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FDI CONTRIBUTION TO TECHNICAL EFFICIENCY IN THE TUNISIAN MANUFACTURING SECTOR

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Abstract

This paper investigates the contribution of FDI to firms' technical efficiency by applying two empirical methodologies over the 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 TFP growth decomposition, our results also show 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 the firm's internal organizational and absorptive capacities.

ملخص

تبحث هذه الورقة مساهمات الاستثمارات الخارجية المباشرة في الكفاءة التقنية للشركات وذلك بتطبيق منهجيتين تجريبيتين على ذلا العينة من الشركات. وباستخدام قائمة بيانات خاصة بـ 674 شركة تنتمي إلى القطاع الصناعي في تونس وقد خصصت للملاحظة في المدة بين عامي 1997 و2001 نستطيع أن نبين من خلال الإحصاءات والقياست الاقتصادية أن قوة تدفق الاستثمارات الخارجية المباشرة تتأثر بالمنهجية التجريبية التي تطبقها الدولة. وعلى أساس تحليل نمو العامل الكلي للإنتاجية تشير النتائج أيضاً إلى أنه عندما يظهر بوضوح تأثير تدفق الاستثمارات الخارجية المباشرة فإن ذلك يصاحبه انخفاض الكفاءة التقنية في المؤسسات المحلية. وتؤكد تلك النتيجة الأخيرة أن فكرة إسهام الاستثمارات الخارجية المباشرة في الكفاءة التقنية تعتمد أساساً على القدرات التنظيمية والاستيعابية للشركات.

I. Introduction

The relationship between foreign direct investment (FDI) and growth has been much debated in 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 receiving South countries (Lichtenberg & De la Potterie, 1996).

However, relying just on the "contagion effect" assumption (Findlay, 1978) would be insufficient to explain FDI's 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) a firm's technical efficiency deserves a specific methodology. In this paper we try 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 percent on reinvested revenues and profits (30 percent starting from 2007), exemptions from customs duties and a 10 percent 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 percent 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 1990s, the net FDI flows to GDP reached 2.2%. FDI distribution by sector revealed that until the first half of the 1990s, FDI was mainly oriented to the petroleum and gas sectors (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 firm level, the manufacturing sector was the most attractive sector for almost all enterprises and jobs creation. In 2002, some 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 regards 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 evaluate the conditions under which these spillovers enhance firms' efficiency and productivity.

To what extent has 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 et al. (1990) and as applied later in Haddad and Harrison (1993) for Morocco and V. Kathuria (2000) for India — reduces the global measures of technical efficiency. How do local firms move to the production frontier when foreign entities 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 as a determinant of the 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 much more information on FDI's contribution to efficiency.

The paper is organized as follows. Section 2 presents 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 presented in section 5. Section 6 concludes.

2. A Brief Literature Survey

Most of the literature investigating the relationship between FDI and efficiency (or productivity) has been focused on 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 and in some cases rejected. 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 datasets that are more appropriate to study fixed and time effects were later introduced in studies that revealed 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 seem to be affected by whether the studies use sector or firm level data, but what is important is whether the data is cross-sectional or panel based.

In this paper, we are not really concerned with the problem of data type since we are using micro-panel data. Also, we will not discuss the nature of spillovers — whether they are of the 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 black-box*".

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 methods 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 a 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 et al. (1992) concerning the Data Envelopment Analysis (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 the 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 not specified properly, 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 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 reason 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 et al. (1990) and applied for Indian manufacturing industries by V. Kathuria (2000). We suppose a Cobb-Douglas production function with two factors as follows:

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

$$a_l + a_k \leq 1$$

Where X_{ijt} is the vector of inputs (capital and labor) used by firm i belonging to sector j in 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} is a measure of time varying productivity level of firm i belonging to industry j.

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

$$y_{ijt} = \alpha_j + \beta' x_{ijt} - u_{ijt} + v_{ijt}\,. \quad ; v_{ijt} \text{ a normal distributed statistical noise} \tag{2}$$

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:

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

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

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

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

Moreover, Cornwell, Schmidt and Sickles (CSS) assume that, regardless of the structure of the error term and the endogeneity problem, using the within estimator could bring us to 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:

$$\hat{\alpha}_{jt} = \max [\, \hat{\alpha}_{1jt} \;,\; \hat{\alpha}_{2jt} , \ldots\ldots, \hat{\alpha}_{Njt}] \tag{5}$$

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

Since $\hat{u}_{ijt} = \hat{\alpha}_{jt} - \hat{\alpha}_{ijt}$, and $\hat{u}_{ijt}$ is in logarithm form, 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 as RTEIV) between 2001 and 1997.

