Trabajo de Licenciatura en Economía

Growth and the Determinants of TFP in Argentina: 1960-2008

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Mentor

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ABSTRACT

Argentina has exhibited great trend and cyclical GDP and TFP growth rate variations during the last 50 years. This paper presents new estimates for Argentina's sources of growth and new measures for aggregate capital and TFP in the 1960-2008 time-span. An appreciation is done of the two basic methodologies to estimate aggregate capital –permanent inventory method and hedonic prices. Capital series derived by Heymann, et al (2007) are adjusted by utilization and labor input series by hours worked. The paper presents seven TFP series based on combinations of the latter. Five basic economic cycles are identified in the period of study that coincide with other authors' estimates analyzing deviations of the GDP series from its trend. Special attention is paid to the last two recovery cycles (1990-1998 and 2002-2008), in order to compare and analyze growth dynamics, given the differences in economic policies during the occurrence of the recoveries. Econometric evidence is then presented for the TFP in Argentina, considering cyclical (terms of trade and real exchange rate undervaluation) and institutional variables (macroeconomic instability and major government changes).

[1] To Jerónimo, Julieta, my family and my friends, I am deeply grateful for having them

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I. INTRODUCTION

Argentina has been at the crossroads of development for almost two decades. It has faced chances given by external opportunities not matched since the beginning of WWII. However, it seems it hasn't taken advantage of the opportunities it has had, either during the opening of the economy in the '90s or the commodities boom during the better part of the '00s. The world economic outlook for 2009-2010 is grim, but it is safe to say economic growth will resume in the following years. Indicators as commodity prices are beginning to show signs of recovery. High growth economies as China and India have developed structural demand for commodities, in part responsible for the last boom of prices from which Argentina has benefited. Argentina has a strategic and competitive advantage over most countries to benefit from this dynamic and get for once and for all on the path to development.

On those premises, the objectives of this paper are to determine the nature of Argentina's growth and recessions over the past 48 years; to uncover the determinants of its cycles and to evaluate its growth strengths and weaknesses.

II. ARGENTINA GROWTH FACTS

Until 2008 Argentina grew at a 7.3% average inter-annual rate since the crash of the economy in 2002, year that marks the end of an economic cycle and model. That model had spanned and lead to growth for 12 years since 1990 -with two hiatus in 1995 and 1999-, characterized by macroeconomic policies defined by the "convertibility" of the Peso. It had been first implemented as a transitional model and designed to stop the hyperinflation process that had sprung during the late 1980s. A new currency was introduced in 1992, the actual Peso, in replacement of the stigmatized Austral. The main characteristic of the new Peso was its hard peg to the dollar by the popular 1:1 ratio. Central Bank Reserves guaranteed the new currency and in a two year span inflation converged to one digit figures. An apparently steady macro economy attracted foreign investments, both capital and financial. Argentina grew steadily for 8 years after 1990, interrupted only during 1995 by the "Tequila" crisis due to Argentina's exposure to foreign financial markets. After the Russian crisis, the year 1999 marked the

beginning of the end of the convertibility model, with growing doubts of its sustainability in the short run. The growing trade and government deficits and its inability to tap on monetary policies to respond to the 1999 Asian Crisis and to correct unbalances such as a 22% unemployment rate were soon uncovered. In January 2002, the Convertibility Law was suppressed and hard financial measures were adopted to prevent a full-scale run. The transitional crisis' toll on Argentina's economy from 1998 to 2002 was an unprecedented 18.4% decline on GDP and a 21.6% decline on per capita GDP.

On that note of recent economic history, this paper aims at uncovering the sources of growth, as well as the determinants of TFP. In order to do so, an estimation of Argentina's capital stock is necessary, and the different alternatives are presented in Chapter III. In growth accounting, the use of an unadjusted capital series hides variations of capital utilization during economic cycles, especially in a long-term study like this paper intends to do. Different measures of capital adjustment are analyzed in Chapter IV. In Chapter V, factor contributions to growth are derived following the Solow methodology, decomposing growth between capital and labor and TFP. TFP has several interpretations in the economic literature, but it is interpreted in this paper solely as a residual of growth accounting –error measurements, in extreme. An econometric methodology is applied to TFP in Chapter VI in an effort to uncover its determinants, considering only hard, quantitative economic variables.

III. AGGREGATE CAPITAL ESTIMATIONS

The estimation of capital is one of the single most important activities set on economic statisticians, second only to the estimation of economic output. Several capital estimation methodologies exist that set apart from one another on data intensity and the assumptions made on capital behavior. In Argentina, several efforts have been made in order to estimate the capital series.

The most straightforward approach to capital estimation is the perpetual inventory methodology, used by Maia and Nicholson (2001) in their approach to calculate a capital series from 1960 to 2004 and Heymann, et al (2007) to extend the capital series from 1990 back to 1950. Perpetual inventory estimation is based on the construction of an aggregate capital series

from quarterly capital investment data. The raw capital series is then depreciated, in their case based on a geometric depreciation model; in essence, capital acquired in one period is added to the surviving capital from all previous periods. A geometric depreciation model is supported by empirical evidence in Hulten and Wycoff (1981); however, the specific nature of their study makes it doubtfully applicable to Argentina's economy. The basic flaws in perpetual inventory capital are the estimation of the depreciation patterns, especially in a long-term time-series where the characteristics of capital goods vary widely, and the inability to capture changes in relative prices of inputs.

Perpetual inventory series are clearly vulnerable when it comes to deriving depreciation indexes, given the heterogeneous nature of capital goods observed in the categories. Hedonic prices models for aggregate capital time-series calculation are far more accurate compared with perpetual inventory models, based on a census-like methodology to calculate capital goods quantities and prices. A hedonic prices capital series estimation was derived by Ariel Coremberg from National Accounts. However, data for the construction of an aggregate capital series with a hedonics prices model in Argentina is available only for the period 1990-2006. Given its dependency on census-like methodology and data collection intensity, it is impossible to extend the series back to 1960 without making several assumptions.

The capital series chosen for this paper is derived by Heymann, et al (2007), based on the hedonic prices methodology from 1990 to 2006 and extended back to 1960 using perpetual inventory methodology. The series was extended until 2008 using GDP and labor data from National Accounts and an extended capital series provided by Ariel Coremberg.

The three core capital estimation series: Maia and Nicholson's (2001) perpetual inventory, Coremberg's (2007) hedonic prices and Heymann, et al (2007) hybrid series are compared. The three series are presented in Figure 1. Since the Heymann, et al (2007) series is derived from Coremberg (2007), the trend is almost identical. However, there is considerable difference between the latter and Maia and Nicholson's. The difference in level between the two groups of series is 22.4%, a significant difference. However, as it can be appreciated in Figure 1, the trend is considerably similar. Table 1 reports the correlations between the three core estimations of the capital series and the Heymann, et al (2007) series applying a Hodrick-Prescott filter.

By construction, the inter-annual growth rate correlation between the Coremberg (2007) and Heymann, et al (2007) series is .998. The correlation between Coremberg (2007) and Maia and Nicholson (2001) is 0.951, a fairly high correlation. This result may satisfy us for two reasons. The first is that although the level is off by more than one fifth, the perpetual inventory time-series is validated because inter-period variations are correlated with hedonic prices time-series'. The second is that, since TFP accounting methodology is based on calculations on inter-period variations, the perpetual inventory methodology time-series could be accurate for TFP analysis. However, a close comparison of both trends yields that the growth trend of the Coremberg (2007) series is higher than Maia and Nicholson's (2001), an observation that combined with a 22.4% estimation error, induces us to discard the perpetual inventory series for this study and adopt Heymann, et al (2007).

The reasons to adopt the capital series from Heymann, et al (2007) rather than Maia and Nicholson's (2001) are two fold: firstly, hedonic prices methodology is exhaustively based on hard data while perpetual inventory relies heavily on assumptions; secondly, given the lower level of capital from Heymann, et al (2007), it is more consistent with a capital to product ratio lower than that of the U.S.

