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Alejandro Gay

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TERMS OF TRADE AND POTENTIAL OUTPUT IN ARGENTINA

Gay Alejandro

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Alejandro Gay[1,2]

Abstract

This paper uses an equilibrium correction model to estimate Argentina's potential output in the 1913-2011 period. The long-term equilibrium is represented by a Cobb-Douglas production function with three factors: capital, labor and land. Capital and labor inputs have been adjusted by quality; and the terms of trade have been exogenously introduced, as we assume they affect the quality of land. The estimated shares of capital, labor and land are 0.44, 0.46 and 0.10, and test do no reject the hypothesis that the terms of trade coefficient equals the share of land. The output gap after Convertibility is analyzed and forecasts have been made about potential output growth.

Keywords: Production function, Potential output, Terms of trade, Cointegration, Argentina
JEL: C32, E23

Resumen

En el trabajo se utiliza un modelo de corrección al equilibrio para estimar el producto potencial de Argentina (1913-2011). El equilibrio de largo plazo está dado por una función de producción Cobb-Douglas con capital, trabajo y tierra. Los insumos capital y trabajo han sido ajustados por calidad, y se supone que los términos del intercambio afectan la calidad de la tierra. Se obtienen participaciones del 0.44, 0.46 y 0.10 para el capital, el trabajo y la tierra. No se rechaza la hipótesis de igualdad del coeficiente de la tierra y de los términos del intercambio. Finalmente, se realizan pronósticos sobre el crecimiento del producto potencial y se estima la brecha del PIB.

Palabras clave: Función de producción, Producto potencial, Términos del intercambio, Cointegración, Argentina
Clasificación JEL: C32, E23

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Email address: agay@eco.unc.edu.ar (Alejandro Gay)
[1]Department of Economics and Finance, Universidad Nacional de Córdoba, Argentina.
[2]CONICET, Argentina.

1. Introduction

Over the last decade, Latin America and Argentina have been benefited with sustained improvement in their terms of trade, which has given rise to general bonanza and an increase in consumption. The purchasing power of the Argentinean exports has significantly grown and has brought along higher imports level and general welfare.

This work introduces a less analysed aspect: the effects of the terms of trade on production. It is usefull to remember the celebrated Prebisch-Singer thesis of declining terms of trade of developing countries, Prebisch (1950) and Singer (1950). It is claimed that since most developing countries are exporters of primary commodities whose prices do not rise as much as industrial country exports, they experience a secular decline in their terms of trade (export prices fall with respect to import prices). This trend contributed to reduce trade gains and implicitly pushes developing countries' production possibilities frontier progressively inward, resulting in a decline in their growth rates.

The course of history has refuted the assumption of a trend towards deterioration in the terms of trade of developing countries. However, the idea that the terms of trade affect productivity has found some empirical support although not necessarily in theory, Kehoe and Ruhl (2008). In some developing countries sharp deteriorations in the terms of trade and drops in total factor productivity are highly correlated in the data, but standard models cannot account for these drops in total factor productivity. In order to establish a causal mechanism that link shocks to the terms of trade to movements in productivity, we introduce the terms of trade in the production function.

We are interested in the period starting in 1913, when Argentina was regarded as the breadbasket of the world, and ending in 2011, after a decade of a renewed central role of agriculture in the growth process. It is only natural, then, to include the production factor land in the production function, together with the production factors, capital and labor.

The relevance of the agricultural sector in Argentina's economy has been closely analyzed by Cavallo et al. (1989), who examined the relations between agriculture and Argentina's global growth for the years 1913-1984, with especial stress on the role played by economic policies in sectoral product. Total product was disaggregated into three sectors: the agricultural, the non agricultural and the state administration sectors. The agricultural sector's product is determined by the per-capita capital stock, the other sector's product, relative prices and the degree of trade openness, while the variability of the sector's relative prices and an indicator of high inflation exercise negative influence. With respect to the non-agricultural sector, production is stimulated by public consumption and trade liberalization, while the variability in the relative price of the sector, the combined effect of deflation shocks, high inflation and banking crisis, plus the per-capita capital stock bear negative influence on the sectoral productivity, the last of the mentioned effects being contrary to expectations. In the state administration sector the product is given exogenously. The methodological strategy of disaggregating output into sectors points to reduce aggregation biases by reducing the heterogeneity as one goes down from such general mixture as "total product" to something more coherent, such as "agriculture".

