Universidad de
SanAndrés

Departamento de Economía
Ciclo de Seminarios

Capital Stock Contribution of the Productivity of the Argentine Economy During the 1990's

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Martes 11 de junio de 2002
Sala de reuniones - CEDI

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UdeSA

Session Number: 8 A
Session Title: Contributed Macro Papers
Paper Number:
Session Organizer: Edward Wolff
Discussant:

Paper Prepared for the 27th General Conference of
The International Association for Research in Income and Wealth
Stockholm, Sweden. August 18 – 24, 2002

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Abstract

The present work is aimed at evaluating the contribution of capital stock to the productivity of the Argentine economy during the 1990's.

The capital stock is estimated according to the recommendations of the recent economic literature about using hedonic valuation method and the traditional permanent inventory method with several types of standard depreciation methods using a high disagregate data. The level of capital stock estimation is founded macroeconomic consistent and its average growth is apparently independent of the types of age efficiency profile.

The growth of the Solow's residual or TFP in Argentina was slightly negative for the 1990's. This trend tends to zero if measurements are made through Chain indices adjusted by the "quality" of production factors, even though only the reproductive capital stock is considered.

Given the relevance and dynamism of capital stock services for growth processes, an accurate measurement of this variable is critical. Thus, heterogeneity acquires more relevance, as well as the type of weights and the index numbers used to estimate its contribution to output.

The effects on the growth accounting of the flexibility aggregation of capital stock and salaried and non-salaried labor sub-aggregates has proved relatively neutral with respect to the efficiency profile used for estimating the capital stock.

According to these results, evidences may indicate that during the nineties there was no productivity gain in the sense of Solow in Argentina. In any case, it may be inferred that the profile of economic growth was of the extensive type based on the accumulation of capital rather than disembodied technological progress or non-pecuniary spillovers.

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CAPITAL STOCK CONTRIBUTION TO THE PRODUCTIVITY OF THE ARGENTINE ECONOMY DURING THE 1990's

Ariel Alberto Coremberg

" The measurement of capital is one of the nastiest jobs that economists have set to statisticians" (J. Hicks 1981), quoted by Ch. Hulten (1990)

1. Introduction

The present work is aimed at evaluating the contribution of capital stock to the productivity of the Argentine economy during the 1990's. Preliminary estimates of capital stock series currently under development according to the latest economic literature are used in this paper[1]. Considering the recommendations in the latest economic literature about capital stock valuation and productivity measurements, changes occurred in Argentine economic growth during the nineties are assessed with a special emphasis on the behavior of the so-called *'Solow's residual' or total factor productivity (tfp)"*

2. The Relevance of Capital Stock

The physical capital stock is the stock of capital goods of an economy, understanding as such the goods used as inputs to the production process i.e., those that entail the production of other goods, whose service life exceeds one year and are generally used by firms.

The relevance of this concept lies in the fact that it is the main component of wealth. Therefore, price variations in this type of assets involve significant wealth effects for their owners. Besides, the physical capital stock is one of the main production factors and its growth is significant not only because of its contribution to output but also because productivity growth and, therefore, long-term economic growth are mostly accounted for by its accumulation.

3. Fundamental Concepts about Capital Stock

Although a detailed discussion of the different concepts involved in capital stock is not the purpose of this work, a brief description of them is provided below[2]:

- Gross Capital Stock: it is the stock resulting from the accumulation over time of consecutive investment flows (vintages) after subtracting retirements due to the end of their service life or economic obsolescence involving their replacement by a more efficient capital asset.

1 This paper reports some preliminary estimates of capital stock in Argentine derived from partial results in a far-reaching work we are carrying out at the National Account Office (DNCN)-Ministry of Economy in Argentina. The work as a whole, as well as the figures and conclusions should be understood as provisional. Only the author is to be held accountable for them.

2 For a detailed discussion, see OECD (2001) and Suárez (2000a)

- Productive Capital Stock: it is the capital stock after deducting the foreseen losses of efficiency due to normal wear and tear. Capital services calculations are based on this concept.

- Net Capital Stock: it is the concept involved in stock as wealth, and results from valuing the productive capital taking into account the market age-price profile of capital goods.

- Capital Services: they are the flow of services –in physical terms– that the productive capital provided annually to output as a factor of production.

- User Cost: it is the price of capital services or the rental price corresponding to the use of a capital good as a means of production, either if the user is the owner or not.

- Capital Services Value: it is the quantity of services derived from capital goods valued at their notional or market user cost.

4. Classification and Coverage

According to the above definitions, capital stocks include all fixed goods repeatedly used in the production process in consecutive accounting periods[3]. The main aggregates included in this classification are: machinery and equipment; transport equipment; dwellings and non-residential buildings, additions and/or improvements; infrastructure; cultivated assets; and intangible assets such as software, etc[4].

In this work an exhaustive estimation of capital stock has been prioritized over the time length of the series. The different groups of capital goods have been identified as uniformly as possible in order to emphasize a detailed statistical information and to obtain a capital stock estimate consistent both with the recommendations of current economic literature and with the high level of heterogeneity involved. Annex 1 details the capital goods included in these estimations, a total of 109 groups according to available data:

- National Durable Equipment: 41 industries classified according to the five-digit index ISIC 3rd revistion, considering the economic use matrix from National Accounts.

- Imported Durable Equipment: 52 types classified according to the five-digit ISIC third revision, that results from aggregating individual capital goods classified at ten-digit Harmonized System for International Trade.

- Dwellings: single-person households, multiple-person households, urban and rural, including major replacement and alterations and shanties

- Non-Residential Private and Public Structures including buildings and their major replacement and alterations

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3 See Chapter X, National Accounts Manual (National Accounts Manual, Chapter 10 (1993)).

4 It includes, besides, capital goods built or manufactured by the companies themselves (not purchased in the market), as well as the expenses incurred in extending the service life of existing capital assets, and the installation and intermediation costs needed to purchase new and second-hand equipment.

- Livestock: cattle, sheep, goats, pigs and horses.
- Agricultural Cultivated Assets: plantations, pastures, forestation, fencing, leveling and greenhouses.

5. Estimation Methodologies – An Overview

There are two main methodologies available to estimate capital stock: the ***Perpetual Inventory Method (PIM)*** and the ***Hedonic Valuation of Census, Survey or Administrative Record Data (HV)***.

5.1 Perpetual Inventory Method (PIM)

In order to estimate the productive capital stock and its services, the gross capital stock (less retirements or scrapping) should be first computed by accumulating investment series and discarding goods from stocks according to a retirement pattern that should reflect the behavior of the capital goods user sector, maintaining constant the productivity of goods that remain in the stock.

One of the shortcomings of the PIM is that it introduces a relatively high degree of uncertainty if the retirement or scrapping pattern of capital assets by user sector has not been determined.

In order to calculate the productive capital stock (less retirements and depreciations), goods still in stock should be depreciated after netting retirements, according to the foreseen reduction in efficiency determined by the normal economic cycle of that user sector. Thus, capital service flows might be estimated since, by assumption, they are proportional to the productive stock.

Selecting the efficiency, depreciation and service-life profiles by asset poses a similar problem. Many developing countries adopt retirement, efficiency and service-life profiles from developed countries. However, since the PIM reliability depends critically on these assumptions, profile selection should reflect the actual conditions at the country involved[5]; otherwise the capital stock level and variation will be biased[6].

In order to obtain the net capital stock (or wealth capital stock), the productive capital stock should be valued according to the market price-age profile.

Consequently, the value of capital services according to age results from the combined effect of retirement or scrapping patterns, the age-efficiency and the age-price profiles. Generally, since detailed data about the age-efficiency and age-price profiles of fixed assets are inexistent, the PIM is limited to estimating the capital stock at constant prices as current prices, by applying standard depreciation methods to investment *"vintages"* as if they represented the actual age profile of services; in other words, as the net result of combining the retirement pattern, the age-efficiency profile and the age-price profile.

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5 For example, the mortality functions are widely used as retirement patterns (18 different types of curves developed by R. Winfrey, who derived his estimations from statistical data from the user industry in the United States for the 1920's and 1930's (!).Normal and lognormal functions or bell-shaped functions without empirical support are also used.