TABLE 1

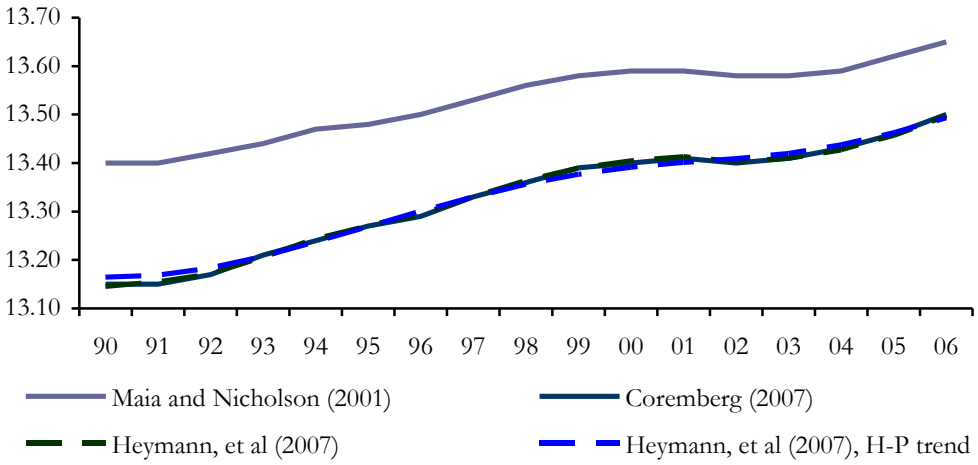
CORRELATIONS BETWEEN CAPITAL SERIES ESTIMATIONS IN ARGENTINA, 1990-2006

Variables in inter-annual percentage variations

	Heymann, et al (2007)	Heymann, et al (2007) Hodrick-Prescott	Maia and Nicholson (2001)
Coremberg (2007)	0.998	0.866	0.951
Heymann, et al (2007)		0.850	0.953
Heymann, et al (2007) Hodrick-Prescott			0.803

FIGURE 1

HEDONIC PRICES AND PERPETUAL INVENTORY CAPITAL SERIES IN ARGENTINA, 1990-2006
(Logarithmic scale)



IV. AGGREGATE CAPITAL ADJUSTMENTS

The basic measure for aggregate capital is the stock of physical capital, which does not account for variations in capital quality or capital utilization. The stock of physical capital could be interpreted as installed productive capacity. However, it is clear that depending on economic cycles, the usage of installed capacity could vary widely. A clear example is the car industry in Argentina during the 2002 crisis, when used capacity of automotive plants was under 10% of installed capacity for some months. Therefore, much of the recovery from the recession in that kind of industries could have taken place without capital investments and further utilization of the installed capacity.

If TFP is derived without adjustments for capital quality and utilization, these are residually credited to TFP. On that point, a capital quality index should be considered to correct this potential calculation error. The first utilization adjustments used in this paper are fairly intuitive. Using a Hodrick-Prescott filter, a smoothened capital series is derived assuming cycle maximums coincide with maximum capital utilization. This first approach is uncontroversial and extremely practical for our purposes. Figure 2 depicts the different adjustments made to capital. Table 2 reports the correlations between the series.

FIGURE 2

CAPITAL SERIES ADJUSTED FOR UTILIZATION IN ARGENTINA, 1960-2008
(Logarithmic scale)

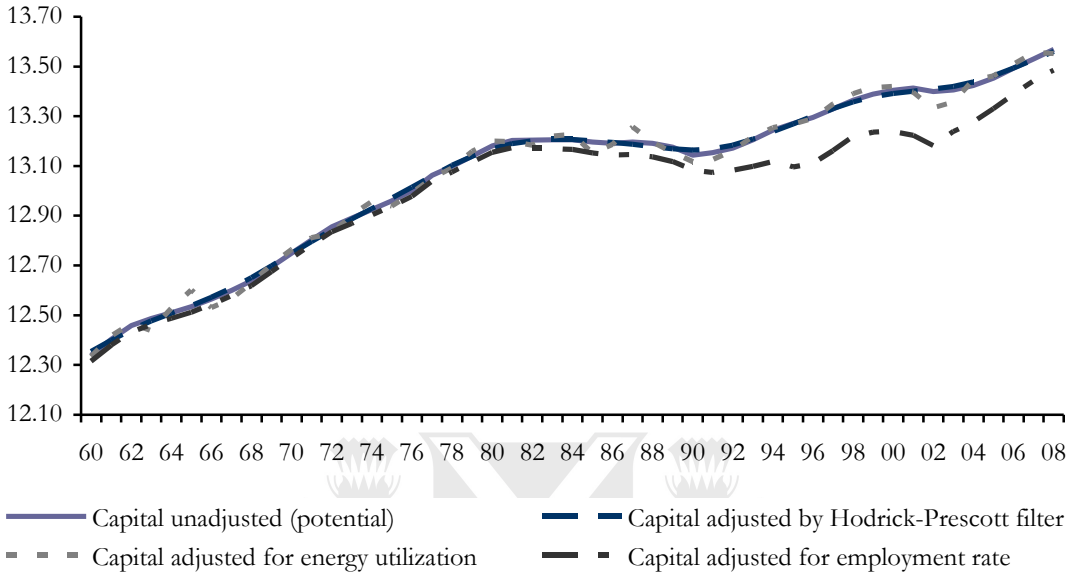


TABLE 2

CORRELATIONS FOR CAPITAL SERIES ADJUSTED FOR UTILIZATION IN ARGENTINA, 1960-2008

Variables in levels

	Capital adjusted with Hodrick-Prescott filter	Capital adjusted for energy utilization	Capital adjusted for employment rate
Capital unadjusted (potential)	0.999	0.996	0.980
Capital adjusted with Hodrick-Prescott filter		0.994	0.979
Capital adjusted for energy utilization			0.979

Variables in inter-annual growth rate

	Capital adjusted with Hodrick-Prescott filter	Capital adjusted for energy utilization	Capital adjusted for employment rate
Capital unadjusted (potential)	0.917	0.593	0.854
Capital adjusted with Hodrick-Prescott filter		0.504	0.772
Capital adjusted for energy utilization			0.594

In Argentina, the optimal adjustment for capital utilization is a capital usage survey, compiled since the 1990s by FIEL. However, there is no practical way of extending it back to 1960, the starting year of this paper's capital series. Jorgenson and Griliches (1967) and Greenwood and Jovanovic (2000) provide different methods to construct capital quality indexes based on relative returns on different investments and the relative price of investment to consumption, respectively.

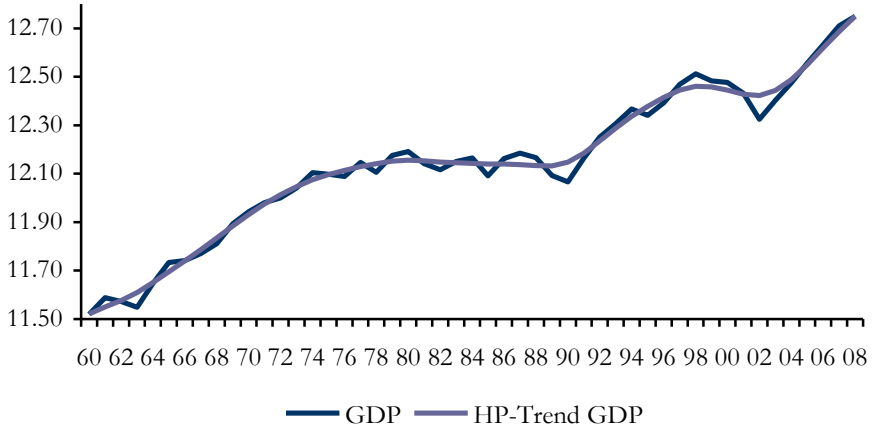
Costello's (1993) measure of capital input, electricity consumption, is included as a capital adjustment alternative in this paper. This method does not consider the substitutability of electricity with other forms of energy in the production of goods and services, so a measure for energy consumption (electricity, oil, gas, etc.) is used instead. The capital adjustment by energy consumption is, in contrast to a capital usage survey or a Hodrick-Prescott filter, controversial. Changes in the relative price of energy may overestimate, in the case of cheap energy, the utilization of capital, or vice versa. In 2002, for example, a depreciation and a strict regulatory pricing policy upset energy and capital goods relative prices.

