.

Table 1: Description of the variables used in the analysis

Dependent Variables:	
Innovprod	Dummy for product innovation (product is new to the market)
Innovproc	Dummy for process innovation
Independent Variables:	
collInternatOrg	Dummy for collaboration with international organizations
collLabUnit	Dummy for collaboration with laboratories and research units
collNaOrg	Dummy for collaboration with other national organizations
collOtherFirms	Dummy for collaboration with others firms
collRecCent	Dummy for collaboration with research centers
collUniv	Dummy for collaboration with universities
ConsultTechn	Dummy for access to external technical assistance
depRD	Dummy for internal R&D department
partState	Share of State in the capital of the firm (in percentage)
Sales	Sales in million dinars

3.2 Methods of analysis

We use different statistical methods to analyze the main determinants of innovative activity in Tunisia: Probit models, decomposition analysis (Fairlie 1999, 2005, Fairlie & Robb 2007) and regression trees (Venables & Ripley (1999), chap10). We use non-parametric regression trees to partition our observation space in order to analyze the interaction between variables and the possible complementary or substitutable relationships between them. The gap in the innovativeness between different groups of firms[4] are analyzed in more details using non-linear decomposition analysis for Probit regressions[5].

Even if the selection problems are quite common in CIS surveys in developing countries, we need to check the robustness of the results in respect with these. We use Monte Carlo Markov Chain simulations to check the potential general sampling bias, and Survey-Weighted Probit estimations to confirm the robustness in respect with the ill-representation of sectors in the sample. The results show that the effect of this problem on our estimates is not significant (for more details *see* the online Supplemental material)[6].

4 Results

We first compare the propensity to innovate of the three sets of firms: NE, PE and EE firms. This comparison (see Table 2, last column) clearly shows that the PE have the highest propensity to innovate, both for product and process innovation. We therefore analyze, in a second paragraph, the conditions under which NE and EE firms have the lowest innovativeness, and lag behind PE. The last paragraph analyzes the characteristics of the firms, in each subset, with the highest propensities to innovate in order to complete our analysis.

4.1 Exports and propensity to innovate

The predicted probabilities (Table 2) show that the NE and EE firms are poor innovators. The WMW-test used to compare predicted probabilities also show that PE firms are likely to

[4] Classification of firm groups following their export ratios: NE (Export = 0%); PE (0% < Export < 100%); EE (Export = 100%).

[5] We complete the estimation process by using some descriptive statistical tools such as *z-test* to compare proportion differences between groups for binary variables and *t−test* mean-comparison for continuous ones. We use also the two-sample Wilcoxon and Mann-Whitney rank-sum (WMW) test to compare the propensity to innovate between the three groups of firms.

[6] Detailed statistical methods and results can be consulted from the online appendix and supplemental material.

be more innovative (in product and process innovation) than EE and NE ones. Table 3 gives the results of the probit estimations for the determinants of the product and process innovation success for each group of firms. The coefficients that are significant for $\alpha \leq 5\%$, are given in bold characters. The results reveal a number of specific differences between these three subgroups regarding the statistical significance of the relationship between the explanatory variables and the propensity to innovate[7]. The observations can be summarized in the following result:

Table 2: Summary of dataset variables

	All firms		NE		PE		EE		z-test
Variable	**Mean**	**Sd**	**Mean**	**sd**	**mean**	**sd**	**Mean**	**sd**	**Comparison**
Innovproc	0.49	0.50	0.42	0.50	0.60	0.49	0.43	0.50	P E > N E = EE
Innovprod	0.41	0.49	0.37	0.48	0.56	0.50	0.29	0.46	P E > N E = EE
collInternatOrg	0.13	0.33	0.15	0.35	0.15	0.36	0.10	0.29	P E > N E = EE
collLabUnit	0.08	0.27	0.08	0.28	0.13	0.34	0.02	0.15	P E = N E > EE
collNatOrg	0.15	0.36	0.15	0.35	0.17	0.38	0.14	0.34	P E = N E = EE
collOtherFirms	0.12	0.32	0.12	0.33	0.12	0.33	0.11	0.31	P E = N E = EE
collRecCent	0.07	0.26	0.10	0.30	0.08	0.27	0.05	0.21	P E = N E > EE
collUniv	0.11	0.31	0.17	0.38	0.14	0.35	0.03	0.18	P E = N E > EE
ConsultTechn	0.41	0.49	0.41	0.49	0.56	0.50	0.27	0.45	P E > N E > EE
depRD	0.54	0.50	0.51	0.50	0.68	0.47	0.43	0.50	P E > N E = EE
lnSales (*)	15.29	1.76	15.35	2.11	15.92	1.55	14.61	1.47	P E > N E > EE
partState (*)	7.17	25.09	19.95	38.76	4.17	19.41	0.90	9.49	N E > P E > EE
Observations	**586**		**157**		**208**		**221**		

The table gives the mean and the standard deviation of each variable. All variables are binary except when signaled by (*) for continuous variables. **NE:** no export, **PE:** partial exporter, **EE:** exclusively exporter. *z- test* of proportion differences between groups for binary variables and mean-comparison *t-test* for continuous ones (WMW-test comparison of the medians gives the same results for continuous variables *lnSales* and *partState*).

