Technological Spillovers From FDI : Evidence from Tunisian Manufacturing Firms.

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ABSTRACT

Foreign Direct Investment (FDI) in developing countries is expected to foster technology transfer from foreign-owned to local firms. Using detailed panel data from Tunisian manufacturing firms, we show that technological spillovers generated by FDI, as a form of technology transfer, help firms move near the best practice frontier (production frontier) measured by the Schmidt and Sickles method. The positive impact on efficiency is confirmed, especially for small and medium size firms (with less than one hundred employees). However, technological spillovers seem to have a greater impact on firms' efficiency when industry concentration level is higher.

Keywords : Foreign Direct Investment, Spillovers, Technical Efficiency

I- INTRODUCTION

Economists have been debating for many decades about the impact of technology transfer on developing countries, which are often characterized by low R&D investments. Multinationals and foreign direct investment (FDI) are indeed expected to contribute to their technological catch up[2]. In fact, theoretical propositions assume that this contribution, which takes the form of FDI technological spillovers, depends on some factors such as educational level of the domestic labor force, learning efforts, R&D and market structure[3] (Findlay, 1978; Wang & Blomström,1992).

These propositions are tested empirically using micro panel data from different developing countries. The results obtained are quite different from a country to another. No FDI spillovers were found both in the Moroccan and Indian manufacturing sectors (Haddad and Harrisson; 1993; Kathuria, 2000). FDI spillovers benefit only to small size firms in the Venezuelan manufacturing sector (Aitken & Harrison, 1999) whereas significant FDI spillovers are detected in some South-East Asia countries such as Indonesia and Taiwan (Sjöholm, 1999; Chang & Lin, 1999).

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[2] . The speed of catch up may be low : the average age of technologies transferred by U.S firms to their overseas affiliates located in developing countries is about 9.8 years according to E.Mansfield & A.Romeo, 1980, p. 739).

[3] . In his model, Findlay showed that technological progress increases in a country only when the proportion of foreign to domestic capital becomes sufficiently high. However, this increase in local efficiency is unfavourable to a large foreign penetration of an economy (Findlay,1978, p.12-13).

In short, this literature suggests that FDI spillovers are neither automatic nor present in all manufacturing sectors in which foreign investment exists. To what extent FDI spillovers, if they exist, could enhance firm's efficiency? We will try to answer this question by studying the case of Tunisia using micro panel data relative to 162 firms belonging to the manufacturing sector through the period 1996-1998.

The remainder of the article is organized as follows. Section II describes the model and the sample used. Statistical results are presented and commented in section III. Concluding remarks follow in section IV.

II- METHODOLOGY AND SAMPLE DESCRIPTION

2.1- Methodology

The objective of the present study is to see if the presence of foreign capital participation could have positive effects on firm's efficiency growth as measured by the Schmidt and Sickles (1984) method (see appendix I). Used by Haddad and Harrisson (1993), this method is appropriate for short term studies. All the estimations we do are based on the following model :

$\Delta\pi_{ij}$ = F(Plant FDI, Sector FDI, C4 concentration ratio, interaction terms, dummy).

$\Delta\pi_{ij}$ is the dependent variable of the model and denotes efficiency growth of firm i belonging to sector j over the period 1996-1998. Positive values of $\Delta\pi_{ij}$ are considered as positive efficiency growth.

Among the explaining variables, we distinguish between two types of technological spillovers from FDI : spillovers internalized in joint ventures and spillovers that could be captured at the sector level. For the first type, the spillover effect on firm's efficiency is supposed to appear mainly for local firms having foreign participation in their capital. In contrast, the second type of FDI spillovers could benefit local firms that don't have any foreign participation in their capital. Following Aitken and Harrisson (ibid., p.610), the two variables could interact, which means that local firms with foreign capital participation could also benefit from spillovers captured from sector FDI.

Accordingly, two variables are defined for FDI : Plant FDI (PFDI) corresponding to the percentage of foreign capital participation and Sector FDI (SFDI) corresponding to the mean value of foreign investment[4] during the period 1996-1998.