The energy adjustment in this paper was applied with an energy consumption long-term trend series constructed using a Hodrick-Prescott filter. Deviations of the energy consumption series from the long-term trend are used to adjust the physical capital series for utilization. The physical capital series is then adjusted by multiplying it by one minus the deviation of the energy consumption series from its long-term trend. This form of adjustment yields a gentler capital adjustment than other more direct forms of adjustment for energy utilization, and far more moderate than employment rate adjustment.

The last adjustment considered was done using the employment rate as proxy for capital utilization. The results for the adjusted capital series is compared to the unadjusted capital series in Figure 2. The level correlation between the series is .991 and the inter-annual growth rate correlation is .179, considerably lower due to the trend component of the series. Another measure of capital utilization is the labor employment rate, with a level correlation of .985. Table 2 depicts the correlations between the original physical capital series and the adjusted ones, in levels and inter-annual growth rates.

FIGURE 3

(A) GDP AND HODRICK-PRESCOTT TREND GDP IN ARGENTINA, 1960-2008
(Logarithmic scale)



(B) CYCLICAL MEASURES BASED ON TREND GDP IN ARGENTINA, 1960-2008
(In percentage)

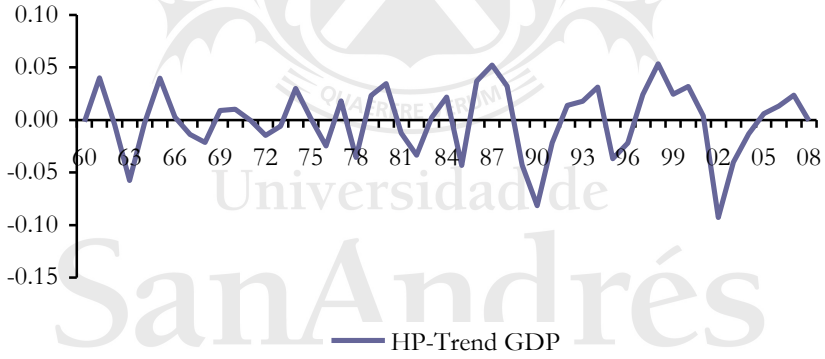


TABLE 4

AVERAGE GDP GROWTH AND STANDARD DEVIATION IN EACH ECONOMIC CYCLE IN ARGENTINA, 1960-2008

	1960-1974	1974-1980	1980-1987	1987-1998	1998-2008	*1990-1998*	*2002-2008*
Average GDP Growth	4.27%	1.45%	-0.08%	3.02%	2.40%	*5.74%*	*7.33%*
Standard Deviation	3.80%	4.43%	4.70%	5.49%	6.34%	*4.64%*	*6.77%*

With regard to the GDP series, five economic cycles were identified analyzing deviations of the series from its trend. In order to enrich the analysis, the recovery portions of

the last two cycles were also identified (1990-1998 and 2002-2008) and will be characterized, given the relevance of recent economic history and the contrast of the economic models to which they correspond.

V. GROWTH ACCOUNTING

In order to understand the contribution of each factor of production in the growth process, the Solow model will be favored in this work for its robustness. It conceives only three sources of growth: capital, labor and a residual – Total Factor Productivity (TFP). TFP has several interpretations, but a simplified attribution is that of a group of growth factors different from capital accumulation and changes in labor. Several authors understand TFP as a technology factor capturing changes in technology, interpreting technology in its broadest sense (e.g. advances in manufacturing techniques, cultural changes, institutional changes, etc.). In the Solow model, a Cobb-Douglas production function with two factors of production is linearly transformed by the TFP factor which adjusts the output of capital and labor to equal real output.

The traditional Solow method is used to derive the contribution from factors of production and TFP residual to GDP growth based on a Cobb-Douglas production function:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \quad (9),$$

where Y_t represents GDP at time t, A_t represents TFP at time t, K_t represents accumulated capital at time t, L_t represents labor at time t and α is the share of capital in GDP. In our model, accumulated capital is adjusted for utilization, so K_t actually represents our adjusted capital series.

As it was mentioned above, TFP is derived as a residual in the Solow model. In order to do so, percentage changes are taken on both sides of equation 9 and rearranged:

$$\hat{A}_t = \hat{Y}_t - \alpha\hat{K}_t - (1-\alpha)\hat{L}_t \quad (10),$$

where the factors with a hat represent percentage changes $((X_t - X_{t-1})/ X_{t-1})$.

Given the available information, it is now possible to calculate TFP factor contribution once the share of capital contribution α is defined. Capital share of income of GDP is usually calculated as a residual, given the share of income of labor and independent workers. However, factor contribution of independent workers includes capital contribution and it should be split between capital and labor. It will be assumed that labor contribution in the income of independent workers resembles labor contribution in the rest of the economy. The average share of income from labor in the studied period is 40%, 15% for independent workers (mixed income) and 45% is the residual attributed to capital income. The 15% share of income of independent workers will be divided between labor and capital income with a 40:60 ratio. The resulting average share of income of labor for the whole economy is 49% and the share of income of capital is 51%. Thus:

$$\alpha = 51\% \quad (11)$$

Table 5 reports the sources of growth of Argentina in 1960-2008.

TABLE 5

SOURCES OF GDP GROWTH IN ARGENTINA, 1960-2008

	GDP Growth	Contribution of labor growth	Contribution of capital growth	Contribution of TFP growth
1) Capital unadjusted				
a) Capital unadjusted (potential) and labor unadjusted	2.72%	0.82%	1.39%	0.50%
b) Capital unadjusted (potential) and labor adjusted for hours worked	2.71%	0.81%	1.39%	0.51%
2) Capital adjusted for utilization				
a) PTF adjusted for H-P cycle and labor adjusted for hours worked	2.70%	0.84%	1.37%	0.49%
b) GDP, capital and labor adjusted for H-P cycle and labor adjusted for hours worked	2.70%	0.84%	1.37%	0.49%
c) Capital adjusted for energy utilization and labor adjusted for hours worked	2.72%	0.81%	1.36%	0.55%
d) Capital adjusted for energy utilization and labor adjusted for H-P cycle and hours worked	2.72%	0.84%	1.36%	0.52%
e) Capital adjusted for employment rate and labor adjusted for hours worked	2.71%	0.81%	1.29%	0.61%

Average GDP growth in Argentina in the period 1960-2008 was 2.7%. When the sources of growth are calculated considering capital unadjusted (potential), the result is an average 1.39 p.p. capital factor contribution to growth. When capital is adjusted for hours worked only in the 1990-2008 period, the contribution of capital to growth is not altered. When the PTF derived from Heymann, et al (2007) is cyclically adjusted using a Hodrick-Prescott filter, the contribution of capital is slightly lower, 1.37%. There is no variation of the latter result when, instead of adjusting the PTF series, capital, labor and output are adjusted using a Hodrick-Prescott filter. When capital is adjusted for the deviations from a long-term trend of energy consumption, the factor contribution of capital is 1.36 p.p., lower than H-P adjusted PTF and lower than unadjusted PTF. An extension of the latter including an adjustment with the labor series using an H-P filter does not yield differences, with capital contribution remaining at 1.36 p.p. On the other hand, when capital is adjusted for the employment rate in each period –assuming that the employment rate is a proxy measure for capital utilization– the factor contribution of capital to GDP growth decreases to 1.29 p.p., or 0.10 p.p. lower than when unadjusted capital is used. In the consideration of adjustments to capital measures, economic cycle adjustments using Hodrick-Prescott filters will be preferred over every other, considering that no capital utilization surveys are available for the whole period of study. In the case of other types of adjustments, energy utilization adjustments will be preferred over adjustments based on employment rates. The logic is that over the 48 year period, several political stances over labor and employment have been taken that have affected employment rates over the effect possibly attributed to capital utilization. That is, although capital certainly has been utilized with varying intensiveness over time, companies have been able to adjust labor with varying degrees of freedom. Take for example the severance payment policies applied in the early 2000's; or the hyperinflation processed of the mid 1980's that pushed the economy to virtually full employment while GDP growth stagnated. Also, a surge of capital intensive industries has occurred in the period of study, risking an underestimation of capital contribution. On this remarks, I consider capital adjustments based on energy utilization more accurate than adjustments based on employment rates. Firstly, the energy measure used considers almost all forms of energy and not just electric energy. Secondly, from the enterprise standpoint, the energy market is far freer than the labor market, since variations in the demand for energy can almost instantly be enforced. The only question that arises is if whether some deviations from the energy consumption trend can be attributed to variations in

the energy efficiency, costs and availability in some industries; namely, variations in relative prices.

