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Total Factor Productivity of Tunisia's manufacturing sectors: measurement, determinants and convergence towards OECD countries

-Annexe 1-

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Compétitivité prix et efficacité productive dans les secteurs manufacturiers des pays d'Afrique du Nord et du Moyen Orient

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Total Factor Productivity of Tunisia's manufacturing sectors: measurement, determinants and convergence towards OECD countries

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Abstract

The purpose of this paper is twofold. First, sector-based Total Factor Productivity (TFP) is calculated for six Tunisian manufacturing sectors over the period 1983-2002. Economic determinants of the productive performance are also investigated. In doing so, we take care of the direction of the causality by using a panel data Granger type-test. The recent literature in international economics has placed a particular emphasis on the relation between TFP and variables reflecting the potential impact of both trade and financial openness. In the sector-based TFP regressions we run, most of the determinants we test prove to be statistically significant, highlighting a causality that supports the stimulating impact of exports and foreign direct investments. The second aim of this paper is to implement some panel data unit root tests to investigate the statistical hypothesis of a TFP convergence between Tunisia and OECD members. Such a convergence can be seen as a potential means to improve both competitiveness and the integration into the world economy. In benchmarking each of the six Tunisian sectors against those of the most developed countries, panel data unit root tests suggest that convergence is limited to only a few sectors.

Keywords: Productivity, convergence, Tunisia, industries, competitiveness

JEL classification: D24, F13, F15, L60

I. INTRODUCTION

For more than a decade after its political independence, Tunisia (1956) supported an inward-oriented productive industry. In 1970, a first watershed occurred with the provision of fiscal incentives to export. Textiles and garments benefited greatly from this policy change, which contributed to strengthening light industry beyond traditional food processing activities. As a result of the structural adjustment policy (1986), the long run trade balance improved, allowing Tunisia to join the GATT in 1990, to promote a stronger convertibility of the dinar, the national currency, and finally, to become a founding member of the World Trade Organization (WTO). Besides the multilateral approach to trade policy, the Euro-Mediterranean partnership also developed and was institutionalized through the Barcelona Declaration. In November 1995, this Declaration established a global framework geared towards strengthening 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 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.

The pace of trade liberalization will 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 faded 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, progressively, the SEM products will have to compete with European goods in their own national markets whereas until now, most of them were sheltered from European exports[1]. Therefore, competition increases in both foreign and domestic markets.

To face this new competitive environment and to offset the economic impact of trade liberalization, a more flexible exchange rate policy could be seen as an adequate solution. However, exchange rate movements are determined according to macroeconomic conditions and, due to the trade liberalization process which varies a lot across activities; its uniform impact is unlikely to fully meet the different sectors needs. In this context, for a wide range of manufacturing firms, the partial compensation between both the currency depreciation and the decreasing customs rates calls for a significant improvement of the productive performance. The ability of organisations to achieve this objective will affect their relative unit cost and, finally, the maintenance of a reasonable profitability. Productivity gains and the ability of Tunisia to catch up with the "best productive practice" are therefore powerful means to meet the twin objectives of domestic competitiveness and integration into the world economy.

In this paper we focus on the long-run Total Factor Productivity (TFP) of six Tunisian manufacturing sectors (1983-2002) and investigate the hypothesis of an international convergence process with the productive performance of OECD members. The paper is organised as follows. In section II, TFPs are calculated for food processing (FOOD); electrical and metal products (ELEMET); chemical activities (CHEM); textiles, clothing and leather (TCL); building materials and ceramics (BGC); and miscellaneous manufacturing products (MISC). Then, TFP levels are regressed on a vector of potential determinants including those reflecting the economic and financial impact of openness. Before running the regression we control for the direction of the causality. Section III is devoted to the analysis of international TFP convergence between Tunisian sectors and those of the OECD members. Both the IPS and the MW tests are implemented by taking

[1] In 1999, the industrial sector accounted for 18% of the Tunisian GDP, the highest percentage in North Africa and the Middle East, after Egypt. In 1995, when the principle of the Euro-Mediterranean partnership was 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 as well as the manufacturing producers. Its macroeconomic and social impacts explain why the public programme of "mise à niveau" was launched.

account of the possibility of correlation across individual residuals as a result of the transmission of TFP shocks among OECD countries. Although the hypothesis of a stochastic convergence is not rejected for some sectors, empirical results prove to be sensitive to the type of panel data unit root test as well as the OECD sample we refer to. In section IV, we summarise the results and discuss avenues for further research.

II. TUNISIAN TFP MANUFACTURING SECTORS: LEVELS AND DETERMINANTS

A. *The sector-based evolution of the Total Factor Productivity*

The performance of the whole industry can be appreciated, both in the long run and for sub-periods reflecting its trade policy changes. Over the period 1983-1987, the effects of the second oil crisis were still being felt. Tunisia faced a severe economic and financial crisis resulting from the decline in oil export earnings and the slowdown in net worker's remittances (Morrisson and Talbi, 1986). A more restrictive external trade policy was implemented to cope with the balance of payments crisis and the sharp fall in external reserves. The period 1987-1995 captures the first consequences of the structural adjustment policy and the effect of the move toward a more market-friendly economy. The last sub-period (1995-2002) reflects the gradual involvement in the implications of the Free Trade Agreement and the need to strengthen the competitiveness.

For each of the six sectors, Total Factor Productivity, (TFP) has been measured by considering the value added at constant market prices. Production technology is 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 for the number of hours worked is not available. However, although the labour market became more flexible over the entire period, public regulations for hours worked did not change. Thus, we can reasonably assume that TFP is not biased when using the number of employees. The capital stock has been calculated, at constant prices, using the perpetual-inventory method for annual investment flows. Since the aggregate data that we refer to contains no information about the composition of the capital stock, two average annual depreciation rates have been considered: 5% and 10%.[2] The stock has been constructed as follows, with (t) denoting the end of year.

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

When measuring productivity, one assumes constant returns to scale and remuneration of production factors at their marginal product. Since the relative contribution of the labour force (α) was calculated by considering the share of wages in the sector value added, we infer the capital share to be (1-α).

$$TFP_t = \frac{Q_t}{L_t^{\alpha} K_t^{(1-\alpha)}} \qquad (2)$$

There is an extensive literature discussing the advantages and disadvantages of using growth accounting techniques to estimate TFP. Here, the non-parametric procedure is preferred as it better serves our purpose of identifying TFP level determinants. Indeed, in adopting this method we do not have to face the simultaneous equation problem resulting from the endogeneity of inputs. We do not have to estimate the input elasticities by regression techniques, but derive them from the observed cost shares. Therefore the non-parametric procedure allows us to analyse the TFP effects of the variables reflecting openness in two steps. In the first step we generate the "Solow residuals" while in the second step, we use a regression analysis to evaluate TFP determinants.

