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ABSTRACT

This paper investigates the contribution of FDI to firms' technical efficiency by applying two empirical methodologies over a same sample of firms. Using a panel data for 674 firms belonging to the Tunisian manufacturing sector and observed over the period 1997-2001, we show statistically and econometrically that the robustness of FDI spillover effects is affected by the empirical methodology adopted. On the basis of a decomposition of TFP growth, our results show also that when spillover effects could be confirmed, they are for a large proportion of firms counterbalanced by internal technical inefficiency. This last result confirms the idea that FDI contribution to technical efficiency relies mainly on firm's internal organizational and absorptive capacities.

Key words: FDI, technical efficiency, TFP growth, spillover effects

JEL Classification: F21; F23; C23; C24; O1

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I. Introduction.

The relationship between foreign direct investment (FDI) and growth has been much debated in a recent literature. Many endogenous growth models supported the idea that FDI enhances total factor productivity and consequently stimulates economic growth especially through advanced technology transfer from the North to the South receiving countries (Lichtenberg & De la Potterie, 1996).

However, relying just on the "contagion effect" postulate (Findlay, 1978) would be insufficient to explain FDI contribution to growth. This is particularly the case when we move from a macro approach to the level of the firm. Hence, the way FDI improves (or not) firm's technical efficiency deserves a specific methodology. We try in this paper to develop this methodology through the specific case of the Tunisian manufacturing sector.

During the last decades, many measures have been adopted by Tunisian policy-makers to attract FDI spurred on by the belief that this inflow will introduce modern technology, enhance productivity and stimulate export-led growth. Tunisia provided a wide range of incentives such as a tax relief up to 35 per cent on reinvested revenues and profits (30 per cent starting from 2007), exemptions from customs duties and a 10 per cent reduction of VAT for imported capital goods having no Tunisian manufacturing equivalent, a suspension of VAT and sales tax on locally produced equipment at company start-up and an optional depreciation scheduling for capital equipment older than seven years. Additional incentives are provided to off-shore industries or totally exporting industries such as full exemption on corporate profits earned on export for the first ten years and 50 per cent reduction thereafter (granted also to partially exporting firms), full tax exemption on reinvested profits and income, total exemption from customs duties on imported capital goods, raw materials, semi finished goods and services necessary for business.

By the 1990's, the net FDI flows to GDP reached 2.2%. FDI distribution by sector reveals that until the first half of the 1990's, FDI was mainly oriented to the petroleum and gas (about 80% against 8% for the manufacturing sector). By 1998, and with regard to the privatization program, an increasing share of total FDI in the manufacturing sector compared to petroleum and gas was observed (35% and 58% respectively). At the level of firms, the manufacturing sector concentrates almost all the enterprises and jobs creation. In 2002, 84% of foreign-owned-firms and 90% of the jobs created by them were in this sector.

This FDI shift to the manufacturing sector certainly has beneficial effects for the local industry and for the economy as a whole particularly with regard to employment, infrastructure modernization, and exports. However, it seems that our beliefs about the particular contribution of FDI in terms of spillovers should be reviewed in order to better appreciate the conditions under which these spillovers enhance firms' efficiency and productivity.

To what extent this sector benefited from the presence of FDI in terms of spillover effects and efficiency? To answer this question, our paper proposes to use a combined empirical approach for studying technical efficiency using micro data and to compare performances of both foreign-owned-firms and domestic firms in the Tunisian manufacturing sector during the period 1997-2001. This empirical strategy is motivated by the fact that the standard measures of efficiency frontiers as developed by Schmidt & Sickles (1984) and, Cornwell & al. (1990) and as applied later in Haddad and Harrison (1993) for Morocco and V. Kathuria (2000) for India reduces to global measures of technical efficiency. How local firms move to the production frontier when foreign take part in their capital? Is it through their own efforts or just through an exogenous technical progress? In the former case, FDI could be considered as an important mechanism while in the latter case, FDI in itself should not be considered so as determinant to local firm's technical efficiency. The use of the Malmquist index which allows for a decomposition of TFP change into internal efficiency change and exogenous technical progress could bring us with much more information on FDI contribution to efficiency.

The paper is organised as follows. Section 2 will present the main literature explaining the relationship between FDI and efficiency. Section 3 introduces the empirical methodology. Section 4 describes the data used. The main results based on the analysis of efficiency scores according to firms' characteristics are commented in section 5. Section 6 will conclude.

2. A Brief Literature Survey.

Most of the literature investigating the relationship between FDI and efficiency (or productivity) has been focusing technological spillover effects resulting from foreign investments. Depending on the nature of the data used and also on specific empirical methodologies, the contribution of

FDI via spillovers is in some cases confirmed while rejected in others. Pioneering studies such as Caves (1974), Globerman (1979) and Blomstrom and Persson (1983) confirmed the existence of positive spillovers on the basis of cross sectional data. However, panel data that are more appropriate to study fixed and time effects was later introduced in studies that reveal weak or insignificant spillovers effects (Haddad and Harrison (1993), Aitken and Harrison (1999)).

These contradictory results on the role of FDI lead us to conclude that the contradiction may be explained by the nature of the data. This is in fact the conclusion reached by Görg and Strobl (2001) who performed a meta-analysis of the literature on productivity spillovers and concluded that the results of productivity spillover studies do not seems to be affected by whether the studies use sector or firm level data, but that is important whether the data used are cross-sectional or panel data.

In this paper, we are not really concerned by a problem of data type since we are using micropanel data. We will not also discuss the nature of spillovers whether they could be of vertical or horizontal type (Sasidharan, 2006). What is important for us is, firstly, to contribute to the debate by checking whether FDI spillovers would stay robust to any change in the empirical methodology applied. Secondly, if FDI spillovers appear to be solid and could be a source of productivity growth whatever the empirical methodology used, then, it will be interesting to examine their contribution after opening the "*TFP blackbox*".

