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Innovation in Tunisia

Empirical Analysis for Industrial Sector

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Abstract. The aim of this article, is to analyze the effects of factors external and internal to the firms on innovation in Tunisia, and how these effects varies according some specificities of the firms, such as the opening of capital to foreign companies. The analysis is based on a sample of 543 manufacturing firms, taken from the Tunisian Survey of Technological Innovation conducted in 2005 by the Tunisian Ministry of Scientific Research, Technology and Skills Development. The results indicate that the firm's technological competences, derived from in-house R&D effort and cooperation are the main determinants of innovation performance of Tunisian firms. They also suggest that firms with high export intensity and significant foreign capital participation are found to be less innovating than partially exporting firms with low foreign capital share.

Keywords: Technological Innovation, Technological opportunities, R&D in Developing Countries, Logit Regression with Interactive variables

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1. Introduction

Over the two last decades, the R&D activity has become a crucial indicator to measure the development of firms and hence nations in the industrialized world. Many studies have shown that the economic growth is strongly linked to the R&D activity. For instance Guellec and van Pottelsberghe (2004) show that the long-term impact of private and public R&D investment is relevant. Moreover, R&D investment enables firms to take advantage of R&D spillovers from public and foreign R&D as well. In other words, R&D activity has not only a direct effect on the economic growth but also an indirect effect which is measured in terms of absorptive capacity. In addition, the R & D and technological cooperation has emerged as an effective way to reduce pressures on costs and technological complexity because it makes knowledge a more public good. The cooperation networks can involve both local and foreign research institutions in addition to local and foreign customers and suppliers. These networks are affected by the existing institution's framework generally called "National System of Innovation" (Nelson R. (1993), Malerba F. (2002-2004)).

This concept can be adopted in some developing countries (UNIDO (2003), Edquist and McKelvey (2001)) that have opted for policies of liberalization and openness. These countries, have undergone in the turn of 1980's, a drastic strategy shift from an inward oriented paradigm, dependent on import substitution policies to an outward oriented paradigm, that requires progressive liberalization of economies and active policy reforms. According to Rodrik (1993), for these countries, economic liberalization could reduce static inefficiencies arising from resource misallocation and enhance learning, technological change, and economic growth. Rodrik (1993) argues that dynamic effects, which originate from productivity growth due to increased exposure of local firms to competition in foreign and domestic markets, have the prospect of triggering sustained economic growth. Thus, the process of globalization is seen as a challenge and an opportunity in the developing economies to integrate the innovation race and catch up (Edwards 1993). Furthermore, between 1995 and 2003, expenditure on R & D subsidiaries under foreign control has been the most dynamic, in the evolution process of globalization and it reported strong and rapid growth. The attractiveness of developed countries is increasingly growing as opposed to developing and emerging economies. But this trend does not deny that emerging and developing countries also receive a significant share of FDI in R&D[1]. These patterns could in the future accelerate the convergence.

[1] According to (UNCTAD 2005), the transnational R&D in the emerging countries has increased from 2% in 1996 to reach 18% in 2002 with a concentration in Asia, particularly in China and India. However, for South Mediterranean countries, the only country that hosted the transnational R&D is Israel with 4.4 % of actual investments. Recently, the Maghreb has become

Nevertheless, in developing countries, due to the low level of human capital and the vulnerability of infrastructure, the in-house innovation and R&D activities are very limited. For instance, in southern Mediterranean countries, only few patent applications from the Maghreb countries are deposited in the European office of patents and they are totally absent in the American Office. Moreover, the part of the Maghreb countries, does not exceed 0.2% from the global scientific publications OST (2006). In Algeria, the total budget dedicated to research represents 0.35% of the GDP in 2004 and doesn't exceed 1% in morocco and Tunisia. Research is almost totally funded from public organizations but there are no tools or programs to make it concrete and valuable[2].

In this context, rather than create new processes and products, the majority of firms try to catch up by adoption and assimilation strategies. Thus, innovation is seen as a learning process and adoption of external technologies. In general, firms invest in the acquisition of new machinery and new equipment, licensing, R&D outsourcing and by hiring highly qualified personnel with relevant specific skills.

