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# TFP Growth in Argentina during the 1990's: A Stylized Fact?\*

Ariel Alberto Coremberg

## *Introduction*

Argentine economy showed an outstanding growth during the 1990's. A higher international liquidity, macroeconomic stability and structural economic reforms, encouraged a significant inflow of foreign capital that favoured an increase of domestic absorption: investment, consumption, and public expenditure.

The privatization of public utilities and market deregulation at the beginning of the decade caused a significant apparent increase in productivity even though the establishment of a convertibility exchange system and higher capital inflows generated a substantial appreciation of the domestic currency.

Productivity gains resulted in significant cost-savings, partially offsetting the competitive disadvantages of real appreciation. An obvious indication of this effect was the remarkable growth of the tradable goods sector, which not only increased its production but also its exports.

However, the drop of the real exchange rate was not sustainable in the long run. Productivity gains were merely apparent; a fact that proved that convertibility exchange system was not sustainable.

In the aftermath of the so-called "tequila" shock in 1995, Argentine economy was unable to absorb the additional shock of Brazil's devaluation in 1998 in the medium term by means of increases in domestic savings and productivity needed to compensate the negative consequences of external shocks on its performance.

By the end of the decade, a sizable accumulated external and fiscal imbalance brought the convertibility system to an inescapable end that entailed important capital flight, bank runs, default of external debt and megadevaluation, a deep economic crisis with after-effects that are still perceptible.

The aim of this work is to discuss briefly whether productivity growth in Argentina during the 1990's was not sustainable in the long run.

The main purpose of the paper is that the apparent nature of productivity gains may be due to error identification. Through an exhaustive analysis of economic growth sources and a consistent statistical methodology, it will be shown that the Argentine economy during the nineties had an extensive growth type based on factor accumulation rather than on organization improvements independent of such accumulation. This might be the reason why "spill over" effects were absent in this apparent productivity growth which did not generate a sustainable increase of real income in the economy as a whole.

The present work has been divided into four sections: the first section discusses the importance of productivity for economic analysis; the second one details the concept of productivity that is relevant for the purposes of this work; the third one analyzes the methodology used for estimating the contribution of productive factors to economic growth (Appendix 1 discusses these methodologies in analytically detail). The fourth section offers the main results obtained by applying this methodology to the Argentine case during the nineties. Finally, conclusions are drawn.

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## 1. *The Importance of Productivity for economic analysis*

One of the main factors that determine the sustainable character of economic growth is the increase in productivity. A higher increase in productivity indicates an increase in the productive capacity of the economy or potential output and indicates whether the growth path of the economy is sustainable in the long run or is merely apparent.

According to the dual approach, an increase in productivity is, at the same time, a decrease in average cost that cannot be accounted for by changes in the relative prices of production factors.

Therefore, productivity growth is a proxy indicator of the degree of competitiveness of the economy. Cost-reduction and the possibility of lowering prices, both in foreign and domestic markets, are correlated to productivity gains, which thus favors market expansion for domestic products.

Considering distortions introduced by other competitiveness indicators based on foreign trade data, prices, or unit costs—influenced by apparent short-term competitive advantages fostered by exchange or trade policies—, indicators based on productivity are the indicators *par excellence* of the intrinsic competitiveness of an economy.

For example, if an indicator of apparent competitiveness, such as unit labour costs, indicates a real appreciation of the domestic currency, competitiveness might be considered as "sustainable" or "in equilibrium" in so far as labour productivity gains are high enough to offset the increase in unit labour costs so that the drop in apparent competitiveness results in fact in an increase in implicit competitiveness.

Productivity is also a fundamental of the value of wealth or permanent income. The prospective value of wealth is given by the current expected value of future consumption flows which are equivalent to the current value of future income net of investment or permanent income. The expected productivity is one of main factors of the permanent income: the greater the expected productivity growth of the economy, the greater its potential output and, therefore, the greater the permanent income or wealth. Since the expected value of wealth is a fundamental variable for production, investment, and consumption decision-making, the evaluation of productivity performance, not only has long-term implications but also affects macroeconomic stability and even helps determine the nature of the economic cycle.

Besides, productivity is also an indicator of a country's standard of living. A higher productivity growth paves the way for improving the *per capita* income of its population.

The sustainable character of productivity gains depends on improvements in production processes, independently of factor accumulation. If productivity gains were based on a greater capital accumulation fostered by a fall in its relative cost, or on a factor substitution, these productivity gains would not deserve such name. Hence the adjective "apparent" applied to them in the sense of this is error identification.

An accurate identification and measurement of productivity becomes fundamental, considering the importance of a country's productivity for analyzing its growth, competitiveness, value of wealth, standard of living, and macroeconomic stability.

In the following sections, the problem of identifying productivity is analyzed in detail, and methodological recommendations for its measurement extracted from recent literature are also discussed.

## 2. Total Factor Productivity (TFP)

From the neoclassical perspective of economic growth theory, i.e., the growth of productivity in the economy, is the increase of the output derived from organizational improvements of the production process (management, layout, etc.), regardless of the accumulation of productive factors such as capital, labour, and inputs.

According to such view, the potential output or production possibilities frontier is determined by the increase of a variable that has been called neutral, exogenous or non-embodied technological progress, total factor productivity (TFP) or "Solow's residual". The growth of TFP indicates a growth in the potential output or a positive shift in the productive possibilities frontier.

The growth accounting approach assumes that TFP is a residual obtained by deducting the weighted growths of productive factors from output growth. The underlying assumptions are:

- Returns to scale: the income from productive factors exhausts the output;
- Profit maximization: the relative price of each factor is equal to its marginal productivity
- Factorial contribution is measured by the effectively utilized capacity<sup>1</sup>.

Thus, the following equation holds for growth accounting:

$$\frac{d \ln A}{dt} = \frac{d \ln Q}{dt} - s_K \frac{d \ln K}{dt} - s_L \frac{d \ln L}{dt} \quad (1)^2$$

where:

A: Solow's residual or TFP

Q: GDP at constant prices

K: capital stock services

L: full-time equivalent jobs

s<sub>i</sub>: share of productive factors in the output at current prices<sup>3</sup>

In OECD (2001a) analyses a summary of TFP's implications and methodological recommendations of its estimation. In this paper we applied the OECD (2001a) to the Argentine case, taking into account the characteristics of its economic statistics.

The neoclassical approach indicates that TFP expresses the increase in output due to neutral technological progress, independently of factor accumulation.

However, some authors of the same school emphasize that technological change may be embodied in new capital goods or intermediate inputs resulting from improvements in design, quality, and provision.

<sup>1</sup> This approach does not dismiss possible positive effects on growth of other major determining factors, such as efficiency improvements, scale economies, the adjustment costs, technological progress embodied in capital assets, or possible causal relationships between TFP and the productive factors mentioned herein. For a detailed discussion of the causes of economic growth, see Barro y Sala-I-Martin (1995).

