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TERMS OF TRADE AND ECONOMIC GROWTH IN ARGENTINA

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Terms of Trade and Economic Growth in Argentina
By Daniel Artana, Enrique Bour, Juan Luis Bour and Nuria Susmel August, 2011

We define the terms of trade (of both goods and services) as an index of Price of Imports (P_M) divided by the Index of Export Prices (P_X). Then, following the usual approach, foreign trade is a sort of technology in which inputs of the country are exports (X) and products are imports (M)[1]. Inputs are processed into products at a rate determined by the relationship between the price of exports and imports, which is the inverse of the terms of trade. From such a point of view, declining terms of trade, as experienced by Argentina in recent years, act exactly as a *technological shock*, since a given quantity of exports can produce a greater volume of imports. Becker and Mauro (2005) have computed for a sample of several countries that the costlier shocks correspond to the terms of trade. Easterly and others (1993) express that "shocks, especially those to terms of trade, play a large role in explaining the variance in growth," thereby contributing to its unstable character.

There is some evidence that the correlation between changes in the terms of trade and real GDP is significant. Kehoe and Ruhl (2007), for example, have pointed that this number ranges between -0.30 for the U.S. and -0.73 for Mexico. It seems that the correlation with changes in the TFP has been even stronger (amounting to -0.54 and -0.71, respectively). However, the same authors have stressed that this effect is not a *first order effect* when the product is measured as a chained index, because if the GDP is measured using a fixed base year (as in Argentina) the effects are ambiguous, even when they may have an impact on consumption and welfare.

Kehoe and Ruhl identify here a puzzle: the increase in the terms of trade is frequently accompanied by declines in productivity, so that, "If there is a causal mechanism that links shocks to the terms of trade to movements in productivity, researchers need to identify it."

In this article we will measure the magnitude of the potential gains associated with the decrease in the terms of trade in terms of productivity, and seek to find a *theory compatible with the observed facts that could be used to explain a first-order effect on GDP measured, as in Argentina, according to a fixed basket of goods and services*.

1. Towards an explanatory theory

[1] Take, for example, Kohli (2004), pointing that "the economic performance of Switzerland over the long run is paradoxical. In most international comparisons, Switzerland is found to have a growth rate that is significantly lower than that of other industrialized nations. And yet, in terms of average living standards, Switzerland always ranks among the top nations. How can Switzerland go slower than everybody else, and nonetheless stay ahead?... The answer to this puzzle has to do, at least partially, with the improvements in the terms of trade that Switzerland has enjoyed over time. From 1980 to 1996, for instance, Switzerland's terms of trade have improved by a stunning 34%. In many ways, an improvement in the terms of trade is similar to a technological progress. It means that, for a given trade-balance position, the country can either import more for what it exports, or export less for what it imports. Put simply, it makes it possible to get more for less. An improvement in the terms of trade unambiguously increases real income and welfare. Yet, unlike a technological progress, the beneficial effect of an improvement in the terms of trade is not captured by real GDP, which focuses on production per se. In fact, if real GDP is measured by a Laspeyres quantity index, as it is still the case in most countries, an improvement in the terms of trade will actually lead to a fall in real GDP." Similarly, in Diewert (2008b), "many observers have noted that an improvement in a country's terms of trade has effects that are similar to an improvement in a country's productivity growth."

The results of the literature generally involve some assumptions that must be reviewed in the case of Argentina.

First, one might assume that the starting point for the recovery of Argentina in 2002 was not a situation of full employment but of deep unemployment of labor (not only open but also through workfare plans named Jefes y Jefas). There was also a low use of the installed capacity of capital according to statistics kept by FIEL, successfully used in an earlier project to represent a usage rate of productive capital (excluding capital in housing). Therefore, increases in public spending and in monetary supply did not have a significant impact on inflation and – in a context of favorable expectations of consumers – allowed an important expansion of production. But more recently the situation has changed, as exemplified by the manipulation of official price indexes.

Second, it must be remembered that the expansion of domestic absorption took place without significant changes in utilities' prices (which deteriorated in real terms by about 70% in the period December 2001-December 2009). Normally, with higher world prices of crude oil, prices of transport, electricity and of other services would have increased in real terms. The Federal government opted to subsidize all consumers with a budget cost that rose from 1% of GDP in 2005 up to 3% of GDP in 2009, and by reducing the price received by domestic suppliers of crude oil, natural gas and electricity. However, large consumers had to pay higher prices and since 2008 onwards high-consumption residential users face additional energy costs, but in any case prices are much lower than long-term marginal costs.

Third, it should be noted that Argentina's trade balance has been positive and growing continuously, thanks to the "tail wind" of the global context. However, amidst a relatively poor business climate, this trade surplus financed capital flight and Argentina was able to locate itself as a "trade surplus country" as well as a "capital-exporting country", enabling it to respond to increased domestic demand for intermediate and capital imports caused by the "good luck" caused by the decreasing terms of trade (to use the same terms *good policy and good luck*, as in Easterly and others, 1993). This could help to improve factor productivity, but quantitative restrictions on imports, which aggravated during the 2009 recession, may have eroded this positive effect, although so far, most controls were applied to imports of consumer goods.

In this section we intend to present a theory of the behavior of total factor productivity and terms of trade along the past decade in Argentina, and subject it to an econometric test. Our *a priori* belief is that a significant portion of recent economic growth can be attributed to an exogenous factor, that is, the more reduced and favorable terms of trade faced by Argentina since 2003[2].

2. Some assumptions and stilized facts in the literature

We follow the modern literature on productivity and price indexes as reviewed in Diewert (2005; 2006; 2008b). The economic approach to price indexes relies on the assumption of competitive, optimizing behavior on the part of economic agents (consumers or producers). We will include the whole of the economy – it should be stressed that in FIEL (2002)[3], we considered only the "business sector", maintaining separate accounts for the agricultural sector[4]. It would have been better to focus on the business sector but the available data did not allow us to do it. For

[2] The negative effect on productivity subsists given the anti-export bias of trade restrictions.
[3] In 2002 we excluded the agricultural sector from the global accounts, that is now included.
[4] In fact, we will include the entire residential housing stock and the consumption of residential housing services in the data. This is an important difference with our previous treatment in FIEL (2002).

example, for owner occupied housing, output is equal to input and hence no productivity enhancements can be generated in this sector according to SNA conventions. There are similar problems to measure productivity in government.

We assume that the market sector of the economy produces several (net) outputs, which are sold at positive producer prices. If a particular commodity is an import into the economy, we will follow Feenstra (2004) in assuming that imports flow through the domestic production sector and are “transformed” (perhaps simply by adding transportation, wholesale and retailing 3
margins) by the domestic production sector.

It is customary to assume constant returns to scale on the technology sets of the economy. We successfully tested this hypothesis in 2002, which implies that the value of outputs will equal the value of inputs in every period. Our focus will be total output. Since total production is distributed to the used factors of production, nominal sector GDP will be equal to nominal sector income. As an approximate welfare measure that can be associated with production, one can choose to measure the real income generated by the sector in period *t*, in terms of the number of consumption bundles that the nominal income could purchase in period *t*. This definition is not sensitive, moreover, to the distribution of income generated by the sector. Following Kohli (2004) and Diewert (2008), one obtains that GDP in period *t*, evaluated at period *t* real output prices and period *t* input vector, gives period *t* real income. Thus, *the growth of real income over time can be decomposed into three main factors: Technical Progress or Total Factor Productivity, growth in real output prices and growth of primary inputs (capital and labor)*. In this section we will concentrate on the first and last drivers, for the following reason: As is well known, Technology Growth and Efficiency are regarded as two of the biggest sub-sections of Total Factor Productivity, the former possessing "special" inherent features such as positive externalities and non-rivalness which enhance its position as a driver of economic growth. Total Factor Productivity is often seen as the real driver of growth within an economy and studies reveal that whilst labor and investment are important contributors, Total Factor Productivity may account for up to 60% of growth within economies. During the Convertibility period in Argentina, TFP grew 58% from 1992 up to 1998 and 113% cumulative when compared with 1990, the year of lowest productivity of the decade. This implied eight years with a cumulative growth of TFP at 9.9% a year.