Result 1 *The most innovative firms (for both types of innovation) are not the ones totally dedicated to exports but the ones that serve both the foreign and domestic markets. Partial-exporters have indeed the highest propensity to innovate.*

The factors related to **product innovation** at a global level are (see column 1 of Table 3): internal R&D, firm size, State participation in the firm (with negative sign), and the collaboration with universities, international organizations (for all types of firms), and recourse to technical consulting organizations. However, the determinants are quite contrasted between the subgroups of firms: the internal R&D plays a role only for the innovation of the EE firms; the firm size and the collaboration with universities and research laboratories only have dominant effects for NE firms ; the access to help from technical consulting organizations only plays a role for PE ones. Firms addressing a diversified market take advantage from both the possibility of risk-sharing over different markets and from the internalization of possible inter-product positive innovation spillovers (Piva & Vivarelli 2007). Moreover, the participation of State in the capital of the firm plays a negative role only for PE or NE firms: being completely dedicated to foreign markets seems to protect firms from this negative influence. Technical information received from international organizations and help from technical consulting organizations plays also a role for PE and EE firms. Large NE firms are less financially constrained regarding their possibility to share costs and risks over a large amount of output (Cohen & Klepper 1996). The generally limited size of domestic market limits the possibility to take advantage of benefits of economies of scale and competition-driven productivity gains

[7] We have also controlled for foreign ownership of the firms and it does not modify our results (this factor is not ignificant, except for EE with a negative sign).

The factors related to **process innovation** at a global level are (see column 5 of Table 3): firm size, State participation in the firm, collaboration with national organizations, access to external technical assistance and technical information received from international organizations. External knowledge sources play a less contrasted role in this case: while collaboration with universities and international organizations are necessary for PE, and collaboration with national organizations are only beneficial for EE firms, all types of firms benefit from technical consulting agencies (see below a more detailed discussion of the respective roles of these sources). We observe that higher sales are positively correlated with process innovation for EE and NE firms. The State participation plays a negative role only for the PE (but this effect is enough robust to be globally significant). The main observations established above are summarized in the following results.

Table 3: Results of the probit estimations for different groups of firms

	Prod. Innov.				**Proc. Innov.**			
	All (1)	**NE (2)**	**PE (3)**	**EE (4)**	**All (5)**	**NE (6)**	**PE (7)**	**EE (8)**
R&D dept.	**0.52** (4.04)	0.49 (1.60)	0.14 (0.63)	**0.72** (3.49)	0.24 (1.92)	0.05 (0.17)	0.23 (1.12)	0.28 (1.40)
log(Sales)	**0.10** (2.73)	**0.19** (2.50)	0.06 (0.85)	−0.01 (−0.08)	**0.13** (3.64)	0.21 (3.03)	0.06 (0.87)	**0.15** (2.06)
PartState	**−0.01** (−4.10)	**−0.01** (−2.45)	**−0.02** (−3.11)	−0.0 (−0.01)	**−0.01** (−2.79)	−0.01 (−1.41)	**−0.01** (−2.10)	−0.01 (−0.62)
CollUniv	**0.57** (2.62)	**0.84** (2.18)	0.35 (1.12)	0.98 (0.15)	0.24 (1.14)	−0.30 (−0.78)	**0.73** (2.16)	0.55 (0.80)
CollRecCent	−0.28 (−1.03)	−0.05 (−0.10)	−0.54 (−1.28)	−0.10 (−0.16)	−0.12 (−0.46)	0.43 (0.85)	−0.58 (−1.48)	−0.34 (−0.63)
CollLabUnit	−0.20 (−0.84)	**−1.57** (−2.37)	0.24 (0.73)	−0.15 (−0.20)	−0.35 (−1.54)	−0.18 (−0.33)	−0.42 (−1.40)	−0.70 (−0.90)
CollNatOrg	0.25 (1.49)	0.30 (0.72)	0.22 (0.78)	0.34 (1.21)	**0.51** (2.97)	0.11 (0.29)	0.21 (0.74)	**0.87** (3.01)
collInternatOrg	**0.86** (4.29)	0.26 (0.66)	**1.37** (3.42)	1.01 (2.78)	**0.57** (2.85)	0.11 (0.26)	**1.12** (3.08)	0.35 (0.94)
collOtherFirms	0.28 (1.47)	0.12 (0.26)	0.40 (1.26)	0.19 (0.59)	0.30 (1.60)	0.66 (1.30)	−0.10 (−0.34)	0.56 (1.74)
ConsultTechn	**0.54** (4.30)	0.43 (1.48)	**0.74** (3.65)	0.33 (1.47)	**0.65** (5.27)	**1.13** (3.89)	**0.64** (3.18)	**0.53** (2.39)
constant	**−2.48** (−4.24)	**−3.71** (−3.18)	−1.49 (−1.34)	−1.05 (−0.95)	**−2.53** (−4.62)	**−3.81** (−3.63)	−1.27 (−1.20)	**−2.77** (−2.64)
Observations	538	126	208	204	538	126	208	204
LR chi-2 (10)	134.35	36.42	53.50	42.32	110.33	38.16	41.09	39.74
Prob > chi-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudo-R2	0.18	0.22	0.19	0.17	0.15	0.22	0.15	0.14
Predict Prob.	0.40	0.29	**0.59**	0.28	0.50	0.42	**0.63**	0.43

