DOI: 10.7763/IPEDR. 2014. V69. 7

Determinants of Technology Diffusion in the Tunisian Manufacturing Sector

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Abstract. This paper attempts to discuss factors or channels that determine the diffusion of technology especially in the Tunisian manufacturing sector during 1993-2012. Technology plays an important role as a source of growth. However, the understanding of mechanisms by which technology involved in determining business performance differs depending on the industry studied (depending on whether it is a high or a low technology), the level of human capital and also the importance of trade and foreign direct investment. In this perspective the empirical study is to analyze the relationship between total factor productivity (as an indicator of the technological progress) and the determinants of technological diffusion. Empirical results suggest that openness to foreign companies and the Trade in *ICT* and in manufacturing medium high technologies had a significant role in the diffusion of technology but the presence of foreign firms hadn't a vehicle for technology diffusion for the Tunisian manufacturing sector. This reveals that the diffusion of technology requires certain conditions such as the importance of research and development and improves the absorption capacity.

Keywords: Technology Transfer, Foreign Presence, Openness, Total Factor Productivity Growth, Trade in Information and Communication Technologies (*ICT*).

1. Introduction

Technological progress is an important driver of economic growth which leads developing countries to rely on the transfer of technology in order to benefit from the positive effects of technology developed countries.

According to the economic growth theory, the question of the diffusion of new technologies is particularly important. Technological changes have an effect on the long-term growth [1] and [2]. In addition, differences in technology represent an important determinant of differences in total factor productivity across countries [3] and [4].

Indeed the determinants of the technological change can be classified into two categories. They can be either exogenous (not dependent on economic conditions) or endogenous (that meet economic obligations)

The technological change is characterized by three stages: invention, innovation and diffusion. The first two steps are part of the activity of research and development (R&D). However, the interaction between R&D and diffusion may well determine and describe the process of the technological change. Usually we measure the change in productivity with the growth of the *TFP* . The *TFP* rises when there is an increase in activities related to innovation, called technological change. However, the *TFP* also increases when the economy uses more effectively and more efficiently its technological and productive factors.

One pertinent issue is to examine the determinants of technology diffusion in the Tunisian manufacturing sector. This paper is organized as follows: Section 2 presents empirical framework for the study of channel of technology transfer. Section 3 analyzes the determinants of technology transfer in the Tunisian manufacturing industry. Section 4 presents the empirical results and their discussion. Finally section 5 concludes.

2. Empirical Literature Review

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Several empirical studies have focused on the effect of the technology and the channels of transmission spillovers. Most of these studies found that the new advanced technology can be transferred in developing countries through the Foreign Direct Investment (FDI).

An analysis of Chinese firms [5] found that the foreign presence has a significant impact on domestic firms through backward and forward (vertical) linkages.

In a similar approach [6], using a cross section finds the evidence of technology diffusion from the foreign direct investment spillovers, however it should be noted that the knowledge spillovers from the foreign presence may take time to manifest themselves. Other scholars [7] found that the R&D stock play a significant role in determining the technology diffusion. However, [8] found the evidence of technological transfer through the effects of competition from the foreign presence using data at the Indonesian firms in the chemical and pharmaceutical industries. Study [9] showed that spillovers productivity exist through the backward linkage in Romania. They find that the foreign investment and the existence of the trade agreements between the host and the home country have positive effects on the domestic producers. Literature has also emphasized the importance of the human capital in the process of the technological transfer. There are many works which consider the learning and the human capital as a factor of the growth especially in the technological change in a host country. By [10] technology diffusion depends on the level of education, [11] argue that adoption of technology diffusion depends on the level of human capital. As well as [12] found a positive effect of the human capital in the absorption of the international knowledge spillovers. [13] Concludes that effect of the technology spillovers varies according to the level of the human capital and the domestic research and development and the physical distance.

3. Determinants of the Technological Diffusion

A various literature surveys on the technological spillovers have identified several channels through which productivity spillovers may occur. Indeed, the technological spillovers may occur through the foreign direct investment (FDI), the trade, the new technologies of information and communication ($NTIC$), the research and development, the level of education (human capital).

3.1. FDI and the development of the manufacturing sectors in Tunisia

The manufacturing sector is the main contributor to the growth in Tunisia. Fig 1 shows that from 2000 to 2011, the value added in the industry has evolved in the relation to its manufacturing component. In effect, since the third quarter of 2006, the manufacturing industry is boosted by the strong expansion of the Mechanical and the Electrical Industries (EMI) and to a lesser extent by the temporary resumption of production industries Textiles, Clothing and Leather (THC) after a long period of decline.