<sup>2</sup> Where  $d \ln X / dt$  is the proportional growth rate of X.

<sup>3</sup> When the sum of each sector's gross production value is used instead of the sum of sectoral aggregates or GDP, the contribution of intermediate inputs should also be subtracted.

For the endogenous-growth approach and the neo-Schumpeterian school, TFP captures factor spillovers on the aggregate productivity of the economy; in other words, it reflects additions to TFP performance derived from the accumulation of certain inputs such as human capital, capital goods and intermediate assets, beyond the contribution of each factor to output growth. Thus, the joint effect or synergic accumulation of such factors might be reflected in TFP. Or, equivalently, there may be increasing returns to scale and/or positive externalities on productivity due to certain factors being included in the production process.

Another focus of the relationship between TFP and growth is the study of causal relations between the variables. The neoclassical approach suggests that TFP causes economic growth. Instead, the so-called "Verdoorn effect" inverts the neoclassical causality. Thus, an increase in productivity is the consequence of output growth, i.e., it is pro-cyclical.

In our opinion, despite the theoretical explanations of the relationship between TFP and growth, it might be possible to ascribe spill over effects to organizational improvements in the production process. In other words: if organizational improvements are absent, there is no chance to make use of the aforementioned positive externalities. Thus this approach reconciles the TFP's Solow view with endogenous economic growth approach.

It should be reminded that productivity is a proxy variable for the standard of living. *Per capita* output is a proxy variable for *per capita* income. Higher capital productivity enables a greater output increase with lesser social costs in terms of current consumption. Besides TFP as a determinant of potential output is an indicator of the sustainable character of the living standard in the long-term.

Consequently, if TFP is misidentified, the possibility arises that the standard of living might not be sustainable in the long term.

Finally, Jorgenson's (1995) definition should also be mentioned: according to this author, TFP summarizes all non-investment effects on output, investment being understood as resources committed with future income expectations, which implies that such returns were internalized by the investor.

It should be emphasized that the Jorgenson's definition describes TFP as a proxy variable for the prospective value of wealth and therefore suggests a connection between the sustainability of its prospective value and that of TFP.

Other authors, as Griliches, have pointed out that TFP is a residual variable that merely captures errors made in measuring the contribution of productive factors to output growth. Moreover, if the growth rate and the value of productive factors were measured properly, the TFP would be equal to zero.

Without lapsing into such a skeptical view, it might be said that, in order to properly interpret TFP estimations, one should know how productive factors are measured. More specifically, if it is available to measure the value of productive factors and their quality component (a major determinant of embodied productivity associated with factor accumulation) at a high desegregation level. It is also important to establish whether calculations may include a measurement of change in factor use besides changes in factor composition. Otherwise, the estimated TFP indicator will inescapably reflect not only its intrinsic concept but also the remaining said variables and even measurement errors.

### **3. The Measurement of Productive Factor Contribution to Output Growth**

As we have seen before, in order to estimate productivity, knowledge is needed, not only of how factor growth rate is measured but also of how their value is determined, so that their contribution to growth may be assessed.

It should be taking into account that both capital and labour are heterogeneous factors. Therefore, their aggregate contribution to output growth may be determined not only by changes at the aggregate level but also changes in its composition. At the same time, factor growth may be induced by favourable changes in relative prices.

If the effects of the heterogeneity and changes in a factor's aggregate composition on its growth rate are not established, such effects will be included in the TFP, thus preventing a genuine identification of the evolution of productivity.

The following sub-sections describe briefly the problems derived from attempts to measure the contribution of productive factors to output growth.

#### **3.1. The Contribution of Capital Stock to Output Growth**

##### **3.1.1. Capital Stock Services**

According to productivity literature, this section defines not only the appropriate concept of capital stock but also the main components of its contribution to output growth.

###### **3.1.1.1 The Quantity of Capital Services**

Its contribution to output growth should be measured in terms of the annual services provided by capital to output (e.g., machine-hours, like the measurement of labour is expressed in terms of man-hours). Generally, the assumption that service flow is proportional to the physical size of capital stock is made<sup>4</sup>.

###### **3.1.1.2 The Price of Capital Services: User Cost**

According to economic theory, the value of a capital asset is given by its replacement cost. If a market exists for it<sup>5</sup>, the market price of a capital asset<sup>6</sup> represents, in equilibrium, the present value of the expected future service flows it will contribute to output or equivalently, the expected future profits that asset will give to the owner.

In other words, the price of capital good takes implicitly into account not only the opportunity cost of investment, but also its foreseen obsolescence in terms of the annual service flows that asset give to the output. Its declining trend is determined by the reduction of the asset's efficiency over time and by its average useful life.

However, the price of capital asset services should reflect its annual user cost or rental price. This represents the price paid for using one capital unit. If the firm demanding the capital asset is not its owner, the user cost will be given by the market

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<sup>4</sup> For a discussion on the measurement of capital services, see Jorgenson and Griliches (1967), Hill (1999), and Hulten (1990).

<sup>5</sup> New and second-hand capital asset markets are considered. The following analysis describes how to determine the prices of capital assets traded in the market, but –and more important for this discussion– it also describes how to determine the prices of assets currently in stock and being used as production means.

<sup>6</sup> The price of a capital asset as an investment asset.

rental price (whereas, when the firm is the asset's owner, the user cost will be an imputed value). According to economic theory, the user cost of a capital asset should be equal to the opportunity cost of investing in alternative liquid assets<sup>7</sup>.

### 3.1.1.3 The Value of Capital Services

The contribution of capital to output growth is determined both by the ratio of the capital services' value over output — $s_k$  weight in equation 1— and by their growth rate. Consequently, variations in any of its components (physical depreciation, interest rate, asset price, etc.) have an impact on the contribution of the factor to the growth of the economy.

#### **3.1.2 "Quality Effect": Changes in the Composition of Capital Stock by Asset Type**

In order to calculate the aggregate contribution of capital stock in terms of service flows, it is necessary to aggregate service flows provided by inherently heterogeneous capital assets.

This implies that the growth rate of aggregate capital stock is influenced by changes in the composition of the stock by asset type.

A measurement of the contribution of capital stock to growth ignoring that the involved assets are heterogeneous implies the assumption that all capital assets contribute equal services to output growth. Nevertheless, in relative terms, one dollar invested in buildings has a lower average annual return than a dollar invested in machinery. This is mainly due to the fact that investments in machinery are recovered more quickly because of their shorter average service life. Given such a high heterogeneity, even within the group of machinery and equipment, an analysis with the highest degree of disaggregation is advisable.

