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Total Factor Productivity within the Tunisian manufacturing sectors and international convergence with OECD countries

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Abstract

The purpose of this paper is to examine Total Factor Productivity (TFP) of six Tunisian manufacturing sectors and to compare these productivities with those of OECD countries. The analysis covers the period 1983-1999. First, TFP is measured and some of the main economic and financial determinants are identified. In carrying out this econometric exercise we are careful to take into account the problem of the direction of causality between variables. For the empirical analysis, panel data causality tests are conducted. The results suggest that TFP growth rates are sensitive to variables reflecting international openness. Secondly, the paper investigates the evolution of the TFP gaps between Tunisia and OECD countries. A stochastic convergence has been considered here. Two panel data unit root tests are employed. A global convergence is evidenced for five sectors.

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I. Introduction

In November 1995, the Barcelona Declaration established a global framework to strengthen a multidimensional partnership between the European Union and twelve South and East Mediterranean (SEM) countries, including Tunisia. The main objective of this Declaration is to promote a shared prosperity on both sides of the Mediterranean Sea, mainly through the development of the regional trade. The gradual creation of a Free Trade Zone, which is to be finalized before the end of 2010, will be the central instrument in achieving this result. This regional policy remains fully compatible with the scope of multilateral integration in the world economy, as required by membership of the World Trade Organization.

The pace of this trade liberalization will, to a great extent, depend on the ability of the SEM countries to promote deep structural reforms in their respective manufacturing industries. Indeed, until the beginning of the nineties, SEM manufactured goods benefited from significant unilateral trade advantages in entering the EU markets. The relative scope of these advantages has gradually vanished with the extension of similar facilities to eastern European countries, which recently joined the European community. In addition, the creation of the Free Trade Zone will rely on the reciprocity rule. This means that the SEM products will have to compete with European goods on their own national markets whereas until now, most of them were sheltered from European exports. Therefore, international competition will increase dramatically on the local as well as the traditional exporting markets, necessitating a greater productive efficiency of manufacturing firms.

In the SEM countries, there is reason to believe that the ongoing process should affect Tunisia in particular. In 1999, the industrial sector accounted for 18% of the GDP, the highest percentage in North Africa and the Middle East, after Egypt. Moreover, not only is the EU a traditional selling market for Tunisian exporters, but most manufactured goods are also still highly protected on the national market.[1] This paper aims at scrutinizing the long-run productive

[1] In 1995, when the principles of the partnership were accepted, and ratified in early 1998 by the Association Agreement with the EU (AAEU), 28% of public revenue resulted from import tariffs. The removal of Tunisian trade restrictions is therefore a highly important measure for the government and the manufacturing

performance of the Tunisian manufacturing sectors by considering Total Factor Productivity (TFP) for both the long run period (1983-2000) and the most significant sub-periods of industrial policy. The history of the Tunisian manufacturing sector and its development pattern are not linear. Export promotion and import substitution coexisted for a long period, both benefiting from public incentive measures, which contributed to relative price distortions between activities.

The paper is organised as follows. In the next section, we begin with the calculation of Total Factor Productivity (TFP) for six Tunisian manufacturing sectors: food processing (FOOD), electrical and metal products (ELEMET), chemical activities (CHEM), textiles, clothing and leather (TCL), building materials and ceramics (BGC), other manufacturing products (OTHER). In the long run, productive performance proved to be highly heterogeneous. Productivity gains were strong for chemical products, but negative for food processing activities. The TFP growth rates are correlated with a limited number of variables, especially those reflecting the trade strategy and the international openness of the sectors. In section III, for each of the six aforementioned sectors, we assess the effectiveness of integration in the world economy by means of a productivity convergence analysis between Tunisia and the OECD countries. On the whole, the hypothesis of statistical convergence is not rejected. However, it proved to be sensitive to the empirical sample. In section IV, we return to the main results of the paper and discuss avenues for future research opened up by this exploratory analysis.

II- Total Factor Productivity (TFP) and its determinants

II.1 The sector-based evolution of the Total Factor Productivity

In the first decade after independence, Tunisia supported an inward-oriented productive system. In 1970, a first watershed occurred with fiscal incentives for export activities. Textiles, clothing and leather (TGL) benefited greatly from this political changeover, which contributed to strengthening light industry beyond the traditional food processing activities. At the beginning of the eighties, the manufacturing sector represented about 15% of the GDP and was much more diversified that in 1958 when Tunisia gained independence. The structure of the industry

producers. Its macroeconomic and social impacts explain why the public programme of “mise à niveau” was launched.

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changed significantly over this period with an increasing share taken by chemical and textile exports. The relative importance of exports increased still further, first with the implementation of the structural adjustment policy (1986) and later, with the Barcelona Declaration (1995). With tariffs on imports being progressively eliminated, international competition has become a major source of stimulation for a higher productivity level and has ensured that the allocation of resources is related to the comparative advantage principle.

In relation to the variations in trade policy, the performance of the whole industry can be appreciated both, in the long run and for significant sub-periods. During the period 1983-1987, the effects of the second oil crisis were still being felt. Tunisia was facing a severe economic and financial crisis resulting from the decline in oil export earnings and the slowdown in net worker's remittances (cf. Morrisson and Talbi, 1986). A more restrictive external trade policy was implemented to manage the balance of payments crisis and the sharp fall in external reserves. The period 1987-1995 reflects the implication of the structural adjustment policy and the move toward a more market-friendly economy. During this period, Tunisia joined the GATT (1990), became a founding member of the World Trade Organization (WTO), and adopted current account convertibility (1993). Besides the multilateral approach to trade policy, the Euro-Mediterranean partnership also developed and found an institutional outcome with the Barcelona Declaration (1995). The last sub-period (1995-2000) reflects the gradual preparation for the establishment of the Free Trade Agreement and the strengthening of competition on local and external markets.

For each of the six sectors, Total Factor Productivity, (TFP) has been measured by considering the ratio of the value added at constant market prices to the inputs. Production technology has been defined assuming constant returns to scale with two primary inputs: the number of permanent employees (L) and the capital stock (K). With regard to the labour force, the data about the number of hours worked were not available. However, although the labour market became more flexible over the entire period, the public regulation for hours worked did not change. We assumed that the level and the evolution of TFP were not biased by this missing information. The capital stock has been calculated, at constant prices, using the perpetual-inventory method for annual investment flows. In calculating this stock, the available information did not allow to breakdown the productive capital in its various components. An average depreciation rate of 10% has therefore been adopted. The choice of a lower rate (5%) to account for the fact that equipments could be used beyond their accounting duration of life did

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not prove to affect the TFP level and its evolution over the period.[2] The stock has been constructed as follows, with (t) denoting the end of year.

$$K_t = I_t + (1-\delta)\, K_{t-1} \quad (1)$$

Productivity has been measured assuming constant returns to scale. As in Bernard and Jones (1996), the relative contribution of the labour force (α) has been calculated by considering the share of wages in the sectoral value-added; and we infer the capital share. On the one hand, the perfect competition that underlies this assumption is somewhat restrictive. However, input shares are free to change on a yearly basis while the econometric estimation of these elasticities would constraint them to be fixed and to ignore their fluctuations over the period (1983-2000). This restriction proved to be strong as regard the evolution of the shares in the Tunisia manufacturing sectors.

$$PTF_t = \frac{Y_t}{L_t^{\alpha} K_t^{(1-\alpha)}} \quad (2)$$

For electrical and mechanical (ELEMET), but also building and ceramics industries (BGC), the long-run annual average rate of TFP is close to what might be expected for a productivity gain: 1.8% and 3.3%, respectively. The situation is quite different for the other sectors. While strong positive gains are illustrated for the chemical (CHEM), but also for textiles, clothing and leather (TCL), 10.5% and 3.3%, respectively, significant losses occur in the FOOD processing industries (-5.4%). Within this last sector, the dramatic fall in TFP only decelerates at the end of the period (1995-2000). Understanding this empirical evolution would require a sub-sector-based analysis, information that is lacking for this analysis to be done. The breakdown of gains and losses according to the two potential sources of TFP evolution (i.e. value-added, input use) gives partial information on what happened to FOOD[3]. In Table 1, average growth rates of the value-added and TFPs are presented for the whole period and for sub-periods. In the explanation of TFPs the results suggest that for most sectors, inputs use has grown more rapidly than the value added did.