The $z-values$ are given below coefficients, between parentheses.

Result 2 *The highest innovative capacity of the partial exporters comes from their collaboration with technical consulting agencies, universities and international organizations.*

This observation again underlines the essential role played by external knowledge sources (Rahmouni et al. 2010).

Result 3 *The usual narrowness of the domestic market limits the possibility to take advantage of economies of scale and competition is mainly driven by productivity gains. The success of innovation is based on both export– and domestic–market–oriented strategy.*

We will now analyze more in detail the differences in the propensity to innovate of different subgroups. We decompose the total effect of the covariates and compute the share that reflects the differences in coefficients linking these factors to the probability of innovation. In order to achieve this, we apply the non-linear decomposition technique. The gap in the innovativeness can hence be decomposed in two parts: the differences in the way the independent variables operate for both groups (i.e. the effects of the independent variables), and the group differences in characteristics with respect to other unobserved factors. We also resort to regression trees, to better understand the interaction between characteristics and to check the possible complementarity or substitutability that can exist between them in the realization of the innovation. The next section will present this analysis.

4.2 Determinants of differences in propensities to innovate

Given the differences between the subgroups of firms in our sample, in observed characteristics and the regression coefficients, the question which arises is: to what extent the differences (of the innovation propensity) across firms can be explained by differences in characteristics of the firms on the one hand, and by differences in the coefficients on the other?.

The decomposition technique helps us to tackle the question on how high would the share of innovators among EE firms (or NE firms) be, if the PE firms were among the group of EE firms (or NE firms). In other words, how high would the propensity to innovate of EE firms (NE firms) be, if the characteristics of the PE firms were linked to the probability of innovation according to the coefficients estimated using the EE sample (NE sample). The results obtained with the decomposition approach are given in Table 4.

Moreover, we can also check the sources of the innovation weakness for the EE and NE firms. We detect these configurations using regression trees that give a partitioning of our observations on the basis of the expected value of the innovation success. Even if we give the results both for the EE and NE firms, our discussion will be exclusively focused on the case of the EE firms, given the dedication of several incentive programs to these firms in Tunisia.

The decomposition of the **product innovativeness** between PE and EE firms is analyzed in the second column of Table 4. Each subgroup can be used as the reference group, and the results usually differ according to the choice of the reference group (the technique used is presented in details in the online Appendix). The differential gap in the rate of product innovation between the PE and EE firms is about 25.9% (= 0.563 − 0.304). Overall, total contribution of group differences in the average values of the independent variables account for about 52.32% of the differential gap when the sample of PE firms is used in order to calculate the coefficients which are the basis of the decomposition. This means that difference between PE and EE firms is mainly due to difference in observable characteristics rather than in the estimated coefficients and hence in the innovation behavior. The others 47.68% are due to the differences in the coefficient effects and also to the unobserved or unexplained factors.

The contribution of each variable to the gap is equal to the change in the average predicted probability from replacing EE firm distribution with the PE firm distribution of that variable, considering the other variables fixed (see the bottom half of Table 4). The large difference in the share of product innovators between PE and EE firms can be explained by the higher intensity of access to external technical assistance and collaboration with international

organizations for PE firms (first column) and also by the insufficient internal R&D department proportion for EE firms, which confirms the descriptive evidence given in Table 2 and results from the regression trees (see below). This result shows that the profile of Tunisian firms can be contrasted with other developing countries. Indeed, one would think, that EE firms could better benefit from external technical assistance and collaboration with international organizations[8].