#### **3.1.3 "Re-Allocation Effect": Changes in Capital Stock Allocation by User Sector**

Other important element to study as a determinant of the contribution to output growth are the changes in capital stock allocation induced by changes in relative prices. The proper interpretation of growth in aggregate capital stock depends on the possibility of detecting substitution among factors and/or capital intensification in sectors favoured by changes in the relative prices of their output or factors. For instance, if a certain sector is favoured by a change in the relative output prices (or in the demand) for its products, the sector's demand for investment will rise accordingly in order to increase its installed capacity and, therefore, its output. If this induced effect of sectoral re-allocation of capital is not disaggregated, the resulting increase of the TFP would be a consequence of re-allocation effect rather than of productivity gains of the economy.

#### **3.1.4 Capacity Utilization by User Sector**

The last consideration to be taken into account for a proper measurement of the contribution to output of aggregate capital stock is that measurements should be made according to capacity utilization in each user sector. Otherwise, measurements would

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<sup>7</sup>  $User\ Cost = m = r + d - \frac{D}{p}$ : the user cost or rental price of a capital asset is equal to the interest rate + the asset's depreciation rate – the expected appreciation of the asset.



reflect annual flows potentially provided by capital stock to output (at 100% utilization), instead of effectively used services.

Therefore, the capital's share in output,  $s_K$ , results from the weighted sum of capital assets valued at their user costs times the capacity utilization rate of installed capacity by user sector.

Taking into account each component of capital contribution to output growth, the causes of TFP may be explained. Otherwise, "quality", "re-allocation" and "utilization" of capital stock would be included in the TFP.

### **3.2. The Contribution of Labour to Growth**

According to ISWGNA(1993) and OECD (2001a), the contribution of labour to output growth should be measured in terms of full-time equivalent jobs, and not in terms of persons, so that the spurious effects of double and partial employment, and variations in average hours worked per week are netted.

Nevertheless, measuring labour in terms of full-time equivalent jobs without taking into account the different "quality" of labour could bias the analysis of its aggregate contribution to output growth, as in the case of capital.

This approach supposes that differences in age, schooling, occupational category, and sector attributes of labour are correlated with differences in the relative salaries of each group. If such differentiation is not reflected in the labour measurement, the TFP will be distorted.

The following are the main components of the contribution of labour to economic growth:

#### **3.2.1. Occupational Category**

It is important to distinguish between salaried labour and non-salaried labour (self-employed and unpaid family members) since there is a significant productivity difference between these categories. An apparently higher labour productivity may be the consequence of substitution of salaried-labour by self-employment.

#### **3.2.2. "Quality Effect": Changes in Labour Demand by Qualification**

Lack of labour differentiation by qualification is a significant source of bias in the analysis of labour productivity and TFP performance. An apparent increase in productivity may be due to a lower relative demand for qualified labour derived from an increase in the relative salary and not from a genuine improvement in the production process. If this effect is not identified, it would be erroneously included in the TFP.

#### **3.2.3. "Re-Allocation Effect": Changes in Labour Demand by Sector**

As in the case of capital, an increase in labour demand may be the consequence of changes in relative output prices favourable to skill-labour-intensive sectors. The measurement of the TFP would be distorted accordingly if this effect is not captured.

Therefore, the conclusion is that three components contribute to this factor's growth rate: a first component capturing changes in "quality", a second one capturing factor re-allocation effects on the aggregate, and a third component reflecting undifferentiated contributions:

$$\frac{d \ln X}{dt} = \left( \frac{d \ln X^q}{dt} + \frac{d \ln X^r}{dt} + \frac{d \ln X^u}{dt} \right)$$

where each term represents the component ( $X^i$ ) of aggregate growth for factor X as follows:

q: "quality", r: sectoral re-allocation, u: undifferentiated growth. In Annex 1, the methodologies used for estimating the various components of factorial contribution and TFP is discussed.

As previously stated, according to OECD (2001), the proper interpretation of the TFP requires a thorough knowledge of the methodologies used for estimating the series of each productive factor.

#### **4. Growth Accounting for Argentina in the 1990's**

The aim of this section is to analyze the impact of measurements of each component that determined the TFP performance in Argentina during the nineties.

As we have seen above, the growth accounting approach assumes that technological progress or TFP is a residue obtained by deducting the weighted growth of productive factors from output growth.

Usually, the exercise is limited to measuring output and factor growth rates according to traditional fixed-base physical volume indices<sup>8</sup> (in the case of labour, regardless of their composition by quality or attribute).

The use of fixed indicators representing factorial contribution to output together with fixed-base physical volume indices implies "freezing" the structure of relative prices and the functional distribution of income at the base-year for the whole series. As mentioned in Annex 1, this results in an impossibility to capture possible inter-sectoral re-allocation effects due to changes in relative output prices, distorting the proper identification of TFP.

If labour is not disaggregated by attribute, the consequence is a lack of differentiation which biases its contribution to growth. The same holds for capital when differentiations by typology, model or "vintage"<sup>9</sup> are not considered.

In order to avoid such biases, the use of ideal indices both for output and productive factors is recommended in recent literature about productivity measurements, especially in OECD (2001a), so that the re-allocation effect may be captured by taking into account the influence of current relative prices on the physical evolution of aggregates. Besides, a period-by-period measurement of each factor's share is also recommended<sup>10</sup>, as well as a measurement of compositional changes in factorial aggregates (quality changes)<sup>11</sup>:

Considering all these recommendations, the following differences with respect to other works arise herein:

- a. All TFP's components were calculated according to optimal indices<sup>12</sup>. The growth of productive factors and output is measured taking into account the changes of relative prices of the sub-aggregates involved. In the case of capital stock, more than a hundred types weighted by estimated user costs were considered; in the case of labour, measurements considered full-time equivalent jobs disaggregated by category and by activity sector as in the case of GDP. By comparison with the fixed-base index, the sectoral "re-allocation effect" of factors and output may be determined.<sup>13</sup>
- b. Factor growth rates were weighted considering annual changes in the functional distribution of income<sup>14</sup>

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<sup>8</sup> Even though a correction for factor quality is performed.

<sup>9</sup> The term "vintage" refers to each cohort into which the capital stock may be disaggregated by considering its age structure. However, common practice uses the concept of net stock (net of depreciations and retirements by vintage)

<sup>10</sup> See Annex 1.

<sup>11</sup> For an important precedent in the sense of disaggregating quality and re-allocation effects for seven Latin American economies including Argentina, see Elías (1992)

<sup>12</sup> See Annex 1.

<sup>13</sup> For a detailed analysis of each factor's estimation, see Coremberg (2002). Relatively slight differences in figures due to database updating may be observed.

<sup>14</sup> Unlike other works, where weights reflect the average of the period under study, or fix them to the level of the base year or an alleged steady-state functional factor distribution.

- c. Non-salaried labour (self-employment and unpaid family members) has been disaggregated as a separate component, so their contribution may be deducted from the TFP.
- d. A measurement of factors in undifferentiated terms is offered, that is to say, quantity variations in factors are measured excluding composition variations by attribute<sup>15</sup>. By comparison with the fixed-base index, the "quality effect" may be determined.

A brief summary of the basic data sources and methods used to calculate TFP's components is offered in the following pages.