6 For a critical discussion of the PIM., see Miller (1983), (1990).

Standard depreciation methods include the linear, the geometric, and the hyperbolic method[7]. The two former methods generate convex age-efficiency profiles; the linear method involves constant depreciation and neglects the residual value at the end of service life. The geometric method involves constant depreciation with a positive residual value at the end of the asset's service life:

Linear method: $V_t = V_0[1-(1/T)]$

Geometric method: $V_t = V_0[1-(1/T)]^T$

t: years1,2,...T (service life)

Less widely used though recommended in OECD (2001a), the sum-of-the-digits depreciation method involves a convex age-efficiency profile where depreciaton amounts decrease with age and the residual value is null at the end of the asset's service life:

Sum-of-the-digits: $V_t = V_0[T-t+1]/[T(T+1)/2)]$

t: years1,2,...T (service life)

The United States Bureau of Economic Analysis (BEA) applies the geometric depreciation method to calculate capital stock adjusting it according to econometric studies that yield the depreciation curve implicit in market prices of capital goods, a function which is also affected by the actual retirement pattern[8]. The geometric depreciation pattern is adjusted by accelerating or delaying the decline of the asset value according to information provided in econometric regressions:

Adjusted Geometric Method: $V_t = V_0[1-(R/T)]^T$

Where R is the coefficient that increases or decreases the efficiency profile according to market information. It should be noticed that, when R=2, this method coincides with the double-declining balance depreciation method.

The hyperbolic depreciation method is used by the United States Bureau of Labor Statistics (BLS) to compute capital services[9] and by the Australian Bureau of Statistics (ABS), which also applies this function to estimate stock and fixed capital consumption. It generates a concave efficiency profile, i.e., the initial decrease in the productivity of the asset at the beginning of the age profile is more slowly than the above methods, represented by a decreasing rate:

Hyperbolic: $V_t = V_0[T-(t-1)]/[T-\beta(t-1)]$

t: years1,2,...T (service life)

β: it is a coefficient that adjusts the profile curvature according to the type of capital asset involved

7 For a detailed discussion of depreciation methods, see OECD (2001a), and Suárez (2000b)

8 See Fraumeni (1997), Katz and Herman (1997), BEA (1999), and Fraumeni and Herman (2000)

9 See for example Lysko (1995)

The rectangular depreciation method consists in maintaining the productivity constant over the asset service life until it undergoes, at the end of its service life, a single and sudden depreciation that exhausts its total initial value. In fact, thus estimated, capital stock coincides with the gross capital stock.

The geometric depreciation method is analytically advantageous because the productive capital stock equals the net capital stock, since only in this case the efficiency profile coincides with the price profile and, therefore, with the value profile of services[10].

However, if the behavior of the age profile were actually geometric, it may result from a combination of price profiles, efficiency profiles, and retirement patterns which are not necessarily geometric[11].

As noted by Hulten (1990) (1999), before making any assumption about the value profile of capital services, their curvature or decline pattern with age should be verified empirically in order to ascertain whether the assumed geometric pattern – however convenient it may seem from an analytical point of view– reflects the actual behavior in the market of the asset under study or its user.

5.2 Hedonic Valuation (HV)

On account of the PIM's drawbacks: assumptions about the service life, retirement pattern, and non-neutral service flow profile for determining the capital stock, most recent economic literature encourages the hedonic valuation of survey or record data if and only if the necessary information in proper form is available: physical stock units and price profile broken down by age and characteristics and extracted, if possible, from the same statistical source[12].

Universidad de San Andrés

The sequence for estimating the HV of capital stock might be the following, depending on the available data:

A. Econometric estimate of the hedonic price indicator:

   $p_H=f$ *(attributes)*

   Where the attributes depend on the intrinsic characteristic of the asset under study, and the age is an attribute common to all assets.

B. Testing Functional Shapes of Depreciation

   Applied first in this context by Hulten and Wycoff (1981a) taking account the Box-Cox transformatin; this method yields, besides the average service life, the depreciation function involved in market price series of capital goods. It is advisable to use this methodology to find the type of hedonic price function to be estimated econometrically in the previous step. These authors suggest that the influence of

10 See Hulten (1990) (1999)

11 If this argument is not taken into account, a fallacy of composition may result.

12 See Hulten (1990), Jorgenson (1999), and Hill (2000) for a detailed discussion and review of the latest literature on the hedonic valuation of capital assets.

the retirement or scrapping pattern on the estimated depreciation curve should be taken into account, as will be discussed below.

C. Valuation of the physical stock according to its structure by attributes: p_H. q_H

The disagregation of the data for valuing should be compatible with the relevance of the attributes identified in the hedonic price regression.

D. Computing the capital stock series valued through HV

If the available data about the physical stock come from census data, inter-censal acquisitions and withdrawals should be computed. Acquisitions may be computed from investment series of the corresponding typology. Withdrawals may be derived from the depreciation curve found in step B and the age structure of the disaggregated physical stock in step C.

Even though the retirement function and the age profile of asset hedonic prices may be implicitly determined, a distortion in the value of the asset may result from two different causes[13].

The problem posed by asymmetric information in the market of second-hand assets or *lemmons problem* described first by Akerlof (1970): the sales price of assets may underestimate the value of capital stock because of the high percentage of *lemons* on sale, the buyers' belief that all second-hand assets are *lemons*. Thus, depreciation is overestimated and the value of capital stock is underestimated.

Besides, Hulten and Wykoff (1981a) have suggested that the hedonic valuation of assets may be biased: generally, the asset sample is not neutral and reflects only the price profile of existing assets excluding information about models already recalled from the market. Unlike the case described above, depreciation in this case would be underestimated and the stock value would be overestimated.

An alternative methodology of intermediate nature is the one used by the BEA, discussed above.

6. *Capital Stock Estimate in Argentine during the 1990's*

6.1 Introduction

Several works may be quoted as the background for capital stock estimates in Argentina[14]. However, some relevant innovations are introduced herein:

- Coverage: estimations for 109 different groups of capital goods have been performed[15] [16]. It should be noted that this decision was a trade-off between coverage and the time-length of the series, since investment series with this disaggregation level are available only since 1970.

13 See Fraumeni (1997), and Fraumeni and Herman (2000)
14 For a bibliographic review, see Coremberg (2001a)
15 Besides models by typology included in the estimate of automotive capital stock through HV
16 See Annex 1.

- Perpetual Inventory Method: this method was applied to the series of public non-residential structures, imported and national durable equipment (except transport equipment) recorded in the five-digit ISIC 3rd revision classification.

- Hedonic Valuation Method: according to the suggestions discussed in section 5.2, this methodology was used for dwellings, private non-residential buildings and transport equipment (freight trucks, buses, and automobiles used for productive activities), which represent 64% of the capital stock.

The following section discusses briefly the methodology used for valuing stock for the typologies mentioned above for the PIM and the corresponding results. The third subsection summarizes the hedonic valuation methodology. The macroeconomic consistency of the estimated capital stock level is discussed in subsection four. Finally, results are briefly analyzed as regards the average growth rate of net capital stock at constant prices per depreciation type.

6.2 The Perpetual Inventory Method applied to Capital Stock in Argentina

From historical evidences and information provided by qualified reporters from user sectors, it was concluded that in Argentina, in the average, assets are recalled from production at the end of their service life, independently of the user sector involved and the age-efficiency profile. This evidence confirms information from other undevelopment countries.

The capital stock was computed at constant and current prices using various alternative depreciation methods: rectangular, linear, hyperbolic, and adjusted geometric method[17].

In every case, the service life declared by the BEA was used, properly adapted to Argentine conditions. The ISIC 3rd. revision five-digit classification was used. In the case of the adjusted geometric method, and the balanced declination rates from BEA were also taken into account in order to guarantee methodological comparability with capital stock estimations from United States[18].

It should be noticed that the service life vector assumed when applying the PIM might decisively affect estimates[19]. Therefore, they may be affected by errors that arise from non-considering the correlation between service life length and the user sector economic cycle, the life cycle of assets or the unforeseen economic obsolescence[20].

The economic obsolescence may be verified in two different ways: the decrease of the service life of new models that are being included in the stock and the decrease in the relative price of existing assets. In the Argentine case, the share of imported capital goods, which are more advanced technologically, in investments in durable equipment increased during the nineties due to the opening-up of the economy, and the relative prices of new capital goods and those already included in capital stock decreased accordingly. This phenomenon was captured in the series of implicit prices from stock series at current and constant prices[21].

