Conférence Femise 2003

4, 5 et 6 décembre 2003, Marseille

Forum Euro-Mediterranéen des Instituts Economiques
www.femise.org

THE EVOLUTION AND DETERMINANTS OF FRONTIER TOTAL FACTOR PRODUCTIVITY GROWTH IN TUNISIA

Sofiane GHALI,
Faculté des Sciences Economiques et de Gestion, Université de Tunis-El Manar

Pierre MOHNEN,
University of Maastricht, UQAM, CIRANO and MERIT

Cette conférence a été réalisée avec le soutien financier de la Commission des Communautés Européennes. Les opinions exprimées dans les contributions n'engagent que les auteurs et ne reflètent pas l'opinion officielle de la Commission.

This Conference was produced with financial support from the Commission of European Communities. The opinions expressed in the contributions are those of the authors only and do not necessarily reflect the opinions of the Commission of European Communities.

Institut de la Méditerranée

FIRST DRAFT

THE EVOLUTION AND DETERMINANTS OF FRONTIER TOTAL FACTOR PRODUCTIVITY GROWTH IN TUNISIA

Sofiane GHALI*

Faculté des Sciences Economiques et de Gestion de Tunis
Université de Tunis-El Manar

Pierre MOHNEN

University of Maastricht, UQAM, CIRANO and MERIT

This version : October 31, 2003

* Corresponding author:
Département des Sciences Economiques,
Faculté des Sciences Economiques et de Gestion de Tunis,
Université de Tunis – El Manar,
Avenue du 7 Novembre,
Tunis 1060,
Tunisia.
E-mail: sofiane.ghali@gnet.tn

The authors wish to thank for their critical comments H. Fehri, M. Goaied , F. Kriaa, M. Lahouel, F. Lakhoua, and T. ten Raa.

Abstract

In this paper we aim to measure and to explain the frontier total factor productivity (TFP) growth in Tunisia over the period 1983-1996. We do not measure TFP growth by the conventional Solow residual. Instead we define TFP growth as the shift of the economy's production frontier, which we obtain year by year by solving a linear program, a sort of aggregate DEA analysis. We then decompose this aggregate TFP growth into changes of technology, terms of trade, efficiency and resource utilization. We can also attribute TFP growth to its main beneficiaries: labor, decomposed into five types, capital, decomposed into two types, and the allowable trade deficit.

We find that potential TFP has been growing after 1986. Labor, in particular machine operators, would be the main source and beneficiary of TFP growth, were resources allocated optimally according to our model. It is only after 1991 that capital, in particular equipment, has been contributing positively to frontier TFP growth. The Solow residual, reflecting technological change, was the main driver of TFP growth. Over the whole period, changes in the terms of trade were detrimental to TFP growth. The Tunisian economy moved closer to its TFP frontier after 1986, but efficiency has again taken a beating after 1991.

JEL code: O47, O55

Keywords: total factor productivity growth, efficiency, frontier analysis, Tunisia

I. Introduction.

Research on the determinants of economic growth and productivity growth suggests that there is a three way complementarity between physical capital, human capital and technical progress in the growth process. All are necessary ingredients for improved productivity performance. The new equipment that investment puts in place requires a well trained workforce for efficient operation. Technical progress is embodied in new equipment. Trained workers can only be fully productive if they have the appropriate equipment with which to work.

De Long and Summers (1992) estimated that 80 per cent of technical change is embodied in new capital equipment, particularly machinery. Without gross investment, technical progress would be difficult if not impossible. De Long and Summers (1991) found that machinery and equipment investment has a strong association with growth and that the social return to equipment investment in well-functioning market economies was in the order of 30 percent per year over the 1960-1985 period. This relationship was confirmed at the level of the developing economies in De Long and Summers (1993).

Over the last twenty years Tunisia has adopted some significant policy measures to open its economy to world trade. In 1987 it introduced the structural adjustment program aimed at reducing market distortions, in 1996 it put in place an industrial restructuring program to help Tunisian enterprises to acquire the necessary equipment and know-how to be competitive on export markets, after signing in July 1995 a free trade agreement with the European Union. The paper seeks to quantify by how much these various policy measures affected the performance of the Tunisian economy.

In the last decades Tunisia followed a policy of sustained capital accumulation with an investment rate of 30% of GDP on average over the period 1981-1986. As a result of this, the capital stock grew on average by 6.9% per year over this period compared to 2.4% for labor. The growth rate in capital dropped to 2.4% during the adjustment period (1987-1991) following the slowdown in investment by state enterprises. In 1992-1996 it started growing again to 2.7% per annum in the wake of the push in investment contained in the structural adjustment program. However, the components of capital did not always grow at a uniform rate. In 1992-1996 buildings grew by 4.8% whereas equipment declined by 1%.

Building on Ghali and Mohnen (2003), a general equilibrium model of the Tunisian economy is used to estimate the TFP (total factor productivity) growth rate at the sectoral and at the aggregate levels between 1983 and 1996. This TFP measure indicates the potential of the Tunisian economy in each year of the period under analysis and its evolution over time. It also indicates the sources of strength and of efficiency.

Conventionally, TFP is defined as the ratio of an output index to an input index (see Diewert (1992)). Its growth therefore represents the growth of output that goes beyond what can be explained by the growth in the inputs. Under certain conditions, among which constant returns to scale, optimal factor holdings and marginal cost pricing, TFP growth as measured by the Solow residual captures the technology shift.[1] It is, however, debatable whether these restrictive conditions hold. In an open economy it makes sense to redefine productivity as the final demand achievable with the domestic resources and the extent of the trade deficit (Diewert and Morrison (1986)). Another strand of literature turning around the Malmquist index distinguishes between movements of and towards the frontier, splitting TFP growth into changes in efficiency and changes in technology (see Caves, Christensen and Diewert (1982)).

The debate about how TFP should be measured and what it actually means is far from being settled (see Lipsey and Carlaw (2001) for a provoking list of alternative interpretations). We shall adopt a new approach for measuring and interpreting TFP, entrenched in a general equilibrium model of an open economy, that does not rely on observed market prices to infer marginal productivities, but only on the fundamentals of the economy, i.e. technologies, preferences and endowments. The approach was developed by ten Raa and Mohnen (2002). We apply it to the case of Tunisia for the period 1983-1996.

We shall proceed as follows. In section II we briefly review the various measures and interpretations of TFP. After that, in section III, we present our model of the Tunisian economy, the calculation of the efficiency frontier and the data sources. We then turn to the application of this model to the Tunisian economy. In section IV we analyse Tunisia's TFP growth first at a macro level and then at the sectoral level. We conclude by summarizing our main findings and suggesting further lines of research.