The contribution of labor to GDP is somewhat more straightforward in Argentina given the information availability constraints and, forcing the consideration of a few reliable variables to make adjustments. If unadjusted labor is considered, its contribution to the 2.7% GDP growth is 0.82 p.p. Unadjusted labor accounts only for variations in the work force, and does not take into consideration variations in improvements in the quality of labor. There are several methods to adjust labor for quality and utilization. Some examples are measures of hours worked and average years of schooling or maximum education attained. Although reliable information on these variables exists for the period of the last fifteen years, the reliability of the series extending back to 1960 is questionable, since data gathering methodology has changed over the years (for better and worse) and in some cases information was not gathered every year. In the case of data for average hours worked, information is not available for the whole period of time and distortions arise from the varying power of labor unions; in most unionized industries, the number of hours worked a week has fallen but overtime hours worked is not considered in the data, leading to conclusions that overestimate the utilization of production capital. When series of hours worked is considered to adjust labor from 1990 to 2008, there is no significant effect on the contribution of labor to growth. The only significant adjustment to labor considered was a Hodrick-Prescott cycle adjustment. When the labor contribution to GDP growth taking into consideration the adjustment for cycles is calculated, the result is 0.84 p.p. of the 2.7% GDP growth average. Percentage-wise, it is a 31% contribution to growth.

With respect to quality adjustments to labor, and in the case of years of schooling, information is not available for the whole 1960-2008 period. Real wages is another source of labor adjustment. Balassa-Samuelson theory indicates a straightforward relationship between real wages and productivity. However, as it was mentioned before, the reliability of data is dubious in a market as rigid and regulated by the government and labor unions as the labor market in Argentina. Internal shocks and imbalances have distorted real wages to the point where there may well not be a relationship between real wages and productivity of the work force.

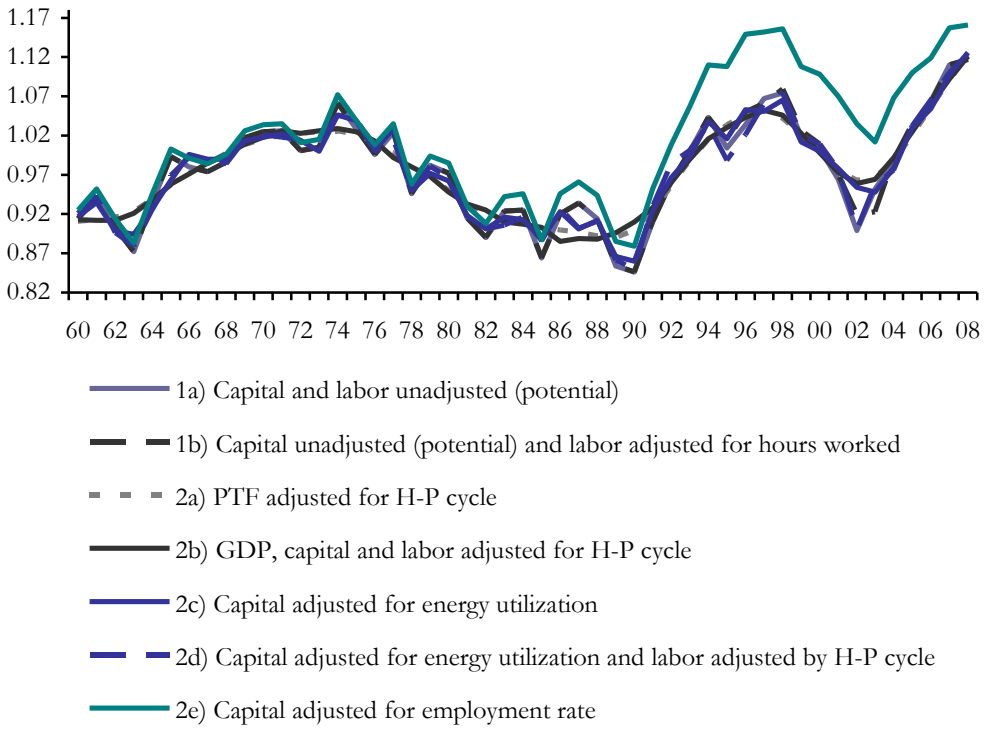
The combination of the three measurements of capital and the three measurements of labor produce seven different measures of TFP in Argentina. The first case is unadjusted capital and labor, where TFP accounts for 0.50 p.p. of the 2.7% GDP growth average, or 19%. The results when labor is adjusted for hours worked are identical. In these first measures, variations in TFP contribute to GDP growth more than variations of labor and capital. Considering labor unadjusted and adjusted for hours worked and adjustments to capital solely based on economic cycles using a Hodrick-Prescott filter, TFP contribution marginally increases to 0.49 p.p., or 18% of GDP growth. If capital is adjusted for utilization based on energy consumption, TFP is 0.55 p.p., or 20%, and the contribution of capital increases from to 1.36 p.p., since capital is used more intensively as indicated by deviations of energy consumption from a long-term trend. When capital is adjusted for the employment rate, TFP yields the highest contributions at 0.61 p.p., reducing the contribution of capital to 1.29 p.p. (23% and 48% of GDP growth, respectively), implying that capital has been underutilized and that some of the variations that were attributed to capital growth should be attributed to TFP. In all cases, TFP variations contributed the most to GDP growth in Argentina, followed by capital variation.

The evolution of the seven TFP series are shown in Figure 4, and a detail of the 3 favored TFP series is depicted in Figure 4B: (1b) Capital unadjusted (with labor adjusted for hours worked since 1990), (2b) Capital, GDP and labor adjusted for H-P cycle, and (2d) capital adjusted for energy utilization and labor adjusted for H-P cycle.

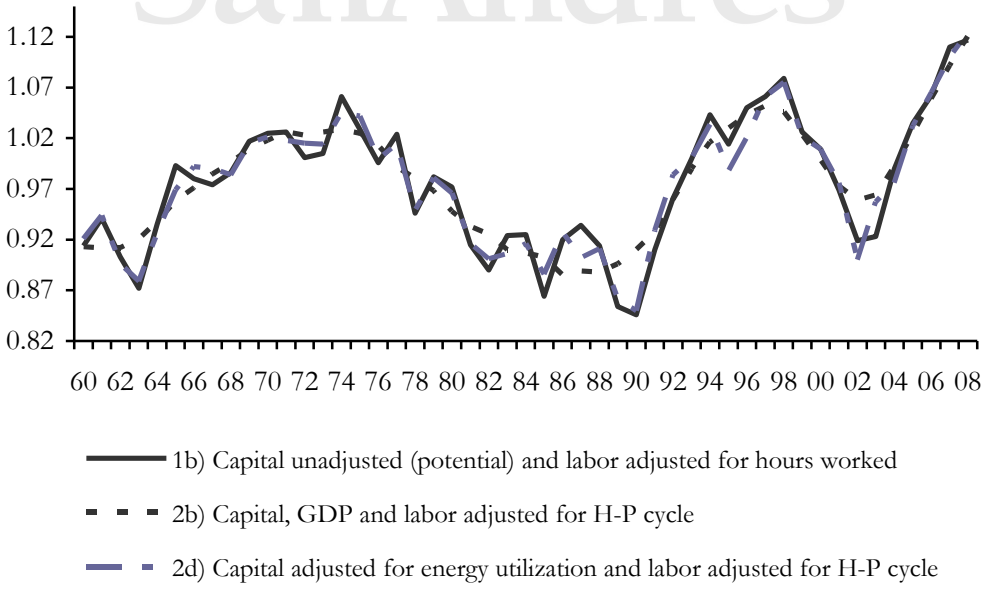
In Figure 4, two clusters of TFP measurements can be identified, corresponding to two sets of data of capital: employment rate adjusted and the rest of adjustments. In the first case, TFP values are consistently higher, and it is clear that adjusting capital using the employment rate is overestimating TFP.