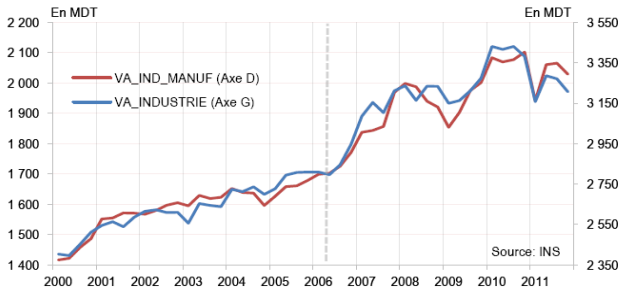

Fig. 1: Evolution of manufacturing and overall industrial activity

There are about 72% of the foreign firms operating in Tunisia which are totally exporting, FDI generate 1/3 of total exports of Tunisia.

The entry of the foreign owned firms increases the level of competition within the industry as long as the share of their output is sold in the host country.

In addition we note that the geographical position influence on the attractiveness of the FDI and facilitate the diffusion of the knowledge and the technology which in turn had an impact on the human capital in Tunisia by contact with the multinationals which helps to learn the new practices of the foreign

firms to the local firms. According to *FIPA*[1], the *FDI* accounted for in 2008, 7% of the *GDP* (see fig 2) and contributed to 23.3% of the gross fixed capital formation and 38% of the private investment.

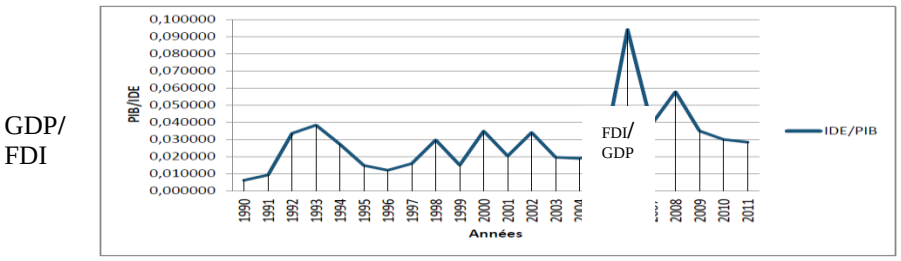

Fig. 2: Evolution of FDI of GDP in Tunisia.

3.2. Openness to trade

The openness is an important factor for explaining the technological diffusion and the technological change. According to [14] "Importing a foreign intermediate good [...] Allows a country to capture the R&D or technology-content of the good". However, the international trade has an impact on the allocation of resources, thus allowing the development of industries and the redeployment of resources from the less efficient sectors to the more efficient sectors this therefore contributes to increase the total factor productivity (*TFP*) in particular for the developing countries of the intensive labor, the low level of development and the strong ability to acquire and attract the human and the physical capital. The export increases the technical efficiency and improves the production process through learning new practices [15]. Exposure to international competition may allow firms to learn about the new technologies. Indeed, access to the intermediate inputs and the capital goods through the foreign imports may be associated with the higher growth for the productivity.

The opening of the Tunisian economy and the creation of a free trade area with Europe for the industrial products since 2008 has resulted in a reversal of the positive trend in the total factor productivity. In a zero growth over the period 1980-1990, the total factor productivity has increased steadily to 1.24% on average in 1990 and 1.38% for the period 2001-2006 [16].

Tunisia has strengthened its integration into the international economy since 1990. The international opening of Tunisia has made the foreign trade and the foreign investment, the two main drivers of the growth. The opening of the economy rate is 107.33% in 2009[1] higher than in Turkey (47.66%) and Morocco (68.08%). Better integration of the onshore economy will increase the effects of spillovers in terms of the growth and the job creation.

3.3. Education level and research and development

The education level is an indicator of the human capital it can test the absorbency and measures the level of the control and the use of the technologies. This variable can be included in determining the technological change.

Tunisia has in 2010 a comprehensive system of the innovation and the technical support to the firms, it is composed of an upper for Scientific Research and Technology to identify policy options, 15 research centers board (146 laboratories and 638 research units), eight sector technical centers to provide technical support to enterprises, 9 technology parks, a national institute of standards and intellectual property agency to promote the research, the innovation and the creation of firms.

The introduction of new technologies in firms requires the promotion of research and development (R&D).

R&D is an important determinant of competitiveness and a necessary condition for the transfer and the technological development, as well, spending on R&D generally reflect the effort of the country in the creation and exploitation of new knowledge and technologies. In this context and in order to encourage companies to invest in R&D, Tunisia has implemented a program upgrade (*PMN*) which aims to stimulate the R&D. The implementation of this program has helped the firms to integrate technology in their industrial

[1] African Development Bank, Report 2012-2013.

activities. These are large firms that have benefited most from the program upgrade, since 81% of them have at least an industrial technology against 70%[2] for small and medium firms.

The analysis by sector showed that the firms in the mechanical and electrical industries and textile clothing industries are those that provide relatively great importance to the contribution of the technological progress to production with 93% and 90% respectively.