3. Empirical Methodology.

Technical efficiency has been measured and interpreted in different ways. The literature offers a large choice of methodologies, each one with its strengths and weaknesses. Kalirajan and Shand (1999) in their discussion on core methods regrouped them in three major approaches: programming or deterministic methods, statistical or stochastic and Bayesian methods. In all this approaches, the frontier concept is used to define firm-specific technical efficiency for a group of firms using the same technology, assuming firm's technical efficiency to be related to its own potential. Two important points emerged from their literature review and the comparative studies performed by Gong and Sickles (1992) and Kalaitzandonakes and al (1992) about the DEA method which belongs to the first approach and the stochastic frontier approach. First, the efficiency measurement is determined by the choice of functional forms considered to represent the production technology, and second, DEA appears to be more appropriate when knowledge about underlying technologies is weak. The relative performance of the stochastic frontier approach vis-à-vis DEA is determined by the choice of the functional forms. The measure of technical efficiency depends crucially on the adopted functional form, which, if misspecified, may bias the efficiency estimate.

From Kalirajan and Shand, we can retain that While DEA and the stochastic varying coefficients frontier approach can facilitate identification of a benchmark of excellence in terms of the best practices in a given sample of observations, the stochastic frontier approach and the Bayesian approach can only provide a signal to indicate whether a firm's overall performance is adequate in terms of realizing its own potential.

On the other hand, Van Biesebroeck (2007) in a study comparing the robustness of productivity estimates of the most used techniques concluded that Data Envelopment Analysis (DEA), while never considered as the ideal method for estimating productivity growth, could be the preferred estimator for productivity levels if technology is likely to vary across firms and scale economies are not constant. He cited an example where one has to pool firms from very different industries, at different stages in their lifecycle or operating in countries with different levels of development. Concerning the stochastic frontiers method, he concluded that when one has good reasons to believe that productivity differences are constant over time, that output is measured accurately and that observations share the same technology, this method produces accurate productivity level estimates.

To test the robustness of our results and because there is not yet a clear consensus about the effect of FDI on domestic firms' efficiency, two methods are used in this paper, one from each principal approach. The first method is based on time varying technical efficiency and belongs to the stochastic frontier approach, the second is the DEA-based Malmquist productivity index belonging to the programming or deterministic methods.

a- Time Varying Technical Efficiency.

The first method is based on time varying technical efficiency as described by Cornwell & al (1990) and applied for Indian manufacturing industries by V.Kathuria (2000). We suppose a Cobb-Douglas production function with two factors as follows:

$$Y_{ijt} = A_{ijt} (X^{L}_{ijt})^{al} (X^{K}_{ijt})^{ak} \quad (1)$$

$a_l + a_k \leq 1$

With X_{ijt} the vector of inputs (capital and labor) used by firm i belonging to sector j for year t.

Y_{ijt} is a measure of real output (= Y_{ijt} nominal deflated by the industrial production price index for sector j) and A_{ijt} a measure of time varying productivity level of firm i belonging to industry j.

Introducing the logarithm, equation (1) could be written as follows:

$y_{ijt} = \alpha_j + \beta' x_{ijt} - u_{ijt} + v_{ijt}$. ; v_{ijt} a normal distributed statistical noise (2)

Theoretically, the term $- u_{ijt}$ designates technical inefficiency with $- u_{ijt}$ equals zero corresponding to the most efficient firm. Equation 2 could be written in the following form:

$y_{ijt} = \alpha_j - u_{ijt} + \beta' x_{ijt} + v_{ijt}$.

$\Rightarrow \text{Ln } y_{ijt} = \alpha_{ijt} + \beta' x_{ijt} + v_{ijt}$ (3)

Cornwell, Schmidt and Sickles (1990) suggest to introduce a flexible function of time (quadratic) in the production function which allows for firm's technical efficiency to vary over time:

$\alpha_{ijt} = W'_t \cdot \theta_{ij}$; $W'_t = (1, t, t^2)$; $\theta_{ij} = (\theta_{ij0}, \theta_{ij1}, \theta_{ij2})$ (4)

Moreover, Cornwell, Schmidt and Sickles (CSS) assume that, regardless to the structure of the error term and the endogeneity problem, using the within estimator could bring us with a consistent and efficient estimate of β'. The residuals of (y_{ijt} - $\hat{\beta}'_{ijt} x_{ijt}$) correspond to firm-specific time varying technical efficiency after applying equation (4)[1]. For year t, the most efficient firm i belonging to industry j is such that:

$\hat{\alpha}_{jt} = \max [\hat{\alpha}_{1jt} , \hat{\alpha}_{2jt} , ..., \hat{\alpha}_{Njt}]$ (5)

[1] . Applying equation (4) brings us with $\hat{\alpha}_{1jt}$, $\hat{\alpha}_{2jt}$,......., $\hat{\alpha}_{njt}$

All the other firms of the sample will be behind the frontier.

Since $\hat{u}_{ijt}$ = $\hat{\alpha}_{jt}$ - $\hat{\alpha}_{ijt}$, and $\hat{u}_{ijt}$ is in logarithm, a relative technical efficiency index (RTEI) noted $\hat{\lambda}_{ijt}$ for these firms is given by:

$$\hat{\lambda}_{ijt} = \exp[\ \hat{u}_{ijt}] \tag{6}$$

For the purpose of our estimates, we use the variation of $\hat{\lambda}_{ijt}$ (noted later RTEIV) between 2001 and 1997.

$$\Delta\hat{\lambda}ijt = \hat{\lambda}_{ij01} - \hat{\lambda}_{ij97} \tag{7}$$

The dynamic frontier approach as described here provide us with a global measure of *relative technical efficiency Index* (RTEI) which allows in a first step to detect the number of cases where positive changes in efficiency are observed if FDI is present. However, changes in efficiency observed would not clearly indicate that FDI explain them. A decomposition of TFP changes is then necessary.

b- DEA-Malmquist Productivity Index.

