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Abstract- This paper aims to investigate the determinants of productivity growth in the Tunisian economy context over the period 1976 to 2010. Our theoretical model incorporates as key variables, domestic innovation, human capital, distance to technology frontier and external technology spillovers through import of high-tech products and foreign direct investments. Empirical results identify that the impact of domestic R&D intensity on the productivity growth is negative but not significant in all alternative regressions. The effect of import of technologically advanced products is positive and more enhanced by the distance to technology frontier but the effect of foreign direct investment is significantly negative. Our findings confirm also that human capital has a positive impact on technology accumulation in Tunisia but not highly significant. Its role is rather more important in the assimilation and absorption of foreign technology.

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I. Introduction

Endogenous growth models emphasize innovation as the engine of growth. In the first generation endogenous growth models of Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992), TFP growth is positively related to the levels of R&D. This leads to an assumption of scale effects in ideas production, i.e., new ideas are proportional to the stock of knowledge. However, these models are not consistent with the evidence. In particular, Jones (1995) shows that the significantly increasing number of scientists and engineers engaged in R&D in the US since the 1950s has not been followed by a concomitant increase in the growth rate of TFP, thus refuting the first-generation R&D-based endogenous growth models. Consequently, endogenous growth theory has evolved into the two following second-generation theories: semi-endogenous growth models and Schumpeterian growth theory. The semi-endogenous models of Jones (1995), Kortum (1997) and Segerstrom (1998) abandon the scale effects in ideas production by assuming diminishing returns to the stock of R&D knowledge. Thus, R&D has to increase continuously to sustain a positive TFP growth. The Schumpeterian growth models of Aghion and Howitt (1998), Dinopoulos and Thompson (1998), Peretto (1998), Young (1998), Howitt (1999) and Peretto and Smulders (2002) maintain the assumption of constant returns to the stock of R&D knowledge. However, they assume that the effectiveness of R&D is diluted due to the proliferation of products as the economy expands. In other term, to ensure sustained TFP growth, R&D has to increase over time to counteract the increasing range and complexity of products that lowers the productivity effects of R&D activity. Endogenous growth theory has also increasingly focused on the roles of technology transfer and absorptive capacity in explaining productivity growth across countries (Eaton and Kortum, 1999; Howitt, 2000; Xu, 2000; Griffith et al., 2003, 2004; Kneller and Stevens, 2006; Madsen et al., 2009). Absorptive capacity captures the idea that the benefit of technological backwardness enjoyed by a laggard country can be enhanced if it has sufficient capability to exploit the technology developed in the frontier countries (Abromovitz, 1986).

Despite the rapid progress in the quality of studies and econometric techniques, the assessment of the effects of R&D productivity and spillovers through empirical analysis remains a controversial subject. To make the empirics of the theoretical model tractable, it is necessary to overcome a series of methodological and conceptual difficulties. In this paper, we first attempt to develop an endogenous model of technology accumulation that incorporates as crucial determinants, domestic innovation efforts, human capital, distance to technology frontier and the diffusion of foreign technology through import of high-tech products and foreign direct investment. Then, several alternative regressions are estimated and many graphical analyses are used to investigate the empirical effects of research intensity, human capital and technology transfer on productivity growth in Tunisia over the period 1976 to 2010.

The rest of the paper is structured as follows. The second section presents the theoretical model of technology accumulation and the regression equations to estimate. The third section reports empirical results with necessary interpretations. The last section concludes.

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II. Technology Accumulation Model

The basic idea behind endogenous growth theories is that in the long run the main underlying determinant of economic growth is the long-run growth rate of total factor productivity (TFP), which in turn depends mainly on the rate of technological progress. Theoretical modeling and empirical investigations in this field have been the subject of an increasing attention in the literature to understand the differences between developed and undeveloped countries. There are two obvious candidates to explain the different levels of TFP across countries or across regions within countries. The more important one is the amount of research carried out in that region/country. A vast literature investigating the national sources of economic growth (e.g., Cameron, 2003) underlines the linkage between R&D expenditures TFP, and growth. The second one is human capital. A sufficient level of knowledge in the workforce is necessary to acquire and exploit technology. The literature analyzed a third important channel that can affect TFP. Since developing countries carry out little or, insignificant R&D activities, the degree of technological diffusion from countries close to the frontier is likely to be one of the key drivers to accelerate the TFP growth in those developing economies (Savvides and Zachariadis, 2005). Coe and Helpman (1995) stress the role of international trade in driving technological spillovers through the imitative process that determines the technological performance of countries that cannot sustain an endogenous technological growth process. Foreign Direct Investment (FDI) by the Multinational Corporations (MNCs) may be another channel for the international transmission of technology (Savvides and Zachariadis, 2005). Distance to the frontier also plays a particularly important role in the convergence debate. Countries that are more backward technologically may have greater potential for generating rapid growth than more advanced countries (Gerschenkron, 1952), essentially because backwardness reduces the costs of creating new and better products (Howitt, 2000). However, backwardness needs not automatically lead to growth since the increasing complexity of products requires large investments in knowledge in order to take advantage of the technology developed elsewhere (Aghion *et al*., 2005).