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[2] In his analysis of Chilean trade liberalization and its aftermath, James Tybout (1996) retains different depreciation rates: 5% for building, 10% for machinery and 20% for vehicles.

[3] For FOOD, Figure 2 illustrates that the evolution of the TFP has also been unfavourable for most of the industrialised OECD countries.

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Table 1: TFP and manufacturing value-added over the period 1983-2000

	1983-1987		1987-1995		1995-2000		1983-2000
Types of Products	I	II	I	II	I	II	I
Food	-	28.7	-	20.9	-	18	-
TFP	-6.8	-	-6.8	-	-0.5	-	-5.4
VA	2.4	-	0.5	-	8	-	2
Building, ceramics	-	10.5	-	11	-	10.2	-
TFP	-2.7	-	5.1	-	3.2	-	3.3
VA	4.3	-	5.8	-	3.4	-	5
Electrical and metal	-	14.8	-	13.9	-	13.3	-
TFP	-0.2	-	3	-	3.9	-	1.8
VA	5.9	-	4.7	-	6	-	5
Chemical	-	4.6	-	9.5	-	10.9	-
TFP	-0.3	-	12.3	-	4.5	-	10.5
VA	10.4	-	10.7	-	5	-	11.7
Textiles and leather	-	28.3	-	31.8	-	34.7	-
TFP	8.7	-	3.3	-	2.2	-	3.3
VA	8	-	8.6	-	5	-	7
Other industries.	-	12.2	-	12.6	-	12.9	-
TFP	3.2	-	-0.4	-	0.9	-	1.9
VA	9.1	-	6	-	5	-	6

I: Annual average growth rate of TFP for each period. II: The relative share of the sector-based value-added over the period for all Tunisian manufactured goods.

Except for textiles and other manufacturing industries, which recorded a good productive performance, the 1983-1987 sub-period was characterised by negative growth rates in TFP for the other sectors. These poor performances resulted from the difficulty in adjusting inputs in an adverse macroeconomic context. Cumbersome regulations governing the labour market were an obstacle to the rapid restructuring of enterprises and some of them had to manage the overinvestment of the previous period. TFP calculations then suffered from the under-utilisation of production capacities. The next sub-period, stretching from 1987 to 1995, was much more favourable for all sectors except the food industry. The macroeconomic recovery and the combination of trade openness and local deregulations contributed to a more efficient management of inputs. Firms enjoyed a “catching-up” effect as they had the possibility to extend their production for a limited increase in their productive inputs.

For the chemical industry, the average annual growth rate of TFP was 10.5%. Performance slowed down after 1995, nonetheless remaining impressive, and always higher than the TFP calculated for textiles, which is the most important sector in the Tunisian manufacturing industry. Although the performance was remarkable in the aforementioned sector it decelerated

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continuously in the long run. In the textiles industry, the average rate of productivity decreased over the two sub periods 1983-1987 and 1987-1995 from 8.7% to 3.3%. And during the most recent sub-period, the average growth rate was a mere 2.2%. This evolution can be seen as an underlying justification for the public modernisation program where special attention has been paid to the textiles industry. This sector, which accounts for 30% of the manufacturing value added, is crucial for hundreds of thousands of Tunisian people. Its future will be narrowly conditioned by the ability of the producers to generate sufficient productivity gains to compensate the impact of foreign competition on international prices. The slowing down of the value-added growth rate (8.6% until 1995, but only 2% after 1995) is symptomatic of the fragility of the Tunisian position on domestic as well as foreign markets.

II.2 The potential econometric determinants of TFP

What can we say about the determinants of the Tunisian manufacturing productivity? Numerous factors would deserve greater empirical attention. Some of them are ignored in this work because as information is lacking to take them into account. Human capital is in this case, which increases the productive efficiency of the labour force, but also the quality of institutions, which reduces transaction costs. Over the last two decades, applied economic literature has shown considerable interest in the analysis of the specific contribution of trade and financial openness. Our empirical analysis will pay special attention to these variables and the nature of their relationship with TFP.

Although there is a large body of empirical studies to support the existence of a positive correlation between openness and both the GDP and the TFP growth rates (see Dollar, 1992; Ben David, 1993; Sachs and Warner, 1995; Edwards, 1998), there are some “prominent trade liberalisation sceptics” to use Edwards (1998)’s words[4]. Rodriguez and Rodrik (1999) stress the methodological problems leaving the results open to diverse interpretations between these variables. The direction of causality is one of these problems, which is more hotly debated than ever[5]. Does the growth of exports induce productivity growth or is the reverse true? Is productivity a precondition for a high external trade performance? In other words, TFP can be a

[4] In his review of prominent trade liberalisation sceptics, Sebastian Edwards includes Krugman (1994) and Rodrik (1995)

[5] See Edwards (1993) for a survey

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result from a learning-by-exporting point of view, but also as the expression of a self-selection effect (see Haddad, Melo and Horton, 1996).

The productivity determinants

Our objective here is to identify the main determinants of TFP in the Tunisian manufacturing industry. To carry out this analysis, special importance is given to those variables reflecting openness. The level and the growth rate of exports (EX) as well as the export ratio (TEX) have to be considered first. Competition on foreign markets is a strong stimulus for promoting economic efficiency. For Tunisia, the pressure from the external environment should, in this context be felt strongly. World economic integration increases a progressive loss of the preferential advantages that the European Union had granted for decades. While Europe is by far the main exporting market for Tunisian manufacturing goods, competition in this market is increasing. To avoid the "trade diversion" resulting from the integration of the new eastern European countries in the EU[6], Tunisian firms must improve their productive performance. A test on the direction of causality between these variables and sector-based TFPs will be implemented. The same precaution will be adopted for net exports (NEX), an indicator of the comparative advantage which we define as being the difference between exports and imports divided by the sector-based value-added, and for all variables for which the issue of direction of causality can be reasonably suspected.

Such a suspicion is strong vis-à-vis the effective rates of protection (ERP). Until the beginning of the eighties, numerous authors agreed that developing countries had to protect their *infant industry*[7]. This theoretical argument has suffered greatly from the liberal credo and the detrimental effects of protectionism, from the possibility arising from this strategy to maintain X-inefficiency and costs above internationally competitive levels[8]. High unit costs, and consequently low TFP levels, might be correlated with the effective rates of protection, and presumably, in a bi-directional manner. On the one hand, the Free Trade Agreement (FTA) should stimulate efforts by providing a clear signal that, in the near future, there will be no protection behind which to shelter. However, on the other hand, lower tariffs can be

[6] Let us recall that the integration process was completed in 2004.
[7] This is the best known argument, reasoning in favour of temporary protection until the "infants" have learned to stand on their own feet, becoming internationally competitive without any state support.
[8] See Bhagwati (1978) or Krueger (1978) for influential analyses on this issue.