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17 Results obtained by applying the sum-of-the-digits and double depreciation methods and others are similar to the results herein. They are available from the author on demand.

18 See Annex 1

19 See Miller (1990)

20 A sensitivity study was carried out by estimating the capital stock through the PIM using different service life vectors. Results are available from the author on demand.

21 Results are available from the author on demand.

6.3 Hedonic Valuation of Capital Stock in Argentina

In this section the adaptation of hedonic valuation to calculate stock for some types of assets is briefly discussed. Such assets, as we have seen above, constitute 64% of the capital stock in Argentina.

i. Dwellings

The dwelling series used in this work corresponds to the estimate of the Housing Property (dwelling services value), that represents about 9% of the Argentine GDP[22]. In this work, a brief summary of the estimation method is offered.

The detailed information from the National Census of Population and Houses 1991 being available (Censo Nacional de Población y Vivienda 1991 - CNPV'91), it is possible to obtain the number of dwellings units in 1991 desegregated by certain attributes: type, zone, size, quality, etc.

$$Q^v = A_i q^v$$

Q^v=dwellings stock desegregated by each a_i attribute considered, where A_i is the matrix representing the stock structure in terms of those attributes, and q^v is the number of censed dwellings

In order to value the corresponding stock, the hedonic price profile should be obtained, according to the attributes declared in the CNPV'91.

Since the information available from CNPV'91 does not provide data about prices, an econometric study of the hedonic price profile was performed resorting to the information provided in the National Survey of Household Expenses (Encuesta Nacional de Gasto de los Hogares 1996 - ENGH'96) about the rental value of surveyed houses and appartments:

$$\log p^v_{alq} = \sum_{i=1}^{n} b_i a_i + u_i$$

p_{alq}: dwelling rent price
b_i: parameters
a_i: attributes: age, size, quality, etc.
u_i: error of estimation

However, this econometric regression presupposes a semilogarithmic function. Thus, a test of functional shapes must be carried out in order to detect the implicit function that best relates rent prices with each of the attributes involved. In the case of age, depreciation type may be econometrically derived from this relationship.

In this case, a Box-Cox transformation similar to the one suggested in Hulten and Wykoff (1981) was applied. This type of econometric tools is useful for estimating both the parameters and the function: in the case of age, the average services life and the shape itself of the depreciation curve.

$$p^{*v}_{alq} = \sum_{i=1}^{n} b_i a_i + u_i, \qquad p^{*v}_{alq} = \left(p^{\theta_p} - 1\right)/\theta_p, \qquad a_i^* = \left(a^{\theta_i} - 1\right)/\theta_i$$

22 For a detailed analysis of the dwelling stock, see Coremberg (2000), where the methodology and the estimates applied to change the base-year in National Accounts is discussed.

$\theta=(\theta_p, \theta_i)$

I=1, ..., n attributes, the first one is age

$\theta_{i,p}=(\theta_p, \theta_{1=edad}, \ldots \theta_n)$*: parameters that determine the function that represents hedonic prices.*

For example, if the restriction is $\theta=(0,1,\ldots)$, the relationship between price and age is represented by a semilogarithmic function: the age-price profile is convex and approximately geometric.

The econometric estimation yielded a hedonic model for rental prices, and the null hypothesis that the age-price profile is at least convex may be accepted. Later, this estimated rent was imputed to the remaining stock according to its characteristics. In other words, the physical desegregated by the attributes considered in the CNPV'91 was premultiplied by the vector of hedonic prices estimated from the data recorded in the EGH'96.

$$\hat{p}^v_{alq} Q^v = \hat{p}^v_{alq} A_i q^v$$

Finally, the ratio rent/price was calculated by type and zone or user cost in order to transform the value of dwelling services into the stock value at market prices:

$$\frac{p^v_{alq} K^v}{P^v_{venta} K^v} = c.u$$

u.c.: user cost of the dwelling

The series of dwelling stocks at constant and current prices was obtained from recorded and non-recorded acquisitions calculated for estimating the added value in the construction sector [23]. Withdrawals were estimated considering the evolution of the age structure between CNPV'70, CNPV'80 and estimates for 1991[24].

ii. Non-Residential Private Structures

It is the other component of the real estate asset stock, representing the main fixed cost for private companies.

Stock was calculated as of 1993 considering the number of business premises by zone and industry surveyed in the 1994 Economic Census (Censo Económico 1994 - CEN '94) and the implicit value of rents declared by jurisdiction and industry. The stock of non-residential building disaggregated by age at market prices was valued applying the estimated user cost for dwellings.

The series was constructed considering acquisitions and withdrawals that calculated for the series of private non-residential buildings included in the construction added value[25].

23 For the methodology for the construction sector in Argentina see Coremberg (1999)
24 See Coremberg (2000)
25 See Coremberg (2000)

iii. Transport Equipment [26]

In order to value the number of vehicles which may be considered capital goods (vehicles for freight services and public transportation, small vans and automotive vehicles used by the enterprises) the following data were used: available admistrative records for the year 2000 about the number of operating vehicles; official information (based on market information) about the price vector by trademark, model, and manufacturing year, as well as their corresponding attributes (horsepower, accelerating power, drive, weight, maximum speed, fuel consumption in liters).

Transversal econometric estimations were performed in order to calculate the hedonic price index, and a Box-Cox test similar to the one described above for dwellings was applied. Thus, the functional shape of the hedonic price profile was determined. The resulting age-price profile was approximately convex.

As an example, estimated through the PIM with the adjusted geometric method and the HV estimate of the automotive capital stock were dissimilar as regards their level but showed similar growth rates which partially validated the use of the BEA's adjustment for the geometric method[27].

6.4 Macroeconomic Consistency of Capital Stock Level Estimates in Argentina

Considering the uncertainty derived from consecutive methodological decisions for determining the capital stock level in the PIM case, a macroeconomic consistency analysis should be performed so as to determine a level which is consistent with the remaining macroeconomic aggregates.

The capital stock level should be consistent with the net operating surplus level in National Accounts, so that the net profitability of the estimated stock is at least similar to the internal rate of return that may be obtained by investing in alternative assets:

$$\frac{rK}{p_k K} \geq tir_{ar} = 13{,}4\%annual$$

rK/p_kK: net profitability of capital stock
rK: profit amount generated by stock, it should be equal to the estimate of the net operating surplus in National Accounts
p_kK: capital stock at current prices
tir_{ar}: internal rate of return that results from investing in an alternative asset that represents the opportunity cost of investing in Argentina (proxy variable: internal rate of return (tir) of the FRB bond ≅ interest rate for foreign currency loans for 90-days unsecured commercial papers)

According to the first column of the following table, this condition holds independently of the depreciation method applied. The same is true for the National Survey of Big Firms (Encuesta Nacional a Grandes Empresas - ENGE): gross profits with respect to non-current assets that declared by big firms amounted to 12% during the same period.

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26 For the methodology of stock of automotive vehicles, see Coremberg (2001b)

27 Whereas the PIM involved the accumulation of investment flows in the automotive industry considering the economic use coefficient, the HV involved a compatible valuation of detailed information about a stock of approximately 8,500 different models of vehicles.

MACROECONOMIC CONSISTENCY OF CAPITAL STOCK ESTIMATES IN ARGENTINA					
1990-2000 Average	**Net profitability**	**K/L**	**K/GDP**	**Depreciation/ GDP**	**Net Investment /GDP**
Rectangular	12.2%	27.315	2.68	11.5%	5.6%
Linear	15.5%	21.372	2.09	10.6%	6.5%
Adj. Geom.	15.2%	21.813	2.14	10.7%	6.4%
Hyperbolic	14.3%	23.289	2.28	10.3%	6.8%

Source: Data worked out by the author, based on information from the DNCN and the IMF and the author's estimates of capital stock

From another viewpoint, if per-capita capital levels are a proxy variable for the country's wealth, as suggested by the convergence hypothesis of the economic growth theory[28], the per-capita capital level in developing countries like Argentina should be lower than that of developed countries like the United States, a situation which is verified by these estimations. Thus, for example, for 1998[29]:

$(K/L)_{USA} > (K/L)_{ARG}$: *92.751>u$s21,565*

This inequality also holds for the capital-output relationship[30] for the same year:

$(K/Y)_{USA} > (K/Y)_{ARG}$: *2.85>1.95*

This relative levels between USA and Argentina capital stocks were maintained during the nineties decade.