As stressed by Stiroh (2001) both neoclassical and “new growth” theories explain the recent rise in U.S. productivity growth. While TFP is a methodological construct essentially exogenous for the former theory, within the second strand there are several contributions: If aggregate technology is specified as $Y_t = A(R).\ f\ (K_t,\ L_t,\ R_t)$ where R is aggregate “stock of knowledge”, Arrow (1962) emphasizes “learning-by-doing” in which investment in tangible assets generates spillovers as aggregate capital increases; past gross investment proxies for experience and determines *A (.)*. Romer (1994) essentially models *A (.)* as a function of the stock of R&D, Lucas (1988) models *A (.)* as a function of the stock of human capital, and Coe and Helpman (1995) argue that *A (.)* also depends on the R&D stock of international trading partners.

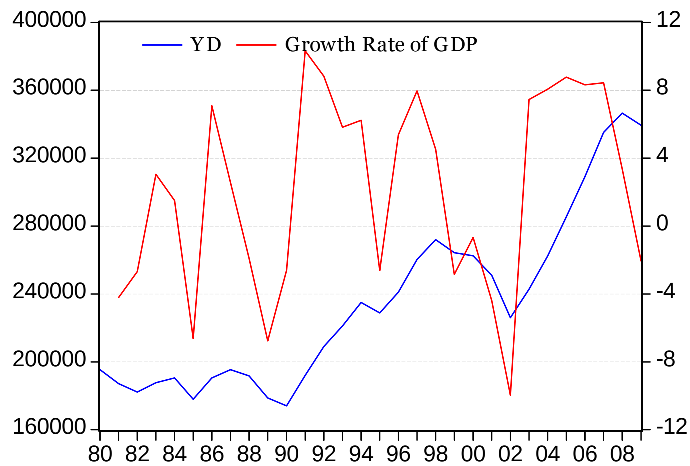
Recently, there has been new research on the channels through which terms of trade and TFP interact. A recent paper by Cavalcanti Ferreira et al. (2010), has two objectives. The first one is to estimate the structural changes in TFP for a sample of 77 countries between 1950(60) and 2000. A substantial part of the disparities in output levels can be partially explained by physical capital and education, but the largest part of these differences are explained by the Solow residual, that is, the TFP. The second one is to identify possible explanations for breaks. Two sources were analyzed: (i) episodes in political and economic history; (ii) changes in international trade - a measure of absorption of technology. The results suggest that about one-third of the TFP time-series present at least one structural break. Downwards breaks are more common, indicating that after a break the TFP has much difficulty to recover; developing countries' breaks are more spread along the decades. Last, the relevance of international trade, measured by trade share percentage of GDP, does not explain abrupt changes in TFP. Using structural breaks technique, Ben-David and Papell (1998) proposed a test for determining the significance and the timing of slowdowns in economic growth, showing evidence that most industrialized countries experienced postwar growth slowdowns in the early 1970s, and that developing countries, in particular Latin American countries, tended to experience even more severe slowdowns.

Another paper by Mendoza (1995) is more concerned with the relationship between terms of trade and economic fluctuations. According to his findings, terms-of-trade shocks account for nearly half of actual GDP variability. But what can be said about the structure of trade and growth? Lederman and Maloney (2003) have addressed this question through an examination of the empirical relationships between trade structure and economic growth, particularly the influence of natural resource abundance, export concentration and intra-industry trade. The paper tests the robustness of these relationships across proxies, control variables and estimation techniques. They find trade variables to be important determinants of growth, especially natural resource abundance and export concentration. In contrast to much of the earlier literature, natural resource abundance appears to have a positive effect on growth whereas export concentration hampers growth, even after controlling for physical and human capital accumulation, among other factors. They find that regardless of estimation technique, trade structure variables are important determinants of growth rates and hence probably should be in the conditioning set of growth regressions. But they also find that many of the stylized facts, particularly those surrounding natural resource specializations, are not robust to estimation technique or conditioning variables.

In the next subsection, we will present the basic statistics to be used in the case of Argentina as well as some description of the elementary relations holding between them. After this, we can embark in the econometric and growth-accounting estimation of the parameters concerning the modeled phenomena. Then, we will be able to test the main hypothesis.

3. The Basic Picture

As can be seen in the attached graph Nº 1, the behavior of GDP at constant prices experienced since 1980 sharp fluctuations. A simple regression of the logarithm of GDP against time, using official data, yields an annual growth rate of about 2.2% in the whole period, but it will be useful to distinguished several sub-periods:



Graph Nº 1. Recent evolution of GDP (YD) according to FIEL estimate

1) In period 1980-1993, the economy grew at an average rate of 0.6%;

2) In 1994-98, growth was at a 2.3% a year;

3) In 1999-2002 there was a regress at an annual rate of -5.1%;

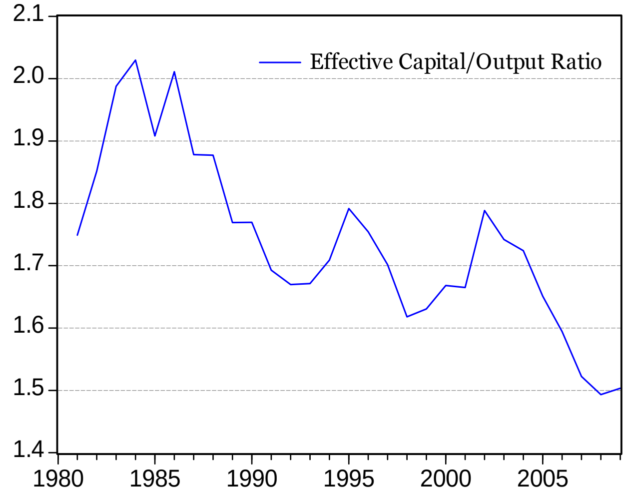
4) Between 2003 and 2007 growth rate reached 8.1% a year;

FIEL has obtained a new estimate of GDP for 2008 and 2009, implying a GDP lower than the official one in those years, by a relative amount of -2.8% (2008) and -5.7% (2009). These data are plotted in graph Nº 1, tilting the expansion of the global economy into a lower level than the official data.

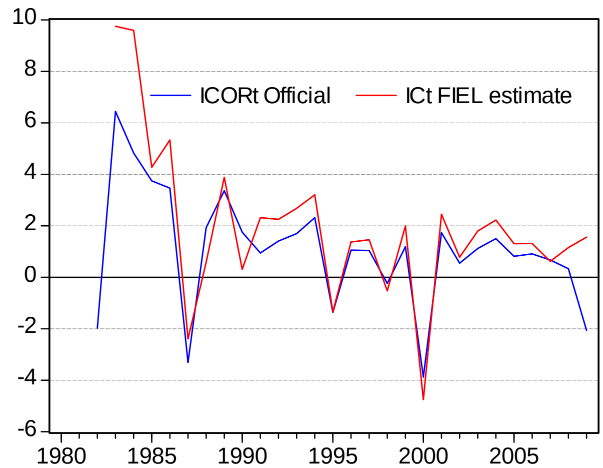
Graph Nº 1 also exhibits the annual behavior of the growth rate. It should be mentioned that after the breaking-up of Convertibility (2001) and the ensuing crisis, the Argentine economy faced a period of negative external shocks which added to the poor performance of the last two years of this monetary policy (1999 and 2000).