Based on these theoretical models and empirical findings, we propose to develop an endogenous model of productivity growth that incorporates as key variables, domestic innovation, human capital, distance to technology frontier and the transmission of foreign technology through import of high-tech products and foreign direct investments. Empirical findings identify that the theoretical specification of the technology accumulation function the most consistent with data takes the following general form:

$$\dot{A} = f(X, \mathrm{A}) \times \left(S^{f}\right)^{\daleth} \qquad (1)$$

Where, A is the level of TFP or, knowledge and $\dot{A}$ is the change in TFP. The function $f(X, \mathrm{A})$ indicates domestic innovation, X indicates R&D input, measured by either the flow of R&D labor, or the flow of productivity adjusted R&D expenditure on labor or human capital and S^f stands for the international technology transmission. The function f takes the following general form $f(X, \mathrm{A}) = \lambda\left(\frac{X}{Q}\right)^{\sigma} A^{\varkappa}$, where, λ is a parameter of research productivity, σ is a duplication parameter $(0 < \sigma \leq 1)$, $\varkappa$ is the return to knowledge and Q is the product variety ($Q \propto L^{\beta}$ or $Q \propto Y^{\beta}$). L is employment or population, Y is the output and β is a parameter indicating product proliferation. The ratio between X and Q is termed as research intensity. In literature different indicators are used to measure research intensity like, $\left(\frac{R}{Y}\right)$, $\left(\frac{L_R}{L}\right)$ or $\left(\frac{H_R}{L}\right)$, where R indicates the real R&D expenditure, L_R is the number of scientists and engineers engaged in R&D and $H_R = hL_R$, where, h is the human capital level.

To develop the model of S^f, our approach is largely based on the studies of (Coe & Helpman, 1995, Lichtenbergh & Van Potteisberghe, 1998, Savvides and Zachariadis, 2005, Islam, 2010 and Madsen et al., 2013).These authors have tried to model the transfer of foreign technology via import of technologically advanced products and foreign direct investment.

International technology spillovers from import are measured by an import-ratio weighting scheme as follows:

$$S_i^{mf} = \sum_{j \neq i}^{n} \left(\frac{m_{ij}}{Y_j}\right) A_{sup} \qquad (2)$$

Where, i stands for the host country (*it's Tunisia in this study*), n indexes Tunisia's import partners (*example l'EU-15 in our case*) and m_{ij} is Tunisia's import of high-technology products from country j.

We indicate by Y_{Leader} the output of the leader partner. This country is assumed to be close to the technology frontier and having the highest level of knowledge noted by A_{sup} . At any period of time it's possible to express the output of a partner country as follow: $Y_j = \beth_j Y_{Leader}$, where $\beth_j$ is a positive constant. So that, it's possible to define S_i^{mf} by the following general form:

$$S_i^{mf} = (n/\text{ב})\left(\frac{\sum_{j\neq i}^{n}\frac{m_{ij}}{n}}{Y_{Leader}}\right)A_{sup} = (n/\text{ב})\left(\frac{M}{Y_{Leader}}A_{sup}\right) \quad (3)$$

Where, (M/Y_{Leader}) is ratio of the total average value of imports to the output of the leader. Technology transfer via foreign direct investment will be modeled in the same way. International technology spillovers from foreign direct investment (FDI) are measured by an FDI-ratio weighting scheme as follows

$$S_i^{fdif} = \sum_{j\neq i}^{n}\left(\frac{fdi_{ij}}{K_j}\right)A_{sup} \approx (n/\text{ב})\frac{FDI}{K_{Leader}}A_{sup} \approx (n/\text{ב})\left(\frac{FDI}{Y_{Leader}}A_{sup}\right) \quad (4)$$

Where, $Y_j \propto K_j$ and K_j is the physical capital in the country j. FDI is the total average value of inward FDI flows from partners. We assume that the country i has the technological level A_i and all other variables are defined as before. Note that "distance to frontier" has been measured using the relative gap of Tunisia's TFP to the leader's one $(A_{sup} - A_i)$. This difference indicates the technological gap in terms of the number of varieties. Based on works of (Hammami & Menegaldo, 2001; Cecchini et al., 2008; Ang & Madsen, 2013), the integrated model describing the international technology transfer can be specified by the following general function:

$$S^f = \left(S_i^{mf}\right)^a \times \left(S_i^{fdif}\right)^b \quad (5)$$

Where, a and b are the elasticities of technology transfer via import and FDI, respectively. If we replace the different elements of Eq.5 by their expressions, we obtain the following model:

$$S^f \equiv (n/\text{ב})^{ab}\left(\frac{M}{Y_i}\right)^a \times \left(\frac{FDI}{Y_i}\right)^b \left(\frac{A_{sup} - A}{A_{sup}}\right)^{ab} A^{ab} \quad (6)$$

If we replace S^f and $f(X, A)$ by their expressions and the domestic R&D intensity by the ratio $\left(\frac{H_R}{L}\right)$, we obtain the following equation:

$$\dot{A} = \delta(n/\text{ב})^{ab\text{ד}}\left(\frac{H_R}{L}\right)^{\theta}\left(\frac{M}{Y_i}\right)^{a\text{ד}}\left(\frac{FDI}{Y_i}\right)^{b\text{ד}}\left(\frac{A_{sup} - A}{A_{sup}}\right)^{ab\text{ד}} A^{\varkappa + ab\text{ד}} \quad (7)$$

If we replace the parameters $(a\text{ד})$, $(b\text{ד})$, $(ab\text{ד})$ et $(\varkappa + ab\text{ד})$ by ϵ, τ, γ et $\emptyset$, respectively, we obtain the following integrated model of technology accumulation:

$$\dot{A} = \delta' \underbrace{\left(\frac{H_R}{L}\right)^{\theta}}_{\text{Domestic innovation}} \underbrace{\left(\frac{M}{Y}\right)^{\epsilon}\left(\frac{IDE}{Y}\right)^{\tau}}_{\text{International technology spillovers}} \underbrace{\left(\frac{A_{sup} - A}{A_{sup}}\right)^{\gamma}}_{\text{Distance to frontier}} \underbrace{A^{\emptyset}}_{\text{Externality effect}} \quad (8)$$