Like the above macroeconomic relationships, depreciation and net investment seem relatively independent of the age-efficiency profile.

The incidence of depreciation on the GDP was approximately 10.5% in the average for the period 1990-2000[31]. It should be noted that, the fixed gross domestic investment for 1990-2000 represented 18.4% of the output; whereas net investment represented less than 50% of the gross investment, that is to say, net savings during the nineties represented approximately 6% of the GDP.

6.5 Productive Capital Stock at Constant Prices by Type of Depreciation 1990-2000 - Some Preliminary Results

This section discusses some results of this estimation for the productive capital stock at constant prices. It should be noted that, in every case, the HV estimation is applied to dwellings, private non-residential structures, and transport equipment, independently of the depreciation method used for the remaining stock, estimated through the PIM. Results obtained by applying the rectangular method are illustrative because they are equivalent to the gross capital stock. It should be recalled that the

28 For a discussion of the convergence hypothesis, see for example Barro and Sala and Martin (1995)

29 Although, for comparisons among different countries, this coefficient should be corrected by the PPP exchange rate, it should be noticed that, in Argentina, from 1991 throughout 2000 the rate of exchange between the American dollar and the domestic currency was 1$ per dollar and a estimation for PPP exchange rate indicate an only 20% level of overvaluation of the domestic currency.

30 This coefficient is not affected by the above considerations since the numerator and denominator are both expressed in the same units. However, it should be noted that countries having higher capital-output coefficients are not necessarily wealthier than others: their relative productivity may be lower.

31 The incidence of depreciation on the product is approximately similar to what has been discussed in the National Accounts Manual, ONU (1995).

productive capital stock estimated through the geometric method is equivalent to the net capital stock, since age-efficiency and age-price profiles are coincident.

The following tables show the average growth rate of the aggregate stock for each sucomponent:

AVERAGE GROWTH RATES OF THE ARGENTINE CAPITAL STOCK				
Period 1990-2000	**Rectangular**	**Linear**	**Adj. Geometric**	**Hyperbolic**
Aggregate Capital Stock	***2.2%***	***3.1%***	***3.1%***	***2.9%***
National Durable Equipment	-3.2%	-3.6%	-3.6%	-3.9%
Imported Durable Equipment	13.3%	16.5%	16.0%	15.6%
Total - Durable Equipment	**0.5%**	**1.9%**	**1.6%**	**1.3%**
Private Construction	4.3%	4.3%	4.3%	4.3%
Public Construction	1.8%	0.4%	1.0%	1.3%
Total Construction	**3.0%**	**3.4%**	**3.5%**	**3.5%**
Cultivated Assets	**1.3%**	**1.3%**	**1.3%**	**1.3%**

Source: Data worked out by the author, based on information from the DNCN and the author's estimates of capital stocks.

Except for the rectangular depreciation method, that yields results coincident with the gross stock at constant prices, the average growth rate of the aggregate productive capital is similar for all the depreciation methods analyzed. In the case of durable equipment, the aggregate result is also similar, even if data are broken down by origin. However, in the case of the hyperbolic method, the decrease in stock of national durable equipment is greater, because weights emphasize the corresponding investment flows since the efficiency loss due to aging is lower for this method. In every case, the highest growth corresponds to the stock of imported durable equipment.

It has been widely discussed whether investments in residential dwellings should be included in the gross capital formation and, therefore, in stock formation. The approach selected at National Accounts is that investments in residential dwellings should be included if users make them as market service producers. In other words, the capital stock includes rented dwellings and excludes dwellings used as such by their owners. However, since the incidence of rented dwellings on the total stock of dwellings is highly variable among different countries, for comparability reasons as regards different GDP's, the total services of dwellings are computed as a portion of the output and, therefore, their total amount is included in the stock, independently of tenancy.

Nevertheless, it is useful to analyze the data in the table above in terms of reproductive capital, excluding dwellings:

AVERAGE GROWTH RATES OF ARGENTINE REPRODUCTIVE CAPITAL STOCK				
Period 1990-2000	**Rectangular**	**Linear**	**Adj.Geometric**	**Hyperbolic**
Reproductive Capital Stock	***1.9%***	***3.3%***	***3.3%***	***3.1%***
National Durable Equipment	-3.2%	-3.6%	-3.6%	-3.9%
Imported Durable Equipment	13.3%	16.5%	16.0%	15.6%
Total – Durable Equipment	0.5%	1.9%	1.6%	1.3%
Non-Residential Structures	3.2%	4.2%	4.3%	4.3%
Cultivated Assets	1.3%	1.3%	1.3%	1.3%

Source: Author's estimates of capital stock

The exclusion of dwellings in the measurement of the stock does not affect the above conclusions. It may be added that the average growth rate of the reproductive capital stock is similar to the aggregated item.

The average share during the 1990-2000 period is also similar for all the depreciation methods considered herein:

STRUCTURE OF THE ARGENTINE CAPITAL STOCK BY TYPE OF ASSET				
1990-2000 Average	**Rectangular**	**Linear**	**Adj. Geometric**	**Hyperbolic**
Aggregate Capital Stock	***100.0%***	***100.0%***	***100.0%***	***100.0%***
National Durable Equipment	23.9%	13.4%	13.0%	15.0%
Imported Durable Equipment	7.2%	6.2%	5.7%	6.4%
Private Construction	46.6%	60.9%	59.7%	56.1%
Public Construction	20.9%	17.8%	19.9%	21.0%
Cultivated Assets	1.3%	1.7%	1.7%	1.5%

Changes in capital stock shares between 1990 and 2000 by type of asset also proved independent of the depreciation method. As an example, the following table for the adjusted geometric case is shown:

STRUCTURE OF THE ARGENTINE CAPITAL STOCK BY TYPE OF ASSET		
Adj. Geometric Case	**1990**	**2000**
National Durable Equipment	18.9%	9.2%
Imported Durable Equipment	2.6%	8.7%
Private Construction	55.7%	62.7%
Public Construction	21.9%	17.9%
Cultivated Assets	1.9%	1.6%

During the nineties the share of imported durable equipment tripled whereas by the end of this period, national durable equipment had decreased to half its share at the beginning of the decade. The higher dynamism shown by the private construction industry may be explained not only by the substituion of the public sector as generator of infrastructure works but also by the growth of non-residential buildings.

Therefore, growth rates and the structure itself of the productive stock at constant prices were relatively independent of the efficiency pattern applied. It should be added that the main conclusions of this section also hold for the productive capital stock at current prices.

7. Capital Contribution to Output Growth

When capital is analyzed as a production factor, its contribution to output growth must be measure by the service flows it generates.

From the point of view of a homogeneous asset, the standard depreciation methods discussed above enable an aggregation over time of different vintages of the same type of asset. Considering as the standard a unit of a new asset, the resulting adjusted stock amount declines with age insofar as its efficiency as a provider of service flows decreases.

Thus, the proportional change in the stock of the homogenous asset in question is equal to the proportional change in the services provided by the stock. the underlying

assumption is that the ratio of service flows provided by stock over its amount remains constant for the same group of homogenous assets[32].

However, in order to determine the aggregate contribution of capital stock in terms of service flows, it is necessary to aggregate the services flows provided by heterogeneous capital goods.

In order to analyze the contribution of capital stock to the growth of the output from the point of view of growth accounting, three main questions should be taken into account: the type of index to be used for measuring capital services, which degree of aggregation should be selected, and which weights should be applied to different assets in the stock aggregate.

7.1 Index Numbers

Independently of the degree of disagregation and the type of weight, different authors agree that both the growth of the output and productive factors should be measured through superlative physical volume indices, such as the Fisher's or Tornqvist's indices propounded in the economic theory.

In practice, for measuring productivity, the Tornqvist index is the most widely used because of its analytical advantages:

- It is a superlative index, i.e., an exact index in the sense of being derived from a flexible function.

- When the growth accounting approach is used for measuring productivity, standard assumptions are made (returns to scale, profit maximization, and perfect competition) consistent with an aggregate translog function of which the Cobb- Douglas function is a particular case. The Tornqvist index is the exact or superlative index for this type of functions.