Graph Nº 2 depicts one of the factors traditionally considered as a growth factor of an economy: the accumulation of capital. We plot the capital-output relation, after correcting the stock of capital by an index of utilization of capital[5]. We call it the *effective* capital-output ratio of the economy. We have 29 data available for extracting some information from this series; the mean reaches 1.73 pesos for every peso produced in the economy. A more significant concept is the Incremental Capital-Output Ratio (ICOR), the ratio of investment to growth which is equal to 1 divided by the marginal product of capital. The higher the ICOR, the lower the productivity of capital. The ICOR can be thought of as a measure of the inefficiency with which capital is used. In most countries the ICOR is in the neighborhood of 3.

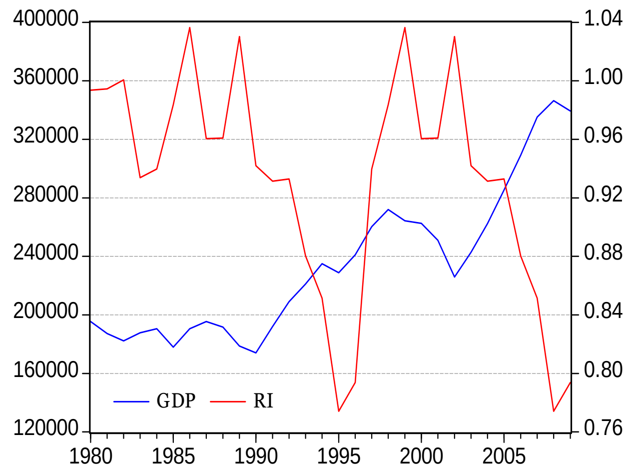
There are some critical points to be mentioned about this ratio: (i) Growth in output can be due to several factors other than investment in physical capital, e.g., growth in productivity, hours employed by



Graph Nº 2



Graph Nº 3



Graph Nº 4

[5] This index is elaborated by FIEL according to a permanent survey of the industrial sector.

worker, human capital, and (ii) The 'investment - increase in output' lag will vary. Thus, to obtain a reliable relationship the measurement of ICOR should be estimated for a longer period, perhaps three or four decades[6]. In the case of Argentina, high instability – and even hostility from the public sector - towards the private sector has meant that ICOR is highly unstable. In Graph Nº 3, we plot the ICOR using official data on GDP and capital, while IC_t stands for data by FIEL. The main difference is not only at the end of the series of GDP, but a lower estimate of the total capital stock of the country. As for ICOR, it reaches a maximum of 6.44 (1983) and a negative minimum value of -3.87 (2000), with a mean value of 1.07 throughout the whole period. In general the IC series exhibits lower values, with a maximum of 9.75 in 1983 and a minimum of -4.75 in 2000, and a mean value of 1,97.

At first sight, one finds here a paradox: is Argentina so productive that production of goods and services can be sustained with such a low ICOR? Given that there has been in practice a modest increase in the labor input[7], we will center our analysis on an external factor, the sharp decrease of the terms of trade experienced in this period (in particular since 2003 on), as shown in Graph Nº 4, as a possible "cause" of an increasing GDP.

Before analyzing this, we should be careful that the unit of measurement of both variables is the right one. We have to analyze if the correct consideration here is in terms of absolute levels, or in terms of first or higher differences. As for this question, the statement *rate of growth of ri does not cause (in the Granger sense) the GDP* is rejected at a 99%. The obverse statement, *GDP does not cause rate of growth of ri* is rejected at a 98%. It seems that we are in presence of *bi-directional phenomena*, a question that should be solved through more sophisticated methods. Consider now a redefinition of units: the statement *ri does not cause rate of growth of GDP* can not be rejected, as well as the statement *rate of growth of GDP does not cause ri.*[8] [Table03 and Table04] In Bour (2000) the influence of the *change* of the terms-of-exchange on GDP was emphasized; but presently, as we shall see, data strongly support the second definition, with *ri* causing growth of GDP.

Additionally, as we have a moderate correlation (-0.47) between terms of trade and a simple trend, there is also an "identification problem" of the terms-of-trade effect in face of disembodied technological enhancements of the productive sector, that could also explain growth in the medium and long term. But as can be seen in Graph Nº 4, co-movement is more acute since from 2003, but sharply differed before that year, so it is expected that standard errors in econometric research will be sufficiently accurate.

4. Approaches to measuring TFP and econometric estimation of coefficients

Total Factor Productivity (TFP) growth can be defined as the rate of growth of outputs for some collection of business enterprises divided by the rate of growth of inputs used by these enterprises. In most economies, outputs grow faster than inputs and so TFP contributes to increases in a country's standard of living. There are two broad approaches to measuring TFP growth:

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[6] World Bank, Statistical Manual.

[7] In period 1980-2009, use of labor increased at a mean rate by 1.54% a year, with 2002 exhibiting the higher decrease (-5.6%) followed by four years of strong recovery.

[8] In fact, an F-statistic on the statement *ri does not cause rate of growth of GDP* is only 0.2944 (with a probability of 75%); while the statement *rate of growth of GDP does not cause ri* has an F=0.64 with probability of 54%.

- The growth accounting or index number approach and
- The econometric estimation approach.

There are problems with both approaches to the measurement of productivity: the growth-accounting approach assumes a constant-returns-to-scale technology and competitive price taking behavior (in fact, the growth-accounting approach can be justified from an axiomatic perspective.) However, the growth-accounting approach cannot give us estimates of the degree of returns to scale nor can it determine the effects of externalities or of noncompetitive pricing behavior; econometric estimation is required in order to obtain estimates of these effects. Moreover, the growth-accounting approach does not generate standard errors for key parameters as does the econometric approach.

On the other hand, the coefficient on the time trend if interpreted as a measure of productivity growth in a regression equation for the production function of a set of industries cannot deal adequately with a large number of inputs and outputs (multicollinearity becomes a problem under these conditions) and the results that the econometric approach generates are often fragile and are generally not reproducible.

The latter approach, however, provides a basic starting point to estimate the basic relationships, so we will begin with it.

Following a similar approach as in FIEL (2002), we estimated first the parameters of an aggregate production function, expressed in differences in logarithms. If no restriction is placed on its parameters, the general specification is as following:

[1] $y' = c[1]*(utci*kato_{-1})' + c[2]*(hrs*nt)' + c[3]*log(ri) + c[4]$

In [1] we denote by *y'* the logarithmic change of GDP (official data), by *utci* an approach to the capacity utilization factor of the industry (a *proxy* for the total economy, produced by FIEL), by $kato_{-1}$ the total capital (including housing) of the previous year[9], by *hrs* the total number of worked hours by employee in the global economy (an official data complemented by FIEL's database), by *nt* the total yearly employment (in persons), and by *ri* the terms of trade of the economy. A "'" after each variable denotes a difference in logarithms (a rate of change). We ran a regression between 1982[10] and 2009 with the available data, using official data on GDP and total capital of the economy, to obtain the following estimate:

[2]

$$y' = 0.31*(utci*kato_{-1})' + 0.70*(hrs*nt)' - 0.23*\log(ri) - 0.011 \qquad SE=0.015$$
$$(0.10) \qquad (0.12) \qquad (0.06) \qquad (0.007) \qquad R^2=0.82;\ DW=2.08$$

According to this estimate, the Argentine economy behaves approximately as a constant-returns–to-scale economy (as 0.31+0.70≈1.00), with an elasticity of 0.23 of the terms-of-trade variable on the rate of growth[11], and a <u>negative</u> TFP amounting to 1.1% a year. This equation has a moderately high coefficient of determination and a good behavior of residuals. However, the standard error of the equation and the unexpected sign of the TFP term lead us to search for a change in variables.