II. The measurement and meaning of TFP

TFP has been measured and interpreted in many different ways (for some surveys, see Diewert (1992), Balk (1998), Grosskopf (2001)). The first choice is with respect to the number of inputs. Materials are sometimes ignored or factored out by an assumption of separability of materials and primary inputs so that output is defined as value-added. Each individual input might itself result from the aggregation of many heterogeneous parts. If the input components are given the same marginal productivities in the face of heterogeneity, we have a measurement error, akin to the measurement error due the non-accounted for quality change. Our model has many intermediate inputs and five different types of labor.

Most of the time TFP is measured in closed economies, ignoring possible substitutions between domestically produced and imported inputs. In an open economy it is possible to increase output without producing more inputs, simply by increasing the amount of imported inputs. It is therefore important in open economy models to adjust TFP to allow for imports, by redefining it as the growth in final

---

[1] The Solow residual is defined as

$$\frac{\dot{A}_t}{A_t} = \frac{\dot{Q}_t}{Q_t} - S_{K_t}\frac{\dot{K}_t}{K_t} - S_{L_t}\frac{\dot{L}_t}{L_t}$$

where K and L representent capital, labor, S_K and S_L their respective output elasticities, and A_t measures the shift of the production function (here specified in terms of value added, Q).

domestic demand minus the growth of the primary inputs, which include the allowable trade deficit. As a result, TFP can now be affected by changes in the terms of trade. TFP accounting in open economies have been handled by Diewert et Morrison (1986) and Kohli (1991). Our model recognizes the openness of the Tunisian economy.

In the productivity literature there are two ways to measure marginal productivities and hence TFP. The first one is the index number approach where observed prices are supposed to equate marginal values. The second one is the parametric approach where marginal productivities are estimated from a production function or a dual representation of it. TFP measurement in the former rests on the assumption of constant returns to scale, optimal factor holdings and marginal cost pricing. The latter approach in principal eschews these restrictions, although in practice it rarely happens that all three assumptions are relaxed at the same time. On the other hand, the latter approach requires the use of specific functional forms whereas the former approach does not, unless it uses index numbers that are exact for specific functional forms.

A third strand of literature, starting with Farell (1957), distinguishes between technology shifts and changes in efficiency by using the concept of a distance function. The output distance function measures the greatest possible expansion of output for given inputs, and the input distance function measures the greatest possible contraction in inputs for a given output. The distance function and the resulting Malmquist productivity index can again be obtained non-parametrically by using linear programming techniques, known as « Data Envelopment Analysis » (DEA) or be estimated through a stochastic frontier with an asymmetrically distributed random error term (for a recent example of DEA and stochastic frontier analysis, see Färe, Grosskopf, Norris and Zhang (1994) and Fuentes, Grifell-Tatjé and Perelman (2001) resp.).

We shall depart from all four approaches : the index-number approach, the parametric production function with technology shift specification, the DEA approach and the estimation of a stochastic frontier specification. We follow the approach proposed by ten Raa and Mohnen (2002), which combines input-output analysis and linear programming. It is close in a sense to the DEA approach, except that it defines a frontier for the entire economy, given its interrelationships in sectoral production, the sectoral technologies, the final demand preferences and the endowments of primary inputs. Using this approach we can follow the evolution of (in)efficiency in the use of primary inputs and factor allocations (the distance to the frontier) and the evolution of the production possibility frontier, in other words the potential of the Tunisian economy.

Besides measuring correctly TFP, it is of course also rewarding to be able to explain the fluctuations of TFP. Senhadji (1999), for instance, defines five types of determinants : 1) the endowments in labor, capital and human capital ; 2) the terms of trade ; 3) the macroeconomic environment ; 4) the trade regime ; and 5) the political stability. There are many ways to decompose TFP growth. We propose two decompositions, one in terms of the individual productivities of the primary inputs and one in terms of changes in technologies (Solow residual), the terms of trade, efficiency and resource utilization.

III. The model

We adopt the measure of TFP growth defined in ten Raa and Mohnen (2002) and we apply it to the model for Tunisia used in Ghali and Mohnen (2003). The idea is to determine the frontier of the economy by sectoral reallocation, international specialization, and full resource utilization. For that we define a competitive benchmark obtained by a sort of DEA analysis at the macro level. Technology, preferences and factor endowments are taken as exogenous. The aim is not to determine how the economy evolves following some kind of shock (as in computable general equilibrium models) but simply to determine what the economy's frontier would be in a world of perfect competition.

On the basis of the fundamentals of the economy, i.e. the technologies, the preferences, the endowments of labor and capital, and the world prices of tradable commodities (because we assume that Tunisia is a small open economy), we set up a linear programming problem or activity analysis model designed to maximize domestic final demand given those fundamentals. For each year we solve such a linear programming problem, which determines the optimal allocation of resources among the various sectors of the economy, the optimal production pattern and the optimal trade in tradable commodities. In this general equilibrium shadow prices support the optimal quantities. In this way we trace the economy's frontier in terms of possible production and consumption and its evolution over time. From these optimal quantities and shadow prices we measure potential TFP growth and we decompose it in its constituent parts. Observed prices and quantities do not enter the TFP expression directly. They only serve as basic inputs into the computation of the economy's efficiency frontier. This frontier corresponds to a hypothetical competitive world where technology, preferences and endowments are exogenous. It corresponds thus to a short-term optimum. Adjustment costs from the observed to the optimal allocation of resources are not taken into account. We could conceive of a dynamic programming problem where technologies, preferences and endowments are endogenized with given initial conditions and with adjustment costs or other rigidities constraining the immediate adjustment to a long-run equilibrium. We leave this complication for future work.

Formally, the efficient state of the economy is obtained by solving the following linear programming problem:

$\max_{t,s,g} (DFD)t$ subject to the following constraints:

$$(V' - U)s \geq ft + Jg \qquad (1)$$

$$(L_1+L_2+L_3+L_4+L_5)'s + (l_1+l_2+l_3+l_4+l_5)t \leq N_1+N_2+N_3+N_4+N_5 \qquad (2)$$

$$(L_2+L_3+L_4+L_5)'s + (l_2+l_3+l_4+l_5)t \leq N_2+N_3+N_4+N_5 \qquad (3)$$

$$(L_3+L_4+L_5)'s + (l_3+l_4+l_5)t \leq N_3+N_4+N_5 \qquad (4)$$

$$(L_4+L_5)'s + (l_4+l_5)t \leq N_4+N_5 \qquad (5)$$

$$L_5's + l_5 t \leq N_5 \qquad (6)$$

$$\hat{K}_e \hat{C} s \leq K_e \quad (7)$$

$$(K_s^{'}) s \leq (K_s^{'}) e \quad (8)$$

$$-\pi' g \leq D \quad (9)$$

$$s \geq 0$$

Where

$DFD = \tilde{P}' f + \tilde{w}' l$

t = (Scalar) level of domestic demand;

s = (nx1) vector of activity levels, where n is the number of sectors;

g = (m_T x 1) vector of net exports, where T indices tradable commodities;