In its current state, the formal theory for aggregation of economic quantities indicates that aggregate production functions do not exist, except in unlikely special cases, Temple (2006).

Solow (1967) has argued that econometric methods should help to resolve the issue:

> The pure theory of production is fundamentally microeconomic in character; it deals with physically identifiable inputs and outputs. In the classroom one usually says that the economic theory of production takes for granted the "engineering" relationships between inputs and outputs and goes on from there. By contrast,

much (though not quite all) of the recent interest in the theory of production has been macroeconomic in character. Since the "inputs" and "outputs" are statistical aggregates like "labor," "plant," "equipment," "durable manufactures," there is no possibility of finding engineering relationships. Econometric methods have to do duty instead. Still, it remains an intriguing idea to deduce economically useful production functions from raw technological information.

Cavallo and Mundlak (1982) (p.107) state that the role Solow attributes to econometric analysis is narrow and not liable to implementation. On the one hand, an ideal aggregation of inputs and outputs depends on prices and requires knowledge of production functions, the very thing one wants to estimate with the aggregated variables. On the other hand, the micro functions change with time and therefore affect the relationships between the aggregate inputs and outputs. They point out that, "strictly speaking, there are no pure engineering-type relationships that can be revealed by econometrics." In fact, they also point out that Solow himself does not really believe in it when he says that "If aggregation is inevitable, relax and enjoy it."

The problems associated with aggregation are not linked only to capital (The Cambridge controversy) but also to labor and output. However, macroeconomics and growth theory develop models using aggregate variables so that it turns into a problem we need to deal with. To mitigate the aggregation problem, we will consider the fact that the quality of inputs may have changed over time. The quality adjustments in labor and capital have already been used in Argentina by Elías (1978), Elías (1992) and Meloni (1999).

Clearly aware of the limitations and difficulties involved, we accept the challenge of estimating an aggregate production function of the Argentinean economy.

The organization of this paper is as follows: Section II presents the production function to be used; Section III introduces the estimation method; Section IV describes the data; the estimations are presented in Section V. Potential output and the output gap in recent years are estimated in Section VI, while Section VII concludes.

2. The Aggregate Production Function

We will try to test empirically the existence of an aggregate Cobb-Douglas production function for Argentina with three factors, capital (K), labor (L) and land (T). Capital and labor are adjusted by their respective qualities (Q_K) and (Q_L), and we assume that the quality of land is affected and can be proxied by the terms of trade (ToT).

$$Y_t = (K_t Q_{Kt})^{\beta_1} (L_t Q_{Lt})^{\beta_2} (T_t \, ToT_t)^{\beta_3} e^{A+\Gamma t} \qquad (1)$$

where Y_t is the output and β_1, β_2, β_3, A, Γ are the parameters to be estimated. Assuming constant returns to scale and perfect competition, β_1 represents the capital share in the product, β_2 is the labor share and ($\beta_3 = 1 - \beta_1 - \beta_2$) is the land share. The parameters A and Γ help to shape technological change over time, where A represents the level of the production function and Γ the trend component.

Labor quality (Q_L) increases when the composition of labor changes in favor of the workers who exhibit greater productivity, measured by the salary received. The same applies to the quality of capital (Q_K), which rises when the composition of capital varies in favor of machinery and tools, to the detriment of buildings and structures that are less productive.[3]

[3]The methodology to calculate quality indices is explained in Appendix.

In relation to the land represented by the millions of hectares cultivated with grains and oilseeds, it may be conceptually possible to develop a quality index which rises when the land composition changes in favor of crops with higher value of production per hectare.[4] We have instead decided to adjust the land factor with the terms of trade index corrected by commercial policy (ToT). The underlying idea is that in an agro-exporting country, increases in terms of trade encourage a greater use of fertilizers and other improvements that enhance the quality of land.