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[9] This is a series produced by the technical staff of the Ministry of Finance.
[10] We lose an observation because *kato* begins in 1980, and a second one because of differencing.
[11] This estimate is in line with those obtained for other countries.

A preferable specification is obtained by a substitution of the official data on GDP for the FIEL estimate; in a similar manner, we opted to substitute total capital for a FIEL estimate, called *katd*, measured after applying a time-varying exponential decay[12]. We also introduced a measure of country risk *crisk*[13] in the *explanans* because we suspect that the cost of capital is not well-taken in the implicit share of capital[14]. We will continue calling *y'* the change of the logarithm of total GDP. After re-estimation, the first option is:

[3]

$$y'=0.27*(utci*katd_{-1})'+0.63*(hrs*nt)'–0.20*log(ri)+0,18 –0.027*log(crisk) \qquad SE=0,006$$
$$(0.08) \qquad (0.10) \qquad (0.05) \qquad (0.05) \qquad (0.007)$$
$$R^2=0.90;\ DW=2.56;\ SE=0.008.$$

This specification is white noise, in spite of a somewhat high Durbin and Watson coefficient. However, the constant of the equation is very high. Returning to our previous variable *crisk in natural units* produces the following result:

[4]

$$y'=0.24*(utci*katd_{-1})'+0.65*(hrs*nt)'–0,23*log(ri)+0.016 –0,000025(crisk) \qquad SE=0.008$$
$$(0.09) \qquad (0.10) \qquad (0.05) \qquad (0.009) \qquad (0.000007)$$
$$R^2=0.90;\ DW=2.29;\ SE=0.008.$$

This is our best econometric estimate. Of course, the parameters change frequently and unstably with changes in data and variables and we cannot pretend to have reached a final explanation (in particular, we have disregarded the stock of human capital from the causes of growth). In sections 6 and 7 we will do some growth-accounting in order to compare the result.

What are the messages coming from eq. [4]?

a.- Firstly, total GDP seems to follow a constant returns to scale production function, as stressed in FIEL (2002). The sum of the elasticities of production of capital (0.37) and labor (0.64) is not one but it is not significantly different from unity. A Wald-test on the constraint that the sum=1 is a F-statistic with 1 and 22 degrees of freedom, with a probability of 26%. So, we must reject the difference[15] as non-significant. These elasticities are within the range of international practice. E.g., Cobb and Douglas (1928) used the method of least squares to fit the data of a C-D function to data between 1899 and 1920, obtaining the following estimates:

$P(L,K) = 1.01\ (L^{0.75})(K^{0.25})$. On Cobb-Douglas production functions, see Border (2004).

b.- These elasticities have remained the same as those estimated in the previous project[16], in spite of the elapsed time.

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[12] The reason for this substitution is basically because the latter data is a longer series and can be easily separated into different components according to need.

[13] This variable has been worked out by Schefer (2004).

[14] Exclusion of *crisk* produces no great alteration of the coefficients: it raises both elasticities of capital and labor, slightly maintains the incidence of the terms-or-trade and makes non-significant the constant of the equation. However, its standard error rises abruptly ut to 0.014.

[15] Alternatively, a χ^2 with 1 degree of freedom corresponds to a probability level of 25%.

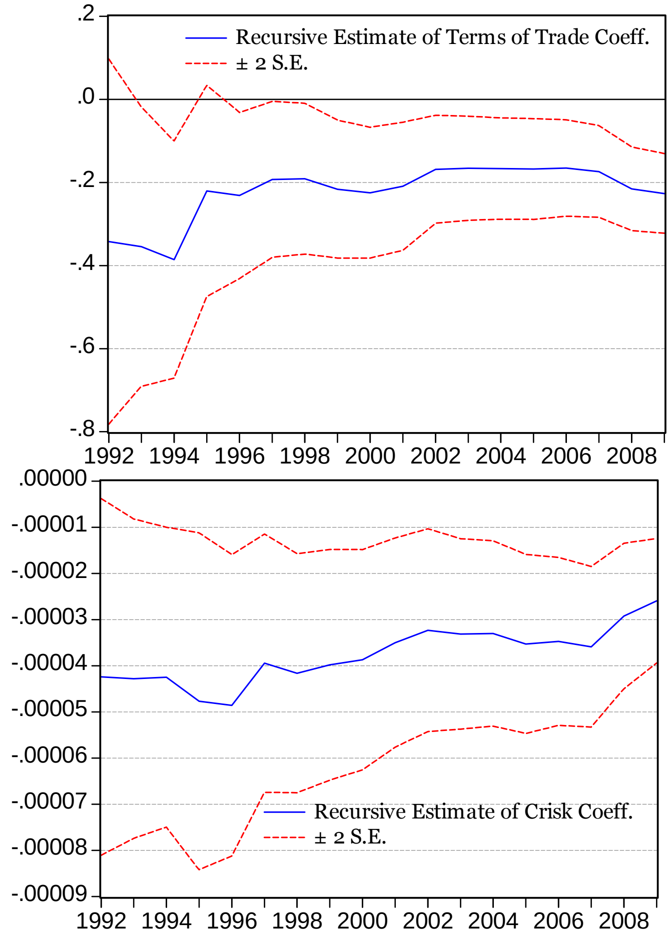
[16] Eq. [3] of Table A4 included the following, "preferred" estimate for the aggregate production function:

$$y'= -0.019+0.65*(hrs*nt)'+0.35*(utci*kat-1)'+0.04*S_{91} \qquad R^2=0.86;\ F=47.3;\ DW=2.36.$$

c.- The terms-of-trade relationship (*ri*) is a significant one at explaining economic growth. The GDP elasticity with respect to it is about -0.23 and very significant. One must note that, according to these equations, a *lower ri* makes for a higher growth rate. That is, it is not its rate of growth what makes a difference in terms of total production, but its level. A possibly explanation here is in terms of inertia by locking incentives to producers and savings. For example, a decline by 10% of the terms-of-trade would *accelerate* the growth rate of GDP by 2.3 percentage points. In other terms, external relative prices act as a cumulative force.

d.- Growth explained by TFP is about 1.6% a year. In Eq. [4] it is significant at 8%. It seems that use of the corrected GDP and total capital by FIEL allow some technical progress at a positive rate, while official data seem more compatible with a technical regress.

e.- Country risk, that is, the price that must be paid over the US Treasury rate to invest in Argentina, is very significant and its coefficient has been increasing since 2007 on (see Graph Nº 5). On the other hand, the coefficient of *ri* has kept stable since from 1995. A *pair wise Granger causality test* with two lags suggests that we should reject the one-sided causality statement *crisk does not Granger cause vyd with a confidence of 99%*.