## **4.1. GDP**

### Sources and Methodology

Estimations of the Gross Domestic Product (GDP) are the official ones from the National Bureau of National Accounts (DNCN-INDEC). The base-year for these estimations is 1993 for the period 1993-2000<sup>16</sup>. It should be mentioned that official GDP data from DNCN include estimations of non-recorded economy by sector.

As previously stated, the GDP series was computed by using ideal or optimal indices that took into account the evolution of relative prices in the period<sup>17</sup>, considering their valuation at producer's prices i.e., excluding non-deductible VAT and import taxes<sup>18</sup>.

The behaviour of the GDP during the 1990's was not essentially different for the two series, both with respect to annual variation rates and average evolution<sup>19</sup>.

## **4.2. Capital Stock**

### Sources and Methodology

The estimations of capital stock and services are extracted from Coremberg (2002). This paper offers an exhaustive estimation that takes into account over more than one hundred types of capital goods based on the Perpetual Inventory Method (PIM) for durable equipment (except of automobile transport equipment, farm tractors and other farm machines and airships) and on public works and the Hedonic Valuation Method (HV) for the remaining categories (the previous types exceptions, dwelling-units, private non-residential construction and cultivated assets. User costs or rental

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<sup>15</sup> In the case of labour –both salaried labour and self-employment–, its undifferentiated growth was estimated according to the traditional methodology by adding up full-time equivalent jobs for each sector regardless of their attribute differences: the relative wage differential by sector according to available data. In the case of capital stock, it was measured independently of its age profile, that is to say, the crude concept of gross capital stock was applied neglecting profitability differences by typology. See OECD (2001a) and Coremberg (2002)

<sup>16</sup> Estimations for the period 1990-92 are not included for two reasons: first, consistent connected series are not available for that period, when the GDP was estimated taking 1986 as base-year. Though a simple series connection between both base years may be performed (using the "rule of three"), it would involve a distortion in the measurement of physical volume growth in output since the relative price structure for both base-years would be operating somehow in the same series, thus generating spurious effects on annual variation rates.

<sup>17</sup> For the concept of ideal or optimal indices and the corresponding methodology, see for example OECD (2001b) and ISWGNA (1993). Calculations for Argentina are further discussed in Coremberg (2002), where results for the various types of ideal indices are similar to those obtained herein.

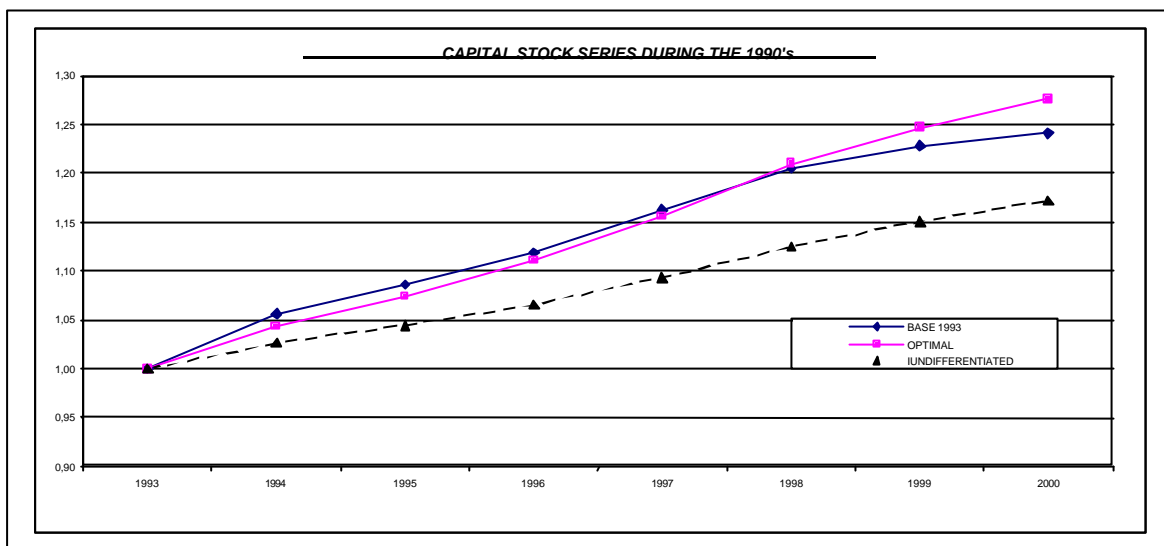
<sup>18</sup> If measured at market prices, the contribution of these taxes' evolution to GDP should be disaggregated. Anyway, results were similar to those at producer prices.

<sup>19</sup> See Table 1, Section 5.4.

prices were calculated for each type in order to express them in terms of annual services and weight them accordingly in the aggregate index<sup>20</sup>.

According to statistical data available in Argentina, capital stock was estimated from the supply side; therefore, neither the series of capital stock nor those of capacity utilization by user sector are available. In this sense, the effects of intersectoral reallocation of stock as well as those of changes in the capacity utilization rate within each sector are included in the TFP.

**GRAPH 1**



No remarkable difference arises from the fixed-base and optimal versions of the capital services series. However, the optimal series shows a slightly higher growth rate.

A substantial difference between the growth of undifferentiated capital services and other indices is evident. Changes in stock composition by typology and age—mainly due to a substantial renewal of durable equipment stock through imported capital assets—not only reduced stock age but also included technologically more advanced assets. Thus, there is hardly any risk in saying that this difference may be due to "quality" changes due to the higher "embodied" technology of imported durable equipment during the nineties, which was the most dynamic component of the capital stock.

<sup>20</sup> The capital stock estimation used herein corresponds to the so-called productive capital stock in terms of services, an important concept for productivity studies. See OECD (2001a)

### 4.3. Labour

#### Sources and Methodology

In the case of Argentina, available data about full-time equivalent jobs and average wage according to the one-digit index CIIU rev., disaggregated by occupational category and self-employed persons, are those published in DNCN (1999), which include an estimation of non-recorded labour for the period 1993-1997, and the author's estimation for the period 1998-2000 based on the same methodology.