- Unlike fixed Laspeyres-type weights, those used in the Tornqvist index are variable; hence its name of flexible aggregator[33]. This is certainly advantageous because it removes the non-substitution bias involved in fixed weights of the Laspeyres type. In other words, the variation rates of the physical volume may be weighted applying current relative prices instead of those of the base-year, as in the Laspeyres approach.

However, it should be noted that:

- The translog shape of the aggregate function may result from the aggregation itself of production functions –either sectoral or individual– with a low elasticity of substitution, thus generalizing even further the approach followed in this paper.

- The type of aggregate function should be tested before deciding which index should be used. Otherwise, a methodological circularity may result.

The Tornqvist index may be represented as follows:

32 See Hill (1999) (2000), Hulten (1990)
33 See Diewert (1976) (1978)

$$X^T = \prod_{i=1}^{n} \left(X_{i,t} / X_{i,t-1} \right)^{1/2\left(v_{i,t} + v_{i,t-1}\right)}$$

where v_i is the incidence, at current prices, of the value of sucomponent X_i on the total value of factor X

This index should be used for the output and for each production factor. It should be remarked that, in the case of capital, the use of the Tornqvist index results in a *flexible aggregation* of the different types of capital goods involved in the stock[34].

The Tornqvist index is a weighted geometric mean of the relative quantities, weighted by the arithmetic means of value ratios for both periods. Hence, its name of symmetrical index: it assigns the same weight to the two situations under comparison and, therefore, its value may be expected to be approximately the mean between the Laspeyres and the Paasche indices, as occurs in the case of the Fisher index[35].

The use of symmetrical indices is advisable only when the objective is to analyze productivity in a context of long-term trends in relative prices. However, since the series considered herein are short in terms of time, the use of a symmetrical index might entail an economic deviation due to an unnecessary smoothing of changes in the structure of relative prices. Such effect might be further amplified if the logarithmic version of the index were used, as is commonly the case in most of the empirical literature about this subject. In order to avoid this effect and retain the variable weight characteristic, the Chain index was used in this paper: the variation rates at constant prices of the subgroups were weighted according to their incidence on the total value of the previous period, at current prices:

$$X^E = \sum_{i=1}^{n} \left(X_{i,t} / X_{i,t-1} \right) v_{i,t-1}$$

It may be remarked that this index retains the advantage of superlative indices when the series under study shows different relative price structures at the starting period and the final one, whereas price figures for intermediate periods are also intermediate[36].

7.2 Aggregate vs Disaggregate Approach

Ceteris paribus the type of index and the weight, the contribution of capital to output growth may be measured as the growth of the aggregate stock weighted by the capital share in the output. Therefore, if a change occurs in the asset type-composition of capital stock, the growth rate of capital stock would be biased.

Measuring the contribution of capital stock to growth disregarding the heterogeneity of the goods involved implies the assumption that the contribution to output growth is the same for all capital goods. In fact, in relative terms, one "peso" invested in buildings has a lower average annual yield than a "peso" invested in

34 More generally, the Tornqvist index should be a flexible aggregator of capital goods classified by type and user sector. This is impossible in the Argentine case because basic data are inexistent, at least in the detailed and exhaustive form they are available from the point of view of supply.

35 Besides, both the Tornqvist and the Fisher indexes satisfies the factor inversion test.

36 See chapter XVI of the National Accounts System (ONU (1995)).

machinery, mainly because the payback period for investments in machinery is shorter due to its lower relative durability.

Some authors suggest that discriminating between machinery and buildings in order to determine the capital contribution to growth involve adjusting data according to capital stock quality. The question remains unanswered because a less profitable investment –or, better, an investment with a longer payback period– does not necessarily imply a lower quality with respect to machinery. Besides, given the wide heterogeneity observed even within the group of machinery and equipment, an analysis with the greatest possible disagregation is advisable.

7.3 Weights – User Cost

The weights to be used in the capital stock index should reflect the incidence of each asset value on the total, considering as such the capital value as asset, i.e., at purchase prices, or the incidence of that capital asset in terms of services .

As we have seen, the contribution of capital to output growth should be measured through an approximation to the value of capital services. Its quantity is proportional to the physical volume of capital stock, whereas the price of services is expressed by the user cost or the rental price of capital. In other words, the price paid for using a capital unit. When the firm demanding the capital asset is not its owner, the user cost is given by the market rental price. But when the demanding firm is the asset's owner, the user cost is a notional or imputed value.

Generally, the user cost may be represented by the following arbitrage condition:

$$p_{k,t} = p_{K,t}\left(r_t + d_t - \dot{p}_{K,t}\right)$$

where

$p_{k,t}$: asset's user cost
$p_{K,t}$: price of the capital asset
r_t: financial cost of the invested capital
d_t: depreciation rate

The asset financing cost would be represented in this case by the first term above, $p_{K,t}(r_t+d_t)$:

$p_{K,t}r_t$: it is equal to the amount of interests if the asset were purchased through a loan; that is to say, it is equal to the opportunity cost if the purchase was made resorting to the company's funds.

$p_{K,t}d_t$: it is the depreciation cost or the asset's loss in value due to the fact that the expected average service life and/or the physical efficiency of the asset decreases with time.

The second term, $p_{K,t}$,represents the nominal benefits resulting from the asset appreciation or revaluation due to price variations, independently of the age (theoretically, these variations are already reflected in $p_{K,t}d_t$), as a consequence of variations in the general price level or unforeseen obsolescence.

QUAERERE VERUM
Universidad de San Andrés

Three different approaches may be found in the literature regarding the method for measuring the user cost of capital assets:

- Depreciation Rate Approach: it was used by Ward (1976) and by Timmer (2000). According to this approach, the simplest way for estimating the user cost in terms of the ratio $p_{k,t,l}$ $p_{K,t,}$ by asset type is given by the depreciation rate: capital goods having a longer service life provide lower annual services.

- Ex-Ante Opportunity Cost Approach: it was first propounded by Jorgenson and Grilliches (1967), and later used by Timmer and van Ark (2000). It consists in estimating the user cost of each fixed asset as the sum of the following: an interest rate which represents the opportunity cost common to investments in every type of fixed assets, plus the depreciation rate by asset type, minus the nominal appreciation or revaluation by asset type. Considering the available data, this approach has the following disadvantages:

  - The interest rate should reflect the true weighted opportunity cost associated to investing in fixed assets, from the point of view of the user sector.

  - In unstable economies, nominal price variations of capital goods (including real variations) tend to increase beyond the expected limits[37]

- Ex-Post Residual Approach: according to Hall and Jorgenson (1967) and Jorgenson, Gollop and Fraumeni (1987), capital services may be calculated approximately by identifying this in the National Accounts System with the total income from capital ownership, as the difference between total output and labor income: gross operating surplus. By dividing this value into the capital stock, the implicit prices of capital services may be obtained[38].

8. *The Growth of Capital Stock Services in Argentina during the 1990's*

This section offers estimates of the growth of capital stock services in the Argentine economy during the nineties.

Calculations were performed as follows:

a. Desegregate Approach: this approach was implemented taking into account detailed estimates of the 109 types of productive capital stock, both at constant and current prices. It should be noted that, if a detailed disagregation is available, the Chain index reflects changes in the relative prices of dissimilar assets and also changes in the relative prices of different relevant subaggegates: for example, public *vs.* private construction; national durable equipment vs. imported durable equipment; machinery vs. transport material or, even, changes in some capital stocks of specific use, such as those used in agriculture and livestock (tractors, other agricultural machinery, cultivated assets)

b. Index Numbers: the variation rates of capital stocks corresponding to homogeneous types at constant prices were aggregated using the Chain index.

37 For example, in inflationary economies, changes in relative prices may reach levels that result in negative user costs.

38 In other words, the profitability of the capital stock is calculated, see section 6.4.

c. Asset Value Weights: weights were calculated taking into account estimates at current prices for each of the stocks at market prices in order to compare these data with those obtained from applying user costs weights.

d. User Cost Weights: in order to determine the aggregate index of capital services, the Ex-Ante methodology was applied to calculate the annual user cost[39], except in the case of typologies integrating the construction stock, where a series of user cost worked out by the author was used.