In the Tunisian context[3], the free trade agreement with the European Union, and the progressive dismantling of the tariff barriers, create for the young Tunisian industry a situation in total rupture with the protectionist orientation which prevailed until the end of the eighties. Tunisia faces a challenge that requires an improving of the structural competitiveness of its strategic sectors. The free trade agreement and the opening policy, would improve, in short-term, methods of management and organization and productivity. In long term, it would stimulate technological innovation through learning effects. Moreover, R&D policy, technological agreement with universities, laboratories, and foreign research organizations would ensures the prosperity of the firms by consolidating their competitiveness, and by improving their profitability, their performance and their positioning within both traditional and new markets.

However, despite the existence of policy and tools to enhance private R&D activities in Tunisia, R&D is carried out mainly by public sectors[4]. Thus, the major orientation of Scientific and Technological Innovation policy in Tunisia consists of encouraging enterprises and industrial support institutions to integrate innovation, technology transfer and R&D in their strategies. In this

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a destination for the transnational firms that intend to invest in R&D in modern and emerging sectors1 besides the strategic sectors (Petroleum, agriculture.).

[2] As pointed out by Khalfaoui (2006), the creation of innovating firms is exclusively the mission of large Algerian enterprises

[3] Tunisia, was the first county (in 1995) to sign the free trade agreement with the European Union in the framework of the Euromed Initiative.

[4] In Tunisia, the part of R&D is about 1% of GDP. Also, 78% of total R&D is funded by public sector, 12.5% by private sector and 9.5% by foreign investments.

country, since the resources are limited, the idea is to implant techno-parks[5] all over the country to establish the ties between training, research and production, to support start-ups and favor the incubation and creation of innovative enterprises by promoting the results of research. Besides the modernization and the improvement of the competitive capacity of the national industrial system, this policy would accelerate the integration into the free-trade zone with the Europe.

This paper aims to investigate the determinants of innovation in Tunisia using the innovation survey conducted by the Tunisian Ministry of Research for the period 2003-2005. First, we will examine the effects of the common innovation determinants, such as R&D and innovation expenditures, cooperation, skills, etc. on the innovation activity of Tunisian firms. Then, we attempt to show, how these effects are moderated by the liberalization as measured by the opening of capital to foreign companies and by trade liberalization especially with Europe.

The rest of the paper is structured as follows. Section 2 presents a succinct literature review on internal and external determinants of innovation. Section 3 introduces the methodology used for our empirical study including data and econometric specification. Finally, section 4 contains the results of our estimations followed by concluding remarks.

2. Literature Review

Several empirical studies highlight the determinants of innovation focusing on the size of the firm, industry structure and competition. But the most important factor of innovation is driven by the R&D activity. However, the value of the R&D activity is directly related to the core competencies of the firm as well as to its efficient innovative processes. The studies by Baldwin & Hanel, (2003) and Duguet, (2000), have shown that the firms which spent more resources on R&D activities have the best competitive advantages in the radical innovation. Hall & Bagchi-Sen (2002) studied the relationships among R&D intensity, innovation measures, and business performance in the Canadian biotechnology industry from 1994 to 1997. Their findings are mitigated. Indeed, they found that R&D intensity correlates with patent measures as proxy of innovation. However, there is no significant correlation between R&D intensity and product or process related innovation. Shefer & al. (2005) show that R&D activities accelerate innovations development inside the company leading to the realization of high financial performance in electronics industry in Taiwan. Tsai (2005) examined the impact of R&D on innovative performance as measured by total factor productivity and found that the efficiency of R&D

[5] Tunisian Government has planned to create 10 techno-parks (with average of one techno-park per year). Actually 8 techno-parks has been established. Moreover many measures have been taken for the development and privatization of ICT sector considered as a determinant for the prosperity of the Knowledge Economy

expenditures in both small and large firms is significant in achieving higher productivity and competitive advantage. Besides R&D, the cooperative strategies with different actors in the industry can be a decisive factor of the performance of the innovation activity. For instance, Fritsch & Lukas (2001) argued that cooperation depends primarily on the specificity of the innovation, the size of the firm and its human capital.