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predetermined by the ability to achieve higher productivity without assuming significant social costs.

The macroeconomic environment also matters, especially the local demand in the manufacturing sectors. This demand has been defined here as current output augmented by imports minus exports (DEM). When domestic demand slows down, it is a real challenge for the producers who have to redeploy their activity to compete on the external markets. The impact of this variable is potentially difficult to differentiate from the previous one. In other words, the greater the trade protection, the stronger the firm's dependence on the swings of local demand. DEM can also be seen as being correlated with the capacity utilisation of the capital stock, which cannot rapidly be adjusted downward, as well as with labour regulations, which slow the speed of the adjustment of the workforce to the optimal level.

How can we assess the impact of price competition on TFP? In every sector, Tunisia is a "price-taker" in the world market. This exogenous price constraint plays on local costs and, then, on TFP levels. Forty-eight real effective exchange rates henceforth referred to as REER, have been calculated over the 1983-1999 period, one for each of the three-digit industries as defined by the Standard International Trade Classification (SITC). Then, six sector-based geometric averages of the REER have been calculated from the relevant 3-digit groups. Each group has been weighted by its respective contribution to the value-added of the sector. The evolution of these indices highlights the long-run underlying competitiveness of the Tunisian manufacturing sectors. In calculating the REER, we considered the consumption price index (CPI) for the ten largest world exporters. Each of these exporters was given a weight according to its relative importance in the world trade at the three-digit level. Assuming that the *law of one-price* holds at this SITC level, any long run deviation in REER will constitute a loss of competitiveness for the Tunisian producers and an incentive for them to increase their TFP.

For fifteen years, the Tunisian authorities have targeted a stable real effective exchange rate. To do this they have resorted to periodic adjustments of the rate, intervening in the interbank foreign exchange market. The Tunisian Dinar is pegged to a basket of the main economic partner countries' currencies. European currencies are dominant in this basket, in line with the trade flows. This policy has been quite successful in terms of macroeconomic equilibrium. The inflation rate has remained low, close to the rate of European countries, nominal exchange rate adjustments eliminating the differentials. However, this policy did not take into

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account the implications of the trade liberalization program and the sectoral constraints of the structural adjustment. We assume that some of the manufacturing sectors have had to compensate for the loss of price competitiveness by a higher TFP.

With regard to financial openness, Foreign Direct Investment (FDI) inflows have been considered. FDI facilitates productivity gains and the integration in the world economy by several channels. The enduring presence of foreign enterprises provides easier access to efficient technologies and organizational methods. In comparison with classical financial debt, FDI incorporates both human experience and organizational know-how. It saves the fixed costs of producing technological innovations and the marginal cost of their replication in the local environment. FDI also contributes to lowering the transaction costs for the penetration of external markets. A capital stock ratio of FDI has been constructed for each of the six manufacturing sectors we are interested in. Inflows have been summed since 1980 with a depreciation rate of the stock of 10%, the same as for the sector-based capital stock (K) to which the FDI stock has been reported.

The specification of the TFP model has been extended to control for additional influences, which are presumably time-variant and potentially not correlated with the previous economic and financial openness variables listed below. Several other variables have been considered. The capital labor ratio (KLR) controls for the capital intensity effect. We assume that this variable has a positive impact on the TFP evolution. Another variable has also been introduced to capture the potential industry compositional effect. As we work on aggregated figures, some redistributions of the sector-based value-added, hereafter referred to as STRUC, may occur with a non-neutral impact on the evolution of TFPs. STRUC is measured per sector to capture this effect. For each sector, it has been measured by means of the annual deviations of the relative value-added shares at the three-digit level. Finally, following Edwards (1998) approach, a principle components analysis has been implemented. It allows the combined relevant information of the partially correlated variables reflecting openness to be taken into account. A composite index has therefore been calculated with the first principal component that we call (OPEN) [9].

[9] Variables, which we retained for OPEN, are: FDI, REER, NEX, EX. In Edwards' (1998) analysis, comparative data for 93 countries are used to analyse the robustness of the relationship between openness and Total Factor

The dynamic panel and the issue of causality

The analysis of the potential determinants of openness has suggested that we should control for the direction of causality between variables. In this perspective, the Granger-causality test (1969) has often been used, requiring long time-series, which are not available here. Therefore, the panel dimension will be considered in our empirical case with the direction of the causality tested as follows. We suppose that X fails to Granger cause Y if in the regression of Y on its lagged variables and X, the δ_j associated with X in (3) are zero[10]. The unobservable heterogeneity over the six manufacturing sectors will be controlled through the introduction of fixed effects.

$$Y_{i,t} = \beta_{0i} + \sum_{j=1}^{P} \beta_j Y_{i,t-j} + \sum_{j=1}^{P} \delta_j X_{i,t-j} + \varepsilon_{i,t} \quad \mathrm{i} = 1,..\mathrm{N};\ \mathrm{t} = \mathrm{p}+1,...\mathrm{T} \qquad (3)$$

Due to the dynamic nature of the panel data model, an empirical problem arises with the estimation of equation (3). As a result of the presence of the lagged endogenous variable on the right hand side of the equation the *within estimator* is not convergent, suffering from an endogeneity bias. An appropriate way of overcoming the estimation problem consists in resorting to the Generalized Method of Moments (GMM). The GMM provides consistent estimators which benefit from the orthogonal property of the lagged instrumental variables while correcting the errors for potential heteroskedasticity. This estimator consists in removing the fixed effect by first differentiating equation (3). The error terms $\Delta\varepsilon_{i,t}$ in the differentiated equation are then correlated with the independent variables $\Delta Y_{i,t-j}$, which need to be instrumented by either $Y_{it-j'}$ or $\Delta Y_{i,t-j'}$[11]. Therefore, the causality test from X to Y will consist in testing the null hypothesis of the coefficients in (3): $\delta_1 = \delta_2 = ... = \delta_p = 0$. The statistic of the test asymptotically follows a Chi-square distribution with p degrees of freedom. The results of this empirical analysis are shown in Table 2, with variables defined in levels and growth rates, respectively.

Productivity growth rates. OPEN has been considered as a potential determinant, but not for the causality test which we carried out in this section.

[10] We use the easiest presentation of the causality test on panel data. A more complex analysis, as in Nair-Reichert and Weinhold (2001), would be to hypothesise that β_j and δ_j are specific to individuals in (3), here the sectors.

[11] See Baltagi (1995) and Sevestre (2002) for a helpful discussion on the methods and especially on the conditions of orthogonality of the Generalized Moments Method for Dynamic Panel Data Models.