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

The dynamic frontier approach as described here provides us with a global measure of the *relative technical efficiency Index* (RTEI) which allows us, as 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 do not necessarily indicate that FDI is responsible to explain them. A decomposition of the total factor productivity (TFP) changes is then necessary.

b) DEA-Malmquist Productivity Index

The second method proposes a measure of 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 behavioral objective (such as cost minimization or profit maximization). One may define input and output distance functions. An input distance function characterizes 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.

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

The Malmquist TFP index measures the TFP change between two data points (for example 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 M*o* 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 in 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 is derived from the national survey on enterprises realized by the National Institute of Statistics (INS).

The sample is reduced 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 regards 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 percent or more during the study period which corresponds to the IMF definition of foreign-owned firms (IMF's Balance of Payments Manual, 1993). They are distributed across industries as follows: 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 regards to the size criterion as measured by the number of employees, 44% of the firms are 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 leads to a different perception of the role of FDI.

Taking the sample of foreign firms, Table 1 shows that the CSS approach over estimates FDI's spillover effect. Comparing CSS and Malmquist index, we find that 80 foreign firms witness positive RTEI variation (RTEIV) while just 73 foreign firms witness positive TFP growth (TFPG) when the 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 witness positive TFP growth and none witness positive RTEI variation. In the Electrical and Electronic Equipments sector, 6 firms witness positive TFP growth and 12 firms witness positive RTEI variation.

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 witnessing 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 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.

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 witnessing 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 obligated to use modern technologies while at the same time, technology worldwide is 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 on FDI benefits seem to be quite pessimistic. Does it mean that looking after FDI is counterproductive? Certainly not. With regards to internal technical efficiency scores, Table 4 shows the opposite, since in most cases firms with foreign capital fare better than those without.

The former fared better over the entire period as they were nearer to the efficient frontier[3] compared to the latter. This result is particularly observable for sectors such as leather, electric and electronic products and transport equipment. 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 equipment, and transport equipment).

So, the question is: in which way does the causality run? Our results show that the more foreign firms produce at high efficiency levels, the more local firms exert effort 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.

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

To go further with this idea, we try to compare the internal efficiency performances of both foreign and local firms over the period of estimation. These comparisons are based on firms'

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2 The only subsector which benefits 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.

3 The closer the value of technical efficiency is to 1, the closer the firm is to producing near the efficient frontier.

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.

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 witness 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 mostly benefits foreign firms.

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

Our results show that only 21% of local firms witnessing positive internal efficiency growth are exporters while among foreign firms reaching the same performance, 80% of them are exporters. With regards to the size criterion, Table 5 shows that foreign firms ensure their internal efficiency through their large size (70 percent of foreign firms). We note finally that the white collars percentage criterion does not allow for distinguishing 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 endogenous variable is 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 exists 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 the international market (25% or more). Exports are assumed to enhance efficiency since exporting firms will be facing international competition. The variable Human Factor (HF) 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 the firm's technological capabilities and is defined as the share of engineers and technicians of the 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 (Tariff) is measured in variation and should reflect the impact of tariffs reduction on efficiency through external competition and/or through imports of equipment. 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:

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

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

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

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 Tables 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 (Tables 7 and 8).

Some counter-intuitive results are also obtained particularly for the human factor variable. For example the negative and significant sign of the variable "SKILLS" in TFPG dependent variable regressions. We have to remember that small and medium-sized enterprises represent 64% of our sample (around 90% of the Tunisian enterprises), which means that a higher share of skilled workers could contribute to bureaucratization and red tape, thus 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 determinants for technical efficiency and that the tariff barriers reductions resulting from the Tunisia – EU commercial agreement do not sustain efficiency.

6. Conclusion and Policy Recommendations

In this paper, we propose 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. On its own, such a result deserves more theoretical investigations.

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 the firm's internal technical inefficiency. This means that FDI alone is not sufficient to enhance the firm's technical efficiency and that internal factors specific to the firm should be further analyzed particularly with regards to the firm's internal organization.