Other studies, related to the business management approach, focused on the internal characteristics of the firm as critical factors of the innovation behavior. These characteristics are summarized by the tangible and intangible cumulative capabilities of the firm which make-up its core competencies. These resource-based competencies include the technological competencies due to the intensive R&D activities as well as the human resources competencies based on skilful and cumulative know-how capabilities. Other factors, such as organizational competencies based on the internal performance of the communication process contribute to further strengthening the resource-based competencies of the firm and stimulate its innovation activities. These aggregated resources, allowed the firm to develop an innovative strategy based on its internal strength as well as on the appropriation of the external technology-based knowledge. Nevertheless, the adoption of the new technologies requires an absorptive capacity of the innovative firm. Cohen & Levintahl, (1989) argued that research activity can facilitate the dissemination of the knowledge provided by the external sources and consequently, in house R&D and the external R&D complement each other.

The literature on developing countries, usually distinguishes two main sources of innovation. The first source relates to the in house innovation developed by the firm which focuses on R & D investment or cooperative activities with suppliers, customers or university and research institutes. The second source concerns the acquisition of external technological capabilities by purchasing new machinery or licensing agreement with foreign innovative companies. Fransman (1985), point out that technological activities in developing countries can be summarized in the appropriation and assimilation of foreign technologies and adaptation of the production processes so as to efficiently utilize these technologies with local resources (labor, raw materials, etc.). But, it is obvious that catching up will not take place automatically. As pointed out by Cohen & Levintahl (1989), it requires a strong technological capability within the company to facilitate the adoption and assimilation of new technologies. The development of such internal knowledge acquisition activity is considered as complementary to the external knowledge acquisition and adoption activities (Arora and Gambardella (1990), Cockburn and Henderson (1998) and Granstrand & al (1992)). For instance, Rothwell (1991), show that the successful adoption of outside expertise for

small and medium enterprises with a low technological basis is conditioned by the availability of skilled human capital (such as the employment of qualified technical specialists and engineers). It also requires institutional conditions and favorable financing policies and regulatory framework. In the absence of these factors, there may be no successful learning. Fransman (1985) and Cooper (1989), explain the failure of the learning process in some developing countries by the lack of in-house innovation strategy comparatively to the industrialized countries. The learning and adoption are often less successful given the weakness of absorptive capacity.

3. Empirical study

3.1 Data Description

Our empirical study is based on the innovation survey conducted in 2005 by the Tunisian Ministry of Scientific Research, Technology and Skills Development. The survey measures the innovation intensity of Tunisian firms for the period 2002-2004. A sample of 586 firms were contacted and required to respond to a questionnaire including, besides their characteristics (recruitment, turnover, exportations, foreign capital share, etc.), several items related to R&D activities, employee skills, product and process innovation, cooperation with universities, research centers, etc. (see appendix). The questionnaire also includes some informations about government mechanisms and tools in order to promote R&D in Tunisia. In our study, we are interested only in manufacturing firms. So, after eliminating companies in service sector, we obtain a sample of 543 firms (Table 1).

3.2 Variables Description

In our empirical model, we attempt to examine the effects of the common innovation determinants, such as R&D, cooperation, skills, size, etc. on the innovation activity of Tunisian firms. Then, we will examine, how these effects are moderated by the opening of capital to foreign companies and by export intensity.

The endogenous variable INNOV is a dichotomous qualitative variable which takes the value 1 if the firm has undertaken process or product innovation during the period 2002-2004 and the value 0 otherwise. For the product innovation, there is no distinction between innovation for the firm or for the market.

Table 1: Composition of the Sample

Sectors	Number of firms	%
Agro-alimentary	89	16
Chemicals	32	6
Electrical and electronic material	100	18
Mechanical and Metal	64	12
Textiles and clothing	110	20
Leather and footwear	16	3
Wood and cork	16	3
Publishing and Printing	10	2
Rubber and plastics	24	4
Mining and energy	11	2
Constructional material, pottery and glass industry	43	8
Other industries	27	5
Total	**543**	**100%**

The R&D expenditure is measured through two variables: a qualitative variable which takes the value 1 if the firm has R&D activity and 0 otherwise. Then, in case of the existence of R&D activity, we calculate the R&D intensity as the share of total expenditures of innovation in turnover. We have restrained the total expenditure of innovation as a basis for our calculations instead of the R&D expenditure because R&D is very weak in Tunisian firms. The total expenditures of innovation include patents acquisition, costs for training and technological learning methods and tools as well as product improvement.