In Table 1, we present the TFP growth rates over the entire period and relevant sub-periods under the two above-mentioned hypotheses regarding the depreciation rate of the capital stock. TFP does not prove to be very sensitive to these rates, especially after 1987. Therefore, in the rest of the paper we will only use the 5% depreciation rate. For three sectors: electrical and mechanical (ELEMET), building materials and ceramics (BGC), textiles, clothing and leather (TCL), the long-run annual average rate of TFP growth ranges between 1.5% for electrical and mechanical

[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.

activities, and 3.5% for textiles and leather over the period 1983-2002. The evolution is somewhat different for the two other sectors. After 1987, TFP strongly increases in the chemical industry (CHEM), by about 9% per year. In the food sector (FOOD), TFP falls sharply, with some deceleration over the 1995-2002 period. Understanding this empirical evolution would require a sub-sector-based analysis with disaggregated data which, unfortunately, are unavailable[3]. A simple breakdown of TFP gains and losses according to the growth of the respective value added and input use, shows that the change in inputs has been the prevailing determinant.

Table 1.

Except for TCL and miscellaneous manufacturing industries, which exhibit good productive performance, the 1983-1987 sub-period is characterized by negative sector growth rates. This poor performance results from difficulties in adjusting inputs in an adverse macroeconomic context. Cumbersome regulations governing the labour market hampered the rapid restructuring of enterprises whilst some of them also had to manage the overinvestment made in the previous period. Thus, TFP suffers from the under-utilisation of productive capacities. The next sub-period, stretching from 1987 to 1995, was much more favourable. The macroeconomic recovery as well as the combination of trade openness and local deregulation contributed to a more efficient management of inputs. Firms benefited[4] from the previous investments and were able to expand their production without a proportional increase in inputs.

In the last sub-period, the TFP growth rate slows down in the chemical industry and does not significantly differ from the growth rates of other manufacturing sectors. For textiles, clothing and leather, although the value added growth remained dynamic, about 5% a year, the growth of the sectoral TFP was far lower than the highest values reached in the eighties. The relative stability of

[3] In an applied study of 21manufacturing industries from 16 OECD countries over the 1971-1994 period, Funk and Strauss (2003) have highlighted a high level of international heterogeneity in sector productivity. The average growth rate of TFP is about 1.35% and 1.14% for iron and steel, and non-ferrous metals, respectively. For the same sectors, the maximum growth rate is 11.5% and 9.9% while the minimum stands at -0.07 and -0.15

[4]Textiles, clothing and leather account for nearly 35% of the manufacturing value added and the economic health of this sector is crucial for thousands of Tunisian workers. Its future will be narrowly conditioned by the ability of local producers to overcome the impact of foreign competition and its implications in terms of international prices and costs.

the real exchange rate has contributed to the present difficulties of firms in managing the end of the multi-fibre agreement (2005). The long run productive performance of Tunisian industries turns out to be heterogeneous across sectors and sub-periods. Some manufacturing activities such as food processing industries are experiencing a decline while others are strengthening their position and contributing to the modification of the national production structure.

B. *The econometric determinants of TFP levels*

In this overview of potential TFP determinants, special attention is paid to the variables reflecting openness. In analyzing both the level and the growth of productivity, recent empirical literature has attributed great importance to this issue. If empirical studies generally provide evidence of a positive correlation between trade or/and financial openness and productivity performance (Dollar, 1992; Ben David, 1993; Sachs and Warner, 1995; Edwards, 1998), there are some "prominent trade liberalisation sceptics" to say it in Edwards' (1998) words[5]. Rodriguez and Rodrik (1999) point to the hotly debated methodological issue of identifying the direction of the causality[6]. Do exports enhance productivity or is productivity a prerequisite for a high external trade performance? Indeed, TFP can result from a learning-by-exporting effect, but also from a self-selection effect, exporting firms or sectors then being those having the best initial TFP performance (Haddad, de Melo and Horton, 1996). In view of the above comments, this subsection is divided as follows. First, we discuss the potential determinants of TFP levels. An analysis based on productivity growth rates would be more general as it would not require specifying a particular functional form of the production function. However, some drawbacks arise from the quality of the data and the explanation of the variance is much more demanding in terms of data quality. In implementing our empirical investigation, we deal with the causality problem and explore the impact of the exogenous variables through a multiple regression analysis[7].

[5] In his review of prominent trade liberalisation sceptics, Sebastian Edwards includes Krugman (1994) and Rodrik (1995)
[6] See Edwards (1998) for a survey
[7] Other potential variables would deserve interest such as the level of human capital. They are not considered in this paper because of data limitations. We assume that this does not create an omitted variable bias.

TFP and its potential determinants

The level of exports (EX) can be considered as a first relevant trade variable. Indeed, competing in foreign markets provides a strong stimulus for promoting economic efficiency. In the case of Tunisia, the integration of the country into the world economy entails a progressive loss of the preferential advantages that the European Union has granted for decades. Europe remains by far the main exporting market for Tunisian manufacturing goods. Avoiding the "trade diversion" effect that may result from the stretching of the EU[8] requires firms to make an effort to achieve greater productivity. The sector-based "net" exports (NEX) can also be considered as a proxy of the Tunisian comparative advantage. This other indicator is defined as the ratio of the difference between exports and imports to the sector-based value added. A causality problem can be reasonably suspected for these two trade variables. The same risk also applies to the effective rates of protection (ERP). Until the beginning of the eighties, numerous authors agreed that developing countries had to protect their *infant industries*[9]. This theoretical argument suffers from the detrimental effects of protectionism, such as the risk of perpetuating X-inefficiency with domestic costs remaining above internationally competitive levels[10]. Thus, high unit costs, and consequently low TFP levels, might be correlated with ERP. But if the Euro-Mediterranean Free Trade Agreement (FTA) stimulates productivity by providing a clear signal that there will be no protection behind which to shelter, tariffs might became endogenous, based on the perceived ability of domestic firms to improve their productivity levels.

The economic environment also matters through the domestic demand in the manufacturing sectors. Here, domestic demand is defined as the current output augmented by imports minus exports (DEM). A slowdown in domestic demand represents a real challenge for producers, who have to redeploy their activities in order to compete in external markets. The impact of this variable

[8] Let us recall that the integration process of the new eastern European countries was completed in 2004.
[9] 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.
[10] See Bhagwati (1978) or Krueger (1978) for influential analyses on this issue.

is potentially difficult to differentiate from the previous one. Thus, the greater the level of trade protection, the stronger will be the firm's vulnerability to the swings of domestic demand. Also, DEM can be seen as correlated with unobservable variables such as the under-utilisation of the capital stock, which cannot be rapidly adjusted downward, as well as with labour regulations, which slow down the speed of adjustment of the workforce to the optimal level.