Where, $\delta' > 0$ is a parameter of research productivity. We assume that $0 \leq \theta < 1$ and $0 \leq \emptyset < 1$. Log-linear transformation of Eq.8 gives the empirical model as follows (Ha and Howitt, 2007):

$$g_A = \alpha_0 + \alpha_1 log\left(\frac{L_R}{L}\right) + \alpha_2 logh + \alpha_3 log\left(\frac{A_{sup} - A}{A_{sup}}\right) + \alpha_4 log\left(\frac{M}{Y}\right) + \alpha_5 log\left(\frac{IDE}{Y}\right) + \varepsilon \quad (9)$$

Where, ε are identically and normally distributed shocks with zero mean and constant variance. In the above equation, TFP growth, or the left-hand term should be stationary (Ha and Howitt, 2007; Zachariadis, 2003), because in steady state, TFP growth should be constant. This model is estimated in the tunisian economy context over the period 1976 to 2010. This country is from the southern shores of the Mediterranean that has signed the bilateral partnership agreements with the EU-15. In order to upgrade its economic sectors, it's necessary to have certain choices to make, as well as reform and modernization efforts to deploy. Since the resources are limited, it needs to invest constantly in education and encourage enterprises and industrial support institutions to integrate innovation and R&D into their strategies.

Besides modernizing and improving the competitive capacity of the national industrial system, other factors, such as foreign direct investment and trade liberalization, especially with Europe, contribute to the productivity growth in Tunisia.

III. Empirical Results and Interpretations

a) Data and measurement Issues

The basic dataset for this study combines variables from different sources. In order to calculate the TFP growth rate, we follow growth accounting decomposition procedure by considering an aggregate production function, where a country's real gross domestic product (GDP), Y , is stated as: $Y = AK^{\alpha}H^{1-\alpha}$, where K is real physical capital stock and L is the total labor force. It is measured in log as follow: $log\, A = log y - \left(\frac{\alpha}{1-\alpha}\right) log\left(\frac{k}{y}\right) - log\, h$.Where y is the output-worker ratio (Y/L) and k is the capital-worker ratio (K/L). Capital's income share (α) is set to 0.30 following Gollin (2002). The ratio (k/y) is constructed using from various issues; Penn World Table (PWT version 6.3) and World Bank. The individual worker's human capital h is obtained from the estimation of a Macro-Mincer model integrating the number of years of schooling and the quality of education in nonlinear form. Average years of schooling in the population aged 15 and over and the ratio of public education expenditure to GDP as a proxy for quality of education are extracted from Barrow and Lee (2010) schooling dataset and Institute of Quantitative Studies (IQS), respectively. This study treats human capital as affecting domestically produced technological innovation and firms' absorptive capacity of new knowledge.

The R&D intensity is measured by the proportion of scientists and engineers engaged in R&D to the total labor force (see Ha and Howitt, 2007; Madsen, 2008; Madsen et al., 2009). It is parameterized by the variable$\left(\frac{L_R}{L} \approx u_R\right)$. Data on R&D activities and innovation in Tunisian firms (carried out by the Ministry of Scientific Research and Competences is obtained from the innovation survey conducted by the Ministry of Scientific Research and Competences and a various issues of the UNESCO Statistical Yearbook. The ratio of the import of technologically advanced products to GDP and the ratio of FDI inflow to GDP are is parameterized by the variables MY and $FDIY$ respectively. Data are collected from WDI (2007), the IMF dataset and the Institute of Quantitative Studies. Distance to the frontier $(A_{sup} - A)/A_{sup}$ is measured by the TFP relative gap between the EU-15 and Tunisia. It's indicated by the variable DTF.

b) Estimation results

Estimation results are reported below in Table 1 (Appendix A). The impact of domestic R&D intensity $(logu_R)$ on the productivity growth is negative (-0.069), but not significant at 5% significance level in all alternative regressions. These findings don't provide support for the Schumpeterian theory (Aghion & Howitt, 2009, Ang & Mabsen, 2012, Islam, 2010, Vandenbussche, Aghion & Meghir, 2006). There are several reasons for this surprising finding. Chellouf, Outtara and Dou (1999), for example, show that in Tunisia only a very limited effort was made to increase funding for scientific research. The innovation is negatively affected because there is no efficient cooperation between industrial firms and partners (universities, research centers, foreign corporations, etc.). In Tunisia, the economy is dominated by public sector, with an excessive control and a centralized authority. This leads to a fragmented strategy of the Research and Innovation value chain, biased by a sectorial approach. To gather all stakeholders and to produce a common ground for a coherent Innovation Agenda, it's necessary to support interface agencies involved with scientific research, to assist the R&D programs and initiatives implementation, to facilitate the Tech Transfer through collaborative projects (Hatem, 2007).

Figure 1 (Appendix B) shows a non significant relationship between R&D intensity and the average TFP growth rate over the period 1976-2010. Many raisons explain this result. One possible raison is that Tunisia allocated an insufficient amount of financial resources to the R&D, as suggested by the low estimated level of its expenditure of the GDP. In addition, the statistics on the researchers in Tunisia include a non-negligible proportion of student researchers with master and doctorate degree. It's important also to note that productive sector in Tunisia is dominated by very small enterprises with less than five employees, with little money to invest in an R&D department and more generally in the innovation activities.

Our estimations indentify that human capital has a positive impact on technology accumulation but not highly significant. One percentage point increase in the human capital creates a 0.05 percentage point increase in the average growth rate of the TFP. This finding does not strongly support the recent endeavour of the Tunisian government in improving the whole nation's education level. It can be explained by a mismatch between training and the needs of productive structures ("Education, Labor Market and Development: The Requirements of Adequacy", 1999). Tunisia has to deepen their efforts in innovation by improving the efficiency and adaptability of skilled workers as well as by adopting external know-how via more active technological collaborations with foreign partners, local laboratories, and universities.