In the building materials and glass ceramic industry there are 58% of the firms that have R&D activities followed by the chemical industry (54%) and the electrical mechanical industry (48%). The sectors that have created more new products since joining the program upgrade are the mechanical and the electrical industry (47%) followed by the chemical industry (19%) and the building materials and the ceramic glass industry (16%). Regarding the effort in the innovation and the R&D, The internal research and development expense as a percentage of GDP in Tunisia reached 1.21% in 2009 against 0.46% in 2000, it is multiplied by three. This proportion remains below the levels observed in Finland and Korea, however, is higher than that recorded in Turkey.

3.4. New technologies of information and communication

Access to information and communication technologies (*ICT)* is a necessary condition for the establishment of a knowledge-based economy. If in addition, these technologies are used well, they help to achieve a good performance in terms of the growth and the productivity.

The information and communication technologies (*ICT*) growth products over the period 2001-2011 has increased exponentially in Tunisia, with a peak of 54% in 2010.

The dynamics of the *ICT* products is reflected in the structure of the manufacturing trade. Indeed, over the period 2001-2010, the share of these products in exports increased from 4.3% to 11.4%. This share is even consolidated in 2011 this share attained 13.6% against 10.6% and 8.6, compared to the same period in 2010 and 2009[3]. It is also clear that the change in the structure of the imports reveals the emergence of the *ICT* products as their share of imports continues to rise, reaching 11.3% in 2010, compared with 8% in 2001.
Furthermore, the growth of the exports of the *ICT* products is growing faster than the imports witch improved the coverage rate. Thus, the rate of coverage of the imports of the *ICT* goods by the exports almost doubled between 2001 and 2010, 68% against 37%, respectively[4].

4. Empirical Estimation and Results

A technological point of view we chose to evaluate the impact of the technological transfer on the growth of the manufacturing sector from a standard Cobb-Douglas function of type $Y = AK^{\alpha}L^{\beta}$, A in this expression represents the total factor productivity (as an indicator of technological progress).

4.1 Model to estimate

Hence the model used in this paper is as follows:

$$\mathrm{TFPG} = \mathrm{f}\left(\mathrm{FP},\ \mathrm{Openness},\ \mathrm{ICT},\ \mathrm{LF}\right)$$

$$\mathrm{TFPG}_t = \alpha_0 + \alpha_1 \mathrm{FP}_t + \alpha_2 \mathrm{Openness}_t + \alpha_3 \mathrm{ICT}_t + \alpha_4 \mathrm{LF}_t + \varepsilon_t \qquad (1)$$

Where:

TFPG = the total factor productivity growth in the manufacturing industry,

FP = share of the foreign firms in the manufacturing industry as measured by the *FDI* in the manufacturing sector in the total *FDI* ,

Openness = the trade ratio of the value added of the manufacturing sector,

[2] From Tunisian Institute of Competitiveness and Quantitative Studies
[3] From national institue of statistics.
[4] Tunisian Institute of Competitiveness and Quantitative Studies

ICT = the sector of information and communication technology output growth in manufacturing[5],

LF[7] = Percentage of the employed person acquired tertiary education.

The application of the method of ordinary least squares to Equation (1) gives us the elasticity's theoretically insignificant and the value of Durbin Watson does not certify the absence of autocorrelation of errors. For this we introduce a dummy variable that takes the value 0 for years prior to 2008[6] and 1 other.

We can on the basis of previous remarks write the model equation as follows:

$$\mathrm{TFPG_t} = \alpha_0 + \alpha_1 \mathrm{FP_t} + \alpha_2 \mathrm{Openness_t} + \alpha_3 \mathrm{ICT_t} + \alpha_4 \mathrm{LF_t} +_? \gamma \mathrm{Dummy} + \varepsilon \quad (2)$$

The application of the OLS method allows us to obtain the following results

$$TFPG_t = \underbrace{0.024042}_{(1.474240)} + \underbrace{0.017285\mathrm{FP}}_{(0.394200)} + \underbrace{(-0.022668)\mathrm{Openness}}_{(2.123275)^{**}} + \underbrace{0.028613\mathrm{ICT}}_{(0.540870)?} + \underbrace{1.903452\mathrm{LF}}_{(1.320570)?} + \underbrace{0.039964 Dummy}_{(2.921005)^{*}}$$

Value in parentheses indicate the value of Student's t (*)

And (**) indicates that the significance level is lower respectively 5% and 10%

4.2 Test of cointegration

These variables (TFP, FP, ICT) are integrated of the same order $I(0)$, so we can apply the Johansen co integration test to obtain the number of the cointegrating vector.

$$\Delta \mathrm{X_t} = \sum \Gamma_{\mathrm{i}} \Delta\ \mathrm{X_{t-i}} + \Pi \mathrm{X_{t-1}} +\ \varepsilon_t$$

The VECM model has information about the short and long run adjustment to change in α_t via the estimated parameters T_i and Π_i

There the expression ΠX_{t-1} is the error correction term and Π can be factored into two separate matrices α and β, such as $\Pi = \alpha\beta'$ denotes the vector of co integrating parameters while α is the vector of error correction coefficient measuring the speed of the convergence to the long run steady state.