The second method proposes a measure of total factor productivity (TFP) change indices by using the DEA-based Malmquist productivity index method described in Fare et al (1994) and Coelli, Rao and Battese (1998). This technique enables a change in TFP and decomposes it into two components, one measuring the change in efficiency (movements towards the production frontier) and the other measuring the change in the frontier technology (shifts in the frontier).

The Malmquist index is defined using distance functions. Distance functions allow one to describe a multi-input, multi-output production technology without the need to specify a behavioural objective (such as cost minimisation or profit maximisation). One may define input and output distance functions. An input distance function characterises the production technology by looking at a minimal proportional contraction of the input vector, given an output vector. An output distance function considers a maximal proportional expansion of the output vector, given an input vector. We only consider an output distance function in this paper.

A production technology may be defined using the output set, P(x), which represents the set of all output vectors, y, which can be produced using the input vector, x. That is,

$$P(x) = \{y : x \text{ can produce } y\}. \tag{8}$$

The output distance function is defined on the output set, P(x), as:

$$d_o(x,y) = \min\{\delta : (y/\delta) \in P(x)\}. \tag{9}$$

The distance function, $d_o(x,y)$, will take a value which is less than or equal to one if the output vector, y, is an element of the feasible production set, P(x). Furthermore, the distance function will take a value of unity if y is located on the outer boundary of the feasible production set, and will take a value greater than one if y is located outside the feasible production set. In this study we use DEA method to calculate our distance measures.

The Malmquist TFP index measures the TFP change between two data points (e.g., those of a particular firm in two adjacent time periods) by calculating the ratio of the distances of each data point relative to a common technology. Following Färe et al (1994), the Malmquist (output-orientated) TFP change index between period t (the base period) and period t+1 is given by:

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right)\left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \tag{10}$$

Where the notation $D_o^{t+1}(x^t, y^t)$ represents the distance from the period t+1 observation to the period t technology. A value of Mo greater than one will indicate positive TFP growth from period t to period t+1 while a value less than one indicates a TFP decline. Note that the above equation is, in fact, the geometric mean of two TFP indices. The first is evaluated with respect to period t technology and the second with respect to period t+1 technology. An equivalent way of writing this productivity index is

$$\boldsymbol{M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right) \times \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}}} \tag{11}$$

Where the ratio outside the square brackets measures the change in the output-oriented measure of Farrell technical efficiency between periods t and t+1. That is, the efficiency change is equivalent to the ratio of the technical efficiency in period t+1 to the technical efficiency in period t. The remaining part of the index in the above equation is a measure of technical change. It is the geometric mean of the shift in technology between the two periods, evaluated at x_{t+1} and also at x_t.

$$\text{Efficiency change} = \left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \right) \tag{12}$$

$$\text{Technical change} = \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \right) \left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right) \right]^{\frac{1}{2}} \tag{13}$$

Hence the Malmquist productivity index is simply the product of the change in relative efficiency that occurred between period t and t+1, and the change in technology that occurred on the same periods.

Following Färe et al (1994), we can calculate the required distance measures for the Malmquist TFP index using DEA linear programs.

4. Data.

The data used in this study are derived from the national survey on enterprises realised by the National Institute of Statistics (INS).

The sample reduces to 674 manufacturing firms for which observations are available over the whole period 1997-2001. This sample is representative of the Tunisian manufacturing sector with regard to control variables such as employment, gross fixed capital formation and output.

Our sample is distributed as follows across industries: 12% belong to agriculture and food products (IAF), 7% to the materials construction, ceramics and glass (CMCG), 18% to the metal and electrical industries (MEI), 10% to the chemical industry (CI), 39% to the textile, clothing and leather (TCL) and finally 14% to other manufacturing industries (OMI).

In our sample, 21% of the firms have a foreign equity participation of 10 per cent or more during the study period which correspond to the IMF definition of foreign-owned firms (IMF's Balance of Payments Manual, 1993). They are distributed across industries as following: 3% belong to the industry of agriculture and food products (IAF), 5% to the industries of construction materials, ceramics and glass (CMCG), 17% to the metal and electrical industries (MEI), 7% to the chemical industry (CI) , 66% to the industries of textile, clothing and leather (TCL) and finally 2% to other manufacturing industries (OMI).

With regard to the size criterion as measured by the number of employees, 44% of the firms are to be considered as small enterprises (less than 50 employees), 20% as medium-sized (between 51 and 100 employees) and 36% as large enterprises (more than 100 employees). Let's note also that more than the third of the firms forming the sample are exporting firms.

5. Results

Our results are presented in two steps: in the first step, we discuss the results on a statistical base in order to see if FDI spillovers could be sensitive to any change in efficiency measures. In the second step, we discuss the results obtained through econometric investigations based on the relationship between measures of efficiency and FDI.

a- Statistical Based Analysis.

Our aim was to see if an empirical analysis of FDI spillovers could be sensitive to any methodological change in the measure of technical efficiency. According to tables 1 and 2, we note that considering two different technical efficiency measures lead to a different perception of the role of FDI.

< Insert table 1 >

Taking the sample of foreign firms, table 1 show that the CSS approach over estimate FDI spillover effect. Comparing CSS and Malmquist index, we find that 80 foreign firms are observing positive RTEI variation (RTEIV) while just 73 foreign firms observe positive TFP growth (TFPG) when Malmquist index approach is applied. The differences are more evident when we look at the results by sectors. For example, in the machinery and non electrical equipment, 4 firms are observing positive TFP growth and none observes positive RTEI variation. In the Electrical and Electronic Equipments sector, 6 firms are observing positive TFP growth and 12 firms observe positive RTEI variation.

< Insert table 2 >

Taking the sample of local firms, table 2 shows that no difference appears between the two efficiency measures when sectoral results are aggregated. Nevertheless, both efficiency measures lead in many cases to sensitive differences if we compare the results sector by sector.

This first result traduces the insufficient robustness of the spillover effects and corroborates the contradictory conclusions on FDI spillovers in earlier empirical literature.