For the technological cooperation, the partners considered in our survey include universities, research laboratories and centers, local public institutions, foreign organization and firms. The variable COOP is scaled from 0-5 and measure the number of firm's partners.

For the variable that indicates the size of the firm, as the majority of Tunisian firms are small or medium enterprises, we use the level of the firm turnover relative to the industrial sector in which it operates. Thus, rather than testing the Schumpeterian hypothesis, the objective is to check if there exist or not, disparities in the size impact from one sector to another.

The skilled labor intensity (SKILL) is calculated on the basis of the proportion of skilled employees (managers and high skilled personnel in the administrative, technical and R&D

departments) over the total number of employees. Its value is codified over an ordinal scale ranged from 1- 4 (4 for the highest skilled proportion and 1 for the lowest proportion). This variable indicates the capability of the firm to mobilize the required qualifications for innovation and new technologies acquisition.

In addition to the previous variables, we consider a control variable which measures the technological level of the firm. It represents the technological intensity of the sector according to the OECD classification. It is codified over an ordinal scale ranged from 1-4 with 1 for low technological intensity sectors (LT), 2 for middle-low technological intensity sectors (MLT), 3 for middle-High technological intensity sectors (MHT) and finally 4 for High technological intensity sectors (HT).

Furthermore, we propose two moderator variables. The first one measures the foreign capital share (FKI) and is codified over an ordinal scale ranged from 0-4 where 0 stands for absence of the foreign capital share in the firm and 4 for a total foreign capital. This variable is integrated into the innovation equation in order to verify if the foreign capital sharing leads to more innovating performances or not. The second variable measures the share of exports in turnover (EXI). It is also codified over an ordinal scale ranged from 0-4. This variable is considered in the innovation equation to examine if it has a positive impact on firm's innovation activities. Theoretically, exportation activities represent a real motivation for firms to innovate since the opening to foreign markets creates business opportunities and requires more dynamism in terms of innovation and research.

3.3 Econometric Specification and Estimation Techniques

Given the qualitative character of the dependent variable (process or product innovation), we utilize the binomial Logit model. This econometric method, allows estimating innovation propensity of the firm as a function of its in-house R&D effort, its external technological factors such as cooperation as well as moderator variables. In our modeling, when the estimated coefficient of the explanatory variable is positive, then the corresponding variable affects positively the probability that INNOV takes the value 1. In return, when the estimated coefficient is negative, this probability is reduced.

In the first model, we consider the sectoral characteristics as explanatory variables besides the specific characteristics of the firm (COOP, SIZE, RD, FKI, EXI, SKILL and TECH). The objective is to estimate, for the totality of the sample, the impact of each variable on the probability of innovation in the Tunisian firm**.**

Model 1: $INNOV = \beta_1 + \beta_2 (RD) + \beta_3 (COOP) + \beta_4 (SIZE) + \beta_5 (FKI) + \beta_6 (EXI) + \beta_7 (SKILL) + \beta_8 (TECH)$

In models 2A and 2B, we keep only 224 firms that have R&D activities during the period 2002-2004 and we propose to estimate the same equation, but we replace the dichotomous variable RD by the quantitative variable RDI which reflects the intensity of R&D and innovation expenditures and hence better represents the innovation process in general. In the model 2A, we try to explain the endogenous variable only by the variables RDI, COOP, SIZE, SKILL and TECH. Then in 2B, we add FKI and EXI which represent respectively the share of the foreign capital and the intensity of exportation. The main purpose is to compare these two modeling and evaluate the impact of capital opening and exportation intensity on innovation performances.

