Domestic R&D Intensity, Technology Transfer and Growth of Productivity: An Empirical Investigation of Tunisian Case

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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 RD 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.

Index terms— innovation, human capital, external technology transfer, absorptive capacity, total factor productivity.

1 Introduction

ndogenous 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 firstgeneration R&D-based endogenous growth models. Consequently, endogenous growth theory has evolved into the two following second-generation theories: semiendogenous 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., 2003Griffith et al., , 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.

ii.

2 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:

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

Where, ?? stands for the host country (it's Tunisia in this study), ?? indexes Tunisia's import partners (example l'EU-15 in our case) and ?? ???? is Tunisia's import of high-technology products from country ??.

We indicate by ?? ???????????? 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 ?? ?????? . At any period of time it's possible to express the output of a partner country as follow: ?? ?? = ? ?? ?? ???????????? , where ? ?? is a positive constant.

So that, it's possible to define ?? ?? ??ð ??"ð ??" by the following general form: ?? ?? ??ð ??"ð ??" = ? ? ??
???? ?? ?? ? ?? ?? ??? ?? ??????

Where, (?? ?? ???????????? ?) 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 FDIratio weighting scheme as follows Where, ?? ?? ? ?? ?? and ?? ?? is the physical capital in the country ??. ?????? is the total average value of inward FDI flows from partners. We assume that the country ?? has the technological level ?? ?? 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 ??? ?????? ? ?? ?? ?. Where, ?? ? > 0 is a parameter of research productivity. We assume that 0 ? ?? < 1 and 0 ? ? < 1. Loglinear transformation of Eq.8 gives the empirical model as follows (Ha and Howitt, 2007):

Where, ?? 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 ?? ?? ??ð ??"ð ??" = (?? ? ?) ? ? ?? ???? ?? ?? ?? ??? ?? ???????????? ? ?? ?????? = (?? ? ?) ? ?? ?? ???????????? ?? ?????? ?**(3) (4)**

(5) iii.?? ?? ð ??"ð ??"????ð ??"ð ??" = ? ? ð ??"ð ??"???? ???? ?? ?? ? ?? ?? ??? ?? ?????? ? (?? ? ?) ?????? ?? ???????????? ?? ?????? ? (?? ? ?) ? ?????? ?? ???????????? ?? ?????? ? ?? ð ??"ð ??" = ??? ?? ??ð ??"ð ??" ? ?? × ??? ?? ð ??"ð ??"????ð ??"ð ??" ? ?? ?? ð ??"ð ??" ? (?? ? ?) ???? ? ?? ?? ?? ? ?? × ? ?????? ?? ?? ? ?? ? ?? ?????? ? ?? ?? ?????? ? ???? ?? ???? ?? ?= ??(?? ? ?) ???? ? ? ?? ?? ?? ? ?? ? ?? ?? ?? ? ??? ? ?????? ?? ?? ? ??? ? ?? ?????? ? ?? ?? ?????? ? ???? ? ?? ?? +???? ?**(6) (7) (8)**

3 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), ?? , is stated as: ?? = ???? ?? ??

4 b) Estimation results

Estimation results are reported below in Table 1 (Appendix A). The impact of domestic R&D intensity (???????? ??) 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, **??**ghion & 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. 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 (????????? ??) 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. (2003Griffith et al. (, 2004)). Figure **??** (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 (?????? ? 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 **??**). The productivity growth is very low for a reduced ratio ? ?? ?? ? 25%? 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 ???????? 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.

5 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. (2003Griffith et al. (, 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 (???????? ?? × ??????????????) 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 ???????? and distance to frontier (???????????? × ??????????????) 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 **??** (Appendix B) shows that the real relationship between technical progress and the interactive term (???????????? × ??????????????) 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 ((?????????? × ??????????????) (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 (?????????? × ???????? ?? and ?????????? × ????????????) are incorporated in the model (Table 3).

Our estimations show that the impact of (?????????? × ???????? ??) on the growth rate of TFP is negative but not significant. A positive and significant correlation is between productivity growth and the interactive variable (?????????? × ????????????). 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 ?? ???? formulated by the following relation ?? ???? = 0.696 + 0.415 × ????????????, (regression 2). If we use the average value of ???????????? calculated over the period 1976-2010 in this equation, we obtain a ?? ???? =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 (?????????? × ???????????? is reported in the figure

??. 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.

6 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.

7 IV.

8 Appendix

Appendix A: List of regression tables [1] [2] [3]

Figure 1:

Figure 2:

Figure 3:

[2] ( ) B Domestic R&D Intensity, Technology Transfer and Growth of Productivity: An Empirical Investigation of Tunisian Case

[3] Domestic R&D Intensity, Technology Transfer and Growth of Productivity: An Empirical Investigation of Tunisian Case

Figure 4:

Figure 5:

1

Figure 6: Figure 1 :

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Figure 7: Figure 2 :Figure 3 :Figure 4 :Figure 5 :

?? 1???

? ?? ?
??????? ???????
? ?.Where
?? is
the

output-worker ratio (?? ?? ?) and ?? is the capital-worker ratio (?? ?? ?). Capital's income share (??) is set to 0.30 following Gollin (2002). The ratio (?? ?? ?) is constructed using from various issues; Penn World Table (PWT version 6.

Figure 8:

1

	(1)	(2)	(3)
Logu R	-0.069		
	(-0.95)		
Logh	0.059	0.040	
	(1.82)	(1.65)	
Loghu R			0.031
			(1.61)
LogDTF	1.53 **	1.479 **	0.94 **
	(2.55)	(3.56)	(2.45)
LogFDIY	-0.128 **	-0.127 **	-0.09 **
	(-4.03)	(-6.87)	(-5.32)
LogMY	0.589 **	0.560 **	0.51 **
	(2.14)	(3.00)	(2.33)
_Cons	-1.46	-1.296	-1.285
	(-1.47)	(-1.82)	(-1.6)
Fisher	211.69	97.03	74.04
R-squared	0.98	0.98	0.97
Note:			

Figure 9: Table 1 :

2

	(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 × LogFDIY	-0.070** (-2.03)			
Logh× LogFDIY		-0.148 (-1.14)		
LogDTF × LogFDIY			0.967** (2.36)	

Figure 10: Table 2 :

3

Variable dépendante: ???????(??)			
	(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:			

Figure 11: Table 3 :

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