V = make matrix (nxm), indicating how much of each commodity is produced in each sector;

U = use matrix (mxn), indicating how much each commodity is used in each sector as intermediate inputs;

J = (nxm_T) matrix selecting tradables;

L_i = employment of labor type i, i=1,…5, where manual workers/trainees are indexed by 1, machine operators by 2, foremen by 3, technicians by 4, and engineers/administrators by 5;

N_i = labor force of type i, i= 1,…,5;

K_e = (nx1) vector of available capital equipment stocks in each sector;

K_s = (nx1) vector of available capital structure stocks in each sector;

C = (nx1) vector of capacity utilization rates in each sector;

π = (m_Tx1) vector of world prices for tradable commodities relative to a domestic-final-demand-weighted average of world prices;

D = observed trade deficit = $-\pi'(V'e - Ue - f)_T$

e = unity vector of appropriate dimension;

$\tilde{P}$ = (mx1) vector of observed commodity prices, where m is the number of commodities;

f = (mx1) vector of domestic final demand;

l_i = (5x1) vector of employment in the non-business sector for each type labor type;

$\tilde{w}$ = (5x1) vector of observed annual labor earnings per worker by qualification in the non-business sector;

^ = diagonalization operator.

The decision variables are the level of domestic final demand (t), the sectoral activity levels (s) and net exports (g). They are determined so as to maximize domestic final demand subject to three sets of constraints. The first set are the commodity balances (1) which stipulate that net production in each sector has to be sufficient to satisfy domestic final demand and net exports. The second set, (2) to (8), states that the inputs used in each sector may not exceed total disposable inputs. Equipment is taken to be sector-specific. In other words, we assume putty-clay technologies. Once installed in one sector, equipment cannot be disassembled and affected somewhere else. In contrast, buildings are assumed to be malleable. A sectoral capital constraint is binding when a sector reaches full capacity utilization. For labor, we distinguish five different types, each corresponding to a certain level of qualification and expertise. Workers can always be affected to jobs requiring lower but not higher qualifications. Part of the labor force is affected to the non-business sector, which essentially comprises services directly consumed by final demand (government services, services provided by non-profit institutions). The last constraint (9) posits that the trade deficit at optimal activity levels may not exceed the observed trade deficit. To increase their level of consumption, Tunisians can import from abroad, but only up to a certain level, which is conservatively taken to be the observed trade deficit. Without constraint (9), Tunisia could reach an infinite value for its objective function by importing without limits. The assumption of a small open economy with exogenous world prices for the tradable commodities is not unrealistic in the case of Tunisia. The observed activity levels correspond to the following values: t=1, s=e, and $D = -\pi'(V'e-Ue-f)_T$. The observed state of the economy is thus our point of reference. Efficiency derives from full capacity utilization, optimal factor allocations across sectors, and international specialization.

The prices sustaining this general equilibrium resource allocation are derived from the dual program :

$$\min_{p,w,r,\varepsilon} w'N + r'M + \varepsilon D \text{ subject to the following constraints}$$

$$p'(V'-U) \leq w'L' + r'K' \qquad (10)$$

$$p'f + w'l = DFD \qquad (11)$$

$$p'J = \varepsilon\pi' \qquad (12)$$

$$p \geq 0, w_5 \geq w_4 \geq w_3 \geq w_2 \geq w_1 \geq 0; r \geq 0; \varepsilon \geq 0. \qquad (13)$$

where p, w, r and ε are respectively the shadow prices of commodities, of the five types of labor, of the sectoral equipment capital stocks and the overall buildings capital stock, and of the trade deficit[2], L' is a 5xn matrix of sectoral labor employment by type of labor, $M=[K_e \mid (K'_s)e]$, $K= [\hat{K}_e \hat{C} \mid K_s]$, and | is the vertical concatenation operator. By the theorem of complementary slackness, a shadow price is positive only if the corresponding constraint in the primal is binding. The shadow prices w and r denote the marginal values of an additional unit of the respective inputs. If at a certain level of qualification the labor constraint is tight, it earns a markup over the level of qualification just below. A sector with less than full capacity utilization earns a zero rate of return on a marginal capital investment, for the very simple reason that it is in no excess demand, as unused capital is still available. The shadow price ε of the trade balance indicates the marginal value in terms of attainable domestic final demand of an additional allowed dinar of trade deficit. The inequalities (10) indicate that at the

[2] Notice that the shadow price of the highest qualified labor type is the sum of the shadow prices of constraints (2) to (6).

optimal solution of the linear program the prices of active sectors equal average cost, and hence that the optimal solution can be obtained as a competitive equilibrium. By the complementary slackness conditions, it can also be said that a sector is active only if it makes no loss. Condition (11) is a normalization condition akin to the choice of a numeraire. At this point it should be noted that the observed prices p and w in no way affect the optimal activity levels, they affect the shadow prices only through the normalization rule (11), i.e. shadow prices are such that on average they reproduce the existing prices. By equality (12) domestic prices for tradable commodities may differ from world prices only by a certain constant ε, which can be interpreted as the exchange rate compatible with the purchasing power parity. All quantities are expressed in constant dinars, except labor, which is denoted in man-years. Hence, all shadow prices are relative constant prices, except the shadow prices of labor which are in constant dinars per man-year.

We now turn to the definition and decomposition of TFP growth. We define TFP growth as the growth of final demand of business and non-business goods and services (where business goods and services refer to those for which there is an intermediate demand) minus the growth in the primary inputs (the endowments of the five types of labor, the sectoral capital stocks and the current trade deficit):

$$T\dot{F}P = \frac{(p'\dot{f} + w'\dot{l})}{p'f + w'l} - \frac{(w'\dot{N} + r'\dot{M} + \varepsilon\,\dot{D})}{w'N + r'M + \varepsilon D} \tag{14}$$

where dots denotre growth rates. We can decompose TFP growth by starting from the equality the optimal value from the primal and the optimal value of the dual, as stated by the first theorem of linear programming :

$$DFDt = w'N + r'M + \varepsilon D. \tag{15}$$

If we totally differentiate (15), and make use of the normalization rule (11), we can obtain, as derived by ten Raa and Mohnen (2002), that TFP growth can be written as the sum of factor productivity growth, the weighted sum of the input prices minus a weighted sum of the commodity prices, and efficiency change:

$$T\dot{F}P = [\dot{w}'N + \dot{r}'M + \dot{\varepsilon}D - (\dot{p}'ft + \dot{w}'lt) - (p'f + w'l)\dot{t}\,] \,/\, (\, w'N + r'M + \varepsilon D\,). \tag{16}$$

Notice that the last term is positive if t declines, i.e. when the economy moves closer to the efficiency frontier. We here recover a decomposition of TFP growth in terms of movements of and towards the frontier of the economy.