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By removing the non significant variable (R&D intensity) from the regression equation, the statistical significance of the explanatory variables was improved except for the human capital (column 2). A new interactive variable ($Loghu_R$) that combine between skill level and the number of scientists and engineers engaged in R&D was created. The results show that this interactive variable has a positive impact on productivity growth (0.031), but not significant. This confirms the Schumpeterian theory of endogenous growth that considers that the rate of technological progress depends positively on the intensity of domestic R&D corrected by the skill level.

The estimated coefficients of distance to frontier are positive and statistically significant at the 5% level in all alternative regressions. In other word, the further a country lies behind the technology frontier, the greater will be its potential to accelerate productivity growth. These results are consistent with the results of Griffith *et al*. (2003, 2004). Figure 2 (Appendix B) shows that the relationship between technical progress and the distance to frontier is positive but not linear. The productivity growth is negative for a reduced gap ($DTF \leq 73\%$). Beyond this value, TFP growth is found to be enhanced by the distance to technology frontier. For a large technology gap the productivity growth is not very important. This implies that catch-up will be more difficult, complex and very expensive for a high technological distance.

The estimated coefficients of import of technologically advanced products are highly significant in all columns. A one percentage point increase in this variable creates an increase in the average growth rate of the TFP by more than 0.5 percentage points. This finding confirms that this variable is an important channel for the international transmission of technology in Tunisia. It is in line with the results of (Baumol, 1993; Mansfield and Romeo, 1980), among others. The graphical analyses show that the relationship between technical progress and the import of technology is not linear (see Figure 3). The productivity growth is very low for a reduced ratio $\left(\frac{M}{Y} \leq 25\%\right)$ and the positive impact on the accumulation of technology doesn't appear only beyond this value.

Estimations reveal some surprising results concerning the effects of the variable $FDIY$ on technology accumulation. Its coefficient is negative and significant thereby rejecting the idea that foreign direct investment constitutes incentives for innovation in Tunisia. One percentage point increase in the share of FDI creates a reduction of 0.11 percentage point in the average growth rate of the TFP. This result doesn't support the theory that consider FDI an important factor of building local technological capabilities for developing countries, and an important channel through which international diffusion of knowledge and technology takes place. Several reasons can explain this unexpected result. In Tunisia, the large share of FDI is concentrated in low value-added activities, including an external control of sourcing, and reliance on expatriates in managerial and technical positions. This is aggravated by the weak domestic absorptive capacity through a very limited effort to increase funding for scientific research and barriers in the domestic business climate.

The economic literature shows that developing countries need to focus more on the acquisition and assimilation of foreign technology through imitation and cooperation with multinational firms, given the high cost of creating new and better products (Howitt, 2000). In addition, technology transfer is not systematic (Sjöholm, 1999). It is closely related to the "absorptive capacity" (Blomström et al., 2000). For this purpose, we create multiplicative variables to measure the importance of the absorptive capacity in the technology spillovers. Some alternative regression will be estimated in the next section.

c) *Technology spillovers and Absorptive capacity*

Countries may differ in their effort and ability to understand and adopt new technologies compatible to their local condition which is popularly known as 'absorptive capacity' (Arrow, 1969). Abromovitz (1986) and Nelson and Phelps (1966) assume that absorptive capacity depends on the level of human capital, whereas Fagerberg (1994) and Griffith *et al*. (2003, 2004) assume that the absorptive capacity is a function of domestic innovation activities.

Tables 2 and 3 (Appendix A) summarize estimated results of TFP growth with absorptive capacity for Tunisia. Our empirical results (column1 in table 2) show a negative and significant relationship between the interactive term ($Logu_R \times LogFDIY$) and the TFP growth rate. The second column shows that the human capital based absorptive capacity exhibit negative relation with productivity but not significant (-0.148). This implies a weak complementarity between the two factors to generate productivity gains. This result is contradictory to the empirical findings results that found positive and statistically significant relationship between human capital based absorptive capacity and TFP growth. It seems that this result is explained by the existence at the lack of learning capacity and concentrated FDI in low value added activities.

Interestingly, while incorporating interaction term between $FDIY$ and distance to frontier ($LogDTF \times LogFDIY$) in the regression, the independent effect of FDI indicator becomes positive (0.13) but statistically non significant. The coefficient associated to the multiplicative variable is positive (0.967) and significant. This implies that, the further a country lies behind the technology frontier, the greater will be technology spillover from FDI. Figure 4 (Appendix B) shows that the real relationship between technical progress and the interactive term $(LogDTF \times LogFDIY)$ is positive but not linear. For a technological gap less than 74%, the correlation is positive. Beyond this threshold value, the correlation becomes negative.

Empirical evidences identify that knowledge spillovers through the channel of imports are not only important because they play an important role for growth in endogenous growth models but also because trade has often been highlighted as playing a key role in facilitating convergence (see for example Nelson and Wright, 1992). The idea behind this spillover hypothesis is that the variety and the quality of intermediate inputs are predominantly explained by R&D and, therefore, productivity is a positive function of R&D.

To test the degree of complementarity between the import of technologically advanced products and FDI to have technology transfer, we create the interactive variable ($(LogMY \times LogFDIY)$ (regression 4 in Table 2). The idea behind this spillover hypothesis is that the local absorptive capacity measured by the degree of openness of the country. The estimated coefficient is positive (0.48) but statistically non significant at the five percentage significance level. This result clearly explains the low technological potential of FDI inflows into Tunisia, which justifies the lack of interaction between the two variables. In other hand, technology spillovers from import of high-tech goods depend on domestic R&D intensity and the distance to technology frontier. For this raison two interactive variables ($LogMY \times Logu_R$ and $LogMY \times LogDTF$) are incorporated in the model (Table 3).