Table 4: Decomposition analysis of the consequences of exports on innovation propensity

	Product Innovation				**Process Innovation**			
	PE vs EE		**PE vs NE**		**PE vs EE**		**PE vs NE**	
Reference Group	**PE**	**EE**	**PE**	**NE**	**PE**	**EE**	**PE**	**NE**
P(innovate=1/Group)	0,563	0,304	0,563	0,341	0,601	0,436	0,601	0,429
Differential gap	0,259	-0,259	0,221	-0,221	0,165	-0,165	0,172	-0,172
characteristics effects	0,135	-0,139	0,145	-0,104	0,123	-0,140	0,116	-0,129
Contibution in percent	52,32%	53,79%	65,54%	47,01%	74,76%	85,22%	67,44%	74,74%
Residual effects	0,123	-0,119	0,076	-0,117	0,042	-0,024	0,056	-0,044
Contibution in percent	47,68%	46,21%	34,46%	52,99%	25,24%	14,78%	32,56%	25,26%
Detailed decomposition								
depRD		-24,83%						
lnSales				-14,55%		-40,38%		-22,86%
partState	-5,68%		22,78%	-19,12%	-6,68%		27,79%	
collUniv					15,12%			
collRecCent								
collLabUnit				9,00%				
collNatOrg								
collInternatOrg	8,74%	-9,05%	3,30%		8,80%			
collOtherfirms								
ConsultTechn	29,04%		23,64%		40,14%	-34,25%	23,09%	-36,25%

The last part reports only significant contribution estimates at 5% level. Contribution estimates given in percent of the gap of mean values of the decomposition using 100 replications (Fairlie 2005)[9].

The results for the configurations corresponding to the weakest innovativeness in the regression trees (*see* Figures 1, 2, 3 and 4) are summarized in Table 5. We observe that EE firms the most deficient in product innovation, when they do not benefit from an internal R&D unit, and when they are small (51 firms correspond to such a configuration –*see* Tree 1). We have, in this configuration, small foreign firms, completely dedicated to exports, and unconcerned by innovating.

The decomposition of the **process innovativeness** between PE and EE firms is analyzed in the fourth column of Table 5. The differential gap in the rate of process innovation between the PE and EE firms is lower, about 16.5% (= 0.601 − 0.436). Overall, total contribution of group

[8] Rahmouni et al. (2010) find that the main contrast concerns the limited role of internal R&D and the insignificant role played by foreign participation.

[9] Following the suggestion of Fairlie (2005), sampling process is also repeated 1,000 times. The separate contributions from independent variables may be sensitive to the ordering of variables. We randomize the ordering of variables, thus approximating results over all possible orderings. The results are the same. In this way, we can largely avoid selection bias from sample differences between different groups.

differences in the average values of the independent variables account for about nearly 75% of the differential gap when the sample of PE firms is used in order to calculate the coefficients which are the basis of the decomposition. This means that difference between PE and EE firms is largely due to difference in observable characteristics rather than in the estimated coefficients and hence in the innovation behavior. We observe that again insufficient size is one of the main factors in the relative deficiency of the EE firms, as well as sub-utilization of technical consulting agencies.

The second column of Table 5 confirms these results and also indicates that the absence of collaboration with other firms and national organizations can be aggravating factors for the EE firms (79 EE firms correspond to such a configuration, see also Tree 2). The determinants of the weakness of EE firms are summarized in the following result:

Result 4 *Exclusively-exporting firms low innovativeness can be explained by the insufficient R&D effort and small size (for product innovation) or the lack of access to external technical knowledge sources and small size (for process innovation).*

A similar proposition can be established for determinants of the weakness of NE firms:

Table 5: Paths to the lowest propensities to innovate for EE and NE firms

	EE firms		NE firms	
Variable	**Product**	**Process**	**Product**	**Process**
collNatOrg		No (1)		
collOtherFirms		No (3)		
ConsultTechn		No (2)		No (1)
depRD	No (1)		No (2)	No (3)
lnSales	Low (2,3,4)	Low (4)	Low (1,3,4)	Low (2)
Expected prob.	0	0.15	0	0.191; 0.255

The table gives, for each class of firms and both types of innovation the combinations of characteristics that correspond to the lowest propensity to innovate. This table summarizes the most deficient cases for these two classes of firms, as they appear in the regression trees given in the Appendix. The numbers in parenthesis give the order of importance of the corresponding factors.

Result 5 *Exclusively-domestic firms low innovativeness can be explained by the insufficient R&D effort and small size (for product innovation) or the lack of access to external technical knowledge sources and small size (for process innovation).*

4.3 Which variables determine higher innovativeness?

Which combinations of the factors do favor the innovativeness of firms in each subgroup? Regression trees can be used to answer this question. Again, our discussion will be focused on PE and EE firms, even if we also give the results for the NE firms. Table 6 summarizes the results of the regression trees on these configurations. We first discuss the results concerning product innovation, before turning to the conditions most favorable to process innovation.