By using constraints (1) to (8) and equality (11) we can decompose TFP growth in a

$$\dot{TFP} = [1/(p'ft + w'lt)]$$

$$\{p'(V'\dot{s} - U\dot{s}) - \dot{p}'[V's - Us) - (ft + Jg)] - p'J\dot{g} - p'f\dot{t} + w'l\dot{t}$$

$$- w'(L'\dot{s} + l\dot{t}) - \dot{w}'[N - (L's + lt)] - r'(K'\dot{s}) - \dot{r}'[M - (K's)]$$

$$+ \varepsilon\,\pi'\dot{g} + \varepsilon\dot{\pi}'g - \varepsilon[\dot{D} - (\pi'\dot{g})]\}$$

which after simplification yields the following decomposition of TFP growth:

$$\dot{TFP} = SR + TT + EC + SL \qquad (17)$$

where

$$SR = \{(f\dot{t} + J\dot{g}) - w'(L'\dot{s}) - r'(K'\dot{s})\} / [(p'ft + w'lt)]$$

$$TT = \varepsilon\dot{\pi}'g \ / \ (p'ft + w'lt)$$

$$EC = -\dot{t}$$

$$SL = \{-w'[\dot{N} - (L'\dot{s} + l\dot{t})] - r'[\dot{M} - (K'\dot{s})] - \varepsilon[\dot{D} - (\pi'\dot{g})]\} / [(p'ft + w'lt)].$$

According to (17) TFP growth can be decomposed into four terms: the Solow residual (SR), the terms of trade effect (TT) , the efficiency change effect (EC), and the change in the slack in the use of primary inputs (SL).

The Solow residual is the traditional measure of TFP growth (value added growth minus the growth in the conventional inputs, labor and capital), except that here it is measured at optimal activity levels and shadow prices. The second term represents the terms of trade effect. An appreciation in the terms of trade gives the economy the opportunity to increase its final demand without augmenting the use of its primary inputs. The third term is the efficiency change : a decrease in the expansion factor of final demand implies a closer position to the efficiency frontier and translates into a higher TFP growth. The fourth term is the change in the slack factor: an increase [decrease] in slack, i.e. less than full resource utilization, decreases [increases] TFP growth.

This decomposition of TFP growth, and in particular the Solow residual portion of it, is a macroeconomic one, in a general equilibrium context. However, we can define sectoral Solow residuals consistent with the macroeconomic Solow residual by the

Domar aggregation rule (see Hulten (1978)). Let j stand for sectors, i for commodities, and k for groups of sectors. The Solow residual for sector-group k can then be written as :

$$SR_k = \frac{\sum_{j\in k}\sum_i p_i v_{ji} s_j \dot{(v_{ji} s_j)}}{\sum_{j\in k}\sum_i p_i v_{ji} s_j} - \frac{\sum_{j\in k}\sum_i p_i u_{ij} s_j \dot{(u_{ij} s_j)}}{\sum_{j\in k}\sum_i p_i v_{ji} s_j} - \frac{\sum_{j\in k} w' L_j s_j \dot{(L_j s_j)}}{\sum_{j\in k}\sum_i p_i v_{ji} s_j} - \frac{\sum_{j\in k} r_j' K_j s_j \dot{(K_j s_j)}}{\sum_{j\in k}\sum_i p_i v_{ji} s_j}.$$

Notice that when k = j , we get the Solow residual for sector j.

According to the Domar aggregation rule :

$$SR = \sum_k \frac{\sum_{j\in k}\sum_i p_i v_{ji} s_j}{(p' ft + w' lt)} SR_k \quad . \qquad (16)$$

We can thus define sectoral Solow residuals that by the Domar aggregation rule are consistent with our Solow residual component of frontier TFP growth.

The basic data that are used in this paper are the input-output tables of Tunisia for the period 1983-1996. Labor is disaggregated into five levels of qualification : manual workers and trainees, machine operators, foremen, technicians, and engineers and administrators. Capital is disaggregated into buildings and equipment. Data on the quantity and remuneration of labor are taken from the national accounts (I.N.S.). Estimates of capital stocks and capacity utilization rates are borrowed from a study performed by the « Institut d'Economie Quantitative » (1996). For more details on the data sources and constructions the reader is referred to Ghali and Mohnen (2003). For the industry definitions, see appendix I.

IV. The evolution of Tunisia's economic potential

IV.1 Macroeconomic decomposition of Tunisia' s potential TFP growth, 1983-1996

As table 1 reveals, over the whole sample period (1983-1996) frontier TFP growth increased by a mere 0.2% per year in Tunisia, if we treat capital as homogeneous. If we allow for capital heterogeneity, i.e. different shadow prices for buildings and equipment, the frontier TFP growth turns slightly negative. This poor global performance is especially due to the negative growth rates over the 1983-1986 period, when frontier TFP actually declined, in other words the economy's potential seriously deteriorated. After 1986, frontier TFP growth became positive and even accelerated after 1991.

The model proposes two decompositions of frontier TFP growth. The first one decomposes it according to the marginal productivities of the individual primary inputs. The second one decomposes it according to the variations of the exogenous variables in the model. The results we obtain are pretty robust to the alternative specifications on factor disaggregation: homogeneity in labor and capital, heterogeneity in labor and homogeneity in capital, and heteregeneity in both labor and capital. In the sequel of the paper, we report the results with five levels of labor qualification and two types of capital stock, i.e. the bottom panel of table 1.

Regarding the input sources and beneficiaries of TFP growth, we notice that among the workers, only manual workers and machine operators play a major role. The action lies with the unskilled workers and not the highly skilled. The shadow price of machine operators increased in all four subperiods, for manual workers, the least qualified workers, it was positive in 1986-91 but dropped in the following period. The other categories of workers contributed slightly to frontier TFP growth. From this we can conclude that unskilled workers, especially machine operators, are the crucial bottleneck for improved growth performance in Tunisia. The excessive wage rates for the more qualified workers are not justified according to our activity analysis. It is a fact that qualified labor is in excess supply in Tunisia. Highly qualified workers are more likely to be demanded by large firms and those are few in numbers in Tunisia. In 1996, according to a study of the World Bank (World Bank (2000a), vol II, table 2.3, p.6) 82.4% of Tunisian enterprises had less than 6 workers, while only 1.6% employed more than 100 workers and a few dozens more than 500.