Now if we assume that FDI is important such that it allows local and foreign firms to produce near the efficient frontier, what kind of contribution doest FDI bring? Is it a contribution to internal technical efficiency (at the level of the firm) and/or a contribution taking the form of exogenous technical progress? To answer these questions, we need to explore the results derived from the Malmquist approach.

Let's remind here that this approach allows a decomposition of TFP growth in two components: internal efficiency change and exogenous technical change.

Looking at table 3, we note that with the exception of two sectors (construction material and glass and mechanical and electrical goods), the other manufacturing sectors have been observing a negative mean TFP growth over the period of estimation. The result corresponding to the textile, clothing and leather is particularly disappointing as this sector is the one with the largest part of foreign direct investments realized in the country[2]. Moreover, table 3 shows that negative mean TFP growth is mainly explained by negative internal technical efficiency growth. This other result is very important as it implies that while FDI could bring technological progress, this contribution would unfortunately be counterbalanced by firms' internal technical inefficiency. The exceptional result corresponding to the Chemical and rubber products sector has to be explained differently.

< Insert table 3 >

[2] . The only subsector which is benefiting more from FDI is leather products because whatever the measure of efficiency we use, we observe that its performances are better compared to those observed for textile products and clothing.

According to Barro's work (1999), the negative technical change - which contributes to negative TFP growth for the chemical sector- does not mean that the sector is observing technological regression all over the world. According to the author, this result should be interpreted as the consequence of an inefficient market functioning. Said differently, this means that if, for example, protectionist measures are adopted, local firms will not be in the obligancy to use modern technologies while at the same time, technology is internationally becoming more and more sophisticated. In this particular case, protectionism will be a source of relative technology regression in the local country.

Until here, our conclusions about FDI benefits seem to be quite pessimistic. Does it mean that looking after FDI is counterproductive? Certainly not. With regard to internal technical efficiency scores, table 4 shows the opposite since in most cases, firms with foreign capital do better than those without.

< Insert table 4 >

The former did better over the entire period as they were nearer the efficient frontier[3] compared to the latter. This result is particularly observable for sectors such as leather, Electric and Electronic products and transport equipments. We also note that foreign owned firms which are technically more efficient are concentrated in sectors where the domestic firms develop the best efficiency scores (Machinery and non Electrical Equipment, Electrical and Electronic equipments, Transport equipment).

So, the question is: in which way runs the causation? Our results show that the more foreign firms produce at high efficiency levels, the more local firms do more efforts to limit the efficiency gap. In this latter case, the spillover effects would benefit local firms working as subcontractors. However, the clothing industry represents a counterexample. In fact, the efficiency "alignment" effort in this industry was not verified because, as shown in table 4, both local and foreign firms are too far from the frontier and this is probably due to the nature of foreign capital in this subsector[4]. The results we obtain would also imply that spillover effects could benefit domestic firms if their technological capabilities are not so different from those of foreign firms.

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[3] . The more the value of technical efficiency is near 1, the more is the firm producing near the efficient frontier.

To summarize, it goes without to say that FDI is undoubtedly important for home countries receiving them. In our work, we insist on the fact that FDI could enhance local firm's efficiency provided that these firms develop their internal organizational capabilities.

To go further with this idea, we tried to compare the internal efficiency performances of both foreign and local firms over the period of estimation. These comparisons are based on firms' characteristics such as size, export performances and the ratio of white collar to blue collar workers as a measure of labor quality.

As shown in table 5, only 41 percent of foreign firms with positive TFP growth observed positive internal efficiency change. Surprisingly local firms did better since 65% of them enhanced their internal efficiency. In both cases however, technical change is the main source of TFP growth which is benefiting mostly foreign firms.

< Insert table 5 >

Now, how could internal efficiency be influenced by firms' characteristics? According to the last three columns of table 5, it seems that exports and firms' size are the main characteristics explaining positive internal efficiency growth for foreign firms while local market competition and imports would better explain locals' internal efficiency growth.

As a matter of comparison, our results show that only 21% of local firms observing positive internal efficiency growth are exporters while among foreign firms reaching the same performance, 80% of them are exporters. With regard to the size criterion, table 5 shows also that foreign firms insure their internal efficiency through their large size (70 percent of foreign firms). We note finally that the white collars percentage criterion does not allow to distinguish between locals and foreign firms on the basis of their internal efficiency performances.

b- Econometrical Investigations.

To econometrically investigate the relationship between efficiency and FDI, we use the two measures of efficiency defined above (RTEIV and TFPG) as endogenous variables, each

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[4] . As mentioned in a report made by J.R Chaponnière and S.Perrin (2005), with the exception of Benetton multinational, the other foreign investors in this subsector are essentially small business affairs made by old migrants coming from Europe.

endogenous explained by a set of exogenous variables. Hence, the two equations to be estimated are of the following form:

RTEIV = F(FDI, FDI sector, Exports, HF, concentration, tariffs, firm size) (14)

TFPG = G(FDI, FDI sector, Exports, HF, concentration, tariffs, firm size) (15)

The exogenous variables are measured as follows: the variable FDI is introduced as a criterion (1 if FDI exist and 0 otherwise) and is assumed to affect efficiency through spillovers. The variable sectoral FDI (FDI sect) corresponds to the ratio foreign direct investments of sector j over yearly Gross Domestic fixed Investments of sector j (foreign investments included) and is also supposed to contribute to more efficiency through spillovers. The variable export (Exp) is introduced as a dummy (1 for exporters and zero otherwise) and is measured by the proportion of firm's sales on international market (25% or more). Exports are assumed to enhance efficiency since exporting firms will be facing international competition. The variable Human Factor is measured in two ways: by the percentage of technical salaries (skills) and by the percentage of white-collar workers. The variable skills is intended to reflect firm's technological capabilities and is defined as the share of engineers and technician of a firm's total employment. The variable white collar workers could reflect managing capabilities and is defined as the share of managers, engineers, technicians and clerks of a firm's total employment. The variable concentration is measured by the C4 index and is presumed to reflect the effects of more internal competition on efficiency growth. The variable tariffs is measured in variation and should reflect the impact of tariffs reduction on efficiency through external competition and/or through imports of equipments. Finally, the variable firm size (Size) is assumed to be correlated to efficiency (J.Page, 1984). This variable is measured by the number of employees in each firm. The econometric form of the model is written as follows for RTEIV and TFPG respectively:

$$RTEIV_i = \gamma_0 + \gamma_1 FDI_i + \gamma_2 FEIsect_i + \gamma_3 EXP_i + \gamma_4 HF_i + \gamma_5 C4_i + \gamma_6 Tariff_i + \gamma_7 Size_i + \varepsilon_i \quad (14)'$$

$$TFPG_i = \eta_0 + \eta_1 FDI_i + \eta_2 FEIsect_i + \eta_3 EXP_i + \eta_4 HF_i + \eta_5 C4_i + \gamma_6 Tariff_i + \gamma_7 Size_i + z_i \quad (15)'$$

Tests for heteroscedasticity based on OLS estimations for equations (14)' and (15)' confirms that $V(\varepsilon_i \parallel Size) = \sigma^2\varepsilon_i . Size_i$ and $V(z_i \parallel Size) = \sigma^2 z_i . Size_i$. This means that $Size_i$ is the regressor responsible for heteroscedasticity[5]. To avoid this problem, we use the weighted least squares procedure.

< Insert table 6 >

The results we obtain over the whole sample of firms confirm the idea that firm FDI spillovers are sensitive to any change in efficiency measures. Looking at table 6 and 7, firm FDI spillovers are confirmed when TFPG is endogenous whereas no spillovers are found if RTEIV is endogenous. The same conclusion is to be done for the variable firm size. However, in Mechanical and Electrical Equipments and Textile, clothing and leather sectors, sectoral FDI are confirmed using both efficiency measures as endogenous variables (table 7 and 8).

< Insert table 7 > < Insert table 8 >

Some counter-intuitive results are also obtained particularly for the human factor variable. For example the negative and significant sign of the variable "SKILL" in TFPG dependent variable regressions. We have to remember that small and medium-sized enterprises represents 64% of our sample (around 90% of the Tunisian enterprises), which means that a higher share of skilled workers could contribute to bureaucratisation and red type, reducing production efficiency. This conclusion was also reached by Chuang and Lin (1999) for Taiwan's manufacturing firms. We also note that Exports and competition are not determinant for technical efficiency and that tariffs barriers reduction coming after The Tunisia – UE commercial agreement do not sustain efficiency.

6. Conclusion and Policy Recommendations.

In this paper, we proposed to use two empirical methodologies not only to test the robustness of FDI spillovers but also to check for their impact through a decomposition of global technical efficiency growth.

Our results show that FDI spillovers are quite sensitive to any change in the empirical approach. This result is also confirmed through econometric investigations. In its own, such a result deserves more theoretical investigations.

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[5] . In other regressions, the variable SKILL was found to be responsible for heteroscedasticity.

However, moving from a global technical efficiency analysis (CSS) to the decomposition approach (Malmquist) allowed us to get interesting results. Our estimates show that when the contribution of FDI in terms of externalities (spillover effects) could be confirmed, this contribution is in many cases counterbalanced by firm's internal technical inefficiency. This means that FDI alone is not sufficient to enhance firm's technical efficiency and that internal factors specific to the firms should be further analyzed particularly with regard to firms' internal organization.

The results we obtain should be of interest to the Tunisian policy makers-particularly with regard to the application of the "Tunisian Industrial restructuring program" (*Programme de Mise à Niveau*) launched in 1996 and aimed at helping Tunisian firms bridge the gap between their current performance and the benchmark performance of their trading partners by upgrading productive capacity and human capital.

Taking into account the fact that FDI contribution to efficiency is more evident in sectors where organizational capabilities of local firms already exist, the restructuring program intervention should then target sectors characterized by a great potential of FDI attractiveness but where, unfortunately, local firms are lacking absorptive capabilities. Developing these capabilities with the help of this National Program would make it more easy to attract strategic FDI.

In a broader sense, it's also the Tunisian fiscal incentives policy that should be in part reviewed and we think that today, this policy is reaching its limits in some cases. As notable deviation of this policy is the behavior of some foreign investors engaging just for the fiscal "privileges" and leaving the country after the period of "grâce". In the Tunisian textile industry, such behaviors exist. It is may be time to rethink the fiscal incentive mechanism specific to FDI promotion. Hence, these fiscal "privileges" must be offered according to the strategic nature of the industries (such as electric and electronic equipments, chemicals...) and not according to a standard scheme which needs an evolution of the FDI policy from a quantitative approach to a qualitative approach. This could be one of the key to enhance the efficiency potential of these industries and to better prepare them for the international competition.

Bibliography

Aitken, B.J. and A.E. Harrison (1999), "Do Domestic Firms Benefit from Foreign Direct Investment: Evidence from Venezuela", *American Economic Review*, Vol 89, pp. 605-618.

Banker, R. D., A. Charnes and W. W. Cooper (1984), "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis", *Management Science*, Vol 30, pp. 1078-1092.

Banker, R. D., R. F. Conrad and R. P. Strauss (1986), "A Comparative Application of Data Envelopment Analysis and Translog Methods: An Illustrative Study of Hospital Production", *Management Science*, 32(1), pp. 30-44.

Barro, R. J. (1999), "Notes on Growth Accounting", *Journal of Economic Growth*, 4(2), pp. 119-137.

Blomstrom, M. and H. Persson, (1983), "Foreign Investment and Spillover Efficiency in an Underdeveloped Economy: Evidence from the Mexican Manufacturing Industries", *World Development*, Vol 11, pp. 493-501.