For both types of innovation, we clearly observe that PE firms are able to attain higher innovativeness than the EE ones.

For **product innovation**, PE firms are sure to innovate when they benefit from technical consulting agencies, and when their size is not too big, while EE firms must rely on their internal R&D unit and the collaboration with international organizations to obtain their best expected propensity (0.86). This result indicates the complementarity between the internal R&D

efforts and collaboration with international organizations for EE firms. Thus, the capacity to benefit from external technological knowledge sources will be explained by the construction of their absorptive capacity via the internal R&D investments. However, in all other cases their expected probabilities to innovate are inferior to 0.63 (see Tree 1). When the sources of innovation (for this case, internal R&D activities and collaboration) are found to be complementary, it will be less efficient to concentrate on one strategy because of the increased complexity. Managing these complementarities can be an important source for a sustainable competitive advantage (Cassiman & Veugelers 2004, Ravkin 2000). These two types of firms clearly have different product innovation profiles: while PE firms could benefit from national policies that would enhance the capabilities of Technical consulting agencies, the mechanisms of EE firms seem completely autonomous from these policies.

Table 6: Paths to the highest propensities to innovate for EE and NE firms.

	EE firms		**PE firms**		**NE firms**	
Variable	**Product**	**Process**	**Product**	**Process**	**Product**	**Process**
collNatOrg		No (1)				
collI nterNatOrg	Yes (2)					Yes (3)
collOtherFirms						
ConsultTechn		Yes (2)	Yes (1)	Yes (1)	Yes (2)	Yes (1)
depRD	Yes (1)			Yes (4)		
lnSales		Medium (3,4)	Medium (2,3)	Medium (2,3,5)	High (1)	High (2)
partState					Low (3)	
Expected prob.	0.8642	0.8095	1	1	0.7778	1

The table gives, for each class of firms and both types of innovation and the combinations of characteristics that correspond to the highest propensity to innovate. This table summarizes the most favorable cases for these three classes of firms, as they appear in the regression trees given in the Appendix. The numbers in parenthesis give the order of importance of the corresponding factors.

We observe more similar profiles for **process innovation**, since for both types of firms, Technical consulting agencies play an important role, completed by an intermediate firm size. But, for the EE firms, the role of Technical centers only appear if these firms cannot benefit from collaboration with national organizations (which can, alone, favor a significant innovativeness – *see* Tree 2). If PE firms do not access to external technical consulting, they can attain a high probability of innovation if and only if they benefit from collaboration with international organizations or universities. This result indicate some substitutability between these sources. Indeed, PE firms are particularly preferment in process innovation.

5 Conclusion

In this article we analyze the relationship between exports and the propensity to innovate for Tunisian firms. At the global level, we observe that EE firms have the highest propensity to innovate because they benefit better from external knowledge sources and a heterogenous demand. Our results show that Tunisian firms do not benefit yet from their internal R&D efforts since they do not have the necessary financial resources and knowledge for undertaking innovative projects. Access to external organizations for technical assistance as well as cooperation are favorable to innovation. But this global result hides important heterogeneity between types of innovation and types of firms (PE, EE or NE firms). The existence of internal R&D capacity is in general necessary for EE firms, while cooperation is favorable for the majority of cases.

In characterizing the innovation process, we distinguished between three types of innovative strategies that are: internal R&D efforts, collaboration and external technical assistance. We find

evidence of complementarity among external sources for product innovation and of substitutability for process innovation. For Tunisian firms, the motives for cooperation are related to technical assistance and not to cost-sharing or risk-sharing. Thus, it is not surprising to find that access to assistance from external organizations is closely related to collaboration which may differ between firms types. But, it is not the sole component in a firm's innovation strategy, and that rises the issue of complementarity among various collaborative agreements. The role of absorptive capacity of firms are less clear. Indeed, internal knowledge development should be necessary to benefit from external knowledge acquisition and R&D activities that are often essential in order to monitor and evaluate research conducted elsewhere (Rosenberg 1990).

In the case of product innovation, collaboration of EE firms with international organizations is complementary to their internal R&D activity. Therefore, it is important to combine internal and external knowledge sources in the innovation process of these firms. This result is in line with Freeman (1991) and Veugelers & Cassiman (1999) for whom the external sources combined with internal research activities are crucial in explaining success of the innovation. However, this does not necessarily suggest a strong complementary relationship between internal R&D and external knowledge acquisition. For other types of firms we also find evidence on complementarity among other external sources (Arora & Gambardella 1990). PE firms' access to external technical assistance and their collaboration with international organizations are complementary for firms that are not too big. However, NE firms would benefit from access to external technical assistance, if public participation in capital is low. Thus, large NE firms with private participation in capital are more likely to benefit from the help of external organizations.