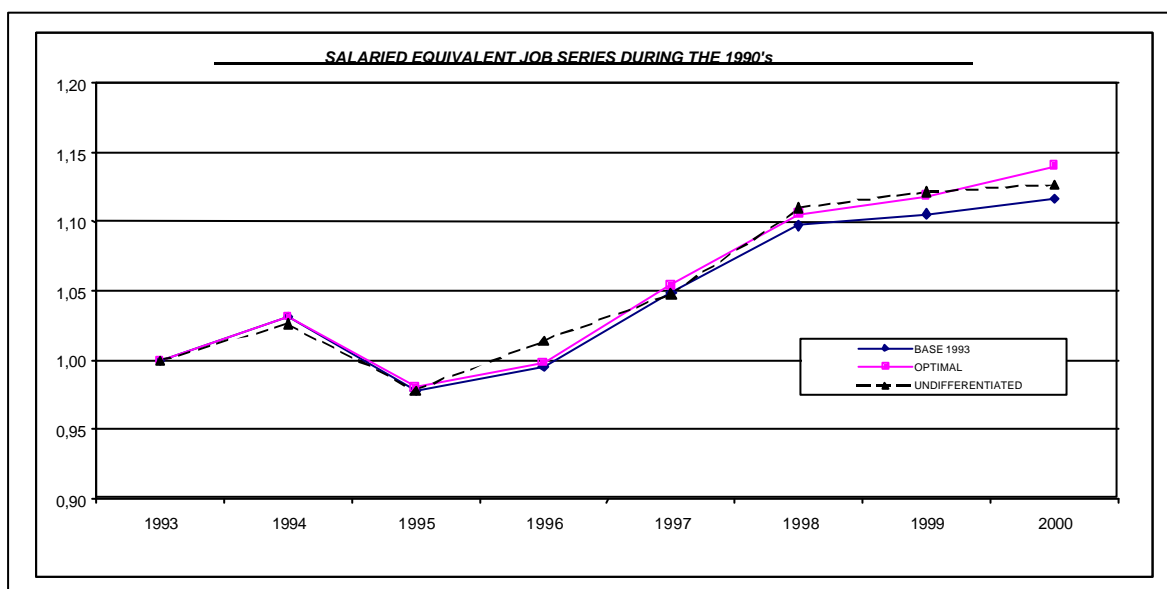
Taking into account the economic statistics available in Argentina, we adopted the implicit differentiation approach: no explicit distinction of worker characteristics, but break down by sectors of activities and occupational categories taking into account the exhaustive estimations of the DNCN. We suppose that such differences in the sector's relative salaries are correlates with the differences in labor qualification. Further research should be devoted to studying other differentiation features in the quality of labor: gender, age, and education.

Through disaggregation by occupational category, self-employment labour may be treated as an individual factor in order to identify the peculiar behaviour of this sector.

#### 4.3.1 Salaried Labour

Graph 2 shows the increase in salaried job positions during the period.

**GRAPH 2**



The slight difference in salaried labour demand between the undifferentiated index and the remaining indices, especially from 1997 onwards, reflects a quality effect that may be ascribed to the fact that labour demand was directed towards sectors with lower relative labour costs. This effect was fully counterbalanced by a re-allocation of labour demand in sectors where relative labour costs increased.

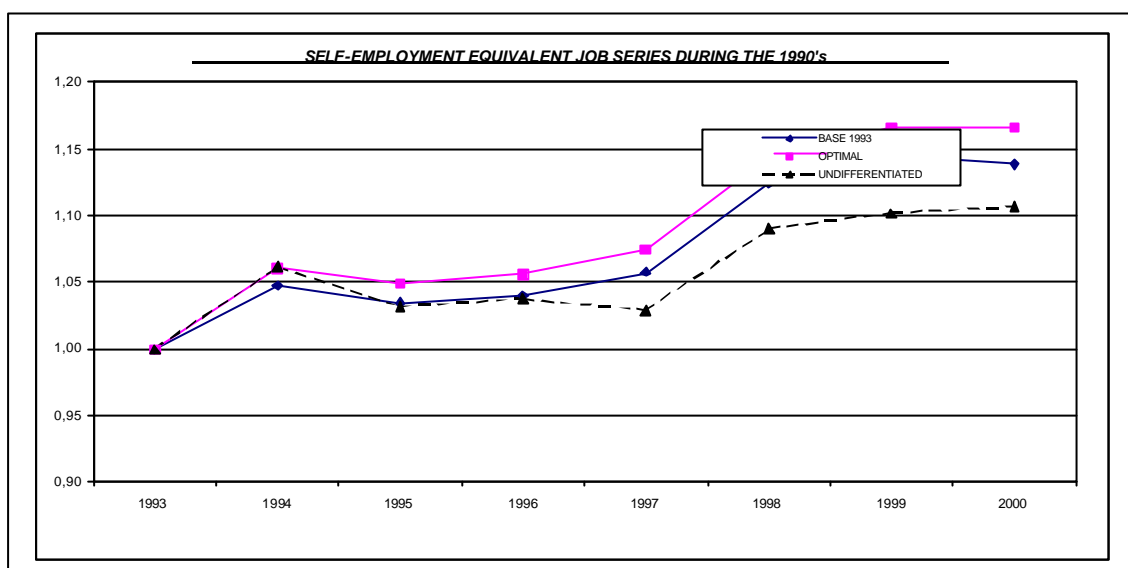
It should be noted that, taking into account exclusively the traditional measurement of labour (jobs not weighted by sectoral relative salary) would lead to a

higher TFP and, especially, to a higher labour productivity as evidenced in Table 1, section 5.4.

### 4.3.2 Non-salaried Labour

Self-employment and unpaid family members increased significantly during the 1990's, and at a quicker pace than salaried employment<sup>21</sup>.

**GRAPH 3**



As may be seen in Table 1 in the following section, quality and re-allocation effects have both positive sign. The quality effect has a positive sign and greater absolute value than that of salaried employment, towards sectors that require qualified labour. Besides, the re-allocation effect caused demand for qualified labour to increase further, favoured as it was by sectoral changes in relative output prices or by the income effect.

The following section discusses the impact of different measurements of output and productive factor growth on the analysis of the evolution of Argentine economy in this period.

### 4.4. The Growth of TFP in Argentine during the 1990's

Since the statistical information available in Argentina limits the estimation of the contribution of productive factors to growth, the following disregarded effects might be included in Solow's residual or TFP:

- Inter-sectoral capital re-allocation: capital stock data by user sector are not available.
- Variations in capacity utilization, both at the aggregate and sectoral levels: reliable data of capital stock utilization by user sector and at aggregate level are not available.
- Economies-of-scale effects.
- Measurement errors.

<sup>21</sup> See Graph 1 section 5.4

Table 1 summarizes the most important results about the TFP trend, based on the above discussion. Table 2 summarizes the main effects involved.