Caves, R.E (1974), "Multinational firms, Competition, Productivity in Host-Country Markets", *Economica*, Vol 41, pp. 176- 193

Chaponnière J.R. et S. Perrin (2005), "Le textile habillement tunisien et le défi de la libéralisation: quel rôle pour l'investissement direct étranger", Agence française de Développement, Mai.

Charnes, A., W. W. Cooper and E. Rhodes (1978), "Measuring Efficiency of Decision Making Units", *European Journal of Operations Research*, 6, pp. 429-444.

Chavas, J. P. and T. L. Cox (1990), "A Non-parametric Analysis of Productivity: The Case of U.S. and Japanese Manufacturing", *American Economic Review*, 80(3), June, pp. 450-464.

Chuang, Y. and C. Lin (1999), "Foreign Direct Investment, R&D and Spillover Efficiency: Evidence from Taiwan's Manufacturing Firms", *Journal of Development Studies*, 35(4), April, pp117-137.

Coelli, T, D.S.P. RAO and G.E. Battese (1998), *An Introduction To Efficiency and Productivity Analysis*, Kluwer Academic Publishers, Boston, 1998.

Cornwell, C., P. Schmidt and R.C Sickles (1990), "Production Frontiers with Cross Sectional and Time Series Variation in Efficiency Levels", *Journal of Econometrics*, Oct-Nov, Vol 46, No 1-2, pp. 185-200.

Färe, R., S. Grosskopf, M. Norris and Z. Zhang (1994), "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries", *American Economic Review*, 84(1), March, pp. 66-83.

Farrell, M. J. (1957), "The Measurement of Productivity Efficiency", *Journal of Royal Statistical Society, Series A*, 120(111), pp. 253-281.

Findlay, R. (1978), "Relative Backwardness, Direct Foreign Investment, and the Transfer of Technology: A simple Dynamic Model", *Quarterly Journal of Economics*, Vol 92, pp. 1-16.

Globerman, S. (1979), "Foreign Direct Investment and Spillover Efficiency Benefits in Canadian Manufacturing Industries" *Canadian Journal of Economics*, Vol 12, pp. 42-56.

Gong, B. H. and R. C. Sickles, (1992), "Finite Sample Evidence On the Performance of Stochastic Frontiers and Data Envelopment Analysis Using Panel Data", *Journal of Econometrics*, Vol 51, pp.84-258.

Görg, H and E. Strobl (2001), "Multinational Companies and Productivity Spillovers: A Meta-Analysis", *The Economic Journal*, Vol 111, November, pp. F723-F739.

Haddad, M. and A. Harrison (1993), "Are There Positive Spillovers From Direct Foreign Investment? Evidence from Panel Data From Morocco", *Journal of Economic Development*, Vol 42, pp. 51-74.

Kalaitzandonakes, N. G., W. Shunxiang and M. Jian-Chun, (1992), "The Relationship Between Technical Efficiency and Farm Size Revisited", *Canadian Journal of Agricultural Economics*, Vol 40, pp. 427-442.

Kalijaran, K.P. and R.T. Shand (1999), "Frontier Production Functions and Technical Efficiency Measures", *Journal of Economic Surveys*, Vol 13, 2, pp. 149-172.

Kathuria, V. (2000), "Productivity Spillovers From Technology Transfer to Indian Manufacturing Industry", *Journal of International Development*, 12, pp. 343-369.

Lichtenberg, F., V. P. De la Potterie (1996), " *International R&D Spillovers : A Re-Examination*", NBER working papers series, July.

Ouellette, P. et P. Lasserre (1984), "Mesure du progrès technique: théories et méthodes", Cahier 8425, Département de Sciences Economique et C.R.D.E., Université de Montréal.

Ouellette, P. et P. Lasserre (1985), "Mesure de la productivité: la méthode de Divisia", *L'Actualité Economique*, 61(4), pp. 507-526.

Page, J. (1984), "Firm Size and Technical Efficiency", *Journal of Development Economics*, 16, pp.129-152.

Sasidharan, S. (2006), "Foreign Direct Investment and Technology Spillovers: Evidence from the Indian Manufacturing Sector", UNU-Merit working paper series, # 2006-010.

Schmidt, P. and R. C. Sickles (1984), "Production Frontiers and Panel Data", *Journal of Business and Economic Statistics*, 2, pp. 367-374.

Van Biesebroeck, J. (2007), "Robustness of Productivity Estimates", *The Journal of Industrial Economics*, Vol LV, 3, pp. 529-569.

Table 1
Foreign firms and global efficiency (2 methods: Malmquist and CSS)

Sectors	TFPG>0 Malmquist	RTEIV>0 CSS	TFPG<0 Malmquist	RTEIV<0 CSS
Food processing	3	3	1	1
Textile	1	1	2	1
Clothing	37	46	48	39
Leather	4	3	3	4
Other manufacturing	3	1	0	2
Chemical and rubber products	6	5	4	4
Construction materials and glass	4	3	3	4
Metal products	3	4	3	2
Machinery and non Electrical Equipment	4	0	0	4
Electrical and Electronic equipments	6	12	7	1
Transport equipment	2	2	0	0
TOTAL	**73**	**80**	**71**	**62**

Table 2
Local firms and global efficiency (2 methods: Malmquist and CSS)

Sectors	TFPG > 0 Malmquist	RTEIV > 0 CSS	TFPG < 0 Malmquist	RTEIV < 0 CSS
Food processing	35	27	42	49
Textile	24	1	27	52
Clothing	31	54	51	28
Leather	15	17	17	14
Other manufacturing	49	56	39	34
Chemical and rubber products	29	24	29	36
Construction materials and glass	27	30	15	13
Metal products	31	36	23	18
Machinery and non Electrical Equipment	9	5	8	12
Electrical and Electronic equipments	9	12	5	2
Transport equipment	7	8	4	2
TOTAL	**266**	**270**	**260**	**260**

Table 3
Malmquist Productivity Indexes
Mean Technical efficiency change, Technical change and TFP change
1997- 2001 (%).