In the case of process innovation, innovators often relay on many different external sources of knowledge (von Hippel 1988, Reichstein & Salter 2006). Cooperation with national organizations or collaboration with other firms and access to external technical assistance are substitutable for process innovation. Access of PE firms to external organizations for technical assistance and cooperation with international organizations for large firms or collaboration with universities are also substitutes. However, for NE firms, a complementarity arises between access to external organizations and cooperation with international organizations for large NE ones.

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Appendix

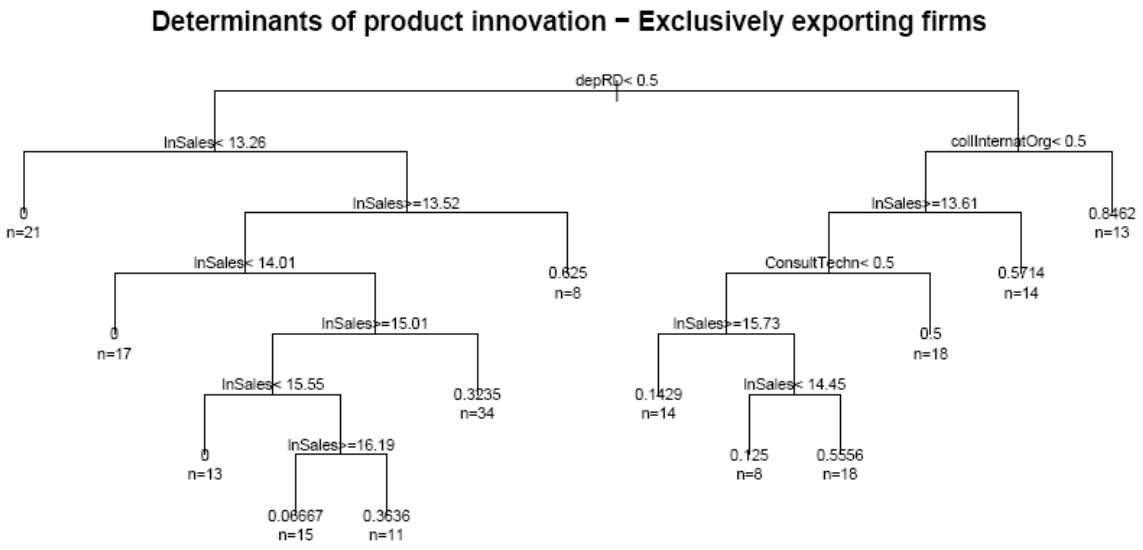

Figure 1: Determinants of product innovation. Exclusive exporters (cp = 0.01).

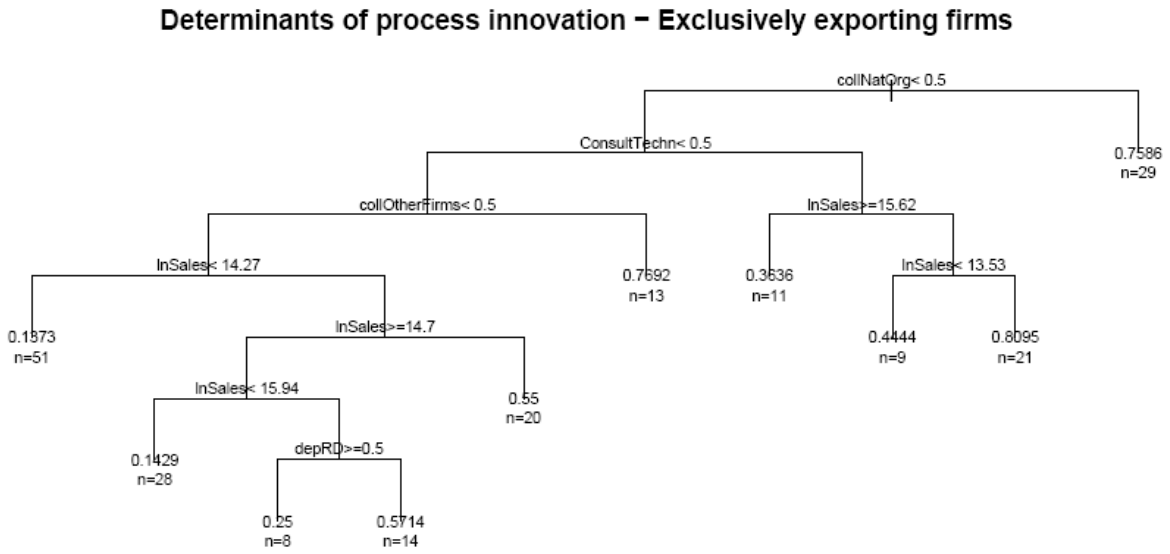

Figure 2: Determinants of process innovation. Exclusive exporters (cp = 0.01).