How can we assess the impact of international price competition on TFP? At the national level, analyses of exchange rate moves often rely on aggregate trade weighted exchange rates. These kind of aggregate indexes can be less effective than industry-specific indexes in capturing changes in industry competitive conditions. Tunisia being a "world price-taker", the price constraint bears on local costs and, then, on the behaviour of firms as regard TFP levels. Forty-eight real effective exchange rates, henceforth referred to as REERs, have been calculated over the 1983-2002 period, one for each of the 3-digit industries (j) as defined by the Standard International Trade Classification (SITC). For a j-industry, the world price being given, the REER potentially allows us to take into account the differential of cost evolution across competing partners. Under the assumption that the *law of one-price* holds, a long run deviation in the REER (i.e. appreciation) constitutes a potential loss of the Tunisian competitiveness and an incentive to raise TFP levels. Six sector-based geometric averages of the REERs have been calculated from the forty-eight relevant 3-digit groups, one for each of the manufacturing sectors we refer to in this paper. Each of the 3-digit level industries (j) has been weighted (q_j) by its respective contribution to the value added of the Tunisian sector. In measuring REERs, the consumption price index (CPI) for the ten largest world exporters (i) of the j-th industry has been considered. The weight given to each partner (p_i) was based on the country's share of world exports over the period 1999-2002. In the formula that follows (3), NERs are the nominal exchange rates of the Dinar vis-à-vis the currencies of those ten exporters (i).

$$REER_{ij} = \prod_{j=1}^{q} \left[\prod_{i=1}^{10} \left(NER_i \times \frac{CPI}{CPI_i} \right)^{pi} \right]^{qj} \qquad (3)$$

For fifteen years, the Tunisian authorities have targeted a stable "macroeconomic" real effective exchange rate by periodically adjusting the nominal rate. The Dinar is pegged to a basket made up of the currencies of the main economic partners, with a prominent role given to the euro. This exchange rate policy has been quite successful in terms of promoting macroeconomic stability. The inflation rate has remained low, close to the rate of the European economies, with the changes in the nominal exchange rate offsetting price differentials. However, this policy did not take into account the specific sectoral constraints of the trade liberalization program. Therefore, some of the manufacturing sectors had to compensate for the loss of price competitiveness by a higher TFP.

As regards financial openness, the common wisdom suggests that Foreign Direct Investment (FDI) facilitates productivity gains and the integration into the world economy through several channels. The enduring presence of foreign enterprises provides easier access to efficient technologies and organizational methods. In comparison with standard financial debt, FDI incorporates both human and organizational know-how. It allows saving on the fixed costs of producing technological innovations as well as on the marginal cost of their replication in the domestic environment. FDI also contributes to lowering the transaction costs of penetrating external markets. A capital stock of FDI has been constructed for each of the six manufacturing sectors we are interested in. Inflows since 1980 have been added together and a 5 % depreciation rate has been applied to the stock.

Another variable has been introduced to capture reallocation effects within each of the six industries. Bernard and Jones (1996b) have shown that these reallocations (or share effect) accounted for 4% of the aggregate TFP growth of OECD countries over the 1970-1987 period[11]. Since we are working on aggregated data, similar redistributions within the sector-based value

[11] The Bernard and Jones' (1996b) method consists in decomposing the productivity growth into a pure productivity growth effect and a share effect by using an accounting framework (RES, 1996, p. 140)

added, hereafter referred to as STRUC, may occur with a non-neutral impact on the evolution of TFPs. This composition effect is measured on a yearly basis by the sector-based average of the 3-digit level absolute differences in value added shares (3):

$$STRUC_{k,t} = \frac{1}{J_k}\sum_{j=1}^{J_k}\left|\frac{Q_{j,t}}{\sum_{j=1}^{J_k} Q_{j,t}} - \frac{Q_{j,t-1}}{\sum_{j=1}^{J_k} Q_{j,t-1}}\right| \qquad (4)$$

Where $Q_{j,t}$ is the value added of the j-th industry and J_k the total number of industries in the *k*-th manufacturing sector. STRUC values range between 0 (no structural change within the sector) and 1, which corresponds to the structure changing entirely from one year to the next[12]. In contrast to other approaches to the share effect, we consider that STRUC captures the impact of a short term or a spontaneous reallocation effect. STRUC reflects the aggregated dimension of the data set and not a specialisation or a long run supply reallocation effect. Therefore, the sign of the regression coefficient is not predetermined.

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. The Granger-causality test (1969) is commonly used. As long time series are not available here, we consider a panel causality test as follows. We assume that X fails to Granger cause Y if, in the regression of Y on its lagged variables and X, the coefficients δ_j associated with X_{t-j} in (5) are not significant[13]. The unobservable heterogeneity over the six manufacturing sectors will be controlled for through the introduction of fixed effects.

[12] The case for STRUC taking a value close to one can be illustrated through the example of a two industry-manufacturing sector (J1, J2). For the initial year (t-1), suppose that J1 represents 99% of the sector-based value added and J2, only 1%. If for the next year (t) these percentages reverse, with J1 representing 1% and J2, 99%, then, according to (4), the calculation of STRUC yields a value of one.

[13] 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 sectors in (5).

$$Y_{i,t} = \beta_{0i} + \sum_{j=1}^{m} \beta_j Y_{i,t-j} + \sum_{j=1}^{n} \delta_j X_{i,t-j} + \varepsilon_{i,t} \quad \text{i = 1,.. N; t = p + 1,... T} \qquad (5)$$

The lag pattern of the variables has to be identified through a specification test[14]. Equation (5) is a general dynamic panel data model. Lagged dependent variables tend to generate biased and non consistent estimators when the within or the ordinary least squares methods are used. An appropriate way to overcome this problem consists in taking the first difference of the equation in order to remove the fixed effect and then resorting to the consistent Generalized Method of Moments estimator (GMM). The error terms $\Delta\varepsilon_{i,t}$ in the differentiated equation are correlated with the independent variables $\Delta Y_{i,t-j}$. Therefore, the latter need to be instrumented by a suitable set of lagged endogenous variables expressed in levels ($Y_{it-j'}$), or in differences ($\Delta Y_{i,t-j'}$)[15]. The causality test from X to Y will consist in testing the null hypothesis of the coefficients in (4) $: \delta_1 = \delta_2 = ... = \delta_n = 0$. The statistic of the test asymptotically follows a Chi-square distribution with n degrees of freedom. As the time series are short, the simplest version of the panel causality test has been performed. In equation (5), the slope coefficients are assumed to be the same across the sectors. This hypothesis can potentially affect the validity of our results if there are disparities across sectors[16]. The results of the empirical analysis are given in Table 2.

Table 2.

A unidirectional causality is not rejected for Foreign Direct Investment (FDI) and net export (NEX), with past values of these variables explaining the present sector-based TFP levels. A bidirectional impact is found for both domestic demand (DEM) and structure (STRUC). This last result suggests a potential endogeneity risk while considering TFP determinants. For ERP, EX and REER, the Granger causality test did not prove to be statistically significant.

[14] We use the sequential method starting with 3 lag lengths for both variables.
[15] Arellano and Bond (1991)

The TFP determinants: the regression analysis

Policy during the period 1990-2002 was more focused on trade openness than in the previous period[17]. We have already noted that Tunisia joined the GATT in 1990, became a founding member of the World Trade Organisation (WTO) and initiated current account convertibility in 1993. The euro-Mediterranean partnership also took shape and was institutionalized through the Barcelona Declaration. For the aforementioned reasons, we have checked for the stability of the TFP model coefficients and rejected this hypothesis by comparing the 1983-89 and the post WTO integration period (1990-2002), through a Chow test. The results obtained with the within estimator are reported in table 3. On the left hand side of this table, the explanatory variables are considered as predetermined. On the right hand side, STRUC and DEM have been instrumented to control for the potential endogeneity bias that was detected by the causality test pertaining to the whole period (table 2). Lagged values for the composition (STRUC) as well as the level of the domestic demand (DEM), net exports (NEX), imports (IMP), and the effective rate of protection (ERP) have been used as instruments. The over-identification p-value of the Hansen J-statistic did not reject, at the 5% level, the relevance of these instruments.

Table 3.