FIGURE 4

(A) TFP MEASURES IN ARGENTINA, 1960-2008 (Index: 1960=100)



(B) FAVORED TFP MEASURES IN ARGENTINA, 1960-2008
(Index: 1960=100)



Based on these results and the considerations for the proposed adjustments, three combinations of measurements will be further analyzed: unadjusted capital and labor adjusted for hours worked; GDP, capital and labor cycle adjusted with an H-P filter; and capital utilization adjusted for energy consumption and labor cycle adjusted using an H-P filter. Table 6 and Figure 5 report the factor contribution for each of the three selected combinations in each economic cycle.

TABLE 6

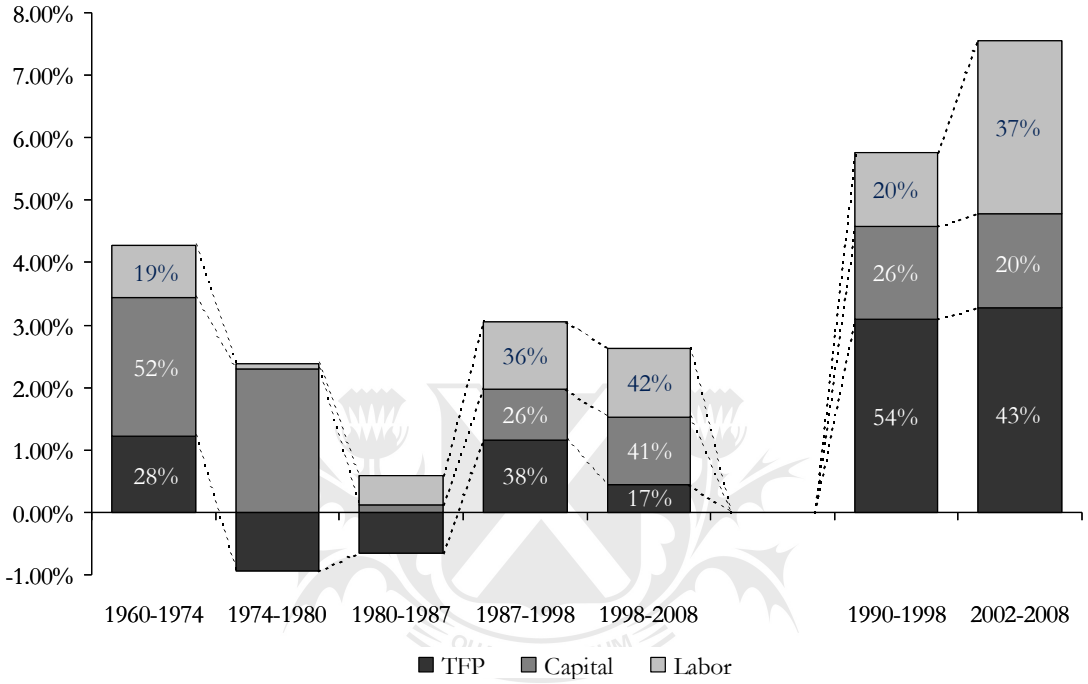
SOURCES OF GDP GROWTH IN ARGENTINA IN EACH ECONOMIC CYCLE IN ARGENTINA, 1960-2008

	GDP Growth	Contribution of labor growth	Contribution of capital growth	Contribution of TFP growth
1) Unadjusted capital and labor adjusted for hours worked				
1960-1974	4.27%	0.83%	2.23%	1.21%
1974-1980	1.43%	0.07%	2.30%	-0.94%
1980-1987	-0.08%	0.47%	0.12%	-0.66%
1987-1998	3.06%	1.09%	0.81%	1.16%
1998-2008	2.63%	1.10%	1.08%	0.45%
1990-1998	5.74%	1.18%	1.48%	3.09%
2002-2008	7.55%	2.77%	1.50%	3.28%
2) GDP, capital and labor adjusted for H-P cycle				
1960-1974	4.26%	0.86%	2.19%	1.22%
1974-1980	1.44%	0.01%	2.15%	-0.73%
1980-1987	-0.09%	0.52%	0.14%	-0.74%
1987-1998	3.03%	0.97%	0.82%	1.24%
1998-2008	2.60%	1.31%	1.08%	0.21%
1990-1998	5.73%	0.88%	1.28%	3.57%
2002-2008	7.58%	1.96%	1.33%	4.29%
3) Capital adjusted for energy utilization and labor adjusted for H-P cycle				
1960-1974	4.27%	0.86%	2.35%	1.06%
1974-1980	1.45%	0.01%	2.17%	-0.73%
1980-1987	-0.04%	0.51%	0.42%	-0.97%
1987-1998	3.06%	1.02%	0.62%	1.42%
1998-2008	2.64%	1.26%	0.83%	0.55%
1990-1998	5.74%	0.95%	1.82%	2.98%
2002-2008	7.57%	1.93%	1.93%	3.71%