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Table 2: Panel data Granger causality test results (p=3 lags)

Variables	Variables (levels)		Variables (growth rates)	
	Direction of the causality	Chi-square statistics	Direction of the causality	Chi-square statistics
(TFP, DEM)	DEM $\Rightarrow$ TFP	K^c=5.317*	DEM $\Rightarrow$ TFP	K^c=10.605**
	PTF $\neq$ DEM	K^c=0.661	PTF $\neq$ DEM	K^c=0.529
(TFP, ERP)	TPE $\neq$ TFP	K^c=3.69	ERP $\neq$ TFP	K^c=0.142
	TFP $\neq$ TPE	K^c=5.257	TFP $\neq$ ERP	K^c=0.424
(TFP, FDI)	FDI $\Rightarrow$ TFP	K^c=8.64**	IDE $\Rightarrow$ TFP	K^c=6.067*
	PTF $\neq$ FDI	K^c=0.594	TFP $\neq$ IDE	K^c=0.759
(TFP, NEX)	NEX $\Rightarrow$ TFP	K^c=6.62*	NEX $\neq$ TFP	K^c=1.569
	TFP $\neq$ NEX	K^c=1.963	TFP $\neq$ NEX	K^c=3.45
(TFP, IM)	IM $\neq$ PTF	K^c=3.51	IM $\neq$ PTF	K^c=0.422
	TFP $\neq$ IM	K^c=1.198	PTF $\neq$ IM	K^c=0.689
(TFP, EX)	EX $\Rightarrow$ PTF	K^c=8.638**	EX $\neq$ TFP	K^c=5.276
	TFP $\neq$ EX	K^c=2.108	TFP $\neq$ EX	K^c=0.569
(TFP, REER)	REER $\neq$ TFP	K^c=1.773	REER $\neq$ TFP	K^c=1.287
	TFP $\neq$ REER	K^c=2.15	TFP $\neq$ REER	K^c=4.886
(TFP, STRUC)	STRUC $\Rightarrow$ TFP	K^c=34.069***	STRUC $\Rightarrow$ TFP	K^c=8.748**
	TFP $\Rightarrow$ STRUC	K^c=9.25**	TFP $\Rightarrow$ STRUC	K^c=10.735**

The symbol ‘ $X \Rightarrow Y$ ’ indicates the direction of the Granger causality. The symbol ‘ $X \neq Y$’, means that there is no causality from X to Y. (***, **,*) denotes significance levels 1%, 5% and 10% respectively.

The results in Table 2 are difficult to compare with other results in the applied literature. As mentioned earlier, causality tests on dynamic panel data models are a relatively recent development. In addition, empirical works generally rely on either macroeconomic or microeconomic databases. As far as we know, there are few sector-based papers on manufacturing activities and no TFP econometric analyses for the North African economies. Beyond this, regressions provide more significant results when variables are expressed in levels than in growth rates and the causality is unidirectional for four variables with the expected sign.

Foreign Direct Investment (FDI) and the local demand for manufacturing products (DEM) are both statistically significant whatever the way the way they are measured (levels or growth rates). This is not the case for exports (EX) and net exports (NEX), the stimulating impact of theses variables not being supported when variables are expressed as growth rates. For the other variables (ERP, IMP, REER), there is no evidence of the Granger-causality. It goes without saying that the statistical significance of this test would benefit from an extension of the

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panel data set by considering sub-sectors (at the three digit level), but also the most recent period (1995-2004), in which the openness policy is more in evidence. In addition, due to the very limited time series data, we have only referred to the simplest version of the panel causality test. In equation (3), the slope coefficients δ_j are assumed to be the same across the sectors. This hypothesis can potentially affect the inference if there are disparities across sectors. In that particular case, it would be less restrictive to replace δ_j in equation (3) by sector specific coefficients $\delta_j^{(i)}$.[12]

Total Factor Productivity (TFP) and its determinants

Solow's residuals are not stable over the whole empirical period. Indeed, 1990 is a transition year. In the previous period, the Tunisian economy combined both the end of the post-independence industrial policy with distortions in trade policy and the first impact of the structural adjustment program. The 1990-1999 period is much more focused efforts towards openness. Tunisia joined the GATT in 1990 and current account convertibility followed in January 1993, two years before the signature of the FTA with European Union. The results of the regression analysis are reported in table 3 below. Regression coefficients also differ according to the econometric specification of the TFP model. In other words, although each variable captures a different aspect of commercial and financial openness, they all potentially share common information, which makes them correlated. This phenomenon is illustrated with FDI, statistically significant when considered alone in the fixed effects model, but not significant when introduced together with the other TFP determinants.

While the explanatory power of the regression logically increases when the econometric specification broadens, two coefficients prove to be statistically significant and reveal the mixed status of the Tunisian manufacturing structure. Productivity depends on the evolution of local demand (DEM), but also on the need to strengthen the Tunisian comparative advantage on external markets (NEX). Inward-looking and export-oriented industries are therefore concerned by these two variables, which are not invariant and sector-specific. If this were the case, the introduction of the fixed effects would capture this impact. The coefficient of the real effective exchange rate (REER) is also statistically significant. The exchange rate policy was connected with macroeconomic objectives, but did not take the sector specific constraints of the

[12] See Hurlin and Venet (2001) for a good discussion of this problem of heterogeneity.

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international competitiveness. This means that industries have had to adjust by themselves to adverse international price shocks, and the most direct way of managing them was by means of a higher TFP.

The composite index resulting from the use of the principle component approach is more statistically significant over the period 1990-1999 than it is from 1983 to 1999. The first principle component explains more than 80% of the variance of the four indicators (FDI, REER, NEX, EX), which we considered. In model (10), the contribution of OPEN reveals strong including when controlling its impact for the joint specific effect of STRUC and KLR. The capitalistic density being an endogenous variable, the instrumental method has been used, all the exogenous variables of the dataset being considered. Although this variable has a positive sign, its statistical power proved to be low, especially for the 1990-1999 period.

Table 3: Tunisian manufacturing sectors and TFP determinants

Variables	**1983 - 1999**					**1990 - 1999**				
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
FDI	1.158	0.306				0.491	0.078			
	(2.48)**	(0.44)				(2.17)**	(0.35)			
REER		0.0056	0.0058				0.007	0.007		
		(1.48)	(1.56)				(1.81)*	(1.90)*		
STRUC		0.178	0.143	-0.435	-0.625		-1.004	-1.044	-1.733	-1.99
		(0.28)	(0.23)	(0.54)	(-0.78)		(-2.18)**	(-2.37)***	(-3.91)***	(-4.08)***
DEM		0.0005	0.0005	0.0003	0.0003		0.0003	0.0003	0.00014	0.0002
		(4.40)***	(4.90)***	(2.42)**	(2.34)**		(2.72)***	(2.93)***	(1.57)	(1.70)*
NEX		0.327	0.338				0.105	0.107		
		(4.23)***	(4.48)***				(2.25)**	(2.32)**		
OPEN				0.00016	0.0002				0.00017	0.0002
				(2.12)**	(2.53)**				(4.22)***	(4.41)***
KLR					0.214					0.08
					(1.69)*					(1.22)
$\overline{R}^2$	0.44	0.56	0.56	0.50	0.51	0.61	0.70	0.70	0.74	0.74

N.B: The numbers in brackets are the t-statistics at the following significant levels of confidence (*) 90%; (**) 95 %; (***) 99 %. The coefficient of determination is adjusted ($\overline{R}^2$). The fixed effects are not reported here, but proved to be highly significant with regard to the Hausman specification test. All the variables are defined in the text.

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III. The international convergence of TFPs

III. 1: Convergence hypothesis revisited

To what extent did Tunisian TFPs converge with the best international standards? Except for a limited range of products, China has become the first world exporter for textiles; OECD countries remain the leaders in the international trade of manufacturing goods. For this reason, and also because of the lack of long-run information for other developing economies, the Tunisian productive performance has been compared to the productive state of OECD countries.