The explanatory power of the estimated models is quite good (table 3). 90% of the variance of the TFP level for the first sub-period (1983-1989), and 88% for the second one (1990-2002), can be explained using the instrumental variable estimator. The fixed effects F-test does not reject the presence of a strong intersectoral heterogeneity. From the regression coefficients we observe that until 1990, the net export (NEX), and the domestic demand (DEM) are the only variables statistically significant at 99% level of confidence. The second sub-period is marked by a better econometric fit; all coefficients being significant with a clear impact of the variables capturing the

[16] In such a case, it would be less restrictive to replace these slopes by sector specific coefficients. See Hurlin and Venet (2001) for a good discussion of this problem of heterogeneity.

[17] A predictive test for stability of the coefficients over the whole period, not reported here, has been carried out. The stability hypothesis was rejected. 1990 proved to be the relevant year for the structural break. Different subsets were considered with 1991, 1992, 1993 and 1994, as alternative cut-off years.

openness strategy in both trade and financial dimensions. It is worth mentioning that the FDI effect turned out to be significant in the second sub period at a time when FDI inflows greatly increased as a result of the privatisation policy pursued in several sectors. This positive impact supports the recent Tunisian policy target to raise foreign capital inflows at a yearly rate of 10%.

As regards the relative price indicators, some significant changes occurred between the first and the second sub-period. The coefficient of the real exchange rates (REERs) is negative and suggests that price competitiveness worked against sector-based TFP gains. The relation between these variables remains a debated issue. On the one hand, the appreciation of the currency may push firms to increase their productivity by increasing both the managerial efficiency and the investment rate that results in an increase of the capital-labour ratio. But, on the other hand, the appreciation of the currency affects the profitability and the production of the tradable sectors. This second effect prevails over the second period of our empirical analysis.

The effective rates of protection display a negative impact on TFPs. This result is consistent with John Hicks' remark about protected firms enjoying a "quiet life" leading to X-inefficiency. Therefore the dynamic of the trade liberalisation policy should, and does indeed prove to be a stimulating force for increasing productivity levels. Over the whole manufacturing sector, the average ERP decreased from 194% in 1983 to 85% in 1990 and 56% in 2002. Finally, STRUC is negatively correlated to TFP and mainly reflects the intra-sector based heterogeneity as discussed above. Beyond these results and in relation with the need to improve productive behaviour so as to overcome the competitive challenge, did Tunisian industries succeed in promoting a long run TFP convergence vis-à-vis the more efficient OECD manufacturing sectors?

III. TUNISIAN SECTORS AND THE INTERNATIONAL TFP CONVERGENCE HYPOTHESIS

A. *The convergence hypothesis revisited*

In this section we want to compare the TFP performance of Tunisian manufacturing sectors with those of the developed countries over the 1983-2002 period. To investigate the question panel data unit root tests are used to evaluate convergence between Tunisia and a sample of 11 OECD countries. In the Solow-type economic growth model, the international convergence of per capita GDPs is assumed to result from the diminishing returns to individual factors. The smaller the per capita capital stock is the higher will be its marginal efficiency. In developing countries, economic and financial openness modifies the relative endowments of capital and labor, allowing the importation of the most efficient technology available on the market. The long-run dynamics should therefore support the international productivity convergence hypothesis.

However, there are some restrictive assumptions underlying the international productivity convergence and, to some extent, the sector-based convergence arguments. Indeed, in a context of increased integration into the world economy, the process of trade specialization may exclude the possibility of a long-run international convergence of productivities for all sectors. In addition, the progress characterizing the technology is neither exogenous nor the same worldwide. OECD countries have a high rate of innovation. For manufacturing activities, they can be seen as *leaders* while developing countries are only *followers* seeking to replicate innovations based on their own human and institutional abilities. If FDI contributes to the international diffusion of the appropriate production technology, some differences inevitably remain, partly connected with non-transferable cognitive apprenticeships. Efficient static and dynamic routines are firms' core competencies in industrialized countries. In a situation where skills are idiosyncratic and non-transferable through FDI, TFP can be higher and production costs lower in OECD countries[18].

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[18] Nelson and Winter (1982) stress the importance of organizational routines that act as stores of collective knowledge which is frequently tacit rather than being readily codifiable. Routines can be interpreted as the equivalent of a firm's

B. *Unit root tests and convergence*

The empirical literature on productivity convergence can be broken down into two categories. The first category is based on cross-sectional data and uses the Sigma or the Beta convergence tests. The second category explores the time series properties of the data and refers to stochastic convergence tests. According to Bernard and Jones (1996b), stochastic convergence implies that sectoral TFP differentials between countries are stationary. The econometric methodology based on the unit root tests is resorted to in this study. For each of the six sectors, we test for stochastic convergence between Tunisian TFP and those of an OECD country sample. Let Y_t be the TFP level of a specific Tunisian industry and Y_t^* the TFP level of one OECD country considered as the benchmark. Testing for convergence consists in conducting the following simple unit root test.

$$\Delta(\ln Y_t^* - \ln Y_t) = \mu + \rho(\ln Y_{t-1}^* - \ln Y_{t-1}) + \sum_{j=1}^{p} \phi_j \Delta(\ln Y_{t-j}^* - \ln Y_{t-j}) + u_t \quad (6)$$

If the difference in log TFPs is non stationary ($\rho = 0$), the TFP series between the two countries diverge, suggesting a persistent TFP shock. On the other hand if the gap is stationary$|\rho| < 0$, the technology shocks are not persistent, and we conclude for a convergence process. Equation (6) is the standard regression equation for the augmented Dickey Fuller test, (ADF). Any univariate unit-root test on this equation helps to test for stochastic convergence. This methodology has been used by Harris and Trainor (1999) to investigate regional convergence within the UK over the 1963-92 period[19].

Although this methodology allows identifying the country pairs for which there is bilateral convergence, long time series are required in order to avoid the low power of univariate unit-root tests. To increase this power, Bernard and Jones (1996b) have suggested running panel unit root tests on a sample of OECD countries. The test is based on following the regression equation:

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genetic code. The organisational dynamics evolve via mutating routines and this constraints response to environmental changes.

$$\Delta(\ln Y_{it}^{*} - \ln Y_{t}) = \mu_i + \rho_i(\ln Y_{it-1}^{*} - \ln Y_{t-1}) + \sum_{j=1}^{p_i} \phi_j \Delta(\ln Y_{it-j}^{*} - \ln Y_{t-j}) + u_{it} \quad (7)$$

Y_{it}^{*} represents the TFP of each of the 11 OECD countries, while Y_t is the TFP of the Tunisian sector. Appendix 1 reports the TFP differentials by industry.

Over the last ten years, the empirical literature analyzing international TFP convergence has significantly stretched. To limit the references to some of the most influential works, let us mention Bernard and Jones' (1996b) pioneering paper on a sample of 14 OECD countries over the 1970-1987 period. Stochastic convergence is tested by using a Levin and Lin (2002) type-test imposing the same autoregressive coefficient in equation (7): $\rho_i = \rho$. Martin and Mitra (2001) referred to a similar test to investigate the phenomenon in agriculture and manufacturing over the period 1967-92, based on a sample of 50 countries. Freeman et Yerger [2001] applied the Maddala and Wu (MW) test to evaluate the labour productivity convergence in the manufacturing sector of 8 OECD countries from 1950 to 1998, while Mukherjee and Kuroda [2002, 2003] have considered the productivity convergence of the agricultural sector in 14 Indian regions (1973-1993) by adopting several panel data unit root tests[20]. Finally, lets us mention the paper by Funk and Strauss (2003) who resorted to the IPS test to analyse the TFP convergence of 21 industries in 16 OECD countries (1971-1994).