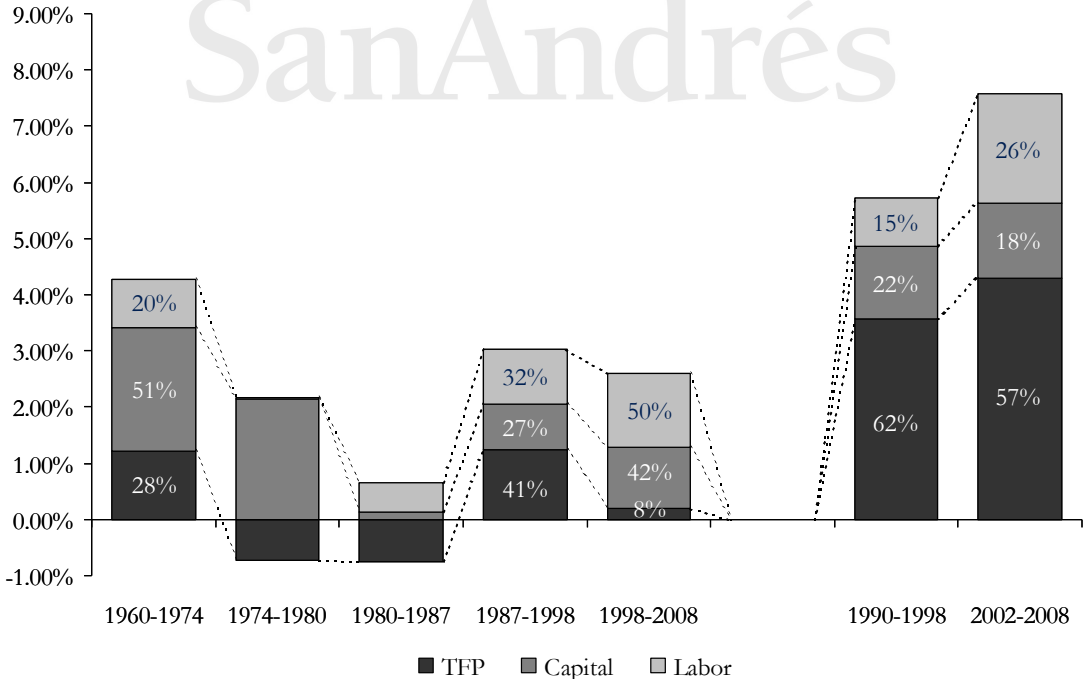
FIGURE 5

SOURCES OF GDP GROWTH IN ARGENTINA IN EACH ECONOMIC CYCLE IN ARGENTINA, 1960-2008

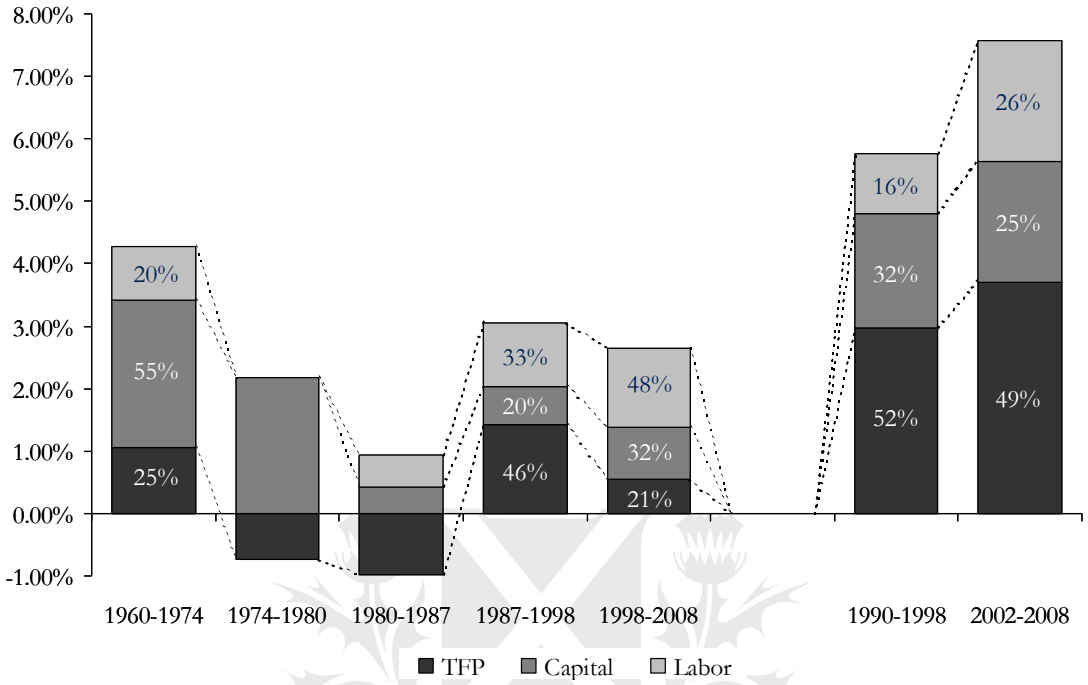
(A) Unadjusted capital and labor adjusted for hours worked



(B) GDP, capital and labor adjusted for H-P cycle



(C) Capital adjusted for energy utilization and labor adjusted for H-P cycle



When analyzing the factor contribution breakdown in the seven defined economic cycles, different patterns arise. In the first and second cycles, 1960-1974 and 1974-1980, capital growth is the predominant factor contribution to GDP growth, accounting for more than 50% of GDP growth. This is consistent with a period of considerably stable growth (4.3% and 1.4% GDP growth, respectively). Furthermore, this period can be characterized by a steady capital growth trend, averaging 4.3% inter-annual growth rate –versus 2.6% average growth for the whole 1960-2008. TFP is the second factor contributor to growth between 1960 and 1980, accounting for approximately 25%-28% of total growth. The 1974-1980 period is characterized by virtually no contribution of labor to GDP growth, while TFP contributed negatively.

The end of the 1974-1980 economic cycle gives way to the worst economic cycle in Argentinean history: 1980-1987. GDP growth averages -0.1% throughout the period and capital accumulation shrinks to only 0.4% per year. Labor contribution is 0.5 p.p. of growth, higher than that of capital and TFP. Again, TFP growth contribution in the period is negative. This dynamic could have several sources, but negative external economic shocks, major political instability, poor monetary policies and a hyperinflation process in the 1980's could

account for most of the explanation. In the following section, the determinants of TFP will be studied; however, the dynamic exhibited by TFP in the period 1980-1987 forces a study on its own.

The period 1987-1998 can be characterized by the rise and fall of an economic and monetary policy that was introduced in 1991 to stabilize a knocked down economy and then maintained to sustain the status quo at the expense of increasing unemployment, inability to exercise monetary policies and mounting external debt. Average GDP growth from 1987 to 1998 was 3.1%, marking the overall success of the economic policies introduced to recover the economy. The Tequila and Russian crises of 1995 and 1998 stressed tested Argentina's ability to access external capital markets in bear sovereign debt markets. By the Russian crisis, the fate of the economy was already sentenced by the end of an economic model based on a hard peg and liquid external debt markets. From 1999 to 2001, prior the devaluation and crisis, the economy contracted on average 2.6% per year. Capital and labor growth rates are among the lowest of the periods analyzed, at 1.6% and -1.5% (considering hours worked). Between 1987 and 1998, TFP , between 38% and 46% to growth, the highest for the periods analyzed. Although there is a strong recovery in the capital accumulation trend, labor continues to second TFP in contribution to GDP growth, at between 33% and 36%.

The last cycle, spanning from 1998 to 2008, is characterized by mixed GDP growth at 2.6% yearly average. Capital contribution increases to between 32% and 42% of GDP growth. These results can have several interpretations. Adjusting the capital series for utilization with a Hodrick-Prescott filter involves penalizing or rewarding capital contribution based on deviations of the capital accumulation long-term trend. The main interpretation is that most of the pre-existing capital in the period was utilized more intensively, and that result can be seen more clearly in the 2002-2008 cycle. A worrying conjecture would be that the exhibited growth in the period was fueled by a more intensive utilization (and overutilization) of the existing capital and not by actual physical capital growth. A worst case scenario would involve the risk of unsustainable growth under the assumption that the overutilization of pre-existing capital greatly contributes to growth. Political and institutional instability as well as general competitiveness are major contributors to the process of capital accumulation. Some of the largest companies in Argentina are beginning to reinstate investing policies they had taken during and after the 2002 crisis; namely, disinvesting by not investing over the depreciation of

physical capital or imposing minimum repayment limits of less than 1 year to investment projects. TFP exhibits the greatest contribution to growth between 1990 and 2008, but the highest is recorded in the 1990-1998 period (52% to 62%). The determinants of TFP growth will be analyzed in the following section; however, the period 2003-2008 is characterized by strong growth fueled by outstanding external conditions, booming commodity prices and a diminishing improvement in competitiveness from the undervaluation of the peso.

VI. TFP DETERMINANTS

The considerable volatility exhibited by the different measures of TFP in the 1960-2008 period in Argentina leads to an in-depth analysis of the determinants of TFP in Argentina using econometric analysis. Two types of variables were considered as candidates for determinants of TFP: macroeconomic and socio-political. It is valid to assume that swings in Argentina's growth path can be attributed to either type of variable, with a special consideration for political variables, given the checkered modern political history in Argentina. Macroeconomic variables should reflect the effectiveness of economic policies, affecting the overall efficiency of the economy.

The cyclical behavior of TFP exhibited in the previous sections motivated the inclusion of pro-cyclical macroeconomic variables, namely terms of trade (absolute and relative to Latin American countries) and real exchange rate undervaluation. Terms of trade measures the competitiveness of Argentina's exports *vis a vis* other countries exports. It is hypothesized that positive shocks in this variable should have explanatory power on the variability of TFP. Real exchange rate undervaluation is a measure of the deviation of the real exchange rate in any given period over the equilibrium real exchange rate over the entire period. Departures of the real exchange rate are important measures of the general competitiveness of Argentina's economy, its exports and the pull forces that drive investments in production. The evolution of the terms of trade and real exchange rate undervaluation variables (in logarithms) can be appreciated in Figure 6.