In the Solow-type economic growth model, the international convergence of per capita GDPs results from the diminishing returns to individual factors. The smaller is the per capita capital stock, the higher its marginal efficiency. In developing countries, not only economic and financial openness modifies the relative endowments of capital and labor, but also, it allows the most efficient international technology to be imported. The long-run dynamics should therefore support the productivity convergence hypothesis, at least for those industries where international specialization emerges in accordance with the Tunisian comparative advantage.

FDI contributes to this process. It tends to broaden the domestic capital stock and potentially raises the quality of this input. However, more efficient productive methods can easily be transferred via "foreign firms", especially if they consist of purely informational transfers. The cost of the local adaptation of foreign technology is much less than its initial production cost. The "new theories of economic growth" have stressed the diversity of sources underlying the productivity convergence. Technical progress is simply the prevailing source. Human capital also matters, due to the expenditure on health or education and training. Developing countries are likely to have both a shortage of skilled labor and a relative abundance of unskilled workers. By promoting investment in human capital, domestic expenditure gradually alters this situation and contributes to filling the international TFP-gap.

However, the aforementioned arguments rely on some restrictive hypotheses, the same as those underlying the long-run convergence of standards of living. This is the case for Solow's assumption that economies run into diminishing returns to capital. The progress of sector-based technology is neither exogenous nor the same worldwide. OECD countries have a high rate of

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innovation. For manufacturing activities, OECD countries can be seen as *leaders* and developing countries as *followers* trying to mimic them in accordance with their own human and institutional abilities. Moreover, although FDI contributes to the international diffusion of the appropriate production technology, some differences inevitably remain. They are connected with non-transferable cognitive apprenticeships, which are part of firms' core competencies, part of their static and dynamic efficiency. At this stage of our analysis, it makes sense to consider whether Tunisian TFPs are converging or not.

III.2 Unit root tests and convergence

The productivity convergence assumption can be tested in several ways. In the economic growth model literature, the Sigma or the Beta convergence analysis would be the standard methodology. The former test is based on the reduction of the TFP sample dispersion while the latter refers to the statistical significance of the negative slope between the growth rate of the TFP and its initial level. Such tests on cross-sectional information lose their statistical power when the number of observations is low. With the STAN database, TFPs cannot be calculated for more than 11 OECD countries over the period 1983-1999. Moreover, neither the Sigma nor the Beta convergence tells us anything about the converging and non-converging countries within the sample. The panel data dimension and the unit root tests can be useful for the investigation of the convergence problematic. This unit root test is based on testing the stationary of the TFP deviation (D) of country i from the benchmark country denoted i*. More formally, let the TFP deviation be noted by:

$$D_{i,t} = [Y_{i*,t} - Y_{i,t}],$$

where $Y_{i,t}$ is the TFP level of the country i at the period t. In its simple form, the productivity convergence test consists in applying a unit root test on the following equation:

$$D_{i,t} = \alpha_i + \lambda_i \, D_{i,t-1} + \varepsilon_{i,t} \qquad (4)$$

The null hypothesis: $\lambda_i = 1$, implies that the deviation from the benchmark country is non-stationary (i.e., no convergence in TFPs). Alternatively, rejecting the null hypothesis means $\lambda_i < 1$. In other words, TFP convergence occurs if deviations are stationary. Using a

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special case of (4), where $\lambda_i = \lambda$, Bernard and Jones (1996) have applied the Levin and Lin (1993) panel data unit root test to assess the TFP convergence within a fourteen OECD country sample. In our case, this procedure has the advantage of improving the statistical power by considering the TFP deviations with respect to the manufacturing sectors to which Tunisia is benchmarked. Testing TFP convergence between the Tunisian and OECD sectors needs to fix the benchmark country. Fixing the most productive one and rejecting the null while applying the unit root test, does not necessarily mean that Tunisia is in a converging process. The evolution can result from the own dynamic of OECD countries. For this reason, equation 4 will be slightly modified. For the Tunisian sectors, each of the 11 OECD countries will be considered as a potential benchmark, and the augmented Dickey-Fuller version of the panel data unit root test will be retained as follows, where $\lambda_i^* = \lambda_i - 1$

:

$$(Y_{i,t}^{OCDEh} - Y_{i,t}^{Tn}) = \alpha_i + \lambda_i^*(Y_{i,t-1}^{OCDEh} - Y_{i,t-1}^{Tn}) + \sum_{j=1}^{p} \varphi_j \Delta(Y_{i,t-j}^{OCDEh} - Y_{i,t-j}^{Tn}) + \varepsilon_{it} \tag{5}$$

$$h = OECD\ country\ 1,2,......11; \qquad t = 1983 + p,...1999$$

It worth noticing that equation (5) is used to test the TFP divergence hypothesis by industry: H0: $\lambda_1^* = \lambda_2^* = ... = \lambda_{11}^* = 0$. Rejecting the null assumption means that $\lambda_i^* < 0$, for the TFP difference to be stationary between Tunisia and OECD countries. For each of the OECD industries[13], the TFP has been determined according to the formula we used for Tunisia in equation (2). Then sectoral panel data unit root tests have been applied according to equation 5.

The most standard panel data unit root tests are those developed by Levin and Lin (1993), Im, Pesaran and Shin (1997, 2003) and Maddala and Wu (1999), hereafter noted LL, IPS and MW, respectively[14]. The LL test differs from the two others as it forces the panel countries to

[13] The OECD countries considered in the sample are: Austria, Belgium, Canada, Finland, France, Italy, South Korea, Norway, Spain, Sweden and USA. Data about Spain, for the chemical industry, and France, for miscellaneous industries, were missing. TFP deviations by industry have been evaluated over the period 1983-1999

[14] Freeman et Yerger [2001] applied the Maddala and Wu test to analyse the labour productivity convergence in the manufacturing sector of 8 OCDE countries over the period 1950-1998. Mukherjee and Kuroda [2002, 2003] consider the productivity convergence of the agricultural sector in 14 Indian regions between 1973-1993; the authors have used several panel data unit root tests such as Levin and Lin's, Im, Pesaran and Shin (1997)'s, Harris et Tzavalis (1999)'s, and Hadri (2000)'s tests. Recently, Funk and Strauss [2003] have applied the IPS test in order to test TFP convergence of 21 industries in 16 OECD countries over the period 1971-1994.

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have identical order of integration[15] $\lambda_i^* = \lambda^* = 0$, under the null. IPS and MW unit root tests are more flexible. They allow the autoregressive coefficients λ_i^* to differ across countries and, unlike the unit root test in the univariate case, the statistical distribution of these tests is known. The IPS and the MW tests are retained in this paper; both are conducted on the equation (5). The IPS statistics used is the so-called t-bar statistics is defined by:

$$IPS = \sqrt{N}\,\frac{(\bar{t} - E(\bar{t}))}{\sqrt{Var(\bar{t})}} \rightarrow N(0,1) \quad (6)$$

where $\bar{t} = (1/N)\sum_i t_i^c$, t_i^c being the Dickey-Fuller unit root statistic which is specific to each country (i). The statistic $\bar{t}$ follows a normal distribution with unknown mean and variance, E ($\bar{t}$) and Var ($\bar{t}$), respectively. These values can be either simulated or obtained from Im et al. (1997, 2003). The MW statistics combine the observed significance levels associated to the individual DF unit root tests in the panel. Assuming cross-sectional independence, p_i denoting the p-value from the DF test on the i[th] time series, the MW statistics follows a Chi-square distribution and is equal to:

$$MW = -2\sum_{i=1}^{N} Ln\,(p_i) \rightarrow \kappa(2N) \quad (7)$$

Because of a potential mixture of stationary and non-stationary series, panel data unit root tests are likely to be sensitive to a compositional effect. Indeed, the IPS and MW tests rely on the joint null hypothesis that Tunisia is diverging with all the OECD country-sample (i.e, all the TFP differences contain a unit root). When the null hypothesis is rejected, (i.e., convergence), it does not mean that all the panel members contain a unit root. Tunisia may be in a convergence process with only some of the members. The objective of this sub-section is to test a global convergence, but not the exhaustive list of countries with which Tunisia is converging. We have conducted the two tests (IPS, MW) on the whole panel dataset as well as sub-panels. Countries have been dropped one by one in the decreasing order of their univariate DF test.