In this paper, we test for sector-based stochastic TFP convergence between the Tunisian sectors and a sample of 11 OECD countries over the period 1983-2002. Using the aforementioned methodology, we test the stationarity of the log TFP gap. The OECD benchmark countries are: Austria, Belgium, Canada, Finland, France, Italy, the UK, Norway, Spain, Sweden and the USA. On the basis of equation (7), two standard panel data unit root tests (IPS, MW) are performed. For both tests, the null hypothesis means: $\rho_1 = \rho_2 = ... = \rho_{11} = 0$. Rejecting the null suggests a convergence process and implies the stationarity of the Tunisian TFP gap with a subset or at least

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[19] These authors also extend the unit root test by adding the trend component in equation (4) and by controlling for structural break.

one OECD country. The specification of the test does not impose the equality of the autoregressive coefficients $\rho_i = \rho$ [21], that is, a converging process at a common rate with respect to all these countries.

Under the assumption that the cross section error terms in (7) are contemporaneously uncorrelated, we can compute the so-called t-bar statistic to test for a unit root which is defined by:

$$IPS = \sqrt{N}\,\frac{(\bar{t} - E(\bar{t}))}{\sqrt{Var(\bar{t})}} \rightarrow N(0,1) \qquad (8)$$

where $\bar{t} = (1/N)\sum_i t_i^c$, t_i^c is the Dickey-Fuller unit root statistic which is specific to each country (i). The $\bar{t}$ -statistic follows a normal distribution with unknown mean, E ($\bar{t}$), and variance, Var ($\bar{t}$). These values can be either simulated or obtained from table 3 in Im *et al*'s (2003). The MW statistic combines the observed significance levels associated to the individual ADF. Presuming cross-sectional independence, p_i denoting the p-value from the Dickey Fuller test on the i^{th} time series, MW statistic follows a Chi-square distribution:

$$MW = -2\sum_{i=1}^{N} Ln\,(\mathrm{p_i}) \rightarrow \chi^2(2N) \qquad (9)$$

Simulation experiments are carried out to obtain the p-values derived from the empirical distribution of the test. Both of these tests are inappropriate if the residuals are correlated across individuals. In our case cross sectional independence is likely to be violated since any TFP shock affecting an OECD country can be transmitted to the other members. To take into account these potential correlations, Im et *al* (2003) assume that the error term in (7) is the sum of two components: $(u_{it} = v_t + \varepsilon_{it})$. They further assume that the random error terms ε_{it} are uncorrelated and independent from the time specific random effect: v_t. To deal with the cross sectional

[20] Let us mention Levin and Lin's (2002), Im, Pesaran and Shin's (1997, 2003), IPS, Harris and Tzavalis' (1999), and Hadri's (2000) tests respectively.

[21] In this particular case, we can employ the Levin and Lin (2002) test.

dependence they suggest demeaning[22] the data before applying the t-bar test to (8). In the simulation he conducted for this test, Jönsson (2006) shows that the tabulated statistics provided by Im *et al* (2003) for $E(\bar{t})$ and $Var(\bar{t})$ are not appropriate when using demeaned data, especially if the number of cross sections is small. Jönsson(2006), provides a response surface fitted regression for the two moments which we use here. Therefore, since the MW test requires the independence assumptions, we have demeaned the data, as for the IPS test, before applying the MW test in equation (9). Moreover, for both tests we started with one lag in the ADF regression so as to remove serial correlation for each country-pair of the panel[23]. Since these often proved to be insignificant, in most cases, lag length was then reduced to zero.

Table 4 reports the IPS and the MW statistics on the demeaned data with their respective p-values. According to the IPS test, we reject the null hypothesis that sector-based TFP differentials have a unit root and conclude that there is a convergence process for three sectors (Building materials, Chemicals, Miscellaneous industries). The results of the MW test are more restrictive, rejecting the unit root only for Building materials. Due to the limited dimension of the panel data set, the heterogeneity of the autoregressive coefficients could affect these empirical results. Conclusions derived from the two tests may be sensitive to a mixture of stationary and non stationary series. In other words, Tunisian sectors may experience a long-term convergence process with some OECD countries and in a divergence process with others. To appraise this potential sensitivity, the two tests have been rerun by dropping 3 countries from the 11 OECD-sample, one by one, according to the lowest individual ADF test values. That way, the benchmark countries to which Tunisian sectors are likely to converge have been dropped sequentially.

Table 4.

[22] Let $q_{it} = \Delta(\ln Y_{it}^{*} - \ln Y_{t}),$ demeaning the data means transforming the data by subtracting the cross-section average ($q_{it} - 1/N\sum_{i=1}^{N} q_{it}$)

[23] As the time series dimension is limited, we did not conduct the usual strategies (sequential method, AIC criterium…) to identify the appropriate lag length to save more degrees of freedom.

Results of the sensitivity are reported in table 5. As regard the building materials and ceramics, and according to the MW test, the convergence indicated in table 4 is now rejected at the 9% level with the elimination of only one country. Conclusions remain unchanged for the other five sectors. The IPS test shows a stronger sensitivity to the subtraction of few countries, in particular for the chemical industry (one country), but also for miscellaneous industries (two countries).

Table 5.

The results of panel data unit root stationary tests have to be interpreted with caution, especially when the sectoral dimension is limited, as is the case in this work. When we reject the null hypothesis, it does not mean that Tunisian sectors are in a convergence process with the whole OECD country sample. A TFP convergence process may exist within a restricted sub-sample. The sensitivity analysis conducted by considering sub-panels has shed some light on this problem. Beyond this limitation and its potential implication for the statistical inference, the two standard unit root type tests have given some support to the existence of a limited overall TFP convergence process for only one sector.

IV. CONCLUSION

In this paper, we addressed two issues regarding the productive performance of six Tunisian manufacturing industries. First, we focused on measuring sector-based TFP levels and analyzing their economic determinants over the 1983-2002 period. Causality relationships between identified determinants of sectoral TFPs were assessed using a panel data Granger causality type test. The GMM estimator has been used to conduct this test in order to take into account the potential endogeneity bias resulting from the dynamic specification of regressions. As regard the TFP determinants, domestic demand and net exports were found to have a significant impact over the period 1983-1989. Over the second sub-period (1990-2002), all the coefficients proved to be statistically significant, including those of the variables reflecting trade and financial openness. These findings give some support to the export promotion strategy that has been implemented in the mid-eighties, but also to the official concern to enlarge foreign direct investment flows. For some specific activities such as the six Tunisian manufacturing sectors we investigated in this paper, productivity gains allow domestic producers to complement the impact of the exchange rate policy that is determined by macroeconomic conditions.