**TABLE 1**

GROWTH ACCOUNTING IN ARGENTINE ECONOMY DURING THE 1990's				
Average Annual Growth Rates				
	UNDIFF. FACT.	BASE 1993	OPTIMAL	
Q	2,49%	2,49%	2,54%	
K	2,30%	3,13%	3,54%	
Ls	1,72%	1,59%	1,89%	
Lns	1,46%	1,86%	2,22%	
<b>TFP</b>	<b>0,55%</b>	<b>0,13%</b>	<b>-0,18%</b>	

Q: gdp, K: capital stock, Ls: salaried labour, Lns: non-salaried labour

**TABLE 2**

EFFECTS (Average Annual Growth Rates)				
	Undiff. Fact.	Quality	Re-allocation	Total
Q	2,49%		0,06%	2,54%
K	2,30%	0,83%	0,41%	3,54%
Ls	1,72%	-0,13%	0,30%	1,89%
Lns	1,46%	0,41%	0,36%	2,22%

- a. The average growth of TFP in Argentina during the nineties was slightly negative when the optimal methodology was used<sup>22</sup>
- b. The TFP tends to increase substantially when its components are measured through fixed-based indices, since this method does not take into account "re-allocation effects" or structural changes in the sectoral composition of the output and productive factors and changes in functional distribution tending to reduce its absolute value. More precisely, inter-sectoral substitution effects are not captured because factor demand growth is underestimated.
- c. The quality effect has several effects. Measured through undifferentiated factor indices, the TFP is greater than measured through fixed-base indices because the growth rate of capital stock and self-employment are lower and more than compensate the higher growth of salaried labour.
- d. According to Table 3, the highest contribution to economic growth is provided by the growth of capital stock, so that an accurate measurement of the latter has a methodological and an explanatory significance as well. Its contribution to growth is reduced substantially if the TFP is computed applying the undifferentiated method and the fixed-base one. The distorting effects of the different methodologies for determining the significance of each factor's contribution in Table 3 should be emphasized: ***in the case of indifferntiated factors, the TFP accounts for 22% of the average growth, whereas in the case of fixed-based indices (corrected for "quality" changes), it accounts for 5%, and finally, in the case of the optimal methodology, it shows a negative contribution.***<sup>23</sup>

<sup>22</sup> It should be noted that, according to the discussion in Annex 1, the growth accounting equation in terms of optimal indices includes all the effects considered herein, so that they may be deducted from the TFP residual variable without distorting measurements. Hence, the term "optimal" applied to it.

<sup>23</sup> Two important official reports contradict the conclusions of the present paper as to TFP's behaviour in the Argentine economy during the nineties: Meloni-SPEyR (1999) and Nicholson-Maia-DNCPM (2001). These papers report substantial TFP contributions to growth. (see also Kydland and Zarazaga (2002)). Notice that, even when the TFP is measured in this paper based on the same

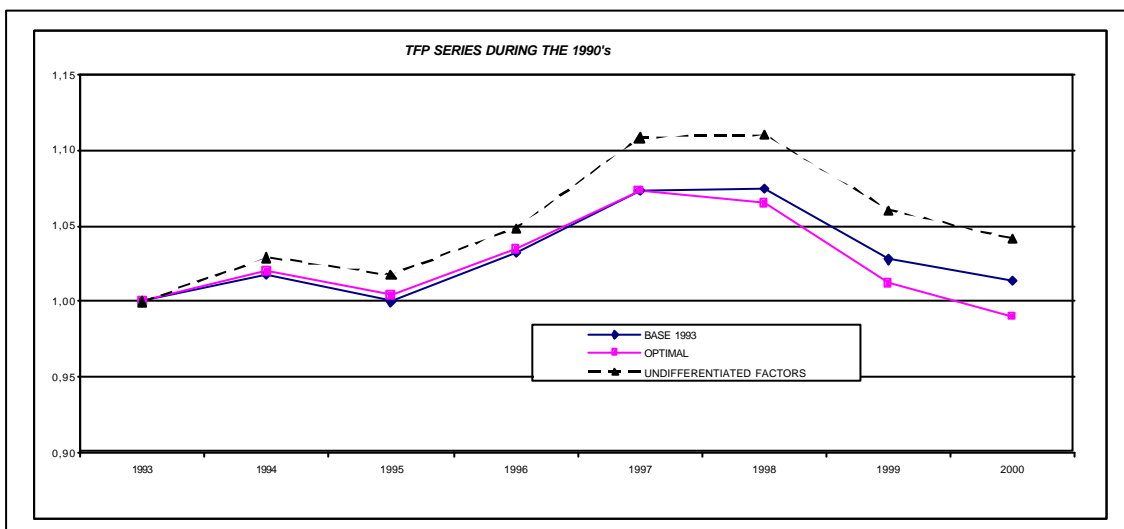


**TABLE 3**

SHARE IN GROWTH			
	UNDIFF. FACT.	BASE 1993	OPTIMAL
Q	100,00%	100,00%	100,00%
K	42,86%	58,38%	64,64%
Ls	24,35%	22,54%	26,25%
Lns	10,74%	13,76%	16,03%
TFP	22,05%	5,32%	-6,92%

e. The following graph shows that TFP's growth decreases when "quality" and "sectoral re-allocation" effects are considered. This is because fixed-base output indices do not take into account changes in relative prices that favoured the services sector as a consequence of the real appreciation of domestic currency, the behaviour of which in the economic cycle is smoother than that of the tradable sector. Such a "smoothing" of GDP involves a smoothing of TFP fluctuations. However, as we have seen above, the greatest difference is due to the fact that the optimal methodology takes into account a greater relative factor contribution to output growth.

**GRAPH 4**



#### 4.5. The Behaviour of TFP in the Argentine Economic Cycle during the 1990's

However, not only the TFP trend is important for our analysis, but also its behaviour during the economic cycle.<sup>24</sup>

If the aim is to measure technological progress through TFP, that is to say, to assess the positive shift of the production possibilities frontier as a consequence of the long-term growth trend of aggregate productivity, factor contribution to growth should be adjusted by their effective utilization. Otherwise, the TFP would be including variations in factor utilization, and its trend would be misidentified<sup>25</sup>.

methodology of the quoted papers (with the undifferentiated and/or quality changes methodologies), the contribution of TFP to GDP growth, according to our results, is substantially lower. Therefore, major differences may be due to the exhaustive and consistent measurement of factor contribution in this paper besides the use of optimal indices.

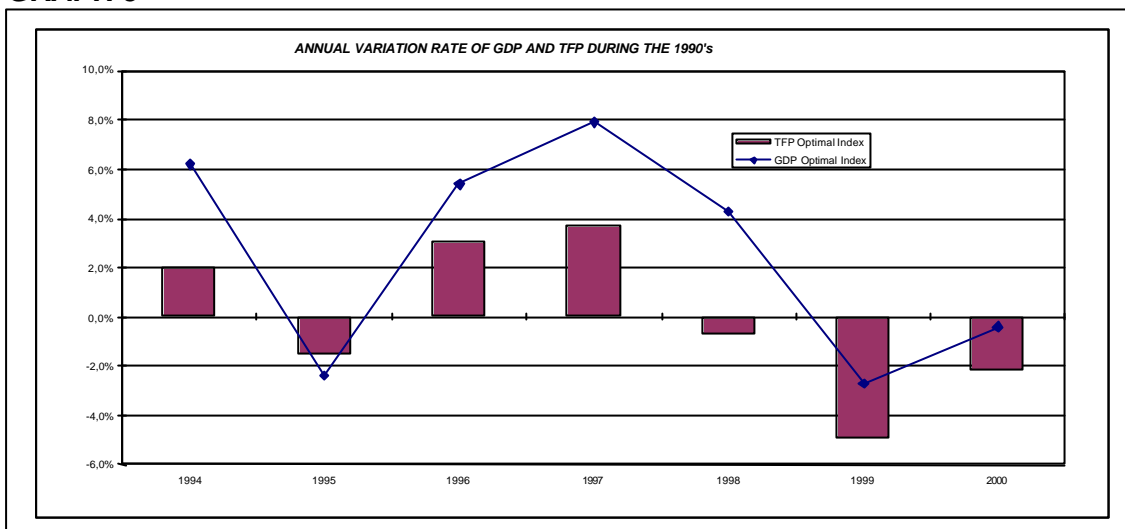
<sup>24</sup> I am indebted to Daniel Heymann for this suggestion.