On the whole, capital, especially equipment, had a negative contribution to TFP growth. Tunisia overinvested in equipment. This was especially so during the 1983-1986 subperiod. The decline in equipment in 1991-1996 was beneficial to aggregate TFP growth. The capital stock in buildings increased by 4.3% on average over the whole period (see table 5). This increase was justified in terms of increasing potential TFP in 1983-1986, but no more afterwards. It must be recalled that in the period stretching from 1972 to 1985 real interest rates were negative in selected key sectors (Morrisson and Talbi (1995), World Bank (1996)). Investment policy changed in 1987. Investment which previously had to be approved was now given financial and fiscal incentives in some priority sectors. In 1993 a more unified code of investment was promulgated which was based on export promotion, regional development, and technological development. Before the structural adjustment program, the price-fixing policy (Ghali (1995), Morrisson and Talbi (1996)), which got revised in 1986 and then again in 1991, depressed competition in many sectors and discouraged innovation. Protectionism was classified at level 8 out of 10 by the IMF (IMF (1999)).

The last primary input in our open model is the allowable trade deficit. Over the whole period it played a slightly negative but modest role in frontier TFP growth (minus one tenth of a percentage point). The marginal value in terms of domestic final demand of an additional dinar of foreign deficit decreased over time.

We now turn to the decomposition of frontier TFP growth in terms of the growth in the quantities of the exogenous variables. The Solow residual grew by 0.5% per year over the whole period. In 1983-1986 it actually regressed but then it rose in the next two sub-periods to reach an annual growth rate of 2.1% in 1991-1996. The improvement in the Solow residual coincides with the structural adjusment program started in 1987. This policy aimed at increasing competition, liberalizing prices, the financial sector and foreign trade, reforming public enterprises, and privatizing certain sectors like the textile and the hotel industries.

To contrast our results with other results reported in the literature, we also computed the Solow residual at observed quantities and prices (see table 2). For that we used the utilized capital stock as the capital input. Paquet and Robidoux (2001) have shown with Canadian data that computing TFP growth without correcting for changes in capacity utilization leads to a procyclical Solow residual as compared to the Solow residual based on utilized capital stocks. To compute the observed Solow residual we have not disaggregated the capital stock and we have calculated the user cost of capital residually. We first notice that our observed Solow residuals are in accordance with those reported in other studies. Only the Solow residuals implicit in the 6th to 8th plans of economic development are somewhat out of line with our computations. Second we notice that the optimal Solow residuals follow over time the same movement as the observed Solow residuals but with greater variation. It is useful to recall here that the optimal Solow residual measures the potential shift of the production possibility frontier, whereas the usual Solow residual, evaluated at observed prices and activity levels, measures the shift of the production function passing through observed points.

What is striking is the strong negative effect the terms of trade exerted on frontier TFP growth in the two sub-periods prior to 1991. In the third sub-period it turned into a positive but minor contribution. Given the structure of Tunisia's net exports, the evolution of world prices was not favorable to Tunisia. On average the price of imported goods rose more than the price of exported goods. In the end the Tunisian economy experienced over the whole period a significant drop in its purchasing power on world markets. The terms of trade effect almost neutralized the Solow residual effect.

The adjustment program was successful in increasing the efficiency of the Tunisian economy. In 1991-1996, Tunisia moved closer to its efficiency frontier. Changes in the slacks in resource utilization played only a minor role.

IV.2 Sectoral decomposition of Tunisia' s TFP growth, 1983-1996

In table 3 we report the sectoral Solow residuals calculated at optimal activity levels and shadow prices and in table 4 we report the Solow residuals calculated at observed activity levels and prices. The observed and optimal Solow residuals follow in the aggregate a similar evolution, but the details are quite different, and reflect the evolution at factor scarcities. The greatest difference is visible in agriculture and fishing. It had the high Solow residual when evaluated at optimal activity levels, but a permanent negative Solow residual when evaluated at observed prices and quantities. Mining had a positive (minor at the end) contribution to the observed Solow residual, but overall a negative one with the optimal prices and quantities. Petroleum and gas, electricity, transport and telecommunications, and other services had a strong positive effect in both cases, even stronger at observed activity levels.

We also notice some significant changes in sectoral productivity performances. The industries of construction materials, textiles and leather, petroleum and gas, construction and public works, transport and telecommunication became more productive in each sub-period, and hotel and tourism and other services substantially in the last sub-period. Negative productivity trends occurred in food processing, chemicals, mining, electricity and water utilities. Tunisia seems to be moving from a resource-based to a services economy.

Tables 3 and 4 also give the weights used in the Domar aggregation of sectoral Solow residuals (at optimal and observed activity levels and prices) to get to the aggregate Solow residual. If we look at the mid sub-period, the greatest weights were attached to other services, agriculture and fishing, construction and public works within the utilities, and food processing within manufacturing. Observed and optimal weights sometimes differ substantially, for example when a sector like textiles and leather becomes inactive in the linear program. Petroleum and gas is a sector that saw a steady decline of its importance over the sample period.

V. Conclusion

In this study we have examined the evolution of frontier TFP in Tunisia over the period 1983-1996 using the framework of ten Raa and Mohnen (2002). Frontier TFP growth captures the shift in the production frontier of the economy as well as variations in efficiency movements with respect to the frontier. The location of the frontier is obtained by the resolution of a linear program (or activity analysis) at the level of the whole economy, taking into account factor resource constraints, inter-industry linkages, preferences and world prices. We have proceeded to various decompositions of TFP growth. One decomposes it with respect to the individual marginal productivities : capital subdivided into buildings and equipment, labor subdivided into five levels of qualification, and the allowable trade deficit. The second one is with respect to the exogenous variables of the model, yielding four terms : the usual Solow residual (but evaluated at frontier quantities and supporting prices), the terms of trade effect, the economy's efficiency and the extent of incomplete resource utilization.

The main results of our analysis can be summarized in the following points :

1. Over the whole sample period (1983-1996) frontier TFP growth hardly increased in Tunisia. This poor global performance is especially due to the negative growth rates over the 1983-1986 period, where frontier TFP actually declined, in other words the economy's potential deteriorated.