Graph Nº 5

5. A prelude to growth accounting

As a first step, we redefined our variables in terms of arithmetical annual rates of growth so that $vyd=yd/yd_{-1}$ and so on. With such a definition, dropping the constant because of non-significance we approached the specification of [3] to obtain:

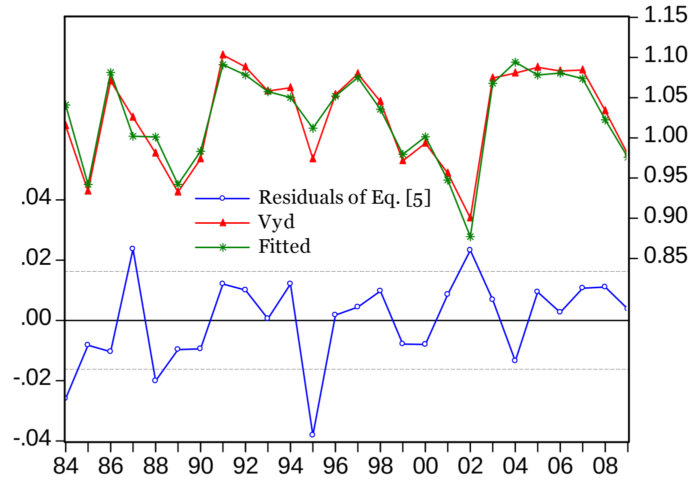
[5] $vyd=0.34*(vu*vkat_{-1})+0.67*(vh*vn)-0.19*ri-0.000014*crisk+0.18*vyd_{-1}$

(0.06) (0.07) (0.02) (0.000004) (0.04)

SE=0.005 AR [1]=-0.50 R^2=0.94; DW=1.99.

In this equation, variable S_{91} was a dummy with zeroes everywhere, excepting the Convertibility period when it was set at 1 during 1991-1999 (page 51). Therefore, "net" TFP in this period is to be calculated as 0,04-0,019= 0,021.

Eq. [5] is a very good alternative to [4] in terms of finite changes. As before, the first three coefficients stand in terms of stability. Terms-of-trade and country risk exhibit some reduction in absolute terms, and the lagged endogenous variable was included as a means to account for positive auto-correlation. The standard error of this equation is even smaller than in equation [4], reaching 0.5%. Only 3 years over 26 observations exhibit a higher significant deviation than 0.5%: 1987 (the equation is unable to follow the exceptional rise of GDP), as well the exceptional decreases in 1995 and 2002. The only turning-point error appears to be in 1995. (See Graph Nº 6)



Graph Nº 6

Eq. [5] can be interpreted as a partial-adjustment equation, where the short-run coefficient of *ri* is -0.19 but the long-run coefficient reaches -0.23, as a shock to the terms-of-trade is distributed over several periods[17]. The same could be done with other explicative variables, including capital and labor. In this case, the production function would no longer be constant-returns-to-scale – but one of increasing ones in the long run. But since no TFP is present, a possible interpretation is that in the finite approach, productivity enhancements come through the factors of production (incorporated technical change).

Summing-up, our preferred equation [4] delivers the following parameters:

Elasticity of rate of growth of GDP w.r.t. the average *ri* in the period =
=--0.23*(-0.07)=1.6
Elasticity of rate of growth of GDP w.r.t. the average *crisk* in the period[18]= --2.3
Elasticity of production w.r.t. capital= 0.27[19]
Elasticity of production w.r.t. labor= 0.73
Total Factor Productivity growth = 0.016.

Under the assumption of perfect competition the capital share is a measure of the elasticity of production w.r.t. capital. The actual capital share for a country should be easily found in national income and product statistics; in most industrialized countries, the capital share is between 0.3 and 0.4, with the labor share varying correspondingly between 0.7 and 0.6. Not surprisingly, our estimate of the capital share is near this range, as should be expected because of the opportunities of transferring *know-how* between different countries through international trade and foreign investment. This means that, without having resort to data at current prices on national statistics (very distorted in Argentina) we can extract a series of TFP using the

[17] As usual, the long-run coefficient is obtained as the quotient of the short-run coefficient and one minus the coefficient of the lagged variable *vyd*.
[18] This variable has a mean equal to 1031, but in 2009 it reached 2837.50.
[19] We have forced the assumption of constant-returns-to-scale, by distributing the shares of the two factors in proportion to their contributions in Eq. [4].

calculated parameters of the production function. Once the capital and labor shares have been found, the following definition can be used to compute productivity values for any given year:

[6] $A_t = GDP_t/(K_t^{0.27} N_t^{0,73})$

In this equation, we are assuming that technical change has a Hicksian neutral form.

6. Growth-accounting in Argentina, 1980-2009

The first step in the derivation is to express the production function in growth rate form (Hulten, 2009):

[7] $Y'/Y = Y'/K' * K/Y * K'/K + Y'/L' * L/Y * L'/L + A'/A$

We now use a dot "'" to denote time derivatives, so that the corresponding ratios are rates of change. This form indicates that the rate of growth of output equals the growth rates of capital and labor, weighted by their output elasticities, plus the growth rate of the Hicksian shift parameter. These elasticities are equivalent to income shares $s^K{}_t$ and $s^L{}_t$ when inputs are paid the value of their marginal products ($\partial Y/\partial K = c_k/p;\ \partial Y/\partial L = w/p$) leading to:

[8] $R_t = (Y'_t/Y_t) - s^K{}_t * K'_t/K_t - s^L{}_t * L'_t/L_t = A'_t/A_t$

This equation is an expression where, in the left-hand, the "residual" R_t of the growth of output is defined as the growth not explained by the share-weighted growth rates of the inputs (the residual is the growth-accounting estimate of TFP_t, also called Multifactor productivity (MFP) as the name given to the Solow residual in the BLS productivity program).

As underlined by Hulten, although linked to an underlying production function, the residual itself is a pure index number because it is based on prices and quantities alone (actually, [8] is a form of the Divisia index). By implication, the shift in the function can be measured without actually having to know its exact form. The trick, here, is that the slope of the production function along the growth path of the economy is measured by real factor prices.

Table 1 includes the figures used in the calculation of Argentina's TFP:

Table 1. Rates of growth[20] of variables[21]

	vyd	*vu*	*vkatd$_{-1}$*	*vh*	*vn*	*vri*
1981	0.957941	0.876289		0.958685	0.993066	1.000885
1982	0.973128	1.007843		1.016094	1.017274	1.006211
1983	1.030462	1.105058	1.020968	1.018712	0.990280	0.933180
1984	1.015032	1.035211	1.020906	0.981999	1.028074	1.006387
1985	0.933801	0.877551	1.017570	0.957878	1.001819	1.046788
1986	1.070811	1.139535	1.008755	1.048021	1.034831	1.053589
1987	1.025618	0.962462	1.015594	0.994460	0.997552	0.926690

[20] In all the instances that we speak of *rates of growth*, it should understood *factors of growth*, i.e. 1+the correspong rate of variation.

[21] We have not included in this table the series of depreciation of capital, which depends on the composition of the capital stock and oscillates between 3.5% and 3.0%, with a mean value equal to 3.2%.