Therefore, the rates of variation of capital services result in the following Chain index in the case of weights based on the asset value or the market price of capital assets, p_K[40]:

$$\dot{K}_{K,t}^{E} = \sum_{i=1}^{109} \left(p_{K_{i,0}} K_{i,t} / p_{K_{i,0}} K_{i,t-1} \right) v_{i,t-1}^{K} \qquad v_{i,t-1}^{K} = \frac{p_{K_{i,t-1}} K_{i,t-1}}{\sum_{i=1}^{109} p_{K_{i,t-1}} K_{i,t-1}}$$

$i = 1,...,109$ types of capital assets

Whereas, in the case of weights based on the user cost or equivalent rental price p_k, the following relationship holds:

$$\dot{K}_{k,t}^{E} = \sum_{i=1}^{109} \left(p_{k_{i,0}} K_{i,t} / p_{k_{i,0}} K_{i,t-1} \right) v_{i,t-1}^{k} \qquad v_{i,t-1}^{k} = \frac{p_{k_{i,t-1}} K_{i,t-1}}{\sum_{i=1}^{109} p_{k_{i,t-1}} K_{i,t-1}}$$

Calculations were made taking into account former estimates of the productive capital stock at constant and current prices for each of the standard depreciation methods applied[41].

The following tables summarize the effects of the different adjustments applied to measurements in order to estimate the growth of capital services for each efficiency profile[42]:

a. Age-Efficiency Profile Effect: it is reflected in the difference between the series of gross capital stock and the series of productive capital stock (less depreciation).

b. Substitution Effect: it is the difference between the Laspeyres index (involving fixed weights for the asset values)[43] and a Chain index (involving variable weights).

39 The interest rate used as proxy for the opportunity cost of capital is the interest rate for loans in foreign currencies associated with unsecured commercial papers due in 90 days published by the Central Bank of Argentina.

40 It should be noted that this index involves calculating the growth of aggregate capital stock as a weighted sum of the growth rates (at constant prices) of the 109 types of capital stocks, according to the structure of relative prices in the previous period. It should also be noted that, generally, estimates at constant prices of macroeconomic and sectoral aggregates in Argentine National Accounts are extrapolations of the respective levels at the base-year calculated with the Laspeyres physical-volume indices. Estimates at current prices, instead, are obtained by indexing values at constant prices through price indices. This remark is very important since the estimates at constant prices in developed countries are usually based on deflating current values.

41 Tornqvist-type indices yield results similar to those of the Chain indices reported herein.

42 For a similar approach, see OECD (2001b).

43 In this case, the base-year 1993.

c. Weight-Change Effect: it results from the difference between two Chain indices of variable base: the previous index with weights based on the asset value, and an index with weights based on user cost estimates.

AVERAGE GROWTH RATES OF CAPITAL STOCK SERVICES IN ARGENTINA DURING THE 1990's

AGGREGATE CAPITAL STOCK	Rectangular	Linear	Adj. Geom.	Hyperbolic
Gross Capital Stock	2.23%	2.23%	2.23%	2.23%
Age-Efficiency Profile Effect	***0.00%***	***1.01%***	***0.97%***	***0.89%***
Productive Capital Stock	2.23%	3.24%	3.20%	3.12%
Substitution Effect	***-0.10%***	***-0.05%***	***-0.04%***	***-0.05%***
Chain Index - aggregation by market prices	2.13%	3.19%	3.15%	3.07%
Weight Change Effect	***-0.07%***	***0.13%***	***0.10%***	***-0.11%***
Chain Index – aggregation by user costs	2.06%	3.32%	3.26%	2.96%

REPRODUCTIVE CAPITAL STOCK	Rectangular	Linear	Adj. Geom.	Hyperbolic
Gross Capital Stock	1.98%	1.98%	1.98%	1.98%
Age-Efficiency Profile Effect	***0.00%***	***1.60%***	***1.51%***	***1.35%***
Productive Capital Stock	1.98%	3.57%	3.49%	3.33%
Substitution Effect	***-0.14%***	***-0.08%***	***-0.07%***	***-0.08%***
Chain Index - aggregation by market prices	1.84%	3.50%	3.42%	3.25%
Weight Change Effect	***-0.03%***	***0.18%***	***0.14%***	***-0.17%***
Chain Index – aggregation by user costs	1.81%	3.68%	3.56%	3.08%

DURABLE EQUIPMENT STOCK	Rectangular	Linear	Adj. Geom.	Hyperbolic
Gross Capital Stock	0.61%	0.61%	0.61%	0.61%
Age-Efficiency Profile Effect	***0.00%***	***1.86%***	***1.36%***	***1.18%***
Productive Capital Stock	0.61%	2.47%	1.97%	1.79%
Substitution Effect	***-0.32%***	***-0.20%***	***-0.23%***	***-0.21%***
Chain Index - aggregation by market prices	0.29%	2.26%	1.73%	1.57%
Weight Change Effect	***0.44%***	***0.95%***	***0.96%***	***0.27%***
Chain Index – aggregation by user costs	0.73%	3.21%	2.70%	1.84%

CONSTRUCTION STOCK	Rectangular	Linear	Adj. Geom.	Hyperbolic
Gross Capital Stock	2.68%	2.98%	2.98%	2.98%
Age-Efficiency Profile Effect	***0.00%***	***0.46%***	***0.51%***	***0.52%***
Productive Capital Stock	2.68%	3.43%	3.48%	3.49%
Substitution Effect	***0.00%***	***0.00%***	***0.00%***	***0.00%***
Chain Index - aggregation by market prices	2.67%	3.43%	3.48%	3.49%
Weight Change Effect	***-0.01%***	***-0.02%***	***-0.02%***	***-0.01%***
Chain Index – aggregation by user costs	2.66%	3.41%	3.46%	3.47%

The following conclusions may be derived:

a. There are some obvious differences between the growth of gross capital stock and that of productive capital, as has been previously remarked.

b. The difference between fixed and variable-base indices for the total capital stock is greater when weights are based on user costs, since durable equipment is

weighted more favorable since they have has a shorter service life and yield therefore relatively higher annual services. Besides, durable equipment has gained incidence on the total stock of productive capital, as occurs in the case of imported durable equipment.

c. The difference between the Chain Index and the Laspeyres Index is mainly due to aggregation by user costs, especially when durable equipment is analyzed separately, maybe because of a greater heterogeneity. Obviously, the substitution effect was weakly reflected because the length of the time series used were short.

d. The effect is more noticeable when the durable equipment stock is analyzed separately.

e. The sign of the subtitution effect is independent of the efficiency profile.

f. The difference in growth rates resulting from weight changes between the rectangular and hyperbolic methods, and the linear and adjusted geometric method are due to the fact that the two former methods weight favorably national durable equipment, whose share decreased abruptly during this period.

9. *The Contribution of Labor to Argentine Growth during the 1990's*

For the sake of methodological consistency, an adjustment by the "quality" of labor was applied. We adopted the implicit differentiation approach[44]: no explicit distinction of worker characteristics, but break down by sectors of activities and occupational categories. 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.

In Argentina, available data about equivalent jobs and average remuneration by sector correspond to the one-digit ISIC 3rd revision classification broken down by occupational category: salaried and non-salaried workers (self-employed and unpaid family members). We take in account the official data published in DNCN (1999), that include an estimate of non-recorded employment for the period 1993-1997 and the author's estimate for the period 1998-2000, based on the same methodology.

For the sake of methodological consistency, a Chain index was used both for salaried labor (L_s) and non-salaried labor or mixed income (L_{ns}), in full accordance with the methodology applied to capital services:

$$\dot{L}_{s,t}^{E} = \sum_{i=A}^{O} \left(w_{s_{i,0}} L_{a_{i,t}} / w_{s_{i,0}} L_{s_{i,t-1}} \right) v_{i,t-1}^{s};$$

$$v_{i,t-1}^{s} = \frac{w_{s_{i,t-1}} L_{s_{i,t-1}}}{\sum_{i=A}^{O} w_{s_{i,t-1}} L_{s_{i,t-1}}}$$

$$\dot{L}_{ns,t}^{E} = \sum_{i=A}^{O} \left(w_{ns_{i,0}} L_{ns_{i,t}} / w_{ns_{i,0}} L_{ns_{i,t-1}} \right) v_{i,t-1}^{ns};$$

$$v_{i,t-1}^{ns} = \frac{w_{ns_{i,t-1}} L_{ns_{i,t-1}}}{\sum_{i=A}^{O} w_{ns_{i,t-1}} L_{ns_{i,t-1}}}$$

$i = A, \ldots, O$: sectors according to ISIC 3rd revision

44 OECD(2001b)

These differences are similar in their magnitude to those determined for capital services:

AVERAGE EMPLOYMENT GROWTH RATES IN AGENTINA		
(1990-2000)	Salaried Labor	Non- Salaried Labor
Laspeyres Index	1.54%	2.04%
Chain Index	1.66%	1.94%
Substitution effect	0.11%	-0.10%

It should be noticed that in the case of non-salaried workers, a drop in the "quality" of labor occurred.