The results we obtain should be of interest to the Tunisian policy makers, particularly with regards to the application of the "Tunisian Industrial Restructuring Program" (*Programme de Mise à Niveau*) which was launched in 1996 with the aim of 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 easier to attract strategic FDI.

5 In other regressions, the variable SKILL was found to be responsible for heteroskedasticity.

In a broader sense, the Tunisian fiscal incentives policy should be reviewed because we think that today, this policy has reached its limits in some cases. A 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 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 (high and medium-high technology industries such as electric and electronic equipments, chemicals, etc. (Hatzichronoglou (1997)) and not according to a standard scheme which needs the evolution of FDI policy from a quantitative approach to a qualitative approach. This could be one of the keys to enhance the efficiency potential of these industries and to better prepare them for the international competition.

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Table 1: Foreign Firms and Global Efficiency (2 Methods: Malmquist and CSS)

Sectors	TFPG>0	RTEIV>0	TFPG<0	RTEIV<0
	Malmquist	CSS	Malmquist	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 equipment	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	RTEIV > 0	TFPG < 0	RTEIV < 0
	Malmquist	CSS	Malmquist	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	0.34	0.359	0.453	**0.46*** **	1.436	0.374	1.508
	(1.19)	(0.09)	(1.0)	(0.12)	**(3.85)**	(0.45)	(1.04)	(0.46)
FDI	-0.046	**5.414** **			-0.033	**4.907*** **		
	(-0.21)	**(2.37)**			(-0.15)	**(2.15)**		
FDI sect			0.004	0.02			0.0037	-0.008
			(0.61)	(0.26)			(0.39)	(-0.10)
Export							0.11	1.967
							(0.72)	(1.18)
Skills	0.003	**-0.088*** **	0.002	**-0.087** **			0.002	**-0.083** **
	(0.78)	**(-2.16)**	(0.66)	**(-2.08)**			(0.62)	**(- 2.02)**
White collar					-0.007	- 0.047		
					(-1.43)	(- 0.92)		
C4 index	0.002	**0.231*** **	0.002	**0.224*** **	0.003	**0.272*** **	0.002	**0.228*** **
	(0.36)	**(3.37)**	(0.35)	**(3.25)**	(0.59)	**(3.98)**	(0.34)	**(3.35)**
Tariffs	0.024	-0.118	0.023	-0.09				
	(1.23)	(-0.65)	(1.32)	(-0.49)				
Size	**0.005*** **	0.006	**0.005*** **	0.014	**0.005*** **	0.0012	**0.005*** **	0.01
	(4.89)	(0.58)	**(4.92)**	(1.32)	**(4.51)**	(0.10)	**(4.54)**	(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	**49.71*** **	-	-	**2.524***	**43.72*** **	-	-
	(1.54)	**(3.01)**			**(1.77)**	**(2.72)**		
FDI	-0.007	**8.232*** **			-0.007	**8.15*** **		
	(-0.27)	**(2.77)**			(-0.30)	**(2.73)**		
FDI sect			0.091	**2.076*** **			**0.105***	**1.604*** **
			(1.56)	**(3.05)**			**(1.81)**	**(2.45)**
Export							-0.051	**7.2*** **
							(-0.26)	**(3.27)**
Skills	0.005	-0.1	0.005	- 0.1				
	(0.87)	(-1.46)	(0.87)	(- 1.43)				
White collar					-0.008	-0.072		
					(- 0.95)	(-0.69)		
C4 index	0.0091	**2.977*** **	0.009	**2.864*** **	0.078	**3.04*** **	0.085	**3.093*** **
	(1.09)	**(3.17)**	(1.11)	**(3.01)**	(0.94)	**(3.23)**	(1.03)	**(3.32)**
Tariffs	0.228	**5.176*** **	0.228	**5.227*** **	0.201	**5.24*** **	0.219	**5.10*** **
	(1.56)	**(3.14)**	(1.56)	**(3.14)**	(1.37)	**(3.16)**	(1.51)	**(3.12)**
Size	**0.008*** **	0.011	**0.008*** **	**0.031****	**0.008*** **	0.0027	**0.008*** **	0.006
	(5.56)	(0.67)	**(6.04)**	**(2.03)**	**(5.22)**	(0.15)	**(5.96)**	(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)	(-0.18)	(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%