The second empirical objective of this paper was precisely to test TFP convergence of the Tunisian manufacturing sectors towards a sample of 11 OECD countries. If they want to maintain a reasonable profitability in a more competitive environment in both domestic as well as external markets, Tunisian producers will have to improve their TFP performance. They will have to catch up with the best productive standards observed in OECD countries. The IPS and the MW panel data unit root tests were used to consider the country TFP differentials and to take into account a potential correlation of TFPs among OECD countries. Empirical results proved to be sensitive to the test we chose as well as the number of OECD members we refer to. To some extent the stationary process that supports the long run convergence hypothesis proved to be strong only for the building materials sector.

Although these results are interesting in themselves, the analysis can be further deepened. To improve the power of the panel data unit root tests, it would be worth re-examining the issue of convergence by using more disaggregated data. Particular attention should be paid to the 3 or 4-digit industry level, as it would allow for a better understanding of intra-sectoral heterogeneity. Depending on the manufacturing sector, and in line with the trade specialization argument, Tunisia should aim to improve its TFP level in activities that offer the best export opportunities, leaving other activities to their own devices. Although detailed information required for carrying out such an empirical analysis is lacking, it remains a stimulating question for further research. It would also be interesting to extend the sample to some large countries such as China or India. Both have a wide range of specialisations in common with the Tunisian manufacturing industries, and are becoming major rivals in world markets.

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Table 1. Sector-based TFP growth and the relative share of the Tunisian manufacturing sectors 1983-2002 period (%)

Periods	1983-1987		1987-1995		1995-2002		1983-2002
Industries	I	II	I	II	I	II	I
Food processing		28.7		20.9		18	
TFP (10%)	-5.7		-6.3		-1.6		-4.6
TFP (5%)	-7.4		-6.3		-2.2		-5.2
Building and ceramics		10.5		11		10.2	
TFP (10%)	-2.7		5.1		4.1		3.4
TFP (5%)	-3.9		4.8		3.3		2.7
Electrical, Mechanical		14.8		13.9		13.3	
TFP (10%)	-0.7		2.7		5.3		2.1
TFP (5%)	-1.9		2.4		4.9		1.5
Chemical		4.6		9.5		10.9	
TFP (10%)	-0.3		12.3		5.1		9.7
TFP (5%)	-0.8		11.6		4.4		9.0
Textiles and leather		28.3		31.8		34.7	
TFP (10%)	8.9		3.4		3.4		3.5
TFP (5%)	6.8		3.3		2.8		2.8
Miscellaneous indus.		12.2		12.6		12.9	
TFP (10%)	3.4		-0.2		1.2		0.4
TFP (5%)	1.4		-0.3		0.5		-0.3

I: Annual average growth rate of TFP for each period. Figures refer to two different depreciation rates of the capital stock, 10% and 5%, respectively; II: Relative share of the sector-based value added over the period for all Tunisian manufactured goods.

Table 2. Results of the panel data Granger causality test: GMM estimation method (1983-002)

Variables	Variables (levels)		P-value	Number of lags (m,n)
(TFP, DEM)	DEM $\Rightarrow$ TFP	K^c=6.49***	0.01	(1,3)
	TFP $\Rightarrow$ DEM	K^c=4.37**	0.04	(1,1)
(TFP, FDI)	FDI $\Rightarrow$ TFP	K^c=3.69**	0.05	(1,3)
	TFP $\neq$ FDI	K^c=0.32	0.57	(1,1)
(TFP, ERP)	ERP $\neq$ TFP	K^c=0.08	0.77	(1,3)
	TFP $\neq$ ERP	K^c=1.76	0.41	(2,1)
(TFP, NEX)	NEX $\Rightarrow$ TFP	K^c=3.03*	0.08	(1,3)
	TFP $\neq$ NEX	K^c=0.76	0.86	(3,3)
(TFP, EX)	EX $\neq$ TFP	K^c=0.69	0.40	(1,3)
	TFP $\neq$ EX	K^c=2.55	0.47	(3,3)
(TFP, REER)	REER $\neq$ TFP	K^c=0.24	0.62	(1,3)
	TFP $\neq$ REER	K^c=5.13	0.16	(3,3)

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. ***, **,* denote significance levels 1%, 5% and 10%, respectively.

Table 3. Tunisian manufacturing sectors and TFP level determinants (1983-2002)

Variables	*Within*		*Variables*	*Instrumental Variable estimator*	
	1983-89	***1990-02***		***1983-89***	***1990-02***
FDI	*0.002 (1.19)*	*0.00028 (4.67)****	*FDI*	*0.0003 (0.20)*	*0.00024 (4.70)****
DEM	*0.00027 (2.42)****	*0.00008 (3.13)****	*DEM*	*0.0004 (2.97)****	*0.0001 (3.84)****
NEX	*0.104 (3.43)****	*0.046 (3.16)****	*NEX*	*0.165 (2.76)****	*0.036 (2.41)****
REER	*0.001 (1.00)*	*-0.0036 (-2.67)****	*REER*	*0.0020 (2.57)*	*-0.003 (-2.65)****
STRUC	*-1.066 (-2.08)****	*-2.325 (-8.40)****	*STRUC*	*-1.060 (-1.12)*	*-3.25 (-5.28)****
ERP	$0.9\ 10^{-6}$ *(0.15)*	*-0.0006 (-1.92)***	*ERP*	*0.00001 (-0.52)*	*-0.0006 (-2.15)****
Chow Test	*12.56****		***Chow Test***	*25.03****	
R^2	*0.87*	*0.90*	R^2	*0.90*	*0.88*
Fixed Effect F-Test	14.03*** F(5,30)	*83.59**** F(5,66)	**Fixed Effect F-Test**	15.49*** F(5,24)	*63.74**** F(5,66)
Hansen over-identification J-statistics: $\chi^2(3)$				*5.54*	6.886

Numbers in brackets are the t-statistics at the following significant levels of confidence: (*) 90%; (**) 95 %; (***) 99 %. The sectoral fixed effects are not reported in this table.

Table 4: Tunisia and the international TFP stochastic convergence tests

Sectors	IPS Test			MW Test		
	$\bar{t}$ -statistic	P-value	Conclusion	MW Statistic	P-value	Conclusion
Food	-1.124	0.13	Non convergence	26.278	0.24	Non convergence
Building mat.	-7.887	0.00	Convergence	37.543	0.02	Convergence
Electric	9.477	1.00	Non convergence	15.717	0.83	Non convergence
Chemical	-1.904	0.03	Convergence	22.424	0.43	Non convergence
Textile	1.511	0.93	Non convergence	15.729	0.83	Non convergence
Miscellaneous industries	-3.586	0.00	Convergence	28.140	0.17	Non convergence

N.B: These calculations have been made by considering the 5% capital depreciation rate. The exact denomination of sectors is: Food processing, Building materials and ceramics, electrical and mechanical, textile and leather, miscellaneous industries

Table 5: Unit root test sensitivity to the exclusion of some OECD countries

Sectors	IPS Test		MW Test		
	$\bar{t}$ -statistic	P-value	MW Statistic	P-value	Sub-sample
Food	1.078	0.86	17.697	0.61	10 countries
	2.829	1.00	10.850	0.90	9 countries
	3.255	1.00	8.524	0.93	8 countries
Building materials	-5.616	0.00	29.135	0.09	10 countries
	-3.546	0.00	21.281	0.27	9 countries
	-2.630	0.00	17.527	0.35	8 countries
Electric	10.556	1.00	11.228	0.94	10 countries
	11.263	1.00	7.954	0.98	9 countries
	11.655	1.00	5.594	1.00	8 countries
Chemical	-0.839	0.20	18.095	0.58	10 countries
	-0.102	0.46	14.790	0.68	9 countries
	0.396	0.65	12.198	0.73	8 countries
Textile	2.721	1.00	10.848	0.95	10 countries
	3.296	1.00	8.056	0.98	9 countries
	3.463	1.00	6.320	0.98	8 countries
Miscellaneous industries	-2.027	0.02	22.269	0.33	10 countries
	-0.698	0.24	17.159	0.51	9 countries
	0.516	0.70	12.400	0.72	8 countries

N.B: The exact denomination of sectors is: food processing, building materials and ceramics, electrical and mechanical, textile and leather, miscellaneous industries.