Our variables are found cointegrated, Trace test indicates 2 co integrating equations at the 0.05 level. The test meaning is that they share a common stochastic trend and will grow proportionally in the other words they move together in the long run or they have a long run relationship.

The results of the model estimation error correction showed that the variables $(FP, XTIC, MTIC)$ can affect jointly the *TFP* growth because $\Pr ob(F - static) = 0.034916 < of\ 0,05$.

4.3 Effect of the technological externalities on the TFP of the Tunisian manufacturing sector

In the following Table I we have tried to determine the effect of the technological externality on the total factor productivity while taking into account the technological content.

Found results clearly show that all three models indicates a significant and negative effect of the foreign trade on the total factor productivity this can be explained by: - The absence of the technological expertise that can reduce the growth rate of the *TFP*.

- Opening to the outside can reduce the growth through the exchange rate (Balassa effect).
- Opening can be beneficial if the country has a sufficient absorption capacity to absorb and develop the new technologies.

[5] Externalities related to ICT are widely spread in the economy that can increase efficiency and productivity rate of technical progress

[6] 2008: Entry into force of the free trade zone EU-Tunisia for industrial products

The TFP growth is explained by the level of the human capital as a significant relationship between the TFP and the labor force as a proxy for the human capital. The negative effect of this variable (LF) is explained by the low level of the human capital in the absorption of the technologies arising from the inefficiency of the Tunisian educational system.

The absorptive capacity is necessary for the success of technological diffusion. According to the table we note that the foreign technology is diffused when there is an absorption capacity ($LF \times MMA$ variable measures the diffusion of technologies by manufacturing imports multiplied by the absorption capacity which is expressed by the labor force)

Trade in *ICT* and in manufacturing medium high technologies had a significant role in the diffusion of technology. A 10% growth of the imports of ICT leads to a TFP growth of 34%.

Table I: Determinant of the Technological Diffusion of the Tunisian Manufacturing Sector [Dependent Variable is TFP Growth]

	1	2	3	4
constante	0.024 (1.474)	1.325** (7.69)	0.03607* (2.7288)	0.0225 (1.1535)
LF: labor force	0.1903 (1.3205)	-0.14918** (8.3111)	-0.46183* (-2.3045)	-0.04599** (-1.937)
Xma: Exportation of manufacturing sector		0.00107** (7.781)	−4.09*E* −06 (−1.1539)	-6.73*E* −06 (−1.194)
Mma: Importation of manufacturing sector		−0.000479 **	−8.88*E*−06 *	−6.25*E*−06 **
Openess rate	−0.022** (−2.1232)		0.017941 (1.2274)	
FP: Foreign presence	0.017 (0.394)	−0.646** (−7.596)	0.0235 (0.57)	0.0585 (1.072)
XICTG: Exportation growth of the information and communication technology in manufacturing	−0.0149 (−0.407)	−0.43305** (−7.929)		0.016 (0.303)
MICTG: Importation growth of the information and communication technology in manufacturing	0.0286 (0.5408)	0.34177** (7.7421)		0.012 (0.211)
Dummy	−0.0399* (−2.921)			
XIMHT: Exports of the medium high-tech manufacturing		−0.000148* (−18.166)		
MIHFT: Import of the medium low-tech manufacturing		−0.002345* *		
Mma.LF			0.001691* (3.06)	0.001859* (2.5785)
R2	0.5085	0.99	0.57	0.54
DW	1.724	1.82	1.88	1.521

The foreign presence has not been a vehicle for the technological diffusion for the Tunisian manufacturing sector that is explained by the lack of investment in hi-tech industries. Most of the investments are concentrated on weak industrial sectors such as the textile sector.

5. Conclusion

In conclusion, the objective of this paper was to analyze how a developing country like Tunisia, could benefit from technological spillovers and to what extent the trade, the FDI and the new technologies can be a most suitable vehicle for technological diffusion to increase productivity.

Therefore, the opening and the introduction of the new information and the communication technologies are seen as a catalyst that is manifested by the technological externalities transmitted through the international trade. The effect of these externalities depends on the work force and the country's ability to assimilate and disseminate these technologies developed. The level of the human capital developed an education and the research and development are the main factors of catch.

Tunisia must have to continue to rely on the adoption and the adaptation of imported via the attraction of the FDI in the sectors with high technological level or through a strategy of moving up market in the sectors exposed to international competition.

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