1988	0.980992	0.975390	1.020840	1.011404	1.018846	1.000427
1989	0.932452	0.883188	1.019005	0.973333	1.010317	1.072267
1990	0.973926	0.989949	1.006917	1.017959	1.010469	0.914242
1991	1.103139	1.090299	1.001705	1.033140	1.050830	0.988856
1992	1.088299	1.066071	1.010775	1.031978	1.024344	1.001589
1993	1.058224	1.039874	1.020726	0.997241	1.010986	0.943568
1994	1.062250	1.048274	1.028631	1.004330	0.985057	0.967309
1995	0.973788	0.983063	1.031073	0.991691	0.970714	0.909178
1996	1.053715	1.006521	1.020691	0.972253	1.018032	1.025424
1997	1.079567	1.019670	1.024088	1.020721	1.058470	1.183785
1998	1.045159	0.959553	1.032434	0.994358	1.040663	1.046788
1999	0.971578	0.944924	1.033353	0.991647	1.009427	1.053589
2000	0.993249	0.991777	1.021664	0.987133	1.001562	0.926690
2001	0.956066	0.939077	1.018408	0.986920	0.977481	1.000427
2002	0.900343	0.959693	1.009084	0.943449	0.944335	1.072267
2003	1.074535	1.057600	0.993214	1.069558	1.050480	0.914242
2004	1.080615	1.063162	1.005662	1.007394	1.072193	0.988856
2005	1.087676	1.024546	1.019533	1.004526	1.045329	1.001589
2006	1.083135	1.014232	1.029666	0.999100	1.055594	0.943568
2007	1.084335	0.993761	1.028573	0.998249	1.036087	0.967309
2008	1.033601	0.972320	1.046325	0.985484	1.004957	0.909178
2009	0.979442	0.943958	1.043981	0.976360	0.986743	1.025424

The resulting estimate of the residual A_t is as follows (Table 2):

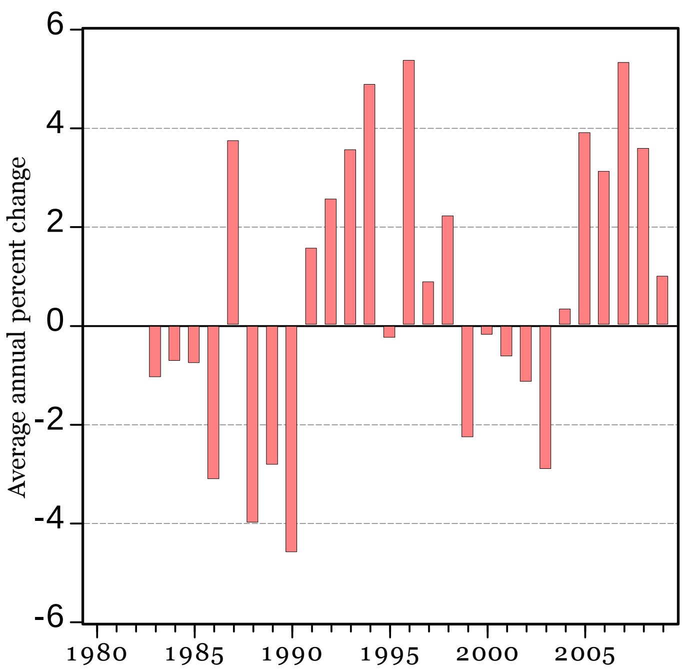
Table 2. The residual A_t

1983	-0.010591
1984	-0.007303
1985	-0.007824
1986	-0.031260
1987	0.037523
1988	-0.040091
1989	-0.028404
1990	-0.046099
1991	0.015728
1992	0.025675
1993	0.035656
1994	0.048908
1995	-0.002620
1996	0.053789
1997	0.008931
1998	0.022279
1999	-0.022787
2000	-0.002066
2001	-0.006379
2002	-0.011508
2003	-0.029270

2004	0.003447
2005	0.039101
2006	0.031278
2007	0.053334
2008	0.035944
2009	0.010070

Graph Nº 7 is a plot of this variable. We can clearly see that periods of general distrust in economic policy are associated with breaks of TFP (1988-1990 and 1999-2003). Eq. [4] also submits that the variability of TFP can be explained by the terms of trade, a rising trend and country risk. We can now test this causality with the new variable.

We began by testing the possible influence of the terms-of-trade relationship, a trend and the country risk. We found that the relation could be modeled as a moving average model of first order (Eq. [9]):



Graph Nº 7

[9] $A_t=0.27–0.27*ri–0.0000018*crisk+0.0004*trend$

$(0.02)\quad(0.02)\quad(0.0000003)\quad(0.0001)$

$R^2=0.79;\ DW=1.93;\ MA\ (1) = 1.00$

So that, in the end, Total Factor Productivity moves according to a model such as the following[22]:

[10] $A_t = m_t + \varepsilon_t + \varepsilon_{t-1}.$

In [10], m_t stands for the mean of the series, ε_t stands for a white noise error term and the (non-stationary) mean is given by *0,27–0,27*ri–0,0000018*crisk+0,0004*trend.* The random shocks at each point come from the same distribution, assumed to be a normal distribution, with location at zero and constant scale. The special feature in this model is that these random shocks are propagated to future values of the time series. This is an interesting property of the series of Total Factor Productivity. The sample correlation between the terms-of-trade and the index of productivity $A_t \approx$ --0.58. The sample correlation between the index of productivity and growth of GDP is about 0.54.

[22] Convergence was attained after 20 iterations, but as the underlying root of the MA process has modulus very close to one, the software reports that it couldn't improve the sum-of-squares.

This implies that the estimation of TFP in the Argentina economy should consider a variant of the Box-Jenkins ARMA model, where it is assumed that the time series is stationary. In fact, Box et al. (2004) recommend differencing non-stationary series one or more times to achieve stationarity, as we did in this section.

7. A Sensibility Analysis

We performed a sensibility analysis of Eq. [5], given the need to obtain a reliable estimate of parameters. First, we substituted the official variables for the previous ones, so Table 1 would display as: 14

Table 3. Rates of growth of official variables

	vydo	*vu*	$vkato_{-1}$	*vh*	*vn*	*vri*
1981	0.957941	0.876289	1.022239	0.958685	0.993066	1.000885
1982	0.973128	1.007843	1.000898	1.016094	1.017274	1.006211
1983	1.030462	1.105058	1.001290	1.018712	0.990280	0.933180
1984	1.015032	1.035211	1.000357	0.981999	1.028074	1.006387
1985	0.933801	0.877551	0.990335	0.957878	1.001819	1.046788
1986	1.070811	1.139535	0.995223	1.048021	1.034831	1.053589
1987	1.025618	0.962462	1.005225	0.994460	0.997552	0.926690
1988	0.980992	0.975390	0.995134	1.011404	1.018846	1.000427
1989	0.932452	0.883188	0.984026	0.973333	1.010317	1.072267
1990	0.973926	0.989949	0.967893	1.017959	1.010469	0.914242
1991	1.103139	1.090299	1.006848	1.033140	1.050830	0.988856
1992	1.088299	1.066071	1.018612	1.031978	1.024344	1.001589
1993	1.058224	1.039874	1.036189	0.997241	1.010986	0.943568
1994	1.062250	1.048274	1.038543	1.004330	0.985057	0.967309
1995	0.973788	0.983063	1.025038	0.991691	0.970714	0.909178
1996	1.053715	1.006521	1.027016	0.972253	1.018032	1.025424
1997	1.079567	1.019670	1.035647	1.020721	1.058470	1.183785
1998	1.045159	0.959553	1.036192	0.994358	1.040663	1.046788
1999	0.971578	0.944924	1.024480	0.991647	1.009427	1.053589
2000	0.993249	0.991777	1.016261	0.987133	1.001562	0.926690
2001	0.956066	0.939077	1.007585	0.986920	0.977481	1.000427
2002	0.900343	0.959693	0.989728	0.943449	0.944335	1.072267
2003	1.074535	1.057600	1.005918	1.069558	1.050480	0.914242
2004	1.080615	1.063162	1.016662	1.007394	1.072193	0.988856
2005	1.087676	1.024546	1.031213	1.004526	1.045329	1.001589
2006	1.083135	1.014232	1.041873	0.999100	1.055594	0.943568
2007	1.084335	0.993761	1.042708	0.998249	1.036087	0.967309
2008	1.063442	0.972320	1.044611	0.985484	1.004957	0.909178
2009	1.009833	0.943958	1.031774	0.976360	0.986743	1.025424

The equivalent equation to [5] is Eq. [S1]. This equation was estimated in period 1982-2002 for the purpose of the simulation exercise in section 8. After dropping *crisk* and the constant because of non-significance, the resulting equation is the following one:

[S1] $$vydo=0.38*(vu*kato_{-1})+0.55*(vh*vn)-0.14*ri+0.20*vydo_{-1}$$

$$R^2=0.89;\ SE=0.021;\ DW=2.69$$

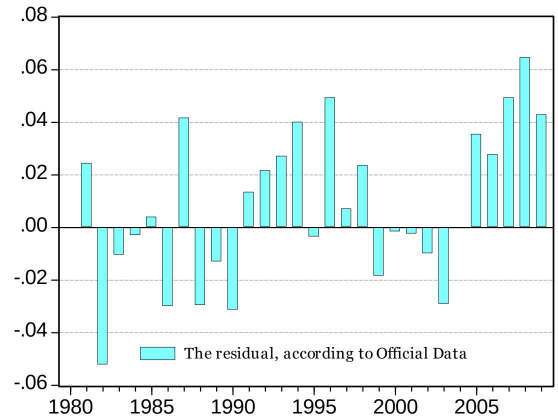
If marginal productivities are adjusted so as to obtain a constant-returns-to-scale production function (a Wald Test has a F-Statistic (1,17)=0.41, so we can not reject this alternative), coefficient c[1] becomes 0.41; coefficient c[2]=1-0.41=0.59, and with these data we can calculate the residual AO_t in Table 4:

Table 4. The residual, according to Eq. [S1]

1981	0.027283
1982	-0.051057
1983	-0.015464
1984	-0.004421
1985	0.008590
1986	-0.032549
1987	0.042916
1988	-0.026741
1989	-0.007490
1990	-0.027919
1991	0.012882
1992	0.020250
1993	0.023690
1994	0.035173
1995	-0.005972
1996	0.047237
1997	0.008431
1998	0.025762
1999	-0.016900
2000	-0.002734
2001	-0.001601
2002	-0.012972
2003	-0.029316
2004	0.000244
2005	0.035482
2006	0.027812
2007	0.049425
2008	0.064715
2009	0.042941

We plot these residuals in Graph Nº 8, where one can note that, in general, the incidence of the factors behind the TFP is not much different than in graph Nº 7. However, it must be noted that residuals are slightly distinct from those of graph Nº 7.

Three main conclusions emerge from this analysis: 1) Marginal productivity of both factors stand[23] in spite of changes of specification and sample, in particular the marginal productivity of labor is higher than that of capital; 2) The influence of the variable *ri*, representing the terms-of-trade factor, also stands withouth change at -0.19. 3) The influence of other factors other than these is more problematic, in particular the influence of total factor productivity and of country risk.



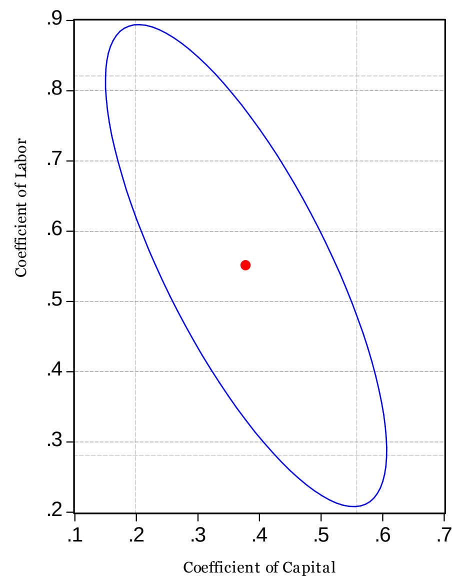
Graph Nº 8

8. The particular impact of terms-of-trade on growth

We'll make an *ex post* exercise aiming at understanding *what would have been the growth of the economy if no external impact from the terms-of-growth had been present*. This is the answer given in Graph Nº 8 by the vertical bars in period 2004-2009. We will call *GrwSim* and *CumGrw* the resulting annual growth factor and the cumulative growth factor of GDP between 2004 and 2009. The following table Nº 5 shows the main results[24]:

Table Nº 5. Simulated Growth Rates and Cumulative Rate since from 2003 with terms-of-trade staying at 2003-level

	GrwSim	*CumGrw*
2004	1.000244	1.000244
2005	1.035482	1.035735
2006	1.027812	1.064541
2007	1.049425	1.117157
2008	1.064715	1.189454
2009	1.042941	1.240530



Graph Nº 9

As total growth of the Argentine economy in the same period was at rate of 48,2% according to official statistics, one can infer that half the accruing growth of Argentina in this period was entirely explained by better (that is, lower) terms of trade.

[23] Graph Nº 9 is the *confidence ellipse* at 5% of both coefficients of capital and labor. This is an alternative approach to displaying the results of a Wald test. For a given test size, say 5%, we display the one-dimensional interval within which the test statistic must lie for not to reject the null hypothesis. Comparing the realization of the test statistic to the interval corresponds to performing the Wald test. In the case of two variables (capital and labor), the confidence ellipse is the region in which the realization of two test statistics must lie for us not to reject the null. As the coefficients of Eq. [5] fall within the ellipse, we can safely assume that equations [5] and S1 depict the same interrelatedness of inputs and output.

[24] Table Nº 5 has been ellaborated taking into account the influence of the lagged endogenous variable, using Eq [S1].

The same exercise can be done with Eq. [9] in terms of the residual. Maintaining the same specification for an equation *using official data*, for a restricted sample since from 1982 until 2003, gives the following equation:

[10] $AO_t = 0.18 - 0.000016{*}crisk - 0.16{*}ri - 0.0001{*}trend$
$\qquad\qquad (0.019) \quad (0.000004) \qquad (0.02) \qquad (0.0001)$

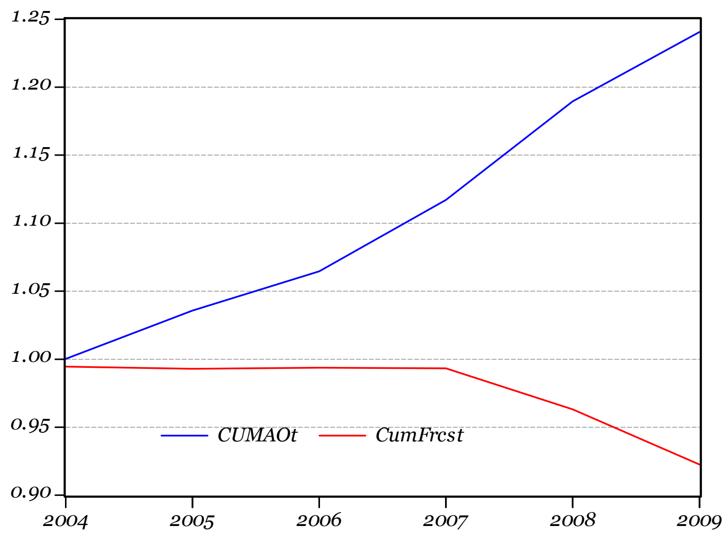
R^2=0.80; SE=0.002; DW=2.67; MA (1)= 0.97.

Now, we'll keep variable *ri* at the same level reached in 2003 (setting 2003=1) and we'll forecast the residual using Eq. [10]. Table 6 exhibits the result:

Table 6. Forecasting the residual with terms-of-trade staying at 2003-level

	AO_t	$Forecast_t$	$CUMAO_t$	$CumForcst_t$
2004	0.000244	-0.005471	1.000244	0.994529
2005	0.035482	-0.001550	1.035735	0.992987
2006	0.027812	0.000733	1.064541	0.993715
2007	0.049425	-0.000507	1.117157	0.993212
2008	0.064715	-0.030270	1.189454	0.963147
2009	0.042941	-0.042083	1.240530	0.922615

The resulting estimate deepens the previous one. The difference in percentage in 2009 reaches almost 35 percentage points, explaining 73% of growth of GDP. In fact, the residual unexplained by the cumulated factors (*CumForcst*) experienced a decrease amounting to 7,8%.