Appendix 1

Fig. 1. TFP Evolution in Food Processing Industries, by Country

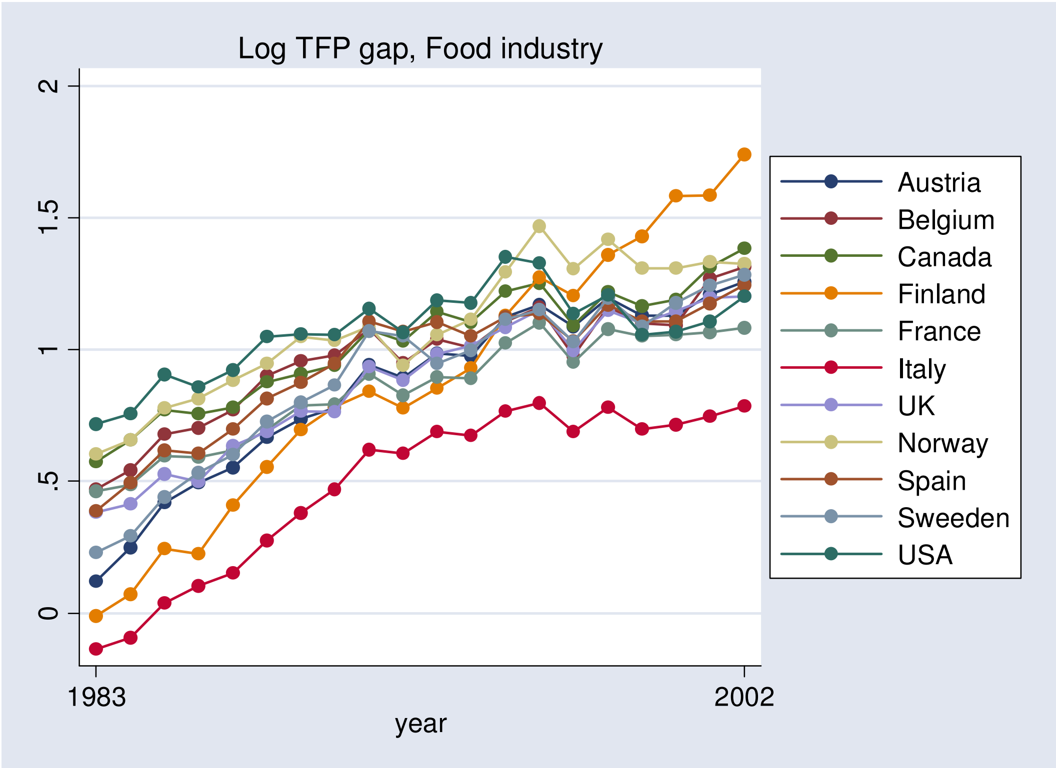

Fig. 2. TFP Evolution in Building Materials and Ceramic Industries, by Country

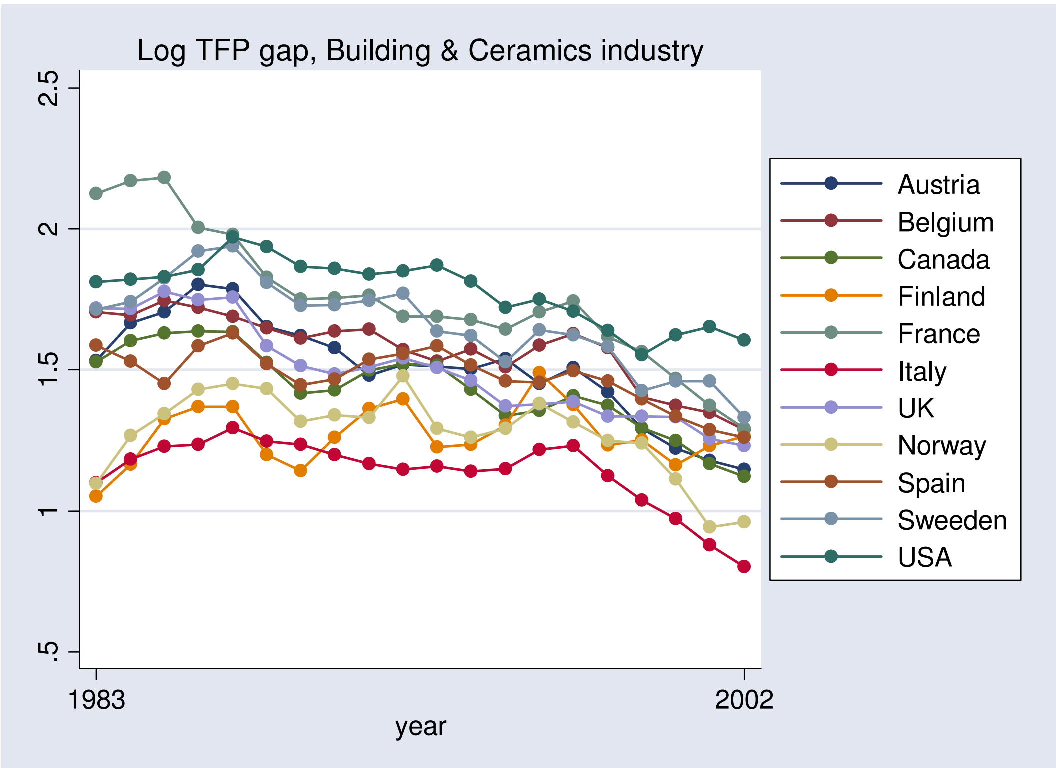

Fig. 3. TFP Evolution in Electrical and Metallic Industries, by Country