Other studies insist also on the difference in magnitude that FDI spillovers could have on firm's efficiency according to the degree of competition or concentration observed in the industry. Strong competition is supposed to sustain not only technical efficiency but also the intensity with which firms exploit sector FDI spillovers. Industries with a high degree of competition are expected to benefit more

[4] . Estimated at the one digit level industry.

from sector FDI spillovers compared to those observing a high level of concentration. A measure of concentration with the C4 index is used in this work. The C4 index is only defined for industries with 4 firms and more, so that some sectors in the sample will not be taken in account.

The role of skilled labor is also considered since skilled labor contribute to learning from spillovers generated by FDI. In our model, two assumptions on the role of skills will be tested using interaction terms to evaluate the importance of skills for firms[5] with foreign capital participation (skills*PFDI) and at the industry level (skills* SFDI).

Given the objectives of this study, different specifications of the preceding model will be tested. The use of a dummy variable allows for the detection of industry specific effects that could influence the impact of FDI spillovers on firm's efficiency.

2.2 - Sample description

The data set employed in this paper was obtained from Tunisia's National Statistics Institute (INS) and the Foreign Investment Promotion Agency (FIPA). It contains information on production value, capital, labor, percentage of foreign capital participation, sector FDI and sector production value. It covers the 1996 to 1998 period. 162 firms are included in the sample with 51 among them having foreign capital participation.

According to FIPA, there are 1795 firms with foreign capital participation in Tunisia. They are mostly located in the textile industry (67% of firms). 958 firms are totally foreign owned firms. Table 1 gives a distribution of the entire sample according to the criteria of sales share (column 5 and 6). Column five of table 1 shows that some sectors are well represented with regard to the sales share percentage despite the low number of firms included in our sample.

[5] . Skilled labour is measured according to the educational level of employees.

Table 1 : Distribution of sample

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Two-digit code industry[(a)]	Industry	Number of firms	Number of foreign firms	Sales share[(b)] (%)	Sales share of foreign firms (%)
11	Meat	1	-	5,9	-
12	Milk products	6	4	69,8	46,5
13	Cereals and noodles	4	1	10,2	0,9
14	Olive oil	4	-	97,9	-
15	Conserves	2	-	2,7	-
16	Sugar and chocolate	3	-	32,5	-
17	Other food products	2	-	0,8	-
18	Drinks	3	1	37,2	16,9
19	Tobacco	1	-	6	-
21	Quarry products	1	-	10,4	-
22	Cement	11	3	42,1	15,8
23	Pottery products	5	1	19,5	2,3
31	Iron and steel	6	2	54,6	3,3
32	Metal products	10	-	13,5	-
33	Machinery and industrial equipments	6	1	41,8	6
34	Cars and other vehicles	8	4	40,9	28,9
35	Transport equipment and maintenance	2	2	84,4	84,4
36	Electrical equipment	14	5	57,8	13,2
37	Electronics	2	2	22,1	22,1
41	Chemical fertilizers	2	-	68,3	-
42	Basic chemical products	3	3	86	86
43	Other chemical products	14	5	84,1	25,9
44	Drugs and Pharmaceuticals	2	1	46,8	21,3
45	Rubber products	1	-	58,1	-
51	Spinning and weaving	5	3	14,2	11,8
53	Hosiery products	1	-	0,2	-
54	Clothing	17	6	6,3	1,73
55	Leather products	1	1	0,3	0,3
61	Wood products	3	-	18,6	-
62	Paper products	8	3	35	14,6
63	Plastic products	7	1	15,9	1,4
64	Other products	7	2	42,2	18,1
	Total	**162**	**51**	-	-

(a) : The two-digit code industry is as defined by the "Institut National de la statistique" (INS) in "Nomenclature des Activités et des Produits" (NAP50).

(b) : Share sales is calculated as the mean ratio of production value of firm i on production value of sector j for each year of the period considered.