<sup>25</sup> If we admit the Verdoon effect, as poskeynesian approach does, the procyclical behaviour of TFP is not a problem, as we have seen before

In what has been discussed up to now, the TFP includes variations in capital stock utilization, since productive capital stock services are not corrected for utilization variations by sector. However, labour is measured through its effective contribution, since the full-time equivalent jobs indicator expresses effective hours worked.

According to the following graph, a remarkable pro-cyclic behaviour may be observed in the estimated TFP:

**GRAPH 5**

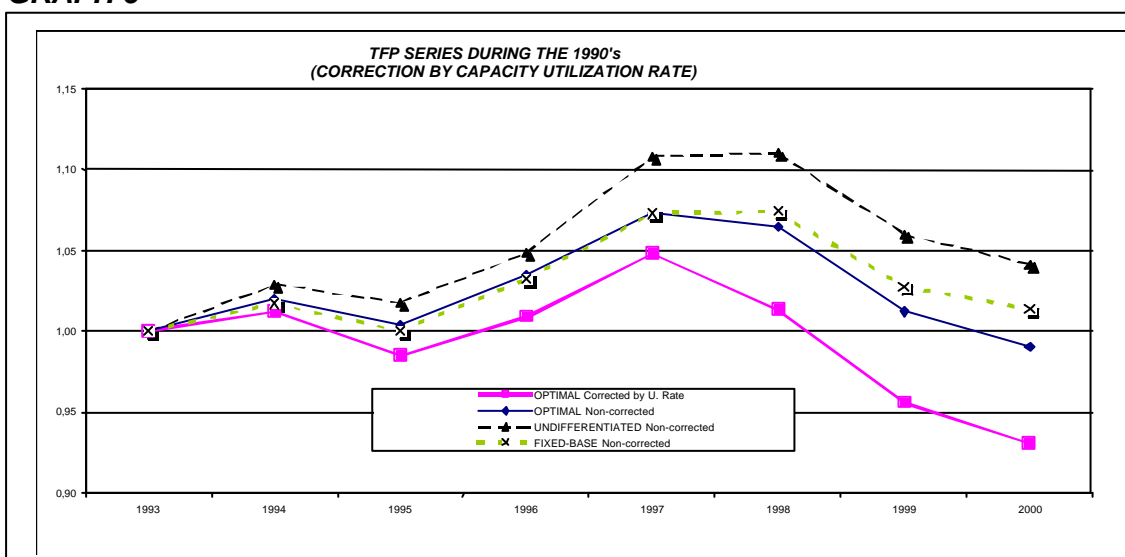


If the effect of variations in capital stock use might be disaggregated by sector, the pro-cyclic character of TFP would decrease.

Although reliable statistical data about capital stock utilization by sector are not available, the correction is introduced by using an available indicator of installed capacity utilization in industry<sup>26</sup>

This indicator was applied to the estimated capital stock services series used above in section 5.2. Results are summarized in the following graph:

**GRAPH 6**



<sup>26</sup> FIEL's indicator of installed capacity utilization was used. It reflects results from a survey of the manufacturing industry. On account of its non-official character and the fact that it does not represent all sectors, results must be considered with caution and as non-conclusive. Moreover, changes in capital stock composition and utilization by user sector are still included in the TFP.

When the contribution of capital services to output growth is adjusted by changes in the utilization of capital stock at the aggregate level, the pro-cyclic behaviour of TFP is smoothed further, whereas its trend is significantly reduced (and even turns negative) in the three alternative methodologies.

**TABLE 4**

<b>TFP: adjustment by aggregate capacity utilization</b>	
Average Annual Growth Rates – Argentina 1993-2000	
	<b>TFP</b>
UNDIFFERENTIATED FACTOR	-0,6%
BASE 1993	-0,8%
OPTIMAL	-1,2%

According to Graph 6, in its optimal version, corrected and non-corrected for capital stock utilization, the TFP dropped since 1998. Measured through the optimal indicator —unlike the other alternative indicators—, the TFP might indicate that the productivity of Argentine economy in 1999 had decreased substantially as compared to its level in 1993.

If no errors were committed in the measure of factors contribution to growth and gdp, it might be said that:

***The growth of Argentine economy during the nineties had an extensive character based on capital accumulation rather than on long-term productivity gains, and that factor accumulation had no "spillover" effect on the rest of the economy<sup>27</sup>***

## **5. CONCLUSIONS**

The present work analyses the hypothesis that productivity growth in the Argentine economy during the 1990's was merely apparent, a fact which may partially explain the later crisis in the convertibility exchange system.

After summarizing briefly major considerations from growth theory about the interpretation of the Total Factor Productivity indicator or TFP, the methodology used for estimating productivity is later discussed.

The TFP of the Argentine economy is estimated taking into account the recommendations of recent economic literature, especially OECD (2001a), as regards the consistent and exhaustive estimation of factor contribution to growth and the advisable use of optimal physical volume indices able to capture the effect of the changes of relative prices on factors and their components, as well as on GDP sub-aggregates.

The average growth of Solow's residual or TFP in Argentina was slightly negative in this decade. However, the trend appears positive if measured through fixed-base indices corrected by the "quality" of productive factors, and it has a higher absolute value when the latter are measured in undifferentiated terms.

The negative trend of the TFP becomes more pronounced when capital services are corrected by aggregate capacity utilization.

<sup>27</sup> Timmer and Van Ark (2000) draw a similar conclusion for Korea and Taiwan.

Considering the relevance and dynamism of capital stock in the growth process, the proper measure of its degree of heterogeneity, the type of weights, and index-numbers applied for measuring its contribution to output become thus more important.