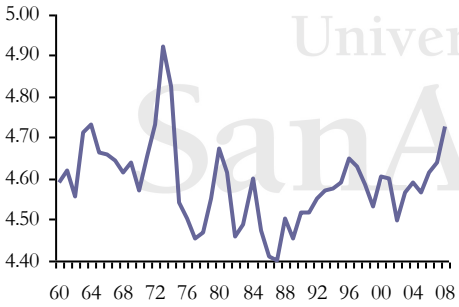
Political variables that affect the behavior of the economy are included in the model as well; however, the difficulty lies in the inherently qualitative nature of the object of measurement (political performance). The first political variable included in the model is a

measure of macroeconomic instability based on inflation. Inflation has been the heartbeat of Argentina's economy and the fingerprint of macroeconomic policies. On that hypothesis, macroeconomic instability is defined as the inverse of the inter-annual inflation rate in each period. For the 2006-2008 period, real inflation has been considered, given the gap between official and real inflation[2]. On the other hand, the strictly political variables considered were conservative and as least controversial as possible. There are several political indicators that may be considered valid (Liberty Index, for example), but given their intensive reliance on qualitative variables and subjective considerations, their reliability for this exercise is dubious. On that note, the only political variables considered were two dummy variables accounting for years when a change of President occurred and the presidential term had not yet ended (coup d'état, death, etc.) and another accounting for years when a Minister of Economy was sacked. The evolution of these political indexes is also depicted in Figure 6.

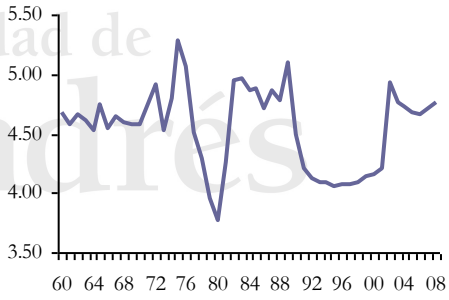
FIGURE 6

INDEPENDENT VARIABLES FOR TFP IN ARGENTINA, 1960-2008

Terms of trade (Log)



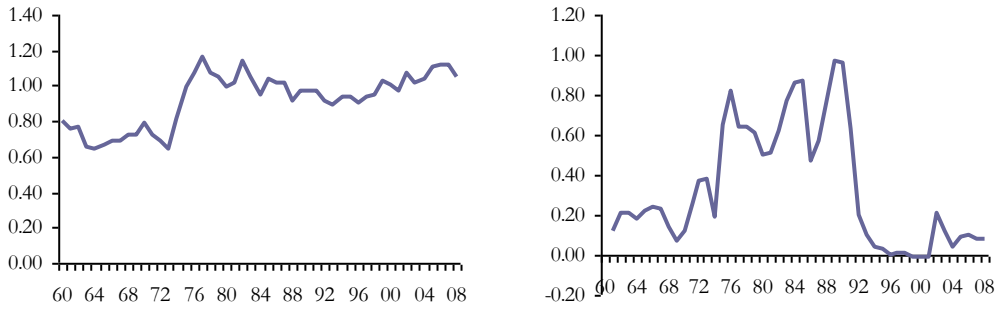
Real exchange rate undervaluation (Log)



Relative Terms of Trade (Index)

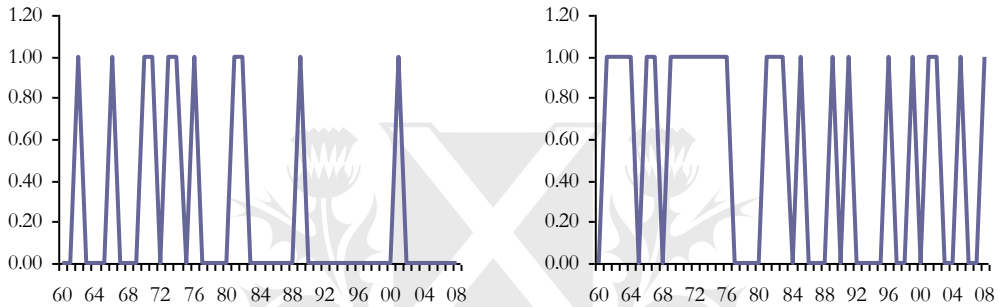
Macroeconomic instability (Index)

[2] Inflation according to private estimations



President change (Dummy)

Minister of Economy sack (Dummy)



The econometric model was constructed with TFP in logarithms as the independent variable, using the TFP series resulting from GDP, capital and labor adjusted for H-P cycle and labor adjusted for hours worked. Only one measure of TFP was considered, given the close correlation between all and the preference for the adjustment using an H-P filter over adjustments based on energy consumption or the employment rate. The variables in Figure 6 were included as explanatory, although the relative terms of trade and President change are rejected for not being statistically significant at a 10% level. The interaction between variables and their lags is unknown and suspected valid, reasons to include the lags of explanatory variables in the model. TFP behavior is also supposed to have inertia and lags of the dependent variables are considered in the model.

Table 7 reports the coefficients and standard deviations of regressors and R squared and standard deviations of the regressions. The fit of the models is high, explaining 73% of the variance of the dependent variable. Explanatory variables are all statistically significant at 10% level at the minimum level. Residuals of the models pass the normality and Q tests. Models

pass the CUSUM stability tests as well as the Durbin-Watson serial correlation statistic. Since the models are specified with lagged variables, the Durbin-Watson test can yield flawed results, so testing is extended to the Breusch-Godfrey Serial Correlation LM test and it is passed. White's heteroskedasticity test is also passed. A unit root is detected on TFP, making the inclusion of a lag of the dependent variable as a coefficient a practical solution.

In the model, all coefficient signs have the expected signs. Terms of trade and real exchange rate undervaluation have a positive effect through greater competitiveness on TFP, although the positive effect is only observed on the second lagged coefficient. In the political and institutional variables, the negative effect on TFP of macroeconomic instability and Ministry of Economy sack is uncovered.

TABLE 7

ESTIMATION OF TFP DETERMINANTS IN ARGENTINA, 1960-2008

	TFP (GDP, capital and labor adjusted for H-P cycle)
Cyclical variables	
Terms of trade (t-2)	0.045
	(0.03)
Real exchange rate undervaluation (t-2)	0.038
	(0.02)
Policies and institutions	
Macroeconomic instability	-0.087
	(0.02)
Ministry of Economy sack	-0.032
	(0.01)
Initial conditions	
TFP (t-1)	0.701
	(0.09)
Adjusted R-squared	0.732
S.E. of regression	0.04

Note: All variables are statistically significant at 10% level. Standard errors are reported in parenthesis. Model residuals pass the normality test and Ljung-Box Q-statistic. The serial correlation null hypothesis is rejected by the Durbin-Watson statistic and Breusch-Godfrey Serial Correlation LM test. The ARCH LM test rejects the null hypothesis of heterosedasticity

Regarding the weights of the coefficients, the first lag of the dependent variable has the greatest effect on TFP, revealing considerable TFP inertia with a coefficient of .70. The interpretation is that a variation of 1 p.p. in TFP in the first period will contribute to TFP

variation in the next period by roughly 0.7 p.p.. Macroeconomic instability has the second greatest effect on TFP with a negative coefficient of .09: an increase of 1 p.p. in macroeconomic instability leads to a 0.09 p.p. decrease in TFP growth. The lagged coefficients for terms of trade and real exchange rate undervaluation follow with positive coefficients of .05 and .04, respectively. The Ministry of Economy sack variable has the smallest effect, at -.03.

Considering the macroeconomic instability index, it is interesting to uncover the interacting forces between inflation (implicit in the macroeconomic instability variable) and real exchange rate undervaluation: the effect of a 1 p.p. positive variation in economic instability is greater than a 1 p.p. positive variation on real exchange rate undervaluation in both models; i.e., TFP decreases if the increments in economic instability and real exchange rate undervaluation are equal in magnitude. The remaining question is, however, which is the predominant force. It is clear that exchange rate devaluations or depreciations with no inflationary consequences have positive effects on TFP in the next periods through improvements in real exchange rate. However, if the inflation pass-through of devaluation is considerable, the resulting effects on TFP will certainly be negative, since the negative effect of inflation in the first period might be greater than the benefits of real exchange rate in the next periods.