Our estimations show that the impact of $(logMY \times Logu_R)$ on the growth rate of TFP is negative but not significant. A positive and significant correlation is between productivity growth and the interactive variable $(LogMY \times LogDTF)$. We remark that by the introduction of this last multiplicative variable, the effect of human capital becomes more significant. The total marginal effect (independent and interactive) of imports of technologically advanced goods on productivity growth is given by the coefficient α_{MY} formulated by the following relation $\alpha_{MY} = 0.696 + 0.415 \times LogDTF$, (regression 2). If we use the average value of $LogDTF$ calculated over the period 1976-2010 in this equation, we obtain a α_{MY} =0.57. This empirical value shows that the import of technologically advanced is a main vector of the transmission of foreign knowledge in Tunisia. Its effect is positive and more enhanced by the distance to technology frontier. The graphical representation of the relationship between TFP growth and $(LogMY \times LogDTF$ is reported in the figure 5. This graph confirms the presence of a positive impact of the import of technology. This effect is important for a high technological gap but negative reduced distance.

IV. Conclusion

This paper aims to investigate the determinants of productivity growth productivity growth in the Tunisian economy context over the period 1976 to 2010. We first examine the effects of key determinants such as domestic innovation, skills, etc. on the productivity growth. We then attempt to show how these effects are moderated by liberalization as measured by the opening up to foreign investment and by import of technologically advanced products, especially from Europe.

Empirical results show that the impact of domestic R&D intensity on the productivity growth is negative but not significant in all alternative regressions. The effect of foreign direct investment is significantly negative. Its interactive effect with capital human on the productivity growth is also negative but not statistically significant. This implies the weak complementarity between the two factors to generate productivity gains. Apparently, Tunisia needs to have reached a certain level of development in education, technology, infrastructure before being able to benefit from a foreign presence in their markets. Our findings confirm that the import of technologically advanced products is an important channel for the international transmission of technology in Tunisia. Its effect on the knowledge accumulation is positive and more enhanced by the distance to technology frontier. Our results identify also that human capital has a positive but not significant impact on technology accumulation in Tunisia. Despite the high priority given by Tunisia to education and training young people, the capacity for innovation is still limited. The role of human capital is rather more significant in the assimilation and absorption of foreign technology.

An innovation strategy for Tunisia should therefore focus not only on creating technology, but also on technology adoption and adaptation. Tunisian firms have to deepen their efforts in innovation by improving the efficiency and adaptability of skilled workers as well as by adopting external know-how via more active technological collaborations with foreign partners, local laboratories, and universities.

Appendix

Appendix A: List of regression tables

Table 1: R&D Intensity, Distance, Foreign R&D capital and TFP Growth

Dependant Variable: Total Factor Productivity $\Delta Log(A)$			
	(1)	(2)	(3)
$Logu_R$	-0.069 (-0.95)		
Logh	0.059 (1.82)	0.040 (1.65)	
$Loghu_R$			0.031 (1.61)
LogDTF	1.53^{**} (2.55)	1.479^{**} (3.56)	0.94^{**} (2.45)
LogFDIY	-0.128^{**} (-4.03)	-0.127^{**} (-6.87)	-0.09^{**} (-5.32)
LogMY	0.589^{**} (2.14)	0.560^{**} (3.00)	0.51^{**} (2.33)
_Cons	- 1.46 (-1.47)	-1.296 (-1.82)	-1.285 (-1.6)
Fisher	211.69	97.03	74.04
R-squared	0.98	0.98	0.97

Note: Figures in parentheses ( ) are t-values significant at 5% level (**).

Table 2: Foreign Direct Investment, Absorptive Capacity and TFP Growth

Dependant Variable: Total Factor Productivity $\Delta Log(A)$				
	(1)	(2)	(3)	(4)
Logh	0.045 (1.58)		0.084 (1.90)	0.049 (1.1)
LogDTF	1.635** (4.92)	1.538** (2.46)		1.12** (2.69)
LogFDIY	-0.198** (-6.64)	-0.138** (-4.08)	0.130 (1.1)	-1.66 (-1.37)
LogMY	0.509** (2.31)	0.563 (1.66)	0.894** (4.84)	
$Logu_R \times$ LogFDIY	-0.070** (-2.03)			
Logh$\times$ LogFDIY		-0.148 (-1.14)		
LogDTF $\times$ LogFDIY			0.967** (2.36)	

LogMY × LogFDIY				0.48 (1.31)
_Cons	- 1.094 (-1.38)	-1.281 (-1.02)	-2.81** (- 4.80)	0.37** (2.87)
Fisher	331.92	36.36	143.44	26.60
R-squared	0.98	0.96	0.93	0.95

Note: Figures in parentheses ( ) are t-values significant at 5% level (**).

Table 3: Imports of foreign technology, Absorptive Capacity and TFP Growth

Variable dépendante: $\Delta \boldsymbol{Log}(\boldsymbol{A})$

	(1)	(2)	(3)
$Logu_R$	-0.056 (-1.08)		
Logh	0.052** (2.47)	0.040** (3.41)	0.042 (1.73)
LogFDIY	-0.123** (-6.04)	-0.128** (-6.81)	-0.121** (-4.59)
LogDTF			1.644** (2.71)
LogMY	0.693** (4.86)	0.696** (.03)	0.511 (1.79)
LogMY ×LogDTF	0.492** (3.84)	0.415** (4.55)	
LogMY × $Logu_R$			-0.013 (-0.55)
_Cons	- 1.767** (-3.23)	- 1.843** (-3.44)	- 1.143 (-1.13)
Fisher	268.46	37.64	334.85
P-value	0.03	0.00	0.00
R-squared	0.98	0.98	0.97

Note: Figures in parentheses ( ) are t-values significant at 5% level (**).