Using computed values of $\Delta\pi_{ij}$ table 2 reports results of bilateral tests (two-tailed test) comparing Tunisian firms performances based on the mean value of $\Delta\pi_{ij}$ with respect to four criteria : size of firms (number of employees), industry concentration level, percentage of foreign capital participation in the firm and sector leadership (FDI or non FDI firms). Two groups of firms are formed according to each criterion. Based on firm size, the two groups are: the group of firms having a maximum of 105 employees (<105 employees in table 2) and those with more than 105 employees. Two other groups of firms are also formed according to the concentration criterion, with 0.5 value of C4 index indicating the frontier between high concentrated industries (C4≥0.5) and low concentrated industries. With regard to the percentage of foreign capital participation, the value of 25% separates the two groups of firms, mainly because significant behavior differences between firms are thus observed. The criterion of sector leadership is defined according to the maximum value of efficiency growth observed at the level of each sector (see appendix II table 8). Industries with an FDI leader firm are those with the following two digit code :12,18, 23, 36, 51, 63 (see table 1)[6].

Table 2 : Bilateral tests comparing mean efficiency growth between groups of firms

Criteria		**T-Value**	**Bilateral significance**
Size (number of employees):	≥ 105 (131 firms) < 105 (31 firms)	2,245	0,026**
C4 Index measure of concentration :	≥ 0,5 (30 firms) < 0,5 (102 firms)	-0,684	0,495
% of foreign capital participation :	≥ 0,25 (29 firms) < 0,25 (133 firms)	1,716	0,088*
Sector Leadership(a) :	F (40 firms) N (83 firms)	-0,286	0,776

Note : T-values are computed under the equal variances hypothesis
*** significant at the five percent level*
** Significant at the one percent level*
(a): F = The leader firm in the sector has foreign capital participation; N= The leader firm in the sector does not have any foreign capital participation

The results suggest that differences in mean efficiency growth are significant when we compare groups of firms according to the two criteria of size and foreign capital participation[7]. Concentration and sector leadership do not seem to be significant criteria for the comparison of mean efficiency growth between high concentrated markets and low concentrated ones and for FDI and non FDI leader sector firms.

III- STATISTICAL RESULTS

Weighed least squares were used for most of the estimations. The weighing variable is the mean value of firm's labor observed on the period considered.

[6] . Sectors where only firms with foreign capital participation are present (35,37,42,55) and those with only firms without foreign capital presence (11, 14, 15, 16, 17, 19,21, 32, 41, 45, 53, 61) have been excluded. The rest of the sectors are characterized by the presence of a non FDI leader firm.

[7] . For this criterion, the number of firms (29) having 25% and more foreign participation in capital does not allow for any regressions.

We start by examining if spillovers generated by FDI at the plant and at the industry level exist. This first step will concern all the firms included in the sample. Results are reported in table 3-a.

Table 3-a : Plant and Sector FDI effects on firm's efficiency growth
Dependent variable : efficiency growth ($\Delta\pi_{ij}$)

	All firms (WLS without dummy)		All firms (WLS with dummy)	
Exogenous variables	**I**	**II**	**III**	**IV**
Constant	0,398		0,131	
	(2,817)***		(1,142)	
PFDI	0,001	-0,027	0,003	0,003
	(0,018)	(-0,304)	(0,053)	(0,052)
SFDI	-1,434**	1,036	-1,344	-1,203
	(-2,321)	(2,39)**	(-2,246)**	(-2,183)**
Dummy			0,004	0,005
			(1,665)*	(2,791)***
Adj.R2	0,528	0,426	0,531	0,533
F. Stat	91,1	120,9	61,9	93,04
Number of observations	162	162	162	162

Note : t-statistics within brackets are based on White's (1980) adjustment for heteroscedasticity
* Significant at the ten percent level
** Significant at the five percent level
*** Significant at the one percent level
The interaction term PFDI*SFDI does not attain significance in any variant of the model, hence has not been reported.

Table 3-a shows that in most cases spillovers from plant FDI are positive but statistically insignificant. However, spillovers from sector FDI are negative (except for regression II) and statistically significant. The introduction of a dummy suggested by Aitken and Harrison confirms the negative effect of sector FDI on efficiency growth for Venezuelan plants. The authors suggested that the negative effect of foreign presence at the sector level could be explained by an increase in average costs of local firms (ibid., p607).