10. Growth Accounting in Argentina during the 1990's

The purpose of this section is to analyze the impact of alternative measurements of capital stock services on the accounting of growth in Argentina during the 1990's. More precisely, its purpose is to determine their impact on the so-called Solow's residual or *total factor productivity (TFP)*.

The approach of growth accounting assumes that technical progress or TFP is a residue that results from deducting the weighted growth of the factors of production from output growth. The underlying assumptions are: a) returns to scale, that is to say, the income from production factors exhausts the output; b) profit maximization: the relative price of each factor is equal to its marginal productivity, and c) the factorial contribution is measured by the effectively utilized capacity.

Thus, the following equation holds for growth accounting:

$$\dot{A}_t = \dot{Q}_t - s_K \dot{K}_{k,t} - s_{Ls} \dot{L}_{s,t} - s_{Lns} \dot{L}_{ns}$$

A: Solow's residual or TFP
Q: GDP at constant prices
K_k: capital stock services
L_s: salaried labor
L_{ns}: non-salaried labor (or mixed income)
s_i: production factors' share in the output

Usual exercises are limited to measuring the growth rates of the output and the factors according to traditional physical-volume indices of the Laspeyres type. Even though adjustments may be made to reflect the quality of the factors, it is usually take the factor share in the total output as a constant. This implies an ex-ante assumption: that the aggregate output function of the economy belongs to the Cobb-Douglas type; besides the Laspeyres-type indices "freeze" the structure of relative prices at their base-year values.

Most recent literature on productivity measurements, especially OECD (2001b), recommends Chain indices both for the output and the factors and suggests that the measurement of the factors share should be made period-by-period[45]. Hence, the equation representing growth accounting turns into:

45 As in section 7.1, it may be said here that a Tornqvist-type index is usually recommended. However, it might entail economic variation because the period under study is very short. Anyway, the use of a Tornqvist index yields results similar to those obtained here through the Chain index.

$$A_t^E = Q_t^E - s_{K,t-1}K_{k,t}^E - s_{Ls,t-1}L_{a,t}^E - s_{Lns,t-1}L_{ns,t}^E$$

The GDP Chain index was calculated considering its sectoral disagregation:

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

$i = A, ..., O$: sectors, according to ISIC 3rd revision
$p_{i,t}q_{i,t}$: added value of the sectors integrating the GDP

The annual growth rates of the factors are those discussed above in 7) and 8), weighted according to their share at current prices in the previous period.

Several differences should be remarked with respect to works from other authors:

a. All the components of the TFP equation are calculated by applying Chain indices. The growth of production factors and the output itself are measured through a Chain index of the sub-aggregates involved. In the case of capital stock, 109 subgroups weighted by their estimated user costs; in the case of salaried and non-salaried labor, hours worked, broken down by activity sector, as the output.

b. The share of factors in the output varies from year to year. If it were constant, as in the case of *Kaldor's stylized facts* (1963), income distribution is constant in a economic growth context in the long run. In Argentina, the income distribution suffered very important changes during the period under study:

Functional Distribution of Income in Argentina		
	1993	2000
GDP	100.0%	100.0%
Gross Operating Surplus	45.0%	50.9%
Salaried Labor	37.8%	31.0%
Non-Salaried Labor	17.1%	18.1%

Source: Author's estimates based on the DNCN

c. The mixed income is considered as a separate factor of production, so its contribution to the growth of GDP may be inferred and discounted of the TFP.

Results derived from applying this methodology are summarized in the following table by efficiency pattern and index type:

Universidad de San Andrés

GROWTH ACCOUNTING IN THE ARGENTINE ECONOMY DURING THE 1990's (Aggregate Capital Stock)				
LASPEYRES INDEX	**Rectangular**	**Linear**	**Adj.Geom.**	**Hyperbolic**
Q	2.28%	2.28%	2.28%	2.28%
K	2.30%	3.33%	3.22%	3.24%
Ls	1.76%	1.76%	1.76%	1.76%
Lns	2.33%	2.33%	2.33%	2.33%
Factorial Contrib.	**2.13%**	**2.64%**	**2.59%**	**2.60%**
K	1.14%	1.66%	1.61%	1.61%
Ls	0.58%	0.58%	0.58%	0.58%
Lns	0.40%	0.40%	0.40%	0.40%
TFP	***0.15%***	***-0.36%***	***-0.31%***	***-0.32%***
CHAIN INDEX	**Rectangular**	**Linear**	**Adj.Geom.**	**Hyperbolic**
Q	2.54%	2.54%	2.54%	2.54%
K	3.27%	3.38%	3.23%	3.27%
Ls	1.89%	1.89%	1.89%	1.89%
Lns	2.22%	2.22%	2.22%	2.22%
Factorial Contrib.	**2.63%**	**2.69%**	**2.61%**	**2.63%**
K	1.63%	1.68%	1.61%	1.63%
Ls	0.63%	0.63%	0.63%	0.63%
Lns	0.38%	0.38%	0.38%	0.38%
TFP	***-0.09%***	***-0.14%***	***-0.07%***	***-0.09%***

a. The average growth of TFP in Argentina during this period was slightly negative measured in terms of Laspeyres-type indices[46]. This type of fixed-base indices tend to bias TFP since they do not capture eventual substitution effects that resulting from changes in sectoral and factorial relative prices.

b. The TFP's negative trend decreases in the Chain index version, which also implies a factorial adjustment by "quality" since structural changes in the sectoral composition of the output and the factors are then detected.

c. The growth of capital stock is the main factor contributing to economic growth. Therefore, an accurate measurement of this variable has a methodological and explanatory relevance.

RELEVANCE OF PRODUCTION FACTORS IN THE ECONOMIC GROWTH OF ARGENTINA DURING THE 1990's		
	Laspeyres Index	***Chain Index***
K (Adj.Geom.)	70.37%	63.15%
Ls	18.07%	19.39%
Lns	22.76%	20.16%
TFP	-13.20%	-3.16%

d. The above results are independent of the efficiency profile applied for measuring capital stock.

46 It should be reminded that the rectangular version of capital stock corresponds to its gross version and, threfore, it overestimates its growth rate.

According to the considerations discussed in section 6.5 about classifying dwellings as capital good, a similar estimation was carried out for the reproductive capital stock:

GROWTH ACCOUNTING IN THE ARGENTINE ECONOMY DURING THE 1990's (Reproductive Capital Stock)				
LASPEYRES INDEX	**Rectangular**	**Linear**	**Adj.Geom.**	**Hyperbolic**
Q	2.28%	2.28%	2.28%	2.28%
K	2.10%	3.77%	3.57%	3.56%
Ls	1.76%	1.76%	1.76%	1.76%
Lns	2.33%	2.33%	2.33%	2.33%
Factorial Contrib.	**2.02%**	**2.77%**	**2.68%**	**2.67%**
K	0.94%	1.68%	1.59%	1.59%
Ls	0.64%	0.64%	0.64%	0.64%
Lns	0.44%	0.44%	0.44%	0.44%
TFP	***0.26%***	***-0.49%***	***-0.40%***	***-0.39%***
CHAIN INDEX	**Rectangular**	**LineaR**	**Adj.Geom.**	**Hyperbolic**
Q	2.54%	2.54%	2.54%	2.54%
K	2.12%	3.81%	3.55%	3.58%
Ls	1.89%	1.89%	1.89%	1.89%
Lns	2.22%	2.22%	2.22%	2.22%
Factorial Contrib.	**2.06%**	**2.81%**	**2.70%**	**2.71%**
K	0.94%	1.70%	1.59%	1.60%
Ls	0.69%	0.69%	0.69%	0.69%
Lns	0.42%	0.42%	0.42%	0.42%
TFP	***0.49%***	***-0.27%***	***-0.15%***	***-0.16%***

The same conclusions hold in this case: rather than neutral technical progress in Solow sense, the accumulation process of (reproductive) capital accounts for the growth of the Argentine economy during the nineties and this result is relatively independent of the depreciation method selected.