Appendix B: List of figures

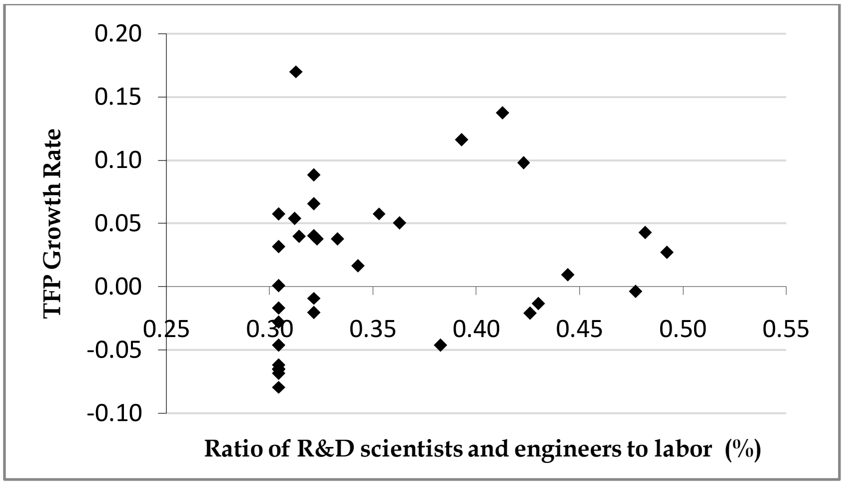

Figure 1: Domestic R&D intensity versus TFP growth (1976 – 2010)

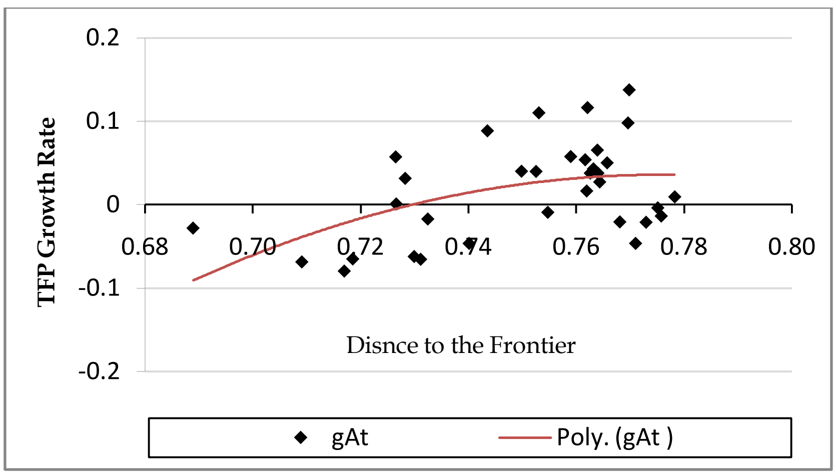

Figure 2: Distance to the frontier versus TFP growth (1976 – 2010)

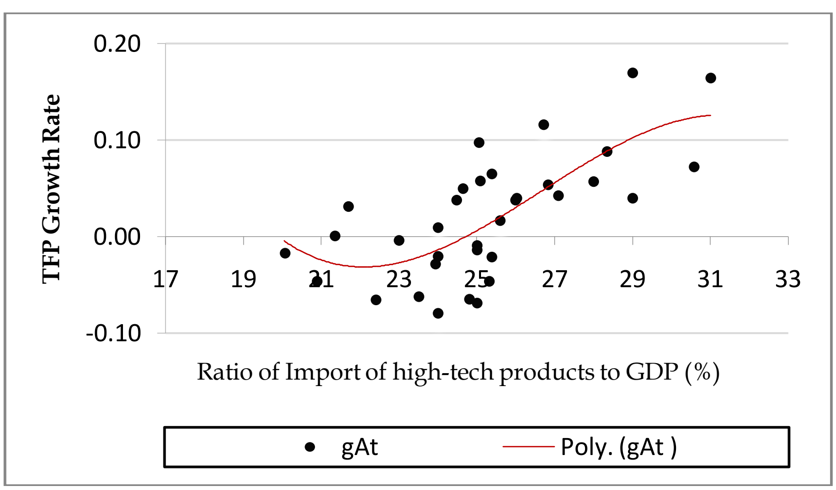

Figure 3: Import of foreign technology versus TFP growth (1976 – 2010)

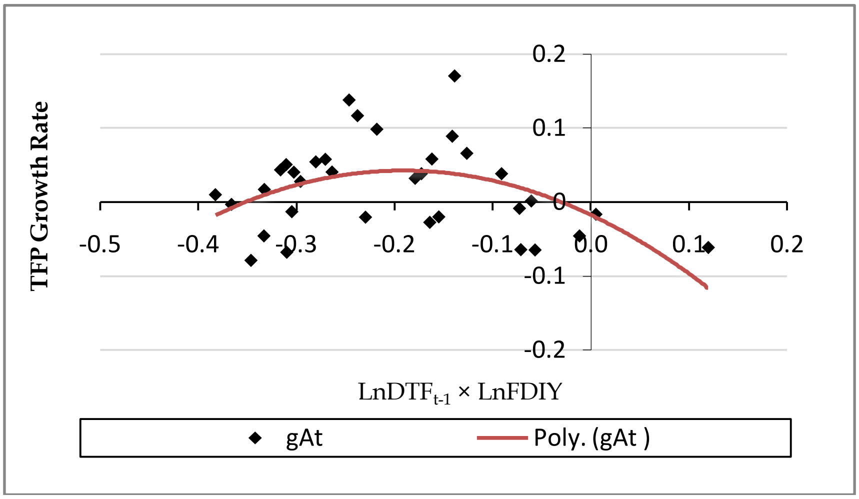

Figure 4: Interactive variable $(LogDTF \times LogFDIY)$ versus TFP growth(1976 – 2010)