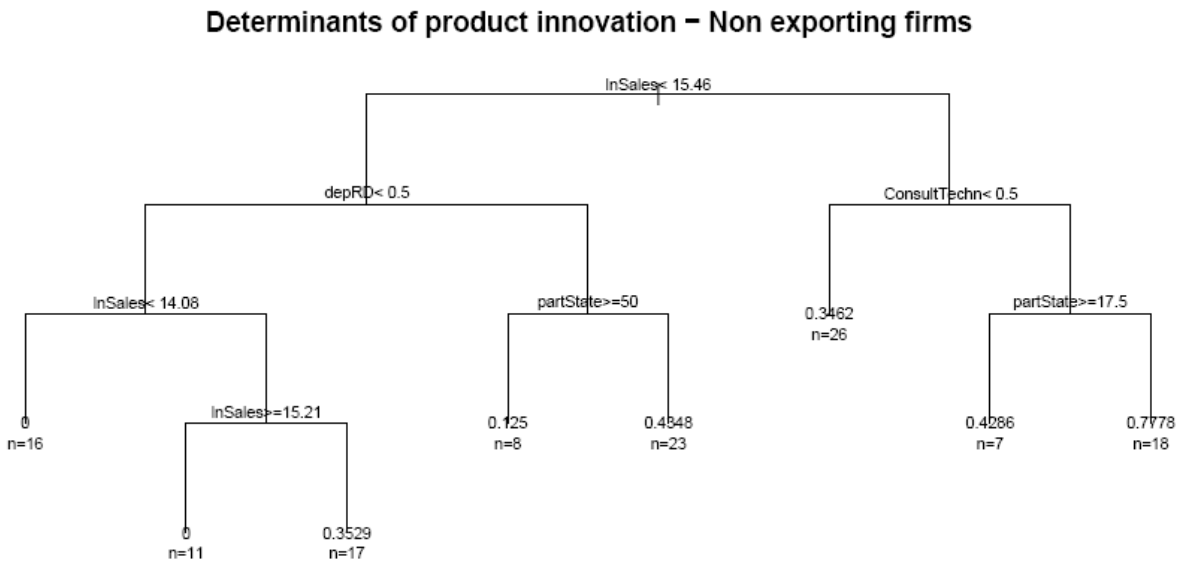

Figure 3: Determinants of product innovation. Non-exporters (cp = 0.01).

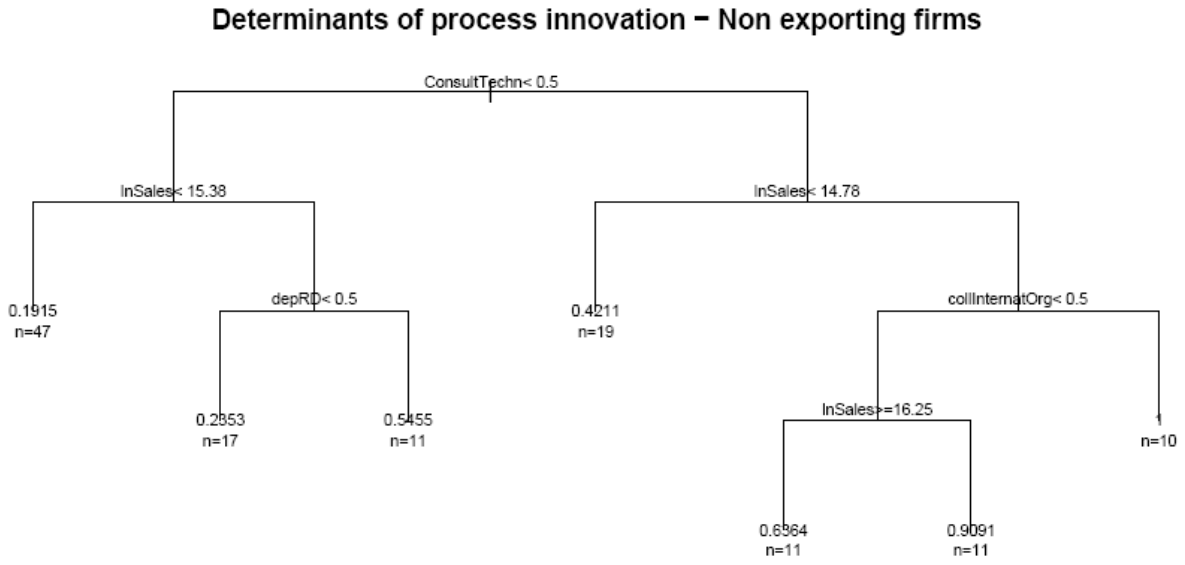

Figure 4: Determinants of process innovation. Nonexporters (cp = 0.01).