[15] This assumption might be too strong in our sample because it means that for the same gap in productivity between Tunisia and two different OECD countries, the reaction would be the same, under the LL specification.

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Empirical results are presented from Tables 4 to 9. In these tables, column 2 highlights the IPS statistics: $\bar{t} = (1/N)\sum_i t_i^c$; column 3 gives the associated p-value, column 5 presents the value of the MW statistics while the associated p-value is given in column 6. For food, and other industries, a convergence process is evidenced with the two tests. By excluding only South Korea from the sample, we obtain the same convergence process for TCL. According to the MW test, Tunisia is converging in two sectors: BGC and ELEMET, but the IPS test does not reject the null. A Monte Carlo study by Maddala and Wu (1999) shows that the MW test dominates the IPS test. In our case study, this fact could explain the opposite conclusions we found for those two sectors. Finally for CHEM, convergence is not found with the IPS test, but with MW. To check the robustness of the mixture in the panel (i.e. combination of stationary and non-stationary series), the countries with the most significant DF statistic according to the univariate DF unit root test have been eliminated one by one. Convergence is rejected for Chemical when one country is excluded[16]. Therefore, the convergence result as suggested by the Maddala and Wu's test is not robust for this sector (table 7).

[16] The DF statistics associated to the productivity gap Tunisia Austria is equal to -3.311 (the most significant). But when we consider the sub-panel excluding Austria, the IPS statistics is equal to 1.988 (P-value=0.976), the MW statistics is equal to 24.852 (P-value=0.129)

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Table 4: Unit Root test for the food processing industry (FOOD)

Groups of countries	IPS Test			MW Test		
	IPS Statistic	P-value	Conclusion	MW Statistic	P-value	Conclusion
G=All	-1.499*	0.07	convergence	59.987***	$0.22\ 10^{-4}$	convergence
G1=G-Finland	-2.124**	0.016	convergence	59.22***	$0.93\ 10^{-5}$	convergence
G2=G1-France	-2.368***	0.009	convergence	56.33***	$0.79\ 10^{-5}$	convergence
G3=G2-Usa	-2.558***	0.005	convergence	52.853***	$0.79\ 10^{-5}$	convergence
G4=G3-Korea	-2.744***	0.003	convergence	49.097***	$0.86\ 10^{-5}$	convergence
G5=G4-Norway	-2.94***	0.0016	convergence	45.138***	$0.97\ 10^{-5}$	convergence
G6=G5-Canada	-2.932***	0.0016	convergence	39.415***	$0.21\ 10^{-4}$	convergence
G7=G6-Sweeden	-2.835***	0.002	convergence	32.942***	$0.60\ 10^{-4}$	convergence

G=All, is the set of the countries Austria, Belgium, Canada, Finland, France, Italy, South Korea, Norway, Spain, Sweden and USA

* Significant at 90% level, ** significant at 95% level, *** significant at 99% level

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Table 5: Unit Root test for Building material and ceramic products (BGC)

Groups of countries	IPS Test			MW Test		
	IPS Statistic	P-value	Conclusion	MW Statistic	P-value	Conclusion
G=All	0.479	0.684	No convergence	44.787***	$0.28\ 10^{-2}$	convergence
G1=G-Usa	-0.11	0.454	No convergence	44.06***	$0.147\ 10^{-2}$	convergence
G2=G1-Austria	-0.604	0.273	No convergence	42.759***	$0.865\ 10^{-3}$	convergence
G3=G2-Canada	-0.732	0.232	No convergence	39.184***	$0.10\ 10^{-2}$	convergence
G4=G3-Spain	-0.813	0.21	No convergence	35.214***	0.13610^{-2}	convergence
G5=G4-France	-0.910	0.181	No convergence	31.233***	$0.18\ 10^{-2}$	convergence
G6=G5-Finland	-0.985	0.245	No convergence	26.976***	$0.26\ 10^{-2}$	convergence
G7=G6-S. Korea	-1.06	0.144	No convergence	22.592***	$0.39\ 10^{-2}$	convergence

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Table 6: Unit Root test for Electric material and metallic industries (ELEMET)

Groups of countries	IPS Test			MW Test		
	IPS Statistic	P-value	Conclusion	MW Statistic	P-value	Conclusion
G=All	2.07	0.981	No convergence	39.703***	$0.11\ 10^{-3}$	convergence
G1=G-Usa	0.816	0.793	No convergence	39.686***	$0.54\ 10^{-2}$	convergence
G2=G1-Finland	0.07	0.528	No convergence	39.264***	$0.26\ 10^{-2}$	convergence
G3=G2-Canada	-0.26	0.397	No convergence	37.133***	$0.20\ 10^{-2}$	convergence
G4=G3-S. Korea	-0.58	0.28	No convergence	34.711***	$0.16\ 10^{-2}$	convergence
G5=G4-Austria	-0.69	0.314	No convergence	30.812***	$0.21\ 10^{-2}$	convergence
G6=G5-Spain	-0.802	0.211	No convergence	26.760***	$0.28\ 10^{-2}$	convergence
G7=G6-Belgium	-0.838	0.20	No convergence	22.107***	$0.47\ 10^{-2}$	convergence

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Table 7: Unit Root test for chemical industry (CHEM)

Groups of countries	IPS Test			MW Test		
	IPS Statistic	P-value	Conclusion	MW Statistic	P-value	Conclusion
G=All	1.294	0.902	No convergence	34.612**	0.022	convergence
G1=G-S. Korea	0.700	0.758	No convergence	33.941**	0.012	convergence
G2=G1-Sweeden	0.347	0.636	No convergence	32.232***	$0.9\ 10^{-2}$	convergence
G3=G2-Italy	-0.01	0.496	No convergence	30.343***	$0.68\ 10^{-2}$	convergence
G4=G3-Usa	-0.383	0.35	No convergence	28.286***	$0.5\ 10^{-2}$	convergence
G5=G4-Belgium	-0.737	0.23	No convergence	25.796***	$0.4\ 10^{-2}$	convergence
G6=G5-France	-0.925	0.177	No convergence	22.173***	$0.46\ 10^{-2}$	convergence

Table 8: Unit Root test for Textile, clothing and leather products (TCL)

Groups of countries	IPS Test			MW Test		
	IPS Statistic	P-value	Conclusion	MW Statistic	P-value	Conclusion
G=All	-0.857	0.196	No convergence	58.931***	$0.32\ 10^{-4}$	convergence
G1=G-S. Korea	-1.296*	0.097	convergence	57.498***	$0.17\ 10^{-4}$	convergence
G2=G1-Belgium	-1.942**	0.026	convergence	56.625***	$0.71\ 10^{-5}$	convergence
G3=G2-Austria	-2.244**	0.012	convergence	53.839***	$0.55\ 10^{-5}$	convergence
G4=G3-Usa	-2.516***	0.006	convergence	50.581***	0.4810^{-5}	convergence
G5=G4-Norway	-2.780***	0.0027	convergence	46.958***	$0.47\ 10^{-5}$	convergence
G6=G5-Spain	-3.069***	0.0011	convergence	43.072***	$0.48\ 10^{-5}$	convergence
G7=G6-Italy	-3.437***	0.0003	convergence	39.065***	$0.47\ 10^{-5}$	convergence