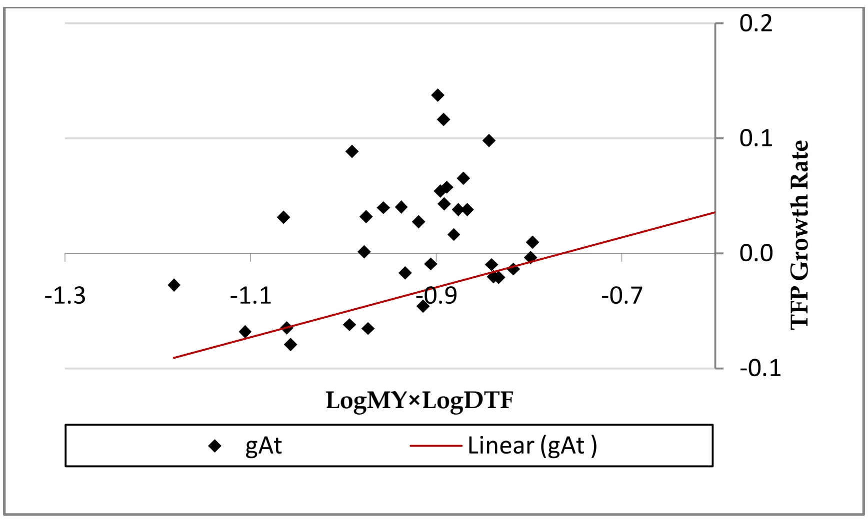

Figure 5: Interactive variable $(LogDTF \times LogMY)$ versus TFP growth(1976 – 2010)

Bibliographie

1. Abromovitz, M., (1986): Catching Up, Forging Ahead, and Falling Behind, *Journal of Economic History*, 46, 386-406
2. Aghion, P. and Howitt, P., (1992): A Model of Growth through Creative Destruction, *Econometrica*, 60, 323-351.
3. Aghion, P. and Howitt, P., (1998): Endogenous Growth Theory, (Cambridge: MIT Press).
4. Aghion, P. Bloom, N., Blundell, R., Griffih, R. and Howitt, P. (2005): Competition and Innovation: An Inverted-U Relationship, *The Quarterly Journal of Economics*, Vol. 120, No. 2, pp. 701-728.
5. Aghion, P. and Howitt, P., (2006): Joseph Schumpeter Lecture Appropriate Growth Policy: A Unifying Framework, *Journal of the European Economic Association* 4: 269-314.
6. Aghion, P. and Howitt, P., (2009): The Economics of growth, MIT Press pp. 267-283
7. Ang, B., Madsen, B. and Saxena, J., (2009): The Indian Growth Miracle and Endogenous Growth, *Journal of Development Economics*, forthcoming, (doi:10.1016/j. jdeveco.2009.06.002)
8. Ang, B and Madsen, B., (2013): International R&D spillovers and productivity trends in the Asian miracle economies. *Economic Inquiry*, *51*(2), 1523-1541.
9. Arrow, J., (1969): Classificatory Notes on the Production and Transmission of Technological Knowledge, *American Economic Review* Papers and Proceedings 59: 29-35.
10. Barro, J. and Lee, J. (2010), A New Data Set of Education Attainment in the World, 1950-2010, National Bureau of Economic Reseach, document de travail n° 15902.
11. Baumol, W., (1993) Entrepreneurship, Management and the Structure of Payoffs, MIT Press, Cambridge, MA, USA.