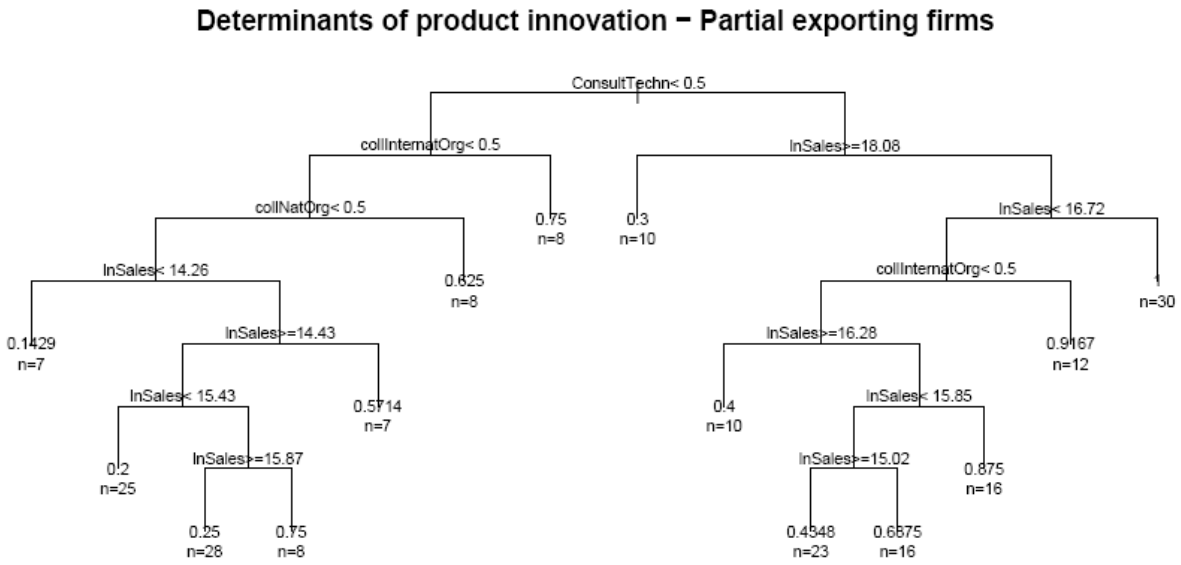

Figure 5: Determinants of product innovation. Partial exporters (cp = 0.01).

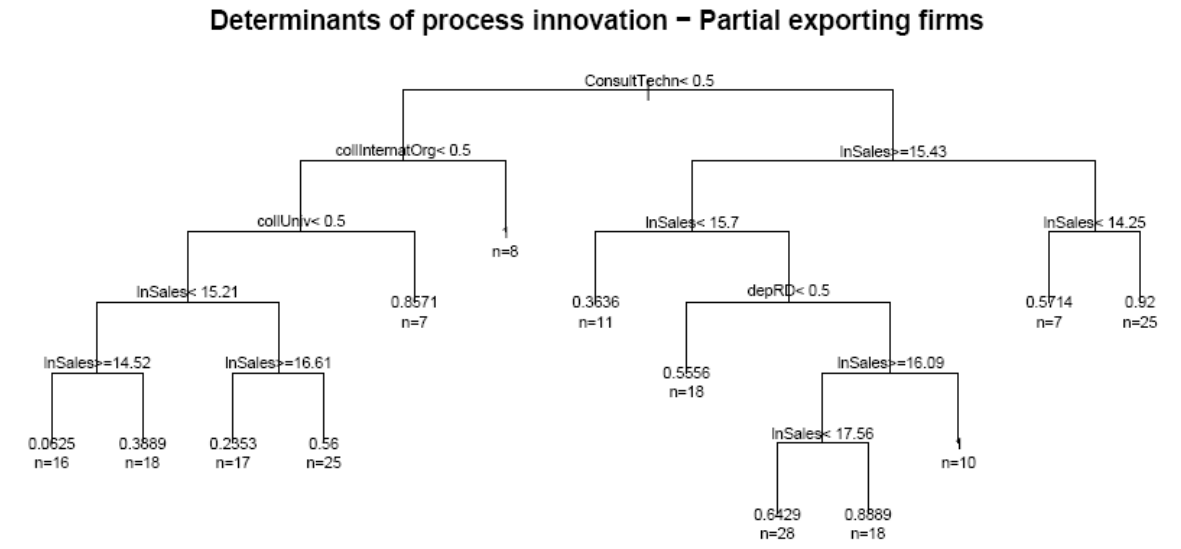

Figure 6: Determinants of process innovation. Partial exporters (cp = 0.01).