The estimations presented in table 3-b consider only firms observing positive efficiency growth ($\Delta\pi_{ij} > 0$). The results obtained are quite different in sign for plant FDI effect and the negative spillovers from sector FDI are still confirmed. We also obtain quite different results when a constant is included in or excluded from the model. Regression VIII, for example, shows that the negative effect of sector FDI is not statistically significant. However, disparities between sectors does exist and are very significant (the dummy is significant at the one percent level).

Table 3-b : Plant and Sector FDI effects on firm's efficiency growth (only positive growth)
Dependent variable : efficiency growth ($\Delta\pi_{ij}$)

	Firms showing positive efficiency growth [$\Delta\pi_{ij}>0$] (WLS without dummy)		Firms showing positive efficiency growth [$\Delta\pi_{ij}>0$] (WLS with dummy)	
Exogenous variables	**V**	**VI**	**VII**	**VIII**
Constant	0,37		0,858	
	(7,245) ***		(2,027)**	
PFDI	-0,069	-0,079	-0,001	-0,116
	(-1,558)	(-2,567)**	(-0,014)	(-2,543)**
SFDI	-1,352	1,05	-2,842	-0,074
	(-3,909)***	(6,948)***	(-2,201)**	(-0,241)
Dummy			-0,006	0,004
			(-1,146)	(4,408)***
Adj.R2	0,852	0,594	0,875	0,806
F. Stat	325,53	165,14	263,65	234,51
Number of observations	113	113	113	113

Note : t-statistics within brackets are based on White's (1980) adjustment for heteroscedasticity
* Significant at the ten percent level
** Significant at the five percent level
*** Significant at the one percent level

3.1-FDI Spillovers and size of the firm

The bilateral test, presented above, comparing performances of the firms included in our sample with respect to their size, is taken in account in order to see if small or medium size firms benefit more from FDI spillovers. Table 4 presents estimations on the same model but only for firms with less than 105 employees. Ordinary least squares are used.

Table 4 : Plant and Sector FDI effects on firm's efficiency growth for firms with less than 105 employees[8]
Dependent variable : efficiency growth ($\Delta\pi_{ij}$)

	Firms with less than 105 employees (OLS without dummy)	Firms with less than 105 employees (OLS with dummy)
Exogenous variables	**IX**	**X**
Constant		
PFDI	0,382	0,388
	(3,901)***	(3,537)***
SFDI	0,544	0,563
	(2,987)***	(2,16)**
Dummy		-0,0001
		(-0,106)
Adj.R2	0,182	0,153
F. Stat	7,68	3,71
Number of observations	31	31

Note : t-statistics within brackets are based on White's (1980) adjustment for heteroscedasticity
* Significant at the ten percent level
** Significant at the five percent level
*** Significant at the one percent level

[8] . Regressions corresponding to the case of firms with more than 105 employees do not provide any significant result

The results confirm the positive effect of both plant FDI and Sector FDI on efficiency growth for small and medium size firms[9]. As shown in table 4, PFDI and SFDI coefficients are positive and statistically significant (regression IX). The introduction of a dummy variable (regression X) does not significantly modify the results although the whole significance of the model decreases when a dummy is introduced [The F-Stat moves from 7.68 to 3.17]. Then, one can argue that spillovers from FDI in the Tunisian manufacturing industries do not benefit all firms but only small and the medium size category. For local firms belonging to this category, a one percent increase in sector FDI contributes to 0.5 percent increase in efficiency relatively to the most efficient firm in the sector. In contrast, those firms belonging to the same category but having foreign participation in their capital benefit more from spillovers. In fact, a one percent increase in foreign capital participation allows the firm to be near the performances of the one which is close to the frontier if we add the two spillovers effects. For this latter case, the increase in efficiency is nearly by 0.9 percent relatively to the most efficient firm.

3.2-Spillovers in the presence of an FDI leader firm.