12. Blomström, M. and Kokko, A., (2000): Foreign Direct Investment, Firm and Host Countries strategies, MacMillan.
13. BM (2000): Rapport sur le développement dans le monde 1999-2000, ed *Eska*.
14. Borensztein, E. De Gregorio, J. and Lee, W., (1995): How Does Foreign Direct Investment Affect Economic Growth? *Journal of international economics*, vol 45.
15. Botirjan, B. (2013), FDI and Total Factor Productivity Growth: New Macro Evidence, *Discussion Paper 27/13*, Department of Economics, Monash University, Clayton, Australia.
16. Bouoiyour, Yazidi (2000): Productivité et Ouverture en Afrique du Nord, Article présenté au colloque international: *Ouverture économique et développement*, 23-24 juin, Tunis.
17. Cameron, G., (2003): Why did UK manufacturing productivity growth slowdown in the 1970s and speed up in the 1980s?, *Economica*, 70 121-41.
18. Cecchini, L. and Lai-Tong, C., (2008): The Links between Openness and Productivity in Mediterranean Countries, *Applied Economics*, 2008, 40, 685–697.
19. Chellouf, I, Outtara, O. et Dou, H., (1999): La Nécessité de la Veille Technologique en Tunisie, *International Journal of Information Sciences and Decision Making*, n°3, pp. 35-47.
20. Coe, T, and Helpman, E., (1995): International R&D Spillovers, *European Economic Review* 39: 859-887.
21. Coe, T, Helpman, E and Hoffmaister, W., (1997): North-South R&D Spillovers, *the Economic Journal* 107: 134-149.
22. Dangerfield, M., (2000): Sub-Regional Economic Cooperation in Central and Eastern Europe: The Political Economy of CEFTA, Cheltenham: Edward Elgar
23. Dinopoulos, E and Thompson, P., (1998): Schumpeterian Growth without Scale Effects, *Journal of Economic growth*, 3(4): 313-35.
24. Eaton, J. and Kortum, S., (1999): International Technology Diffusion: Theory and Measurement, *International Economic Review*, 40, 537-70
25. Fagerberg, J., (1994): Technology and International Differences in Growth Rates, *Journal of Economic Literature*, 32, 1147-75
26. Gerschenkron, A, (1952): Economic Backwardness in Historical Perspective, dans Bert F. Hoselitz, ed. *The Progress of Underdeveloped Areas*, Chicago, University of Chicago Press, p. 3-29.
27. Gollin, D., (2002): Getting Income Shares Right, *Journal of Political Economy*, 110, 458-74
28. Griffith, R, Redding, S and Van Reenen, J., (2003): R&D and Absorptive Capacity: Theory and Empirical Evidence, *Scandinavian Journal of Economics*, 105, 99-118
29. Griffith, R, Redding, S and Van Reenen, J., (2004): Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries, *Review of Economics and Statistics*, 86(4), 883-895.
30. Grossman, G and Helpman, E., (1991): Quality Ladders in the Theory of Growth, *Review of Economic Studies,* 58, 43-61.
31. Ha, J and Howitt, P., (2007): Accounting for Trends in Productivity and R&D: A Schumpeterian Critique of Semi-Endogenous Growth Theory, *Journal of Money*, *Credit and Banking*, 30(4): 733-774.
32. Hall, R and Jones, C., (1999): Why Do Some Countries Produce So Much More Output Per Worker Than Others, *Quarterly Journal of Economics*, Vol. 114 (1) 1999, 83-116.
33. Hammami, Menelgado (2001) : Ouverture et Externalités Internationales de la R&D : Une Analyse du Sud de la Méditerranée, Colloque International *d'Économie*, Tunis.
34. Hatem, M. (2007): Le système national de recherche en Tunisie, Projet ESTIME, Contrat n°510696 Appel d'offre FP6-2002- INCO- COMultilat RTD/SSA-5.
35. Howitt, P., (1999): Steady Endogenous Growth with Population and R&D Inputs Growing, *Journal of Political Economy*, 107, 715-730.
36. Howitt, P., (2000): Endogenous Growth and Cross-Country Income Differences, *American Economic Review*, vol. 90, pp. 829-846.
37. IÉQ (2001): Impact de l'Instauration d'une Zone de Libre-échange avec l'Union Européenne, *Cahiers de l'IEQ* - Numéro: 15.
38. IÉQ (2008): Rapport Annuel sur la Compétitivité 2007, Tunis.
39. Islam, R. (2010), Human Capital Composition, Proximity to Technology Frontier and Productivity Growth, Department of Economics, discussion paper, 23(10), 1-41.
40. Jones, C., (1995): R&D-Based Models of Economic Growth, *Journal of Political Economy* 103: 759-784.
41. Kortum, S., (1997): Research, Patenting and Technological Change, *Econometrica*, 65, 1389-1419.
42. Kneller, R and Stevens, P., (2006): Frontier Technology and Absorptive Capacity: Evidence from OECD Manufacturing Industries, *Oxford Bulletin of Economics and Statistics*, 68, 1-21
43. Lichtenberg, R and Van Pottelsberghe de la Potterie, B., (1998): International R&D Spillovers: A Comment, *European Economic Review*, 42, 1483-1491.
44. Madsen, B and McAleer, M., (2000): Direct Tests of the Permanent Income Hypothesis under Uncertainty, Inflationary Expectations and Liquidity

Constraints, *Journal of Macroeconomics*, 22(2), 229-252.

45. Madsen, B., (2008): Semi-Endogenous versus Schumpeterian Growth Models: Testing the Knowledge Production Function using International Data, *Journal of Economic Growth*, 13, 1-26.
46. Mansfield, E and Romeo, A., (1980): Technology Transfer to Overseas Subsidiaries by U.S.-Based Firms, *Quarterly Journal of Economics* 95, p. 737–750.
47. Mincer, J., (1974): Schooling, Experience and Earnings, National Bureau of Economic Research, Columbia University Press, New-York.
48. Nelson, R. and Phelps, S., (1966): Investment in Humans, Technological Diffusion, and Economic Growth, *American Economic Review*, 56, 69 -75.
49. Nelson, R. and Wright, G., (1992): The Rise and Fall of American Technological Leadership: The Postwar Era in Historical Perspective, *Journal of Economic Literature* 30: 1931-1964.
50. Neven, Mimica (2002): How are Stabilisation and Association Agreements paving the way to EU Membership?, address given at the Wilton Park Conference *Enlarging the European Union*, Sofia, 19 March.
51. Romer, P., (1990): Endogenous Technological Change, *Journal of Political Economy*, vol. 98, no 5, pp. 71-102, October.
52. Savvides, A. and Zachariadis, M., (2005): International Technology Diffusion and the Growth of TFP in the Manufacturing Sector of Developing Economies, *Review of Development Economics* 9(4): 482-501.
53. Segerstrom, P., (1998): Endogenous Growth without Scale Effects, *American Economic Review,* 88, 1290-1310.
54. Tlili, A., (2006) : Retombées de la R&D Domestique et Étrangère sur la Productivité Totale des Facteurs: Un Essai d'Évaluation Pour le Cas de la Tunisie, Thèse de Doctorat, Faculté des Sciences Économiques et de Gestion de Sfax.
55. Vandenbussche, J., Philipe, A. and Costas, M., (2006): Growth, Distance to Frontier and Composition of Human Capital, *Journal of Economic Growth* 11 (2): 9–127.
56. Young, A., (1998): Growth without Scale Effects, *Journal of Political Economy* 106(1): 41-63.
57. Xu, B., (2000): Multinational Enterprises, Technology Diffusion, and Host Country Productivity Growth, *Journal of Development Economics*, 62, 477- 93
58. Zachariadis, M., (2003): R&D, Innovation, and Technological Progress: A Test of the Schumpeterian Framework without Scale Effects, *Canadian Journal of Economics*, 36, 566-86.