Table 8 reports the contributions of each independent variable to TFP growth and the values of predicted TFP growth by the model compared with actual values. The first appreciation is the fairly solid predictive power of the model. Actual TFP growth in the 1960-2008 period is 0.46%, while growth as predicted by the model is underestimated at 0.37%, a 20% error. Actual TFP growth in 1990-1998 and 2002-2008 is 3.57% and 4.29%, respectively; while predicted growth is 2.35% and 2.54%, underestimating TFP growth by 34% and 41%. An explanation of the explanatory power of the model between periods relies on the greater significance of the variables in the latest economic cycles compared to the whole period.

TABLE 8

SOURCES OF TFP GROWTH IN ARGENTINA, 1960-2008, 1990-1998 and 2002-2008

	TFP (GDP, capital and labor adjusted for H-P cycle)		
	1960-2008	1990-1998	2002-2008
Average TFP growth			
Actual	0.46%	3.57%	4.29%
Predicted	0.37%	2.35%	2.54%
Contribution of cyclical variables			
Terms of trade	0.00%	0.10%	0.01%
Real exchange rate undervaluation	0.01%	-0.48%	0.35%
Contribution of policies and institutions			
Macroeconomic instability	0.02%	0.71%	0.07%
Ministry of Economy sack	0.00%	0.00%	-0.64%
Contribution of initial conditions			
TFP (t-1)	0.34%	2.02%	2.75%

VII. CONCLUSIONS

This paper contributes to Argentina's growth literature in several aspects:

1. A cycle adjusted capital and TFP series extending from 1960 to 2008 based on the capital series proposed by Heymann, et al (2007). The series was extended using data provided by Ariel Coremberg, GDP was adjusted based on more conservative private estimations and labor was adjusted using hours worked. Factor utilization was adjusted for using a Hodrick-Prescott filter.

2. The reconciliation between perpetual inventory and hedonic prices methodologies to construct capital series in Argentina, showing that even though the difference in levels between the two series is significant, the inter-annual percentage change correlation is high. However, there is a clear underestimation of the growth trend of capital in the perpetual inventory methodology, calling the attention on the fact that the assumptions made on the geometric depreciation model might be off (evidenced by the high capital to GDP ratio yielded by the perpetual inventory model). A continuation of the work

done in this paper should include the full reconciliation of both methodologies to uncover the reasons for the gap between the two, acknowledging that both are *estimations* and the final purpose is to obtain a reliant series. However, the work done enables a comparison of Argentina's growth a factor contributions since 1960 with other countries.

3. The capital series adjusted for utilization (1) based on deviations from a Hodrick-Prescott capital accumulation trend, (2) based on deviations of energy consumption from a long-run consumption trend and (3) based on the employment rate. The adjustments for utilization are particularly useful to analyze the dynamics of capital contribution to growth in post-recessionary environments with scarce capital investments and considerable growth, particularly the 2002 Argentinean crisis, where capital's contribution to growth is underestimated if it is not adjusted for utilization. However, special care has to be taken using energy and employment rate adjustments, given the existence of distortions in their respective markets

4. The analysis of the Argentinean economy's GDP growth and the validation of five economic cycles from 1960 to 2008, matching almost perfectly the five economic and political "moments" in recent Argentinean history: (1) 1960-1974 with 4.3% average GDP growth, (2) 1974-1980 with 1.5%, (3) 1980-1987 with -0.1%, (4) 1987-1998 with 3.0% and (5) 1998-2008 with 2.4%. The cycles where identified by measuring the deviations of the actual GDP growth series from a GDP trend constructed using a Hodrick-Prescott filter.

5. Seven different measures of sources of growth were constructed from the combinations of the adjusted and unadjusted capital and employment series. Three of these measures were preferred for an in-depth analysis: (1) unadjusted capital and labor adjusted for hours worked; (2) GDP, capital and labor cycle adjusted with an H-P filter; and (3) capital utilization adjusted for energy consumption and labor cycle adjusted using an H-P filter. With average GDP growth at 2.7% in the 1960-2008 period, capital is the greatest contributor at an average 1.4%, labor at 0.8% and TFP at 0.5% (51%, 31% and 18%, respectively).

6. The factor contribution is derived for the three selected measures of capital and employment for the five identified economic cycles. Not surprisingly, TFP is the

greatest contributing factor to GDP in two of the cycles with greatest growth (1987-1998 and 1998-2008). Capital contribution varies between cycles, predominating in 1960-1974, 1974-1980 and 1998-2008. Labor contribution is only significant in the last two cycles (1987-1998 and 1998-2008), accounting for between 32 and 50% of growth, exceeding capital for the first time and evidencing the lagging capital accumulation in the periods.

7. Using econometric analysis, the determinants of TFP growth were uncovered for the 1960-2008 period. A model was constructed using TFP based on adjusted capital. It proved to be robust, prioritizing parsimoniousness. Cyclical and political and institutional variables and their lags were considered, as well as lags for the dependent variable. The lagged variable for the dependent variable proved to be the greatest determinant. Regarding the independent variables, macroeconomic instability was the greatest determinant of TFP.

8. An evaluation of the model was done using the actual values to analyze the contribution of the variations of each variable to TFP growth. The model proved to have very good predictive power, although the adjustment to recent cycles was lower than the whole period. Special attention was paid to the 1990-1998 and 2002-2008 periods, yielding interesting results. A dominance of institutional variables over cyclical ones is exhibited. In 1990-1998, TFP was benefited by a stable economy, increasing TFP growth by 0.7 p.p. (30% of total growth); however, real exchange rate overvaluation resulting from the hard peg of the peso resulted in a negative effect that reduced TFP by 0.5 p.p. In 2002-2008, the impact from economic stability was null (given the lack of it), but a mild benefit from an exchange rate undervaluation (0.35 p.p. or 14% of TFP growth).

9. Improvements in real exchange rate undervaluation and terms of trade in 2002-2008 proved to be partially successful. However, all positive effects from improvements are offset by declines in institutional variables: macroeconomic instability and Ministry of Economy sack. A lesson learned for the next economic cycle would imply to focus on overall exchange rate undervaluation but strict monetary and political stability. The implementation of a really independent Central Bank, an effective inflation targeting

methodology and fiscal responsibility legislation would generate the basic environment for sustained growth.

VIII. REFERENCES

Barro, R. (1998). "Notes on Growth Accounting", *Discussion Paper, Harvard University*.

Coremberg, A. (2005). "The measurement of TFP in an Unstable Economy: Argentina 1990-2004", *International Productivity Monitor, Fall 2008*.

Coremberg, A. (2009). "The measurement of the Sources of Growth in an Unstable Economy: Argentina", *Studies and Perspectives, CEPAL, Vol. 41.*.

Coremberg, Goldszier, Heymann and Ramos (2007). "Investment and savings patterns in Argentina", *Development Macroeconomics, CEPAL, Vol. 63*.

Costello, D. M. (1993). "A Cross-Country, Cross-Industry Comparison of Productivity Growth", *Journal of Political Economy*, 101(2), 207-222.

Fuentes, R., M. Larraín and K. Schmidt-Hebbel (2006). "Sources of Growth and Behavior of TFP in Chile", *Cuadernos de Economía, Central Bank of Chile*, Vol. 43 (May), 113-142.

Greenwood, J. and B. Jovanovic (2000). "Accounting for Growth", *Working Paper No. 475, Rochester Center for Economic Research, University of Rochester*.

Hulten, C. and J. Wykoff (1981), "The Estimation of Economic Depreciation using Vintage Asset Prices", *Journal of Econometrics*, 15.

Hulten, C. (1991). "The Measurement of Capital", *Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth*, Chapter 4, 119-158.

Jorgenson, D. W. and Z. Griliches (1967). "The Explanation of Productivity Change", *The Review of Economics Studies*, 34(2), 249-80.

Maia, J. L. and P. Nicholson (2001). "Capital Stock and Total Factor Productivity in Argentina", *Dirección Nacional de Coordinación de Políticas Macroeconómicas*.

Schmidt-Hebbel, K. (2006). "Chile's Economic Growth", *Cuadernos de Economía, Central Bank of Chile*, Vol. 43 (May), 5-48.

Solow, R. (1957). "Technical Change and the Aggregate Production Function", *Review of Economics and Statistics*, 39 (August), 312-20.