2. In the two sub-periods 1983-1986 and 1986-1991, corresponding to the 6th and 7th plan of economic development, labor was the main contributor to frontier TFP growth, and in particular machine operators. In the 1991-1996 sub-period capital (and particularly equipment) took over from labor the positive contribution to frontier TFP

growth. The allowable trade deficit played a slightly negative but modest role in frontier TFP growth over the whole period.
3. The Solow residual computed at frontier levels grew by 0.5% per year over the whole period. In 1983-1986 it actually regressed but then it rose in the next two sub-periods to reach an annual growth rate of 2.1% in 1991-1996. The improvement in the Solow residual coincides with the structural adjustment program started in 1987. What is striking is the strong negative effect the terms of trade exerted on frontier TFP growth in the two sub-periods prior to 1991. Given the structure of Tunisia's net exports, the evolution of world prices was not favorable to Tunisia. In 1991-1996 Tunisia became more efficient in managing its resources.

4. Over the whole period, agriculture and fishing experienced a high Solow residual if evaluated at optimal activity levels. The other strong performers in the frontier allocation of resources are hydrocarbons, electricity, transport and telecommunication. However, we also notice some significant changes in sectoral productivity performances. The industries of construction materials, textiles and leather, petroleum and gas, construction and public works, transport and telecommunication became more productive in each sub-period, and hotel and tourism and other services substantially in the last sub-period. Negative productivity trends occurred in food processing, chemicals, mining, electricity and water utilities. Tunisia seems to be moving from a resource-based to a services economy.

These results while suggestive of changing trends and deep restructurings in the Tunisian economy should nevertheless be taken with some reservations. Nugent (1970) already pointed out that activity analysis models like this one may depend heavily on model and data imperfections. Data on capacity utilizations and labor force by type of qualification are partly constructed and hence particularly subject to measurement errors. Quantities are hard to measure in the service sectors and future studies will certainly improve our measure of productivity in services. The same could be said about quality changes with possible mismeasurement of output, especially in high-tech commodities. It would be more rewarding to have a disagregation of labor by skills rather than by occupations. To assume sector-specific capitals might be too restrictive. It might be more realistic to assume different types of capital with substitution across industries. At the other extreme it is also too restrictive to assume perfect labor mobility. Finally, time, adjustment lags and expectations are completely absent from this essentially static model. Introducing these elements into the model would call for an intertemporal optimization model.

Bibliography

Balk, B. (1998), *Industrial Price, Quantity, and Productivity Indices: The Micro-Economic Theory and an Application*. Kluwer Academic Publishers, Boston.

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

Ben Slama et al. (1996), "Relations technologiques intersectorielles et décomposition des sources de la croissance", cahiers de l'I.E.Q., no. 12.

Bosworth, B., S. Collins and Y. C. Chen (1995), "Accounting for differences in economic growth", Brookings Discussion Papers in International Economics, No 115.

Caves, D.W., L.R. Christensen and W.E. Diewert (1982), "The economic theory of index numbers and the measurement of input, output, and productivity", *Econometrica*, 50, 1393-1414.

De Long, J. Bradford and L. Summers (1991), "Equipment Investment and Economic Growth", *Quarterly Journal of Economics*, 106 (2), 445-502.

De Long, J. Bradford and L. Summers (1992), "Equipment Investment and Economic Growth: How strong is the nexus.", *Brookings Papers on Economic Activity*, Vol 1992 (2), 157-199.

De Long, J. Bradford and L. Summers (1993), "How Strongly do Developing Economies Benefit from Equipment Investment ?", *Journal of Monetary Economics*, 32, 395-415.

Diewert, W. E. (1976), "Exact and Superlative Index Numbers", *Journal of Econometrics*, 4, 115-145.

Diewert, W. E. (1981), "The theory of total factor productivity measurement in regulated industries", in Cowing, T. and R. Stevenson (eds.), *Productivity measurement in Regulated Industries*, Academic Press, New York, 1981.

Diewert, W. E. and C.J. Morrison (1986), "Adjusting output and productivity indexes for change in the terms of trade", *Economic Journal*, 96, 659-679.

Diewert, W. E. (1992), "The measurement of productivity", *Bulletin of Economic Research*, 44(3), 163-198.

Domar, E. (1961), "On the measurement of technical change", *Economic Journal*, 70, 710-729.

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

Farrell, M. J. (1957), "The measurement of productivity efficiency", *Journal of Royal Statistical Society A*, 120, 253-281.

Fuentes, H.J., E. Grifell-Tatjé, and S. Perelman (2001), "A parametric distance function approach for Malmquist productivity index estimation", *Journal of Productivity Analysis*, 15, 79-94.

Ghali, S. (1995), "Régimes des prix et organisation de la concurrence", in *Schéma Global de Développement de l'Economie Tunisienne à l' Horizon 2010*, Etude stratégique No 3, Vol III, Institut d'Economie Quantitative, Novembre.

Ghali, S. and P. Mohnen (2003), "Restructuring and Economic Performance: The Experience of the Tunisian Economy", in *Trade Policy and Economic Integration in the Middle East and North Africa: Economic Boundaries in Flux*, (Hassan Hakimian and Jeffrey B Nugent, eds), London: Routledge-Curzon, 2003.

Griliches, Z. (1996), "The discovery of the residual: A historical note", *Journal of Economic Literature*, 34, September, 1324-1330.