Sectors	Efficiency change	Technical change	TFP change
Mean	-11.8	11.2	-1.9
Food Processing	-9.1	8.5	-1.3
Textile and Leather Products	-17.8	16.5	-4.2
Other Manufacturing	-2.0	1.8	-0.3
Chemical and Rubber Products	0.7	-2.3	-1.6
Construction Materials & Glass	-4.8	7.9	2.7
Mechanical and Electrical Goods	-4.9	6.6	1.4

Table 4

DEA Mean Technical Efficiency by Sector, 1997–2001.

			1997	1998	1999	2000	2001	Mean
Food Processing		**Total**	0.431	0.387	0.348	0.332	0.302	0.360
		Local	0.437	0.390	0.351	0.334	0.306	0.364
		F.O.F	0.314	0.319	0.301	0.306	0.234	0.295
Textile and Leather Products		**Total**	0.127	0.104	0.087	0.076	0.061	0.091
		Local	0.101	0.080	0.064	0.055	0.044	0.069
		F.O.F	0.174	0.148	0.127	0.112	0.092	0.131
	Textile	**Total**	0.427	0.378	0.325	0.382	0.384	0.384
		Local	0.407	0.362	0.316	0.363	0.366	0.366
		F.O.F	0.755	0.650	0.475	0.701	0.678	0.678
	Clothing	**Total**	0.141	0.120	0.100	0.089	0.104	0.104
		Local	0.119	0.097	0.076	0.066	0.053	0.082
		F.O.F	0.163	0.142	0.124	0.111	0.091	0.126
	Leather	**Total**	0.475	0.505	0.515	0.527	0.469	0.498
		Local	0.476	0.511	0.521	0.515	0.449	0.494
		F.O.F	0.474	0.479	0.488	0.584	0.558	0.517
Other Manufacturing		**Total**	0.382	0.270	0.334	0.304	0.363	0.331
		Local	0.383	0.265	0.328	0.299	0.358	0.327
		F.O.F	0.363	0.406	0.514	0.477	0.520	0.456
Chemical and Rubber Products		**Total**	0.362	0.356	0.341	0.309	0.376	0.349
		Local	0.344	0.346	0.327	0.291	0.353	0.332
		F.O.F	0.467	0.415	0.425	0.417	0.511	0.447
Construction Materials & Glass		**Total**	0.569	0.503	0.527	0.471	0.491	0.512
		Local	0.550	0.491	0.516	0.454	0.474	0.497
		F.O.F	0.687	0.581	0.595	0.574	0.588	0.605
Mechanical and Electrical Goods		**Total**	0.222	0.203	0.176	0.197	0.194	0.198
		Local	0.211	0.187	0.165	0.183	0.188	0.187
		F.O.F	0.269	0.264	0.222	0.253	0.219	0.245
	Metal Products	**Total**	0.208	0.320	0.306	0.330	0.313	0.295
		Local	0.213	0.321	0.301	0.327	0.323	0.297
		F.O.F	0.165	0.309	0.350	0.357	0.226	0.281
	Mach & non Electrical Equip.	**Total**	0.282	0.247	0.268	0.270	0.238	0.261
		Local	0.267	0.208	0.243	0.240	0.200	0.232
		F.O.F	0.345	0.415	0.372	0.399	0.400	0.386
	Electric &Electronic prod.	**Total**	0.551	0.564	0.613	0.557	0.491	0.555
		Local	0.506	0.499	0.553	0.511	0.473	0.508
		F.O.F	0.607	0.645	0.687	0.614	0.513	0.613
	Transport Equipment	**Total**	0.679	0.664	0.712	0.491	0.582	0.626
		Local	0.664	0.634	0.681	0.456	0.563	0.600
		F.O.F	0.763	0.830	0.884	0.684	0.691	0.770

F.O.F : Foreign Owned Firms Local: Domestic Firms Mean = Mean of the period

Table 5
Decomposition of TFP and firms' distribution by characteristics (%).
TFP growth > 0

	Number of Firms	Efficiency Change (% of firms)			Technical Change (% of firms)			Export (% of firms)			Firm size (% of firms)			% of White Collars (% of firms)	
		> 0	< 0	= 0	> 0	< 0	= 0	N	P	T	S	M	B	≤ 15	> 15
FDI	73	41	58	1	86	14	0	21	14	66	16	14	70	70	30
Locals	266	65	32	3	70	30	0	79	11	10	58	20	22	71	29

N= Exports < 25% of production, P= Exports between 25% and 75%, T= Exports > 75%
S= Small firms (0 <L ≤50) , M= Medium size firms (51 ≤ L ≤100), B= Big firms (L > 100)

Table 6 : Weighted Least Squares Regressions results (whole sample)

Dep.variable	**RTEIV‡**	**TFPG‡‡**	**RTEIV‡**	**TFPG‡‡**	**RTEIV‡**	**TFPG‡‡**	**RTEIV‡**	**TFPG‡‡**
Exogenous	***[1-a]***	***[2-a]***	***[3-a]***	***[4-a]***	***[5-a]***	***[6-a]***	***[7-a]***	***[8-a]***
Constant	0.416 (1.19)	0.34 (0.09)	0.359 (1.0)	0.453 (0.12)	**0.46***** **(3.85)**	1.436 (0.45)	0.374 (1.04)	1.508 (0.46)
FDI	-0.046 (-0.21)	**5.414**** **(2.37)**			-0.033 (-0.15)	**4.907***** **(2.15)**		
FDI sect			0.004 (0.61)	0.02 (0.26)			0.0037 (0.39)	-0.008 (-0.10)
Export							0.11 (0.72)	1.967 (1.18)
Skills	0.003 (0.78)	**-0.088***** **(-2.16)**	0.002 (0.66)	**-0.087**** **(-2.08)**			0.002 (0.62)	**-0.083**** **(- 2.02)**
White collar					-0.007 (-1.43)	- 0.047 (- 0.92)		
C4 index	0.002 (0.36)	**0.231***** **(3.37)**	0.002 (0.35)	**0.224***** **(3.25)**	0.003 (0.59)	**0.272***** **(3.98)**	0.002 (0.34)	**0.228***** **(3.35)**
Tariffs	0.024 (1.23)	-0.118 (-0.65)	0.023 (1.32)	-0.09 (-0.49)				
Size	**0.005***** **(4.89)**	0.006 (0.58)	**0.005***** **(4.92)**	0.014 (1.32)	**0.005***** **(4.51)**	0.0012 (0.10)	**0.005***** **(4.54)**	0.01 (0.9)
Adj R-sq	0.157	0.045	0.157	0.037	0.156	0.043	0.156	0.039
F(k , n-k)	21.06	6.17	21.13	5.2	25.08	6.93	18.17	5.41
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Obs.number	646	647	646	647	649	650	649	650