It should be noted that, since capital stock has not been adjusted by its degree of utilization, the residue might include its effects, resulting in a pro-cyclic behavior. Apart from estimation errors, other effects difficult to identify through this non-parametric methodology may be included in the residue: non-constant returns to scale, externalities, etc[47].

It may be concluded that, during the period under study, during the nineties, Argentina had an extensive-type economic growth[48] based in the accumulation of capital more than disembodied technological progress or non-pecuniary spillovers.

11. Conclusions

The contribution of capital stock to productivity In Argentina during the nineties has been analyzed by applying the economic theory of index numbers and the recommendations in the most recent economic literature about hedonic valuation of capital goods as an alternative of perpetual inventory method.

47 For a discussion of this approach, see OECD (2001b) and Basu, Fernald and Shapiro (2001).
48 The conclusions of Timmer y Van Ark (2000) for Korea and Taiwan are similar.

The level of the capital stock estimation results consistent with the principal macroeconomic aggregates and its trends are relatively independent of the assumptions about depreciation methods.

The growth of the Solow's residual or TFP in Argentina was slightly negative for the 1990's. This trend tends to zero if measurements are made through Chain indices adjusted by the "quality" of production factors, even though only the reproductive capital stock is considered.

Given the relevance and dynamism of capital stock services for growth processes, an accurate measurement of this variable is critical. Thus, heterogeneity acquires more relevance, as well as the type of weights and the index numbers used to estimate its contribution to output.

The effects on the growth accounting of the flexibility aggregation of capital stock and salaried and non-salaried labor sub-aggregates has proved relatively neutral with respect to the efficiency profile used for estimating the capital stock.

According to these results, evidences may indicate that during the nineties there was no productivity gain in the sense of Solow in Argentina. In any case, it may be inferred that the profile of economic growth was of the extensive type based on the accumulation of capital rather than disembodied technological progress or non-pecuniary spillovers.

QUAERERE VERUM
Universidad de
SanAndrés

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Universidad de San Andrés
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ANNEX 1

	National and Imported Capital Goods clasiffied by kind of activity by ISIC 3rd revision	Method.	Service Life	Declining-Balance Rate	Deprec. Rate
20290	Other products of wood, manufacture of articles of cork, straw	PIM	12	1.6500	0.1375
22130	Publishing of recorded media	PIM	10	1.6500	0.1650
22300	Reproduction of recorded media	PIM	10	1.6500	0.1650
23300	Processing of nuclear fuel	PIM	10	1.6500	0.1650
25111	Manufacture of rubbers	PIM	8	1.6500	0.2063
25112	Recycle and renovating rubbers	PIM	8	1.6500	0.2063
28110	Manufacture of structural metal products	PIM	16	1.9600	0.1225
28120	Manufacture of tanks, reservoirs and containers of metal	PIM	16	1.9600	0.1225
28130	Manufacture of steam generators	PIM	16	1.9600	0.1225
28910	Forging, pressing, powder metallurgy	PIM	16	1.9600	0.1225
28920	Treatment and coating of metals, general mechanical engineering	PIM	16	1.9600	0.1225
28930	Manufacture of cutlery, hand tools and general hardware	PIM	16	1.9600	0.1225
28991	Manufacture of tin plate bottling	PIM	10	1.6500	0.1650
28999	Manufacture of metallic product n.e.c.	PIM	16	1.9600	0.1225
29110	Manufacture of engines and turbines, vehicle and cycle engines	PIM	20	1.6500	0.0825
29120	Manufacture of pumps, compressors, taps and valves	PIM	8	1.6500	0.2063
29130	Manufacture of bearings, gears, gearing and driving elements	PIM	18	1.6500	0.0917
29140	Manufacture of ovens, furnaces and furnace burners	PIM	18	1.6500	0.0917
29150	Manufacture of lifting and handling equipment	PIM	10	1.6500	0.1650
29190	Manufacture of other general purpose machinery	PIM	18	1.6500	0.0917
29211	Manufacture of tractors	PIM	9	1.3064	0.1452
29219	Manufacture of machinery for agriculture and forestal	PIM	14	1.6500	0.1179
29220	Manufacture of machine- tools	PIM	16	1.9600	0.1225
29230	Manufacture of machinery for metallurgy	PIM	16	1.9600	0.1225
29240	Manufacture of machinery for mining, quarrying and construction	PIM	10	1.5498	0.1550
29250	Manufacture of machinery for food, beverage and tobacco proc.	PIM	16	1.6500	0.1031
29260	Manufacture of machinery for textile, apparel and leather prod.	PIM	16	1.6500	0.1031
29270	Manufacture of weapons and ammunition	PIM	12	1.6500	0.1375
29290	Manufacture of other special purpose machinery	PIM	16	1.6500	0.1031
29300	Manufacture of domestic appliance n.e.c.	PIM	10	1.6500	0.1650
30000	Manufacture of office, accounting and computing machinery	PIM	7	2.1832	0.3119
31100	Manufacture of electric motors, generators and transformers	PIM	20	1.6500	0.0825
31200	Manufacture of electricity distribution and control apparatus	PIM	20	1.6500	0.0825
31500	Manufacture of electric lamps and lighting equipment	PIM	5	1.6500	0.3300
31900	Manufacture of other electrical equipment n.e.c.	PIM	16	1.7150	0.1072
32100	Manufacture of electronic valves, tubes and other electronic comp.	PIM	16	1.7150	0.1072
32200	Manufacture of television and radio transmitters and telephony	PIM	11	1.6500	0.1500
32300	Manufacture of television and radio receivers, sound or video	PIM	11	1.6500	0.1500
33110	Manufacture of medical and surgical equipment and orthopedic app.	PIM	12	1.6203	0.1350
33120	Manufacture of instruments for measuring, checking, testing,	PIM	12	1.6203	0.1350
33130	Manufacture of industrial process control equipment	PIM	12	1.6203	0.1350
33200	Manufacture of optical instruments and photographic equipment	PIM	12	1.6203	0.1350
33300	Manufacture of watches and clocks	PIM	12	1.6203	0.1350
34100	Manufacture of motor vehicles	HV	10	1.7252	0.1725
34200	Manufacture of bodies (coachwork) for motor vehicles	PIM	10	1.7252	0.1725
34300	Manufacture of parts and accesories for motor vehicles	PIM	8	1.6500	0.2063
35110	Building and repairing of ships	PIM	20	1.6500	0.0825
35120	Building and repairing of pleasure and sporting boats	PIM	20	1.6500	0.0825
35200	Manufacture of railway and tramway locomotives and rolling stock	PIM	28	1.6500	0.0589

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35300	Manufacture of aircraft and spacecraft	PIM	15	1.6500	0.1100
35920	Manufacture of bicycles and invalid carriages	PIM	5	1.7252	0.3450
35990	Manufacture of other transport equipment n.e.c.	PIM	9	1.7252	0.1917
36101	Manufacture of furnitures and parts of furnitures	PIM	12	1.6500	0.1375
36102	Manufacture of furnitures and parts of furnitures (metal, plastic, etc.)	PIM	14	1.6500	0.1179
36910	Manufacture of jewellery and related articles	PIM	12	1.6500	0.1375
36940	Manufacture of games and toys	PIM	12	1.6500	0.1375
36990	Other manufacturing n.e.c.	PIM	12	1.6500	0.1375
	Dwellings: single-person and multiple-person households, urban and rural, including major replacement and alterations and shanties	HV			
	Non-Residential Private Structures including buildings and their major replacement and alterations	HV			
	Public Structures including buildings and their major replacement and alterations	PIM			
	Livestock: cattle, sheep, goats, pigs and horses.	SD			
	Agricultural Cultivated Assets: plantations, pastures, forestation, fencing, leveling and greenhouses	PIM			

Source: Data worked out by the author, based on information from user matrix and series from DNCN (National Account Office-Ministry of Economy-Argentina) and BEA methodology

PIM: Perpetual Inventory Method
HV: Hedonic Valuation
SD: Survey data

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