Graph Nº 10

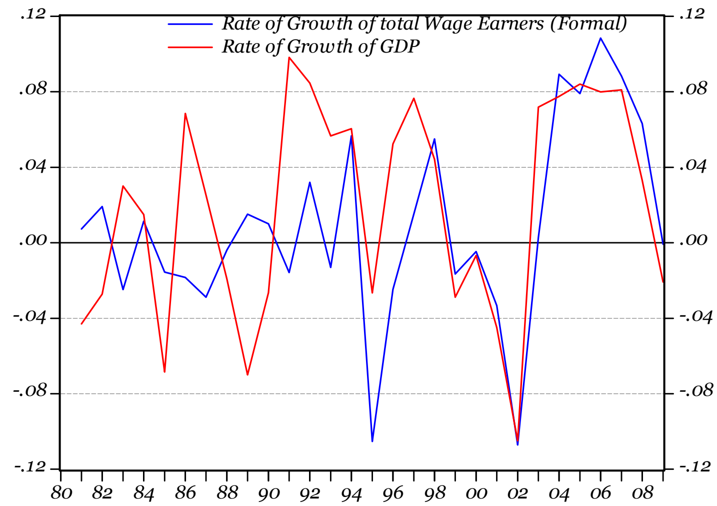
Graph 10 illustrates these paths.

9. The informal economy

As a result of the poor behavior of institutions and the high marginal tax on formality on labor, the Argentine economy has developed over time in a context of high informality in the market labor. We encounter here a possible problem of marginal productivities at different rates. We approached this problem by observing the statistical association between the rate of growth of GDP and total amount of (formal) wage earners[25]. We obtain Graph Nº 11, where it can be seen that total GDP and Total Wage Earners

[25] Average data for the whole country on informal workers have been processed by FIEL according to information of Household Surveys of INDEC. In addition, we tried to include a variable to take into account the human capital of the economy, through the usual computation of years of schooling of the labor force, but this variable was not significant at all, both for formal and informal workers.

(Formal) are highly associated. In fact, sample correlation between the two variables is ≈ 0.57, and reaches 0.92 if taken between 1998 and 2009. On this basis, we obtained an alternative estimate of parameters of [4], that is the following Eq. [11] where *inf* is the percentage of informal workers in the economy:

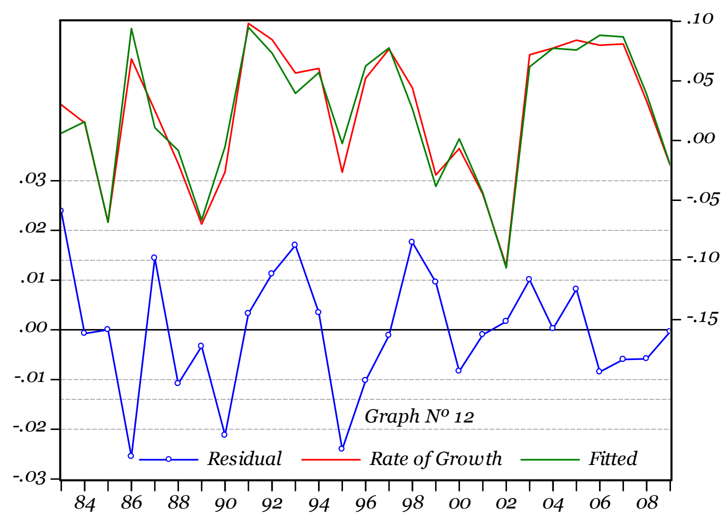


Graph Nº 11

[11] $$y' = 0.45*(katd_{-1}*utci)' + 0.42*(hrs*nt*(1-inf))' - 0.16*\log(ri) + 0.019 - 0.00002*crisk$$
$$\qquad (0.08) \qquad\qquad (0.04) \qquad\qquad (0.03) \qquad (0.004)\ (0.000004)$$

$$+0.09*(hrs*nt*inf)' \qquad R^2=0.95;\ SE=0.004;\ DW=1.84;\ MA(1)=1.00$$
$$(0.03)$$

We should point that the R^2 adjusted for degrees of freedom of this equation is 0.94. In comparison with Eq. [4], the last equation adds explanatory power (the R^2_{ad} of [4] is 0.89). The elasticity of GDP w.r.t. capital is 0.45. As for labor, marginal productivity of formal workers is much higher than that of informal ones. This follows from the following identities:



Marginal Productivity of L≡Elasticity of GDP w.r.t. L/Average Product of L

Marginal Productivity of K ≡ Elasticity of GDP w.r.t. K/Average Product of K

It is found that – without consideration of differences of human capital or of hours worked – formal workers' productivity overcomes that of informal ones by a factor of 1.797[26]. The trend is

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[26] This kind of measurement shoud be taken for the proper activities, but lacking information for this purpose it was assumed that both kind of workers are spread accross the same activities. It is also assumed that schooling and hours worked by employee in each category are the same.

slightly higher than in the alternative [4] (1.9% a year). As a consequence, the recent data seem to confirm the TFP growth of the Argentine economy found in FIEL (2002), although at a lesser rate. Country risk has a similar impact than in equation [4]. All the coefficients are highly significant at 0.1%, with the exception of informal workers (the coefficient being significant at 1.3%). In addition, one can not reject the presence of constant returns to scale.

Graph Nº 12 displays the residuals. As it can be seen, Eq. [11] seems to give a good track-record of the behavior of GDP.

10. Conclusions

Now we can posit the main conclusions:

1. Terms-of-trade had a great influence on Argentina's growth. We estimated that a sustained decrease of 1% once, gives rise to a steady increase of GDP rate of growth of 1,6%. In particular, since 2003 on the behavior of external prices gave place to a decrease of about 35 percentage points, comparing GDP in 2009 with GDP in 2003. This amounts to explaining up to 73% of growth of total GDP. The sample correlation between terms-of-trade and the index of productivity $A_t \approx -0.58$*. The sample correlation between the later one and growth of GDP is about 0.54.*

2. We have surmised that the terms-of-trade shocks on GDP can be explained by the unused capacity of capital and labor that followed the depression as a consequence of the political and economic changes after the Convertibility period. The main implication of the previous point is that once reached a high utilization of capital, total GDP should enter into a region of no major changes, unless TFP of the economy grows strongly enough, investment and trade surplus becoming the main leading factors.

3. In this article a Cobb-Douglas constant-returns-to-scale production function was used as the basic specification. In fact, the Cobb-Douglas imposes herself as the adequate explanation of data. TFP growth continues at a lesser rate than in the Convertibility period, at a rate between 1.6% (Eq. [4]) and 1.9% (an estimate obtained by splitting workers between formal and informal sectors, Eq. [11]).

4. Using growth accounting we were able to extract a series of the residual of GDP. We tested this variable using as explaining factors the terms-of-trade relationship, a linear trend and the country risk. The main result is the confirmation of the influence of these factors, as well as the convenience to model TFP as a moving-average process, with random shocks propagating to future values of the time series.

5. If we use official data for GDP or capital and some changes of specification and sample, we do not alter in a significant manner the marginal productivities of capital and labor, as well as the coefficient representing the terms-of-trade influence. This robustness does not extend, however, to TFP and country risk.

6. Finally, we partitioned wage-earners between formal and informal ones, and re-estimated the coefficients of the production function obtaining that formal workers' productivity overcomes that of informal ones by a factor of almost 1.8.

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