***Considering the above results, evidences would suggest that no productivity gains in Solow's sense occurred in Argentina during the nineties. TFP growth in the Argentine economy during this decade would have been apparent in its several senses: potential output, competitiveness, prospective value of wealth, and standard of living.***

***The pattern of economic growth would have an extensive character, based on capital accumulation rather than on "neutral technological progress or non-pecuniary externalities".***

## **Annex 1: Productivity Indices and Factor Contribution**

### **Capital Service Index**

Considering the heterogeneity of capital assets, the growth rate of services provided by aggregate capital stock is given by:

$$\frac{d \ln K}{dt} = \sum_{i=1}^k \frac{m_i K_i}{\mathbf{mK}} \frac{d \ln K_i}{dt}; \mathbf{mK} = \sum_{i=1}^k m_i K_i$$

$i=(1\dots k)$  types of capital assets

$\mu_i$ : user cost of each capital asset in terms of annual services or rental price

$K_i$ : capital stock by type  $i$

If allocations by sector were taken into account:

$$\frac{d \ln K}{dt} = \sum_{j=1}^n \sum_{i=1}^k \frac{m_{i,j} K_{i,j}}{\mathbf{mK}} \frac{d \ln K_{i,j}}{dt}; \mathbf{mK} = \sum_{j=1}^n \sum_{i=1}^k m_{i,j} K_{i,j}$$

$j=(1\dots n)$  economy sectors

$K_{i,j}$ : capital stock by type  $i$  belonging to sector  $j$  (corrected by the capacity utilization rate)

### **Labour Index**

Considering the heterogeneity of employment, the aggregate growth rate of labour would be given by the following formula:

$$\frac{d \ln L}{dt} = \sum_{i=1}^E \frac{w_i L_i}{wL} \frac{d \ln L_i}{dt}; wL = \sum_{i=1}^E w_i L_i$$

$i=(1\dots E)$  schooling levels, for example

$w_i$ : hour-wage by schooling group

$L_i$ : full-time equivalent jobs by type  $i$

Notice that, the more attributes are considered for measuring employment, the greater must be the disaggregation of jobs (which results in an additional sum for each attribute)

If allocation by sector were also considered:

$$\frac{d \ln L}{dt} = \sum_{j=1}^n \sum_{i=1}^E \frac{w_{ij} L_{ij}}{wL} \frac{d \ln L_{ij}}{dt}; wL = \sum_{j=1}^n \sum_{i=1}^E w_{ij} L_{ij}$$

$j=(1\dots n)$  economy sectors

$L_{i,j}$ : full-time equivalent jobs by type  $i$  belonging to sector  $j$

$w_{ij}$ : hour-wage by attribute  $i$  belonging to sector  $j$

### **Factor Quality Index**

Considering disaggregation by type of each productive factor, the effect on the aggregate growth rate of quality changes for each factor might be identified.

According to OECD (2001), the effects of compositional changes of each factor may be identified as a difference between the total growth of the factor and its undifferentiated growth, i.e., regardless of their differentiation by type. For example, in the case of full-time equivalent jobs:

$$\frac{d \ln L^u}{dt} = \sum_{j=1}^n \frac{L_j}{L^u} \frac{d \ln L_j}{dt}$$

The index of "quality" changes in labour would be given by<sup>28</sup>:

$$\frac{d \ln L^q}{dt} = \frac{d \ln L}{dt} - \frac{d \ln L^u}{dt}$$

Where "quality" refers to changes in the growth rate of aggregate employment derived from changes in composition by attribute: schooling, gender, age, etc.

### **Inter-sectoral Re-allocation Index**

When a sectoral disaggregation of productive factors is available, it is possible to estimate the effect of changes in sectoral relative prices on the growth rate of the factors.

Traditional fixed-base indices such as Laspeyres's indices *freeze* the structure of relative prices at the reference year and thus re-allocation effects cannot be captured. In order to include the latter, indices allowing a valuation of physical volumes according to relative prices in the period should be used so as to reflect properly the influence of relative prices on factors and output growth. As an alternative, the so-called ideal or optimal indices, such as Törnqvist Fisher, etc., may be used. In the present work, the following index was considered, which admits the use of current-period relative prices to weight physical volume<sup>29</sup>:

$$X_O = \sum_{i=1}^n (X_{i,t} / X_{i,t-1}) v_{i,t}$$

where  $v_i$  is the weight of the factor ( $X_i$ ) installed in the  $f^{\text{th}}$  sector on the total factor aggregate  $X$  of the economy.

The difference between the factor's physical evolution measured through a traditional fixed-base index as Laspeyres's and through an Optimal index will reflect the inter-sectoral re-allocation effect of the factor under analysis. In the case of labour, the following formula holds:

$$\frac{d \ln L}{dt} = \frac{d \ln L_O}{dt} - \frac{d \ln L_B}{dt}$$

<sup>28</sup> A similar index is proposed for capital.

<sup>29</sup> A detailed discussion of this subject lies beyond the scope of this work. See, for example, OECD (2001a) and Coremberg (2002) for the importance of optimal indices in productivity analysis. For the economic theory of ideal indices, see Diewert (1976) (1978)

O: optimal index  
 L: fixed-base index  
 r: inter-sectoral substitution effect

### **Output Index**

Inter-sectoral re-allocation effect should also be captured at the output level<sup>30</sup>. If the sectoral value-added is measured with fixed-base indices, the same problem arises. For example, a change in relative prices favourable to the tradable sector may have a positive impact on its growth. If this effect is not reflected, one might erroneously infer that sector output has increased as a consequence of its productivity rather than of output relative prices.

The optimal index for GDP was obtained by taking into account its sectoral disaggregation<sup>31</sup>:

$$\dot{Q}_t^O = \sum_{i=1}^N \left( p_{i,0} Q_{i,0} / p_{i,t-1} Q_{i,t-1} \right) v_{i,t}^Q, \quad v_{i,t}^Q = \frac{p_{i,t-1} Q_{i,t-1}}{\sum_{i=A}^O p_{i,t-1} Q_{i,t-1}}$$

$i = 1, \dots, N$  sectors according to CIIU rev.3  
 $p_{i,t} q_{i,t}$ : value-added of the sectors of the GDP

### **Consistent Index of Total Factor Productivity (TFP)**

Considering all the above-mentioned effects, the growth accounting equation might be written as follows:

$$\boxed{\frac{d \ln A^O}{dt} = \frac{d \ln Q^O}{dt} - s_K \left( \frac{d \ln K^q}{dt} + \frac{d \ln K^r}{dt} + \frac{d \ln K^u}{dt} \right) - s_L \left( \frac{d \ln L^q}{dt} + \frac{d \ln L^r}{dt} + \frac{d \ln L^u}{dt} \right)}$$

where each term represents the component in aggregate growth of the factor involved: q: "quality", r: sectoral re-allocation, u: undifferentiated growth

A: Solow's residual or TFP  
 Q: GDP at constante prices  
 $K_k$ : capital stock services  
 $L_a$ : salaried labour  
 $L_{na}$ : self-employment  
 $s_i$ : share of productive factors in the output at current prices

As previously stated, according to OECD (2001), the proper interpretation of the TFP requires a thorough knowledge of the methodologies used for estimating the series of each productive factor.

<sup>30</sup> Ver Jorgenson, Gollop and Fraumeni (1987)

<sup>31</sup> It should be noticed that the intermediate consumption of each sector's production value is netted in the aggregate.

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