An FDI leader firm is a firm with foreign capital participation observing the greatest efficiency growth in its activity sector during the period considered. Using the same model specification, we would like to see if sectors having an FDI leader firm exhibit greater FDI spillover effects on local firms' efficiency growth. Results are reported in table 5.

Table 5 : Plant and Sector FDI effects on firm's efficiency growth for sectors with an FDI leader firm
Dependent variable : efficiency growth ($\Delta\pi_{ij}$)

	FDI leader firm (OLS without dummy)	FDI Leader firm (OLS with dummy)
Exogenous variables	XI	XII
Constant		
PFDI	0,311	0,299
	(2,893)***	(2,992)***
SFDI	0,17	0,059
	(0,851)	(0,189)
Dummy		0,0007
		(0,6)
Adj.R2	0,14	0,12
F. Stat	7,12	3,68
Number of observations	40	40

Note : t-statistics within brackets are based on White's (1980) adjustment for heteroscedasticity
* Significant at the ten percent level
** Significant at the five percent level
*** Significant at the one percent level

The results obtained from regressions XI et XII suggest that sectors where the leader firm has foreign capital participation are characterized by a unique form of FDI spillovers which is generated only at the firm level. FDI Spillovers at the sector level are in that case negligible and statistically insignificant. This result could be

[9] . The table 4 presents estimations without a constant since the constant is not significant .

explained by the nature of activities developed in the sectors which are studied[10]. In these sectors, the type of knowledge transferred should be of a managerial type (at the plant level) whereas the technology used at the sector level is mainly of the standard type so that low or no learning effects would materialize.

3.3-Concentration and spillover effects

When the impact of concentration on spillover effects from FDI is tested, the results obtained by other studies are generally in contradiction. For the Mexican manufacturing industry for example, Kokko found that concentration is negatively correlated with labor productivity in sectors where large technological gap exist between local firms and foreign firms. The author conclude at the absence of spillovers considering that foreign affiliates may in such circumstances, operate in isolation from local firms (ibid., p.288). For Morocco, Harrison and Haddad found positive correlation between productivity[11] and concentration measured by the herfindahl index but without using any interaction term between concentration and sector FDI (ibid, pp63). In the case of Indonesian manufacturing sector, Sjöholm found that competition increases the degree of spillovers from FDI[12] ; when foreign firms operate in a competitive environment, they have to bring much more technology to sustain competition so that spillovers are larger.

Table 6 : Plant and Sector FDI effects on firm's efficiency growth considering industry concentration Dependent variable : efficiency growth ($\Delta\pi_{ij}$)

	Concentration and FDI spillovers at the firm level (WLS without dummy)	Concentration and FDI spillovers at the firm level (WLS with dummy)	Concentration and FDI spillovers at the sector level (WLS without dummy)	Concentration and FDI spillovers at the sector level (WLS with dummy)
Exogenous variables	XIII	XIV	XV	XVI
Constant				
C4	0,017	0,013	-0,61	-0,691
	(0,215)	(0,078)	(-1,49)	(-1,348)
C4*PFDI	0,419	0,418		
	(4,645)***	(4,132)***		
C4*SFDI			3,741	3,983
			(1,87)*	(1,883)*
Dummy		0,00006		0,0005
		(0,028)		(0,217)
Adj.R2	0,105	0,09	0,04	0,04
F. Stat	16,51	8,2	6,83	3,84
number of observations	132	132	132	132

Note : t-statistics within brackets are based on White's (1980) adjustment for heteroscedasticity
* Significant at the ten percent level
** Significant at the five percent level
*** Significant at the one percent level

[10] . The sectors where the leader firm have foreign participation in capital are those corresponding to the following two digit code industry : 12, 18, 23, 36, 51, 63. These sectors are essentially "low-tech" if we consider the classification made by some authors to study spillover effects from FDI in low and High tech sectors (Mairesse, Haddad &Harrison, Kathuria…).

[11] . The dependent variable is fire productivity defined as the deviation of a firm from sector level best practices.