‡*: Relative Technical Efficiency Index Variation over the period 1997-2001*
‡‡*: Total Factor Productivity Growth over the period 1997-2001*

t-stat in parenthesis

****: significance at 1%   **: significance at 5%   *: significance at 10%*

Table 7 : Weighted Least Squares regressions results (Textile, Clothing and Leather Sector)

Dep.variable	RTEIV‡	TFPG‡‡		RTEIV‡	TFPG‡‡		RTEIV‡	TFPG‡‡		RTEIV‡	TFPG‡‡
Exogenous	**[1-b]**	**[2-b]**		**[3-b]**	**[4-b]**		**[5-b]**	**[6-b]**		**[7-b]**	**[8-b]**
Constant	2.251 (1.54)	**49.71***** **(3.01)**		-	-		**2.524*** **(1.77)**	**43.72***** **(2.72)**		-	-
FDI	-0.007 (-0.27)	**8.232***** **(2.77)**					-0.007 (-0.30)	**8.15***** **(2.73)**			
FDI sect				0.091 (1.56)	**2.076***** **(3.05)**					**0.105*** **(1.81)**	**1.604***** **(2.45)**
Export										-0.051 (-0.26)	**7.2***** **(3.27)**
Skills	0.005 (0.87)	-0.1 (-1.46)		0.005 (0.87)	- 0.1 (- 1.43)						
White collar							-0.008 (- 0.95)	-0.072 (-0.69)			
C4 index	0.0091 (1.09)	**2.977***** **(3.17)**		0.009 (1.11)	**2.864***** **(3.01)**		0.078 (0.94)	**3.04***** **(3.23)**		0.085 (1.03)	**3.093***** **(3.32)**
Tariffs	0.228 (1.56)	**5.176***** **(3.14)**		0.228 (1.56)	**5.227***** **(3.14)**		0.201 (1.37)	**5.24***** **(3.16)**		0.219 (1.51)	**5.10***** **(3.12)**
Size	**0.008***** **(5.56)**	0.011 (0.67)		**0.008***** **(6.04)**	**0.031**** **(2.03)**		**0.008***** **(5.22)**	0.0027 (0.15)		**0.008***** **(5.96)**	0.006 (0.38)
Adj R-sq	0.328	0.171		0.241	0.149		0.328	0.166		0.328	0.177
F(k , n-k)	22.17	9.96		21.7	10.16		22.21	9.63		26.48	12.21
Prob > F	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000
N	260	260		260	260		260	260		260	260

‡: *Relative Technical Efficiency Index Variation over the period 1997-2001*
‡‡: *Total Factor Productivity Growth over the period 1997-2001*

t-stat in parenthesis

****: significance at 1%   **: significance at 5%   *: significance at 10%*

Table 8 : Weighted Least Squares regressions results (Mechanical and Electrical Sector)

Dep.variable	**RTEIV‡**	**TFPG‡‡**	**RTEIV‡**	**TFPG‡‡**	**RTEIV‡**	**TFPG‡‡**	**RTEIV‡**	**TFPG‡‡**
Exogenous	**[1-c]**	**[2-c]**	**[3-c]**	**[4-c]**	**[5-c]**	**[6-c]**	**[7-c]**	**[8-c]**
Constant	1.4	-	-	-	0.41	-0.007	-	-
	(1.67)				(1.54)	(-0.21)		
FDI	- 0.274	0.586			- 0.271	-0.926		
	(- 0.67)	(0.18)			(- 0.69)	(-0.28)		
FDI sect			0.068	0.392			**0.078****	**0.364***
			(1.65)	(1.29)			**(2.25)**	**(1.80)**
Export							0.15	**- 5.782****
							(0.47)	**(- 2.1)**
Skills	-0.0138	**-0.081***	- 0.014	**- 0.124*****			**- 0.015***	**- 0.113****
	(-1.44)	**(-1.69)**	(- 1.55)	**(- 2.15)**			**(- 1.64)**	**(- 2.04)**
White collar					0.017	-0.257		
					(0.98)	(-1.62)		
C4 index	0.005	**0.231***	0.005	0.198	-0.002	**0.368*****	0.0037	**0.260***
	(0.50)	**(1.83)**	(0.54)	(1.55)	(-0.16)	**(3.01)**	(0.33)	**(2.11)**
Tariffs	-0.011	-0.366	-0.016	0.032				
	(-0.27)	(-1.23)	(-0.38)	(0.08)				
Size	0.0006	-0.008	0.0003	-0.001				
	(0.26)	(-018)	(0.14)	(-0.02)				
Adj R-sq	0.153	0.049	0.157	0.021	0.148	0.059	0.158	0.099
F(k , n-k)	4.54	2.52	5.39	1.66	6.22	2.90	6.64	4.30
Prob > F	0.000	0.045	0.000	0.164	0.000	0.024	0.000	0.002
N	117	117	117	117	120	120	120	120

‡: *Relative Technical Efficiency Index Variation over the period 1997-2001*
‡‡: *:Total Factor Productivity Growth over the period 1997-2001*

t-stat in parenthesis

****: significance at 1% **: significance at 5% *: significance at 10%*