Model 2A: $INNOV = \beta_1 + \beta_2 (RDI) + \beta_3 (COOP) + \beta_4 (SIZE) + \beta_5 (SKILL) + \beta_6 (TECH)$

Model 2B: $INNOV = \beta_1 + \beta_2 (RDI) + \beta_3 (COOP) + \beta_4 (SIZE) + \beta_5 (SKILL) + \beta_6 (TECH) + \beta_7 (FKI) + \beta_8 (EXI)$

Finally, in models 3 and 4, we propose to estimate the impact of R&D intensity and cooperation with partners on innovation while controlling this impact through specific variables that represent the exportation intensity and the foreign capital share. To examine the moderator effects of the interactive variables of FKI and EXI on the relationship existing between innovation, R&D intensity and cooperation with partners, we proceed as Tsai (2005) and Nieto (2005). We calculate these interactive variables by multiplying the moderating variables (FKI and EXI) by the moderated variables (RDI and COOP). By doing so, we have an indication on the impact of the R&D intensity and cooperation on innovation performances when the exportation intensity or foreign capital share is increased by one unit. When the corresponding estimated coefficients of these interactive variables are significant, we can confirm that the effect of the R&D intensity and cooperation on innovation depends on exportation intensity and foreign capital share.

Model 3: $INNOV = \beta_1 + \beta_2 (RDI) + \beta_3 (COOP + \beta_4 (RDI) * (FKI) + \beta_5 (COOP) * (FKI) + \beta_6 (SKILL) * (FKI) + \beta_7 (SIZE)$

Model 4: $INNOV = \beta 1 + \beta_2 (RDI) + \beta_3 (COOP) + \beta_4 (RDI) * (EXI) + \beta_5 (COOP) * (EXI) + \beta_6 (SKILL) * (EXI) + \beta_7 (SIZE)$

4. Results

Table2 presents the results of the regression analyses for each of the four models. In general terms, the econometric specifications have an acceptable predictive power. The percentage of correct predictions exceeds 68.3% for all models. Moreover, the Chi-2 values corresponding to each model are significant, which allows us to reject the null hypothesis that all parameters, except the constant, are null. Eventually, we note that the integration of interactive variables (RDI*FKI) and (COOP*FKI) in model 3 and (RDI*EXI) and (COOP*EXI) in model 4 improves the explained variance since the overall % of correct predictions increase from 68% to 74.1% and 77.2%.

The results of model 1 show that for industrial Tunisian firms, the common effects of R&D, cooperation and size are confirmed. R&D makes possible not only the creation of new products and processes but also facilitates the absorption capacity of the firm to adapt and acquire new technologies. In addition, when a firm cooperates with partners (universities, research centers, foreign corporations…), its probability of innovation is positively affected.

Nevertheless, our estimation reveals some surprising results in model 1 concerning the effects of the variables SKILL and TECH. The qualification of employees and the technological intensity affect negatively the probability of innovation in Tunisian firms. The situation in Tunisia can be then interpreted as follows: the Middle or Low technological intensity firms are more motivated to innovate. This innovation does not require highly qualified personnel and mobilization of costly R&D resources. The negative sign of the variable SKILL puts into doubt the role of managers and qualified executives in the innovation process. They are not able to stimulate innovation and their vocation is rather limited to operational tasks that slow down innovation performances.

Another surprising result consists in the negative effect of exportation and foreign capital share on innovation for Tunisian firms. The estimated coefficients of these two variables are negative and significant which rejects the idea that they constitute incentives for innovation in Tunisia.

The estimation of model 2A, confirms the results of model 1 concerning the expected effects of R&D intensity, cooperation, firm size, personnel qualification and technological intensity. Moreover, when we introduce the variables FKI and EXI into model 2B, the results show that their estimated coefficients are negative and significant but COOP and RDI are no more significant. Once again, our estimation proves that exportation intensity and foreign capital share have negative effects on innovation for Tunisian firms that declare undertaking R&D activities. Therefore, the innovation probability of an exporting firm is less than the innovation probability of

a non exporting firm. In the same way, a local firm has more incentives to innovate than a non resident firm.