Grosskopf, S. (2001), “Some remarks on productivity and its decompositions”, mimeo.
Hall, R.E. (1988), "Invariance properties of Solow's Residual", in Diamond, P. (ed.), *Growth / Productivity / Unemployment*, M.I.T Press, Cambridge, M.A.
Hulten, C. R. (1978), "Growth accounting with intermediate inputs", *Review of Economic Studies*, 45, 511-518.
Hulten, C. R. (1986), "Productivity change, capacity utilization and the sources of efficiency growth", *Journal of Econometrics*, 33, 31-50.
Hulten, C. R. (1987), "Divisia Index Numbers", *Econometrica*, 41, 1017-1025.
Institut d’Économie Quantitative (1996), *Étude stratégique No. 8, compétitivité, restructuration, diversification et ouverture sur l’extérieur des industries manufacturières et des services*, 8622/96.
Institut National de la Statistique, *Les comptes de la nation*.
International Monetary Fund (1999), *Tunisia: Staff Report for the Article IV Consultation*, IMF Staff Country Report No. 99/104, September, Washington D.C.
Jorgenson, D. W. and Z. Griliches (1967), "The explanation of productivity change", *Review of Economic Studies*, 34(3), 308-350.
Jorgenson, D. W. and Z. Grliches (1972), "Issues in growth accounting: A reply to Edward F. Denison", *Survey of Current Business*, 52, 65-94.
Kohli, U. (1991), *Technology, Duality, and Foreign Trade: The GNP Function Approach to Modeling Imports and Exports*, Ann Arbor: University of Michigan Press.
Lipsey, G. L. and K. Carlaw (2000), "What does Total Factor Productivity measure?", *International Productivity Monitor*, Fall, 1, 31-40.
Morrisson, C. and B. Talbi (1996), *La croissance de l’économie tunisienne en longue période*. Centre de développement de l’OCDE.
Nugent, J. (1970), “Linear programming models for national planning: demonstration of a testing procedure”, *Econometrica*, 38(6), 831-855.
Paquet, A. and B. Robidoux (2001), "Issues on the measurement of the Solow residual and the testing of its exogeneity: Evidence for Canada", *Journal of Monetary Economics*, 47, 595-612.
Rama, M. (1998), "How bad is unemployment in Tunisia? Assessing labor market efficiency in a developing country", *The World Bank Research Observer*, 13(1).
Redjeb, M.S. et B. Talbi (1995), "Performance de l'Economie Tunisienne durant la Période 1961-1993", in *Schéma Global de Développement de l'Economie Tunisienne à l' Horizon 2010*, Etude stratégique No 3, Vol II, Institut d'Economie Quantitative, Novembre.
Redjeb, M. S. et L. Bouzaiane (1999), "Contribution du secteur privé à la croissance économique en Tunisie", in *L'entreprise au seuil du troisième millénaire: Défis et Enjeux*, Institut Arabe des Chefs d'Entreprises, Novembre.
Senhadji, A. (1999), "Sources of economic growth: An extensive growth accounting exercise", I.M.F Working Paper, WP/99/77, June.
Solow, R. (1957), "Technical change and the aggregate production function", *Review of Economics and Statistics*, 39, 312-320.
Ten Raa, T. and P. Mohnen (2002), " Neoclassical Growth Accounting and Frontier Analysis : A Synthesis ", *Journal of Productivity Analysis*, 18, 111-128.
Wolff, E. N. (1985), "Industrial composition, interindustry effects, and the U.S productivity slowdown", *Review of Economics and Statistics*, 67, 268-277.
World Bank (1996), *Tunisia's global integration and sustainable development, strategic choices for the 21*. Washington D.C.

World Bank (2000a), *Tunisia-Private sector assessment update, meeting the challenge of globalization*, report No.20173-TUN, December.
World Bank (2000b), *Republic of Tunisia. Social and Structural Review 2000.* Washington D.C.

Table 1

Decomposition of FrontierTotal Factor Productivity Growth (1983-1996), (in percentages)

	1983-1996	1983-1986*	1986-1991**	1991-1996***
Homogeneous labor				
TOTAL	**0.2**	**-4.0**	**0.8**	**2.1**
Labor	1.8	3.7	4.0	-1.6
Capital	-1.6	-7.0	-4.7	4.7
Trade Deficit	-0.1	-0.2	-0.1	-0.0
Changes in commodity prices	0.2	0.5	-0.0	0.1
Efficiency	-0.1	-1.0	1.6	-1.1
---	-----------------	-----------------	-----------------	-----------------
Solow Residual	0.9	-1.1	0.5	2.5
Terms of trade	-1.0	-3.0	-1.3	0.6
Efficiency	-0.1	-1.0	1.6	-1.1
Resource utilization	0.4	1.2	0.0	0.2
Labor decomposed into five levels of qualification				
TOTAL	**0.2**	**-4.0**	**0.8**	**2.0**
Manual workers and trainees	0.3	1.0	1.0	-0.8
Machine operators	1.5	1.9	2.1	0.7
Foremen	0.2	0.3	0.3	0.1
Technicians	0.2	0.4	0.3	0.1
Engineers/administrators	0.1	0.2	0.1	0.1
Capital	-2.3	-7.0	-4.5	2.6
Trade deficit	-0.1	-0.2	-0.1	-0.0
Changes in commodity prices	0.2	0.5	0.0	0.1
Efficiency	0.0	-1.1	1.5	-0.9
---------------------------------------	-----------------	-------------------	-------------------	-------------------
Solow Residual	0.8	-1.1	0.4	2.5
Terms of trade	-1.0	-3.0	-1.2	0.3
Efficiency	0.0	-1.1	1.5	-0.9
Resource utilization	0.4	1.2	0.1	0.1

* 6th Economic Development Plan: 1982-1986.
** = 7th Economic Development Plan: 1987-1991.
*** = 8th Economic Development Plan: 1992-1996.

Table 1 (con'd)

Decomposition of Total Factor Productivity Growth (1983-1996), (in percentages)

	1983-1996	1983-1986*	1986-1991**	1991-1996***
Labor decomposed into five levels of qualification and capital decomposed into buildings and equipment				
TOTAL	**-0.2**	**-4.7**	**0.8**	**1.6**
Manual workers and trainees	0.0	-0.1	1.6	-1.5
Machine operators	1.7	1.3	2.2	1.4
Foremen	0.3	0.2	0.3	0.2
Technicians	0.3	0.3	0.3	0.2
Engineers/administrators	0.1	0.1	0.2	0.1
Equipment	-2.1	-10.1	-2.6	3.2
Buildings	-0.6	2.2	-2.2	-0.6
Trade deficit	-0.1	-0.1	-0.1	-0.0
Changes in commodity prices	0.2	0.6	0.1	-0.0
Efficiency	0.1	0.9	1.0	-1.3
--	-----------------	-------------------	-------------------	-------------------
Solow Residual	0.5	-2.5	0.6	2.1
Terms of trade	-0.6	-2.7	-0.6	0.6
Efficiency	0.1	0.9	1.0	-1.3
Resource utilization	-0.0	-0.2	-0.2	0.2

* 6th Economic Development Plan: 1982-1986.
** = 7th Economic Development Plan: 1987-1991.
*** = 8th Economic Development Plan: 1992-1996.

Table 2

Our estimates of TFP growth compared to previous studies (in percentages)

	1982-1988	**1986-1992**	**1986-1996**	**1987-1993**	**1989-1992**	**1982-1986**	**1986-1991**	**1991-1996**
Our results	**(1983-1988)**					**(1983-1986)**		
Optimal Solow Residual								
Homogeneous Labor	-0.7	1.3	1.5	1.8	3.6	-1.1	0.5	2.5
Heterogeneous Labor	-0.7	1.2	1.4	1.7	3.7	-1.1	0.4	2.5
------------------------	------------	------------	-------------	-------------	-------------	-------------	--------------	--------------
Observed Solow Residual								
Homogeneous Labor	-0.5	1.0	1.5	1.7	3.7	0.2 (0.3)*	0.1 (1.8)*	2.9 (2.4)*
Heterogeneous Labor	-0.7	0.9	1.3	1.5	3.5	-0.05 (-0.02)*	-0.02(1.6)*	2.7 (2.3)*
Bosworth & Al (1995)		1.4						
Redjeb-Talbi (1995)				2.1				
Redjeb-Bouzaiane (1999)				1.9				
Morrisson-Talbi (1996)	-0.2				3.0			
World-Bank (2000b)		1.8	1.2					
VIth **Plan** (1982-1986)**						-1.7		
VIIth **Plan** (1987-1991)**							2.2	
VIIIth **Plan** (1992-1996)***								1.3

* The numbers in parentheses have been obtained using the total capital stock (not corrected for capacity utilization rate)

** Source: VIII ème Plan de Développement , 1992-1996, Contenu Global, Vol I, Ministère du Développement Economique, République Tunisienne.