[12] . Sjöholm found positive and statistically significant correlation between FDI and Growth of value added in sectors characterized by high competition level (ibid, pp68)

All these contradictory results may be explained by differences in estimation techniques and methodologies. Our own results for Tunisia are reported in table 6. These results suggest that concentration could have positive impact on efficiency growth *via* spillovers generated by FDI. It seems also that when concentration increases, spillovers from FDI at the sector level (regressions XV and XVI) are much more evident than those generated at the plant level (regression XIII and XIV), even though the plant FDI effect is statistically more significant than the sector FDI effect both for coefficients and for the model as whole (the adjusted R squared statistic and F statistic are low for regressions XV et XVI). Thus, the positive correlation between concentration and FDI spillovers would appear to be specific to Tunisian manufacturing industries. On the one hand, a low competition on the local market may favor some technology transfer from foreign firms to their Tunisian affiliates since they do not face an important local competition threat on the markets they serve, and, on the other hand, the knowledge transfer would also benefit the Tunisian affiliates particularly when their activities are mostly export oriented.

3.4-Skilled labor and FDI spillovers

Empirical applications on the role of skilled labor for learning and adopting technical or managerial knowledge transferred through FDI lead rarely to significant results. Ben Habib and Spiegel found only positive and significant correlation between human factor and the attraction of foreign capital (ibid.,pp164), confirming the Nelson-phelps intuition on the role of skills in the adoption of foreign technologies. V.Kathuria didn't find any significant result for the skills variable (ibid., pp359). We obtain here some significant results concerning the role of skilled labor at the firm level but not at the sector level (table 7).

Table 7 : Plant and Sector FDI effects on firm's efficiency growth and the role of skilled labor
Dependent variable : efficiency growth ($\Delta\pi_{ij}$)

	The role of skilled labor at the firm level (OLS)	The role of skilled labor at the sector level (OLS)
Exogenous variables	XVII	XVIII
Constant		0,168
		(3,046)***
PFDI	-0,168	
	(-2,217)**	
Skills*PFDI	1,064	
	(3,688)***	
SFDI		-0,463
		(-1,299)
Skills*SFDI		-0,286
		(-0,307)
Dummy	0,002	
	(4,76)***	
Adj.R2	0,01	0,004
F. Stat	1,62	1,28
number of observations	119	119

Note : t-statistics within brackets are based on White's (1980) adjustment for heteroscedasticity
* Significant at the ten percent level
** Significant at the five percent level
*** Significant at the one percent level

Regression XVII reported in table 7 shows that all coefficients are statistically significant at the one percent level but the whole model has a weak significance, given the adjusted R squared and the F statistic values. Computing the semi-elasticity of $\Delta\pi_{ij}$ with respect to PFDI, we could consider that skills influence (positively) firms' efficiency via FDI spillovers when the ratio of skilled labor is more than 15.8 percent[13]. Yet, this result should be taken with some caution with regard to the low significance of the model.

IV-CONCLUSION

This paper tried to investigate the role of FDI spillovers in enhancing firm's efficiency using the Farrell's approach technique to represent the best practice frontier. Based on Schmidt and Sickles method for estimating production frontier, three main results were obtained for the Tunisian manufacturing industries. First, technological spillovers from FDI seem to benefit essentially to small and medium size firms (with less than 105 employees). The gains in relative technical efficiency are estimated at 0.9 percent generated both by plant and sector spillovers FDI. This result is very important since 72.5 percent of firms with foreign capital participation in the Tunisian manufacturing sector have less than 100 employees[14]. A quite similar result was also obtained by Aitken and Harrison concerning the manufacturing sector in Venezuela, especially for firms with a size of less than 49 employees[15]. The second result we obtain, linking FDI spillovers with competition, is more controversial, if we compare it with those of other studies. Hence, we show that high concentrated markets enable firms to move to the best practice frontier when FDI spillovers are observed, but only at the plant level. The effect of this type of FDI spillovers (Plant FDI) on efficiency growth is also confirmed when the leading firm in the sector is an FDI firm.