The models with interactive terms (model 3 and model 4) emphasize these results since the estimated coefficient of the interactive variable is negative and significant for both FKI (in model 3) and EXI (in model 4). In other words, the effect of cooperation and R&D intensity on innovation performances is reduced when FKI or EXI increase by one unit. These effects are justified by the nature of activities of exporting firms in Tunisia. In fact, the average of foreign participation in the capital of Exporting Tunisian firms is about 70%. These firms are either affiliates of foreign business groups or simply subcontracting firms which totally export abroad. In the first case, the affiliate firms in Tunisia do not conduct R&D activities since they mainly depend on innovation conducted abroad either in the parent firm or in any other attractive region of the world in terms of R&D execution. In the second case, in general, the subcontracting firms are not allowed to undertake any R&D activity.

Table 2: Results of the logistic regression

	Model 1	**Model 2A**	**Model 2B**	**Model 3**	**Model 4**
Intercept	- 4.765	- 5.673	- 5.673	-4.762	-5.876
RD	1.098*				
COOP	1.143*	0.342*	(ns)	1.102**	0.876**
RDI		0.453*	(ns)	0.766*	0.453**
SIZE	0.277**	0.245**	0.325*	0.324*	0.325*
SKILL	-0.123*	- 0.321**	(ns)	(ns)	(ns)
TECH	-0.415**	-0.357 * *	-0.342**	(ns)	-0.254**
EXI	-1.186*		-0.122**		
FKI	-1.089*		-0.142*		
RDI*FKI				-0.213**	
COOP*FKI				-0.342**	
SKILL*FKI				(ns)	
RDI*EXI					-0.124*
COOP*EXI					-0.342*
SKILL*EXI					(ns)
Mc Fadden R^2	0.23	0.27	0.25	0.31	0.33
LR statistics	739.657	934.123	765.34	876.671	998.876
Overall % of correct predictions	76.4%	68.3%	71.3%	74.1%	77.2%
*significant at 1%; ** significant at 5%, (ns): non significant					

4. Conclusion

This study examines, first the effects of two main determinants of innovation, the in-house innovation expenditure and the outside knowledge on innovation capability of the Tunisian firms. Then, it investigates how these effects are moderated by the liberalization of the Tunisian economy as measured by the capital opening to foreign companies and by free trade policy especially with Europe. Several results derive from this study and are of interest in explaining the innovation challenge of Tunisian manufacturing firms. First, Tunisian firms have to deepen their efforts in innovation by internal more active R&D strategy and by improving the efficiency of skilled workers as well as by adopting external know how via technological collaboration agreements. Second, the results show that the efficiency of innovative efforts depends negatively on the capital opening to foreign companies and the export intensity. The preliminary conclusion of our study is a set of recommendations to policy makers aiming at further strengthening the innovation especially for the firms that open their capital to foreign companies. In fact, the liberalization strategy has certainly contributed to the growth in Tunisia, but the current period requires a policy of targeting competitiveness in high-tech sectors and more active and innovative foreign direct investment policy. The foreign investors should play their role with their local partner as promoter of innovation in Tunisia. Future strategies and innovation policies in Tunisia, should involve foreign investors in the definition of certain local teaching programs. Moreover, it should link foreign investors with universities and schools to launch R&D activities and develop and finance incubator programs in collaboration with public organizations and private sector.

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Appendix

Tunisian Innovation Survey: Summary Statistics

	Non Resident Firms (*)	Resident Firms	Total Sample
R&D and Skills			
R&D Unit or Department	7,9%	21,1%	17,4%
R&D Budget	7,3%	19,0%	15,7%
High and Medium Skill Employees / Total Employment	22,9%	27,1%	25.7%
Innovation and Patenting			
Product Innovation	32,9%	58,5%	51,4%
Process Innovation	41,4%	51,4%	48,6%
Patent	2,5%	4,0%	3,6%
Cooperation			
Universities	3,7%	13,3%	10,6%
Research Centers	1,8%	6,7%	5,3%
Laboratories	0,0%	9,0%	6,5%
Local Public Institutions	14,0%	19,0%	17,6%
Foreign Firms and Organizations	11,0%	13,5%	11,1%

(*) Foreign Capital Share exceeds 2/3