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Table 9: Unit Root test for other industries (OTHER)

Groups of countries	IPS Test			MW Test		
	IPS Statistic	P-value	Conclusion	MW Statistic	P-value	Conclusion
G=All	-1.648*	0.05	convergence	58.986***	$0.10\ 10^{-4}$	convergence
G1=G-Usa	-2.175**	0.015	convergence	57.557***	$0.50\ 10^{-5}$	convergence
G2=G1-Canada	-2.376***	$0.90\ 10^{-2}$	convergence	53.865***	$0.54\ 10^{-5}$	convergence
G3=G2-S. Korea	-2.45***	$0.54\ 10^{-2}$	convergence	43.67***	$0.69\ 10^{-5}$	convergence
G4=G3-Norway	-2.518***	$0.58\ 10^{-2}$	convergence	43.821***	$0.16\ 10^{-4}$	convergence
G5=G4-Italy	-2.460***	$0.70\ 10^{-2}$	convergence	37.614**	$0.44\ 10^{-4}$	convergence
G6=G5-Belgium	-2.398***	$0.82\ 10^{-2}$	convergence	30.999***	$0.14\ 10^{-3}$	convergence

IV Conclusion

Up to the mid eighties, Tunisia based its industrial strategy on the development of a diversified and rather protected manufacturing sector. In 1987, a first turning point occurred with the launching of a structural adjustment policy that promoted competitiveness and favoured the exporting sector. This external trade openness found a further extension through the adherence to the General Agreement on Tariffs and Trade (1990) and the bilateral agreement with the European Union (1995) to build a free trade zone, which is to be finalised before 2012. This economic orientation challenges the productive efficiency of the manufacturing sector. If the real exchange rate policy remains determined by macroeconomic fundamentals as it was over the last ten years, most firms will have to face the downward pressure price resulting from the trade liberalisation and the stronger competition on local and international markets. Improving the productive efficiency is therefore a big challenge conditioning the ability to integrate the world economy.

In this paper, the productivity performance of six major manufacturing industries has been calculated over the period 1983-2000. Economic determinants of TFP gains have been identified by considering the panel dimension of the database. In this econometric analysis the Granger causality test has been carefully used. To conduct this test, the GMM estimator has been used in order to take into account the heteroskedasticity on the one hand, and the potential endogeneity bias resulting from the dynamic specification of regressions on the other hand. TFP measures have shown that the performance differed across sectors and sub-periods. According to the criterion of the productive performance, three sectors proved to be successful. The chemical industry outperformed the electric and metal industries, but also those of textile, clothing and leather. The performance of CHEM contributed to strengthen its relative share in the whole production of the manufacturing sector. On the contrary, the TFP performance of FOOD processing industries enhanced a continuous regression of its sectoral share over the period 1983-2000.

To appreciate the relative performance of the six Tunisian manufacturing sectors, the third section of the paper focused on international TFP comparisons. The prevailing idea was to gauge this performance with those of OECD countries that reflect the “best productive practice” in the world. International comparisons have been achieved by adopting TFP unit root panel data convergence tests. Two-unit root tests have been used: the Im, Pesaran, and Shin’s; and the Maddala and Wu’s. Both tests, conducted by considering sub-panels, proved to be sensitive to the composition of the sample, which conditions the converging or diverging process of Tunisian manufacturing activities. Except for the chemical sector (CHEM), a global TFP convergence is evidenced when OECD countries are taken as the benchmark.

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Figure 2: TFP Evolution in Food Processing Industries, by Country

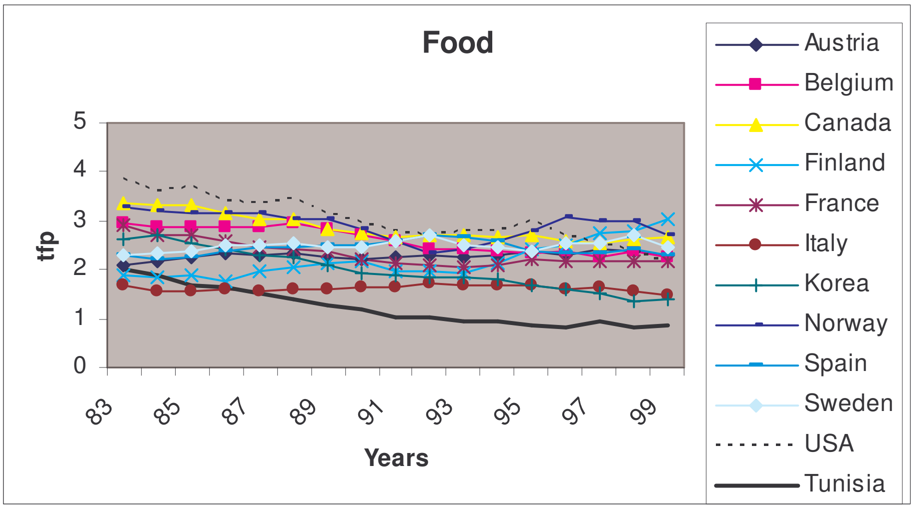

Figure 3: TFP Evolution in Building Materials and Ceramic Industries, by Country

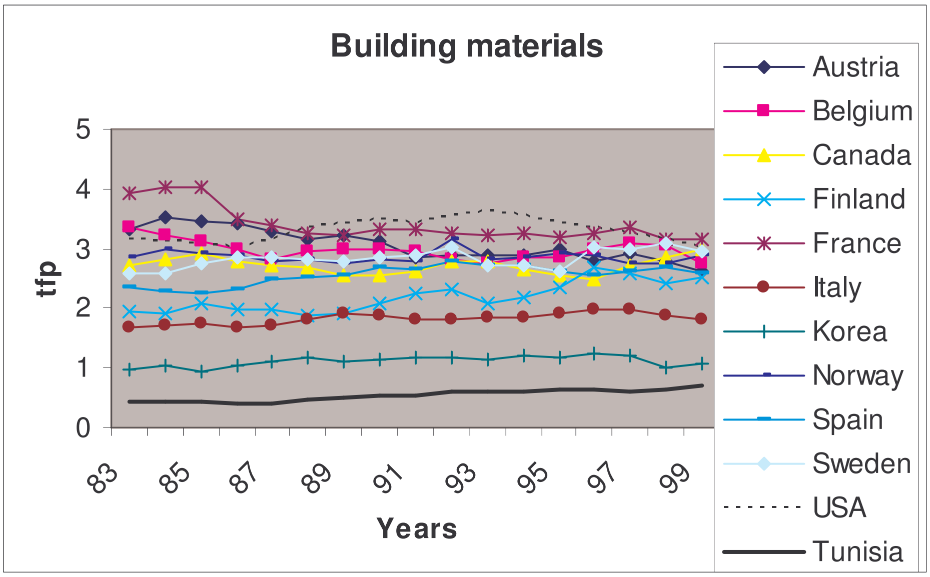

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Figure 4: TFP Evolution in Electrical and Metallic Industries, by Country