*** Source: IX ème Plan de Développement, 1997-2001, Contenu Global, Vol I, Ministère du Développement Economique, République Tunisienne.

Table 3

Solow residual and mean weights in Domar aggregation at optimal activity levels and shadow prices (1983-1996), Annual growth rates (in percentages)
(Labor decomposed into Five Levels of Qualification)

	1983-1996		1983-1986[1]		1986-1991[2]		1991-1996[3]	
	Solow	Domar	Solow	Domar	Solow	Domar	Solow	Domar
Agriculture and fishing	2.7	0.22	2.0	0.20	5.3	0.22	0.5	0.22
Food processing	-0.7	0.20	1.3	0.19	-1.8	0.26	-0.7	0.15
Construction materials & glass	0.4	0.08	-0.6	0.07	-0.9	0.08	2.3	0.08
Mechanical and electrical goods	1.1	0.15	1.4	0.11	1.0	0.15	1.1	0.17
Chemical and rubber products	0.6	0.12	1.0	0.10	1.3	0.16	-0.2	0.09
Textile and leather products	2.9	0.04	8.4	0.00	1.8	0.04	0.7	0.06
Other manufacturing	0.3	0.06	0.0	0.00	-0.2	0.07	0.9	0.09
Mining	1.0	0.01	0.5	0.02	1.1	0.02	1.3	0.01
Hydrocarbons	0.3	0.13	0.6	0.24	-0.7	0.12	1.2	0.08
Electricity	1.9	0.03	4.2	0.03	0.4	0.03	2.0	0.02
Water	0.6	0.01	1.9	0.01	-1.5	0.01	2.0	0.01
Construction and public works	0.3	0.17	-0.2	0.18	-0.9	0.16	1.8	0.19
Transport and telecom.	1.4	0.14	-0.5	0.14	-0.4	0.13	4.3	0.15
Hotel and tourism	-0.5	0.11	-1.5	0.11	-3.1	0.11	2.7	0.12
Other services	-0.7	0.36	-4.5	0.39	-1.0	0.34	1.9	0.36
Aggregate	0.8	1.83	-1.1	1.78	0.4	1.88	2.5	1.80

(1) 6th Economic Development Plan: 1982-1986
(2) 7th Economic Development Plan: 1987-1991
(3) 8th Economic Development Plan: 1992-1996

Table 4

Observed Solow residuals (1983-1996) (annual growth rates in percentages)

and mean weights in Domar aggregation.

(Labor decomposed into Five Levels of Qualification)

	1983-1996		1983-1986[1]		1986-1991[2]		1991-1996[3]	
	Solow	Domar	Solow	Domar	Solow	Domar	Solow	Domar
Agriculture and fishing	-0.8	0.20	-1.5	0.18	-0.1	0.21	-1.1	0.20
Food processing	-0.1	0.20	-1.5	0.18	-1.4	0.21	0.2	0.21
Construction materials & glass	0.7	0.06	-0.4	0.05	-0.4	0.06	2.5	0.06
Mechanical and electrical goods	1.2	0.11	1.4	0.10	1.0	0.11	1.2	0.12
Chemical and rubber products	1.0	0.12	2.0	0.11	1.5	0.13	0.1	0.10
Textile and leather products	1.0	0.18	0.8	0.12	0.9	0.17	1.3	0.22
Other manufacturing	0.7	0.07	1.6	0.06	0.1	0.08	0.7	0.08
Mining	1.0	0.01	1.3	0.02	1.6	0.02	0.2	0.01
Hydrocarbons	0.5	0.12	1.2	0.15	-0.9	0.13	1.4	0.09
Electricity	2.5	0.03	4.5	0.03	1.5	0.03	2.4	0.03
Water	1.1	0.01	2.5	0.01	-1.4	0.01	3.0	0.01
Construction and public works	-0.4	0.17	-1.4	0.19	-2.0	0.15	1.8	0.17
Transport and telecom.	2.0	0.12	0.4	0.11	0.4	0.12	4.6	0.13
Hotel and tourism	-0.3	0.10	-1.2	0.08	-3.1	0.10	3.0	0.11
Other services	1.2	0.31	-2.0	0.26	1.6	0.32	2.7	0.32
Aggregate	1.0	1.79	-0.05	1.63	-0.02	1.84	2.7	1.84

(1) 6th Economic Development Plan: 1982-1986
(2) 7th Economic Development Plan: 1987-1991
(3) 8th Economic Development Plan: 1992-1996

Table 5

Annual growth rates for labor (by type of qualification), capital (by structure) and trade deficit (in percentages)

	1983-1996	1983-1986[1]	1986-1991[2]	1991-1996[3]
Manual workers and trainees	1.1	0.4	1.8	1.0
Machine operators	3.1	3.3	3.0	3.2
Foremen	2.4	2.3	3.2	1.8
Technicians	2.5	1.2	2.7	3.1
Engineers/administrators	3.4	6.7	2.6	2.5
Total labor	2.5	2.4	2.6	2.5
Capital	2.7	5.3	1.8	2.1
Equipment	1.0	4.9	0.4	-0.6
Buildings	4.3	5.9	3.4	4.6
Trade deficit	-14.3	-12.8	-12.2	-32.3

(1) 6th Economic Development Plan: 1982-1986
(2) 7th Economic Development Plan: 1987-1991
(3) 8th Economic Development Plan: 1992-1996

Appendix I: Nomenclature and symbols

Industry	**Commodity code**
AGRICULTURE & FISHING	
Agriculture & fishing	00
MANUFACTURING	
Food processing	10
Construction materials & glass	20
Mechanical & Electrical goods	30
Chemical & Rubber products	40
Textile & Leather products	50
Other Manufacturing	60
UTILITIES	
Mining	65
Hydrocarbons	66
Electricity	67
Water	68
Construction & Public works	69
SERVICES	
Transport &Communications	76
Hotels & Tourism	79 + 99
- hotels, coffees and restaurants	79
- tourism and other stays	99
Other Services	72+ 82 + 85 + 94
- commodity trade	72
- financial services and insurance	82
- other market services	85
- non market services	94