The role of skilled labor deserves more investigations although our results show significant coefficients and a positive role played by skilled labor for learning from FDI spillovers.

Finally, we consider that this work should be extended by integrating the varying technical efficiency hypothesis suggested by Cornwell & al. This hypothesis needs, in order to be tested, more data covering a longer period of time, which is not yet available, and could be more meaningful as to the long term FDI spillovers effects on firms' efficiency.

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[13] . According to regression XVII, $\partial\Delta\pi_{ij} / \partial$ PFDI = -0,168 + 1,064*Skills. The semi elasticity is positive if skills > 0.168 / 1.064 (= 0,158).

[14] . see Appendix II table 9.

[15] . ibid. pp 616

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Appendix I : Estimating efficiency growth ($\Delta\pi_{ij}$)

The efficient frontier principle for evaluating firm's efficiency (Farrell, 1957) is based on the notion of the highest level of output a firm could produce given a set of inputs. The definition of efficiency indexes based on TFP is a first step for this evaluation. The second step concerns efficiency growth which indicates the potential for a firm to increase its output without any increase in inputs. In doing so, the firm moves toward the best practice frontier. In our work, TFP' indices are derived from fixed effects panel data regression assuming Cobb-Douglas production function with constant returns to scale : $Y_{ijt} = \alpha_{ijt} F(K_{ijt}, L_{ijt})$. Introducing logarithm, we obtain:
$\text{Log } Y_{ijt} = \log(\alpha_{ijt}) + \beta X_{ijt} + \varepsilon_{ijt}$, where Y_{ijt} = output of the firm i belonging to the industry j at time t ; X_{ijt} = vector of inputs (Labor and Capital) of the firm i belonging to the industry j at time t.

Following the Schmidt and Sickles (1984) method, relative technical efficiency at the firm level is measured as follows. We consider $\text{Log } \alpha_{ijt}$ as the estimated TFP at the level of firm i belonging to industry j at time t computed in logarithm. Let $\log \alpha_j$ be the highest efficiency level in the industry j for the three years of our study :

$\text{Log } \alpha_j = \max [\log \alpha_{ijt}]$

Let $\theta_{ijt} = \log \alpha_{ijt} - \text{Log } \alpha_j \Rightarrow (\alpha_{ijt} / \alpha_j) = \exp(\theta_{ijt})$

Relative Technical Efficiency at the firm level that we note π_{ijt}, is:

$\pi_{ijt} = \exp(\theta_{ijt}) = (\alpha_{ijt} / \alpha_j)$

π_{ijt} could also be considered as a measure of the dispersion in productivity. The purpose is to explain the variation of π_{ijt}. A positive variation of π_{ijt} should be interpreted as a move of the firm toward the efficient frontier or the best practice frontier.

Let $\Delta\pi_{ij} = \pi_{ij98} - \pi_{ij96}$

Positive values of $\Delta\pi_{ij}$ are considered as positive efficiency growth

Appendix II

Table 8 : Efficiency growth and leadership sector

Sector leadership	Max $\Delta\pi_{ij}$	Industry code
F	**0,29828926**	**12**
N	0,2200749	13
F	**0,29049148**	**18**
N	0,43359392	22
F	**0,64989984**	**23**
N	0,22273235	31
N	0,14444518	33
N	0,29074276	34
F	**0,30978629**	**36**
N	0,3694076	43
N	0,22587893	44
F	**0,29870104**	**51**
N	0,64262299	54
N	0,3432744	62
F	**0,55417777**	**63**
N	0,41610727	64

F = The leader firm in the sector has foreign capital participation;
N= The leader firm in the sector does not have any foreign capital participation
Source : Author's calculations

Table 9 : Employment in the Tunisian firms with foreign capital participation

Class	Number of firms	Employees
less than 10 employees	214	1528
10 to 20	226	3613
20 to 30	195	5013
30 to 40	139	5030
40 to 50	140	6515
50 to 100	387	28788
100 to 200	305	44312
200 to 300	83	20597
more than 300 employees	106	57771
Total	1795	173167

Source : Foreign Investment Agency Promotion (March 2001)