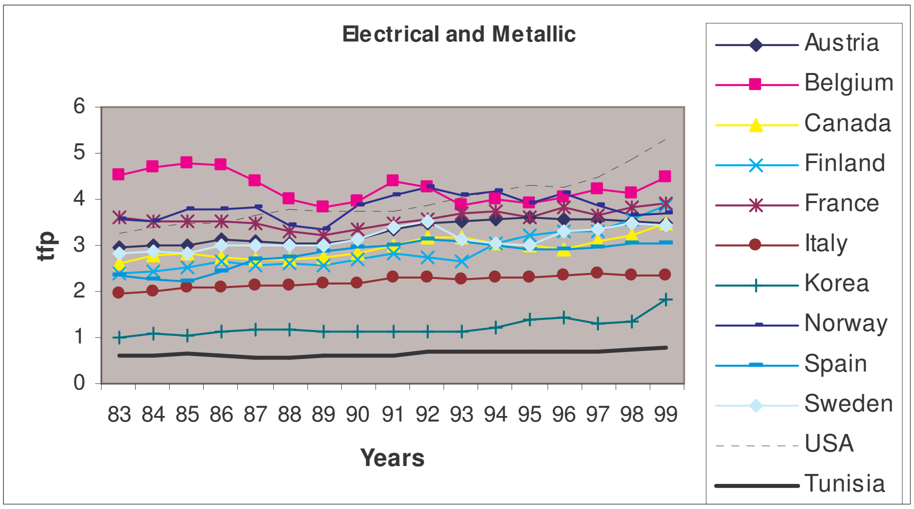

Figure 5: TFP Evolution in Chemical Industries, by Country

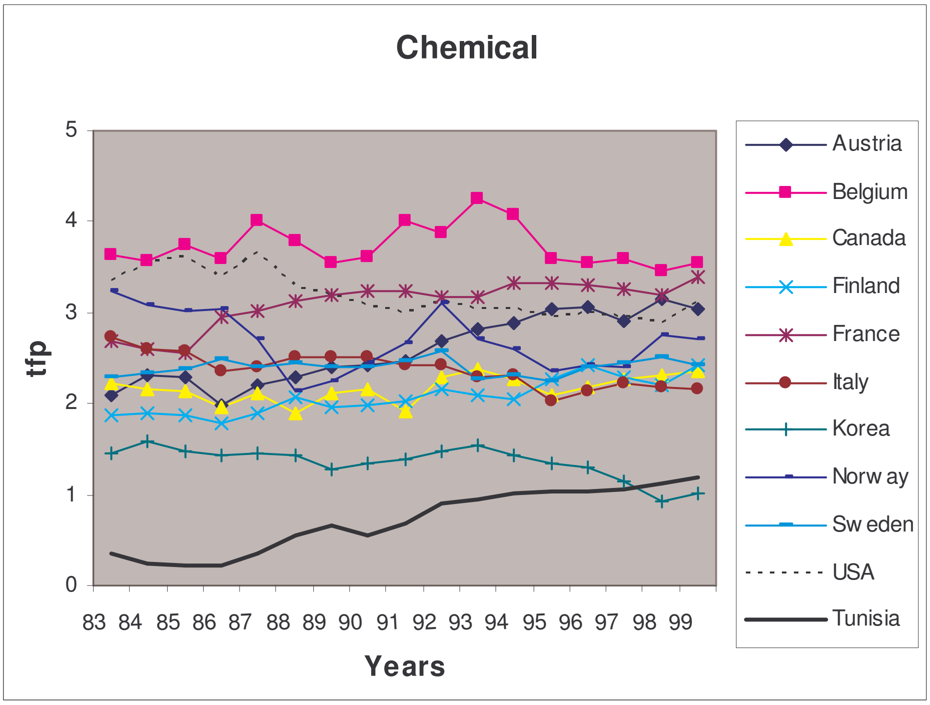

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Figure 6: TFP Evolution in Textile, Clothing and Leather Industries by Country

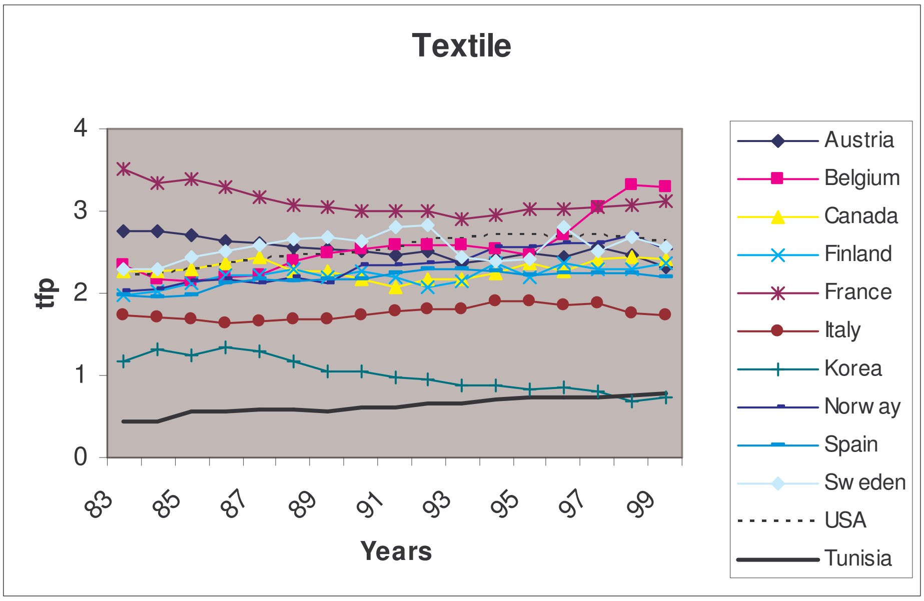
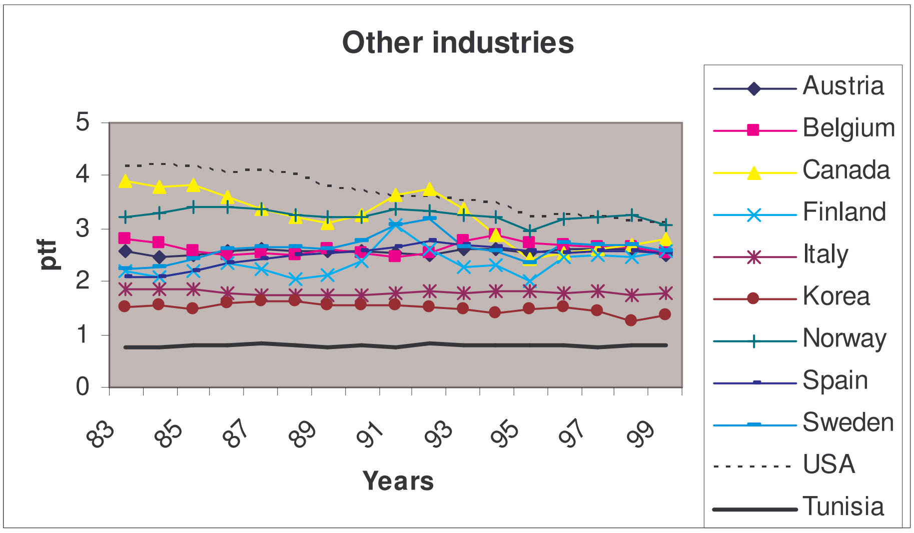


Figure 7 : TFP Evolution in Other Industries by Country



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