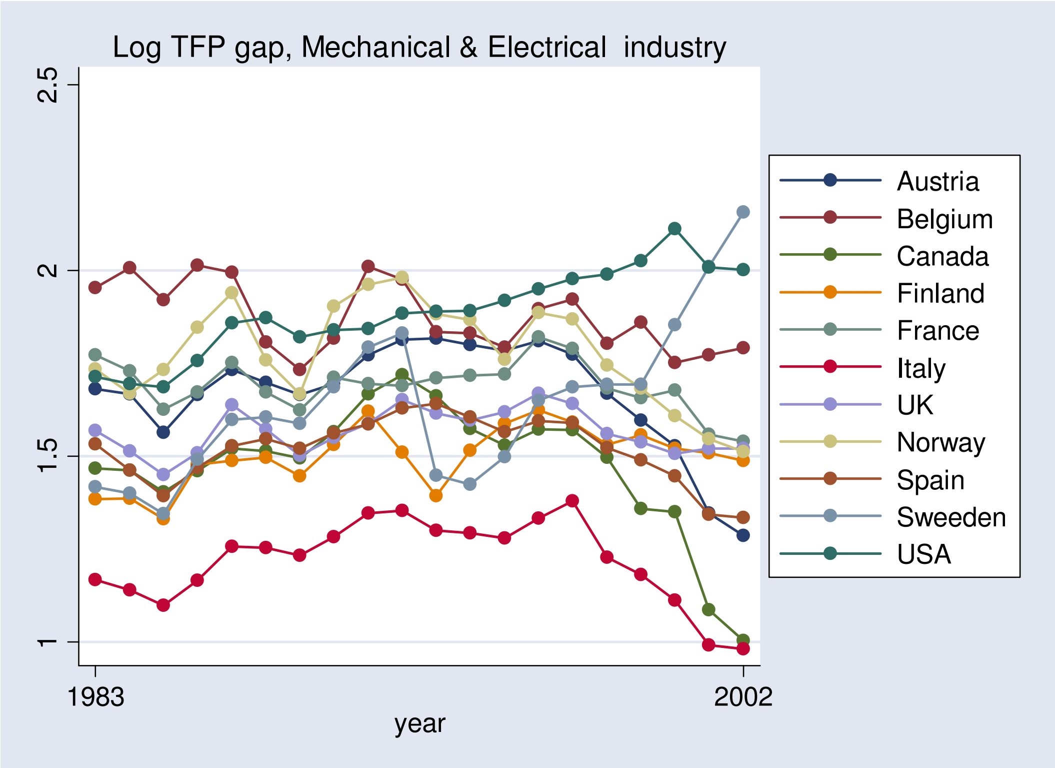

Fig. 4. TFP Evolution in Chemical Industries, by Country

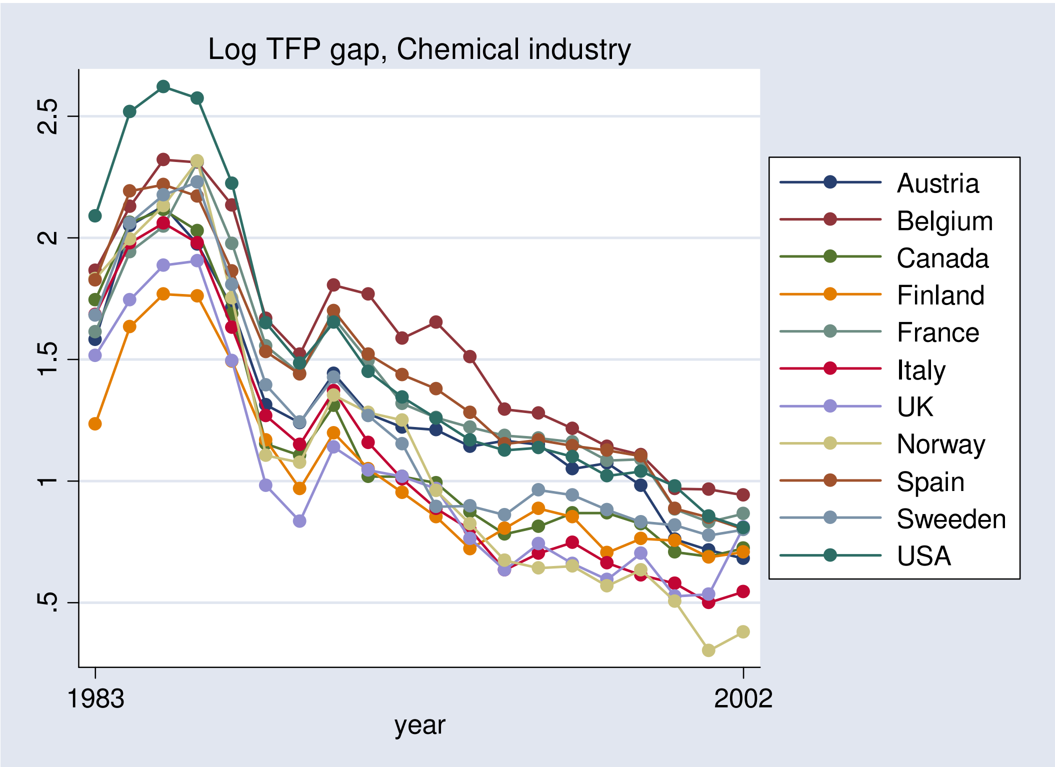

Fig. 5. TFP Evolution in Textile, Clothing and Leather Industries by Country

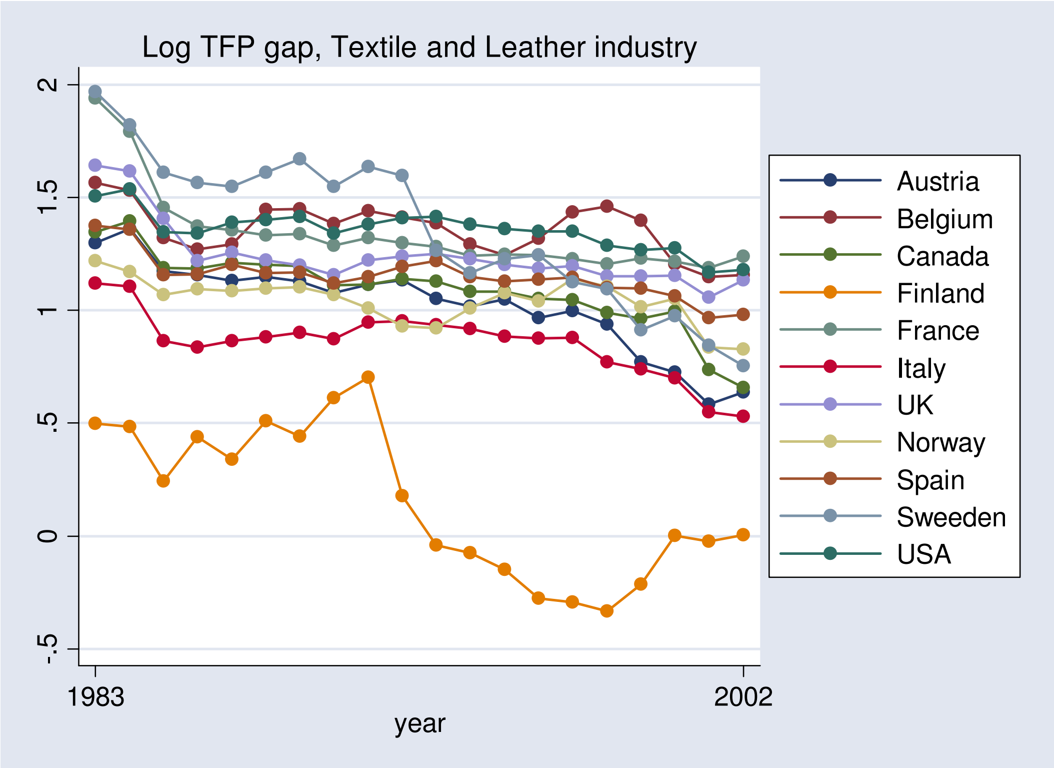

Fig. 6. TFP Evolution in Other Industries by Country