In logarithms, the equation to be estimated is:

$$ln(Y_t) = \beta_1 ln(K_t Q_{Kt}) + \beta_2 ln(L_t Q_{Lt}) + \beta_3 lnT_t + \beta_3 lnToT + A + \Gamma t \quad (2)$$

The quality indices are derived from disaggregating the factors into their different categories; for instance, labor may be disaggregated into different categories according to the workers' educational level, where each category exhibits different market wages.

The rate of change of the input quality is meant to capture the effects of the changes in the composition of the input. A worker with a high educational level is more productive than one without education. The differences in input productivity are reflected in their unit prices. A rate of change in the input quality will be positive when it increases the participation of the inputs with higher productivity, which, in the case of labor, is reflected in higher unit wages.

The accounting of the sources of growth proposed here offers two advantages over the traditional analysis: on the one hand, it introduces the land in the analysis; on the other, it gives support to the idea that in some countries, changes in the terms of trade affect growth. For both reasons, we get a measure of the total factor productivity, calculated as a residual, which is more precise. The term Γ stands for growth in total factor productivity which have been assumed as constant throughout the period, but which, at the time of empirical implementation, may be allowed to change introducing structural breaks.

3. The Cointegrated VAR Model

The idea of using cointegration techniques to estimate the production function arises naturally if we adopt the hypothesis that the process of determining the GDP can be described as an equilibrium correction model, given the endogeneity between output, capital, labor and land, upon attaining the long-term equilibrium path. The framework is also useful because it makes a clear distinction between the business cycle dynamics and the evolution of potential output.

Defining the vector:

$$X_t = (lnY_t, lnK_t Q_{Kt}, lnL_t Q_{Lt}, lnT_t, lnToT_t)' \quad (3)$$

of 5 x 1 dimension, which contains the variables to be used in output estimation. Assuming that output, quality-adjusted capital, quality-adjusted labor, land and the terms of trade are linked by cointegration relationships, an equilibrium correction model will be built; that is to say, a VAR I(1) model of the following kind:

$$X_t = \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + ... + \Pi_k X_{t-k} + \Phi D_t + \varepsilon_t \quad (4)$$

[4] Alternatively it is possible to consider instead of the land variable (hectares cultivated), a variable which represents the cropland weighted by the production value of each type of hectare, as done in Cavallo et al. (1989). This later variable includes the quality component.

where the X are fixed, $\varepsilon_1, ..., \varepsilon_T$ are $iid\, N_p(0, \Omega)$ and D_t is a vector of deterministic variables which may include a constant, a linear trend and/or dummy variables.

A convenient reformulation of (4) in terms of differences, lagged differences, and levels of the process is the so-called vector equilibrium correction model:

$$\Delta X_t = \Pi X_{t-1} + \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k+1} + \Phi D_t + \varepsilon_t \tag{5}$$

where $\Pi = \sum_{i=1}^{k} \Pi_i - I_p$ y $\Gamma_i = -\sum_{i=i+1}^{k} \Pi_i$.

The properties of the vector equilibrium correction model are determined by the properties of the characteristic polynomial of the process. Assuming that all the roots of this polynomial have a modulus greater than one, then the vector X_t is stationary. However, if this polynomial has unit roots, then, the vector X_t may be I(1). If $z = 1$ is one of the roots, the matrix Π will exhibit a reduced rank $r < p$. This implies that Π may be written as $\Pi = \alpha\beta'$, where α and β are matrices of p x r dimension and full rank column.

The cointegration hypothesis may be interpreted as a reduced rank condition on the matrix Π. Such condition particularly implies that the processes ΔX_t and $\beta' X_t$ are stationary, while X_t is not. Thus, it is possible to interpret the relations contained in $\beta' X_t$ as stationary relationships between variables that are not. In particular, the cointegration relations imply that certain linear combinations of the variables in the vector X_t are of lesser order than the process X_t itself. Also, the cointegrated variables are under the influence of the same persistent shocks. Therefore, if the non-stationarity of a variable is associated to the non-stationarity of another, there will be a linear combination between them, which is itself stationary. These cointegrated relations included in vector $\beta' X_t$ can be interpreted as long-term economic relations, which is a point of especial interest for the production function estimation.

4. Data

Data values are expressed in 1993 prices. For each variable, the upper figure shows the level of the variable in logarithms and the lower figure the differences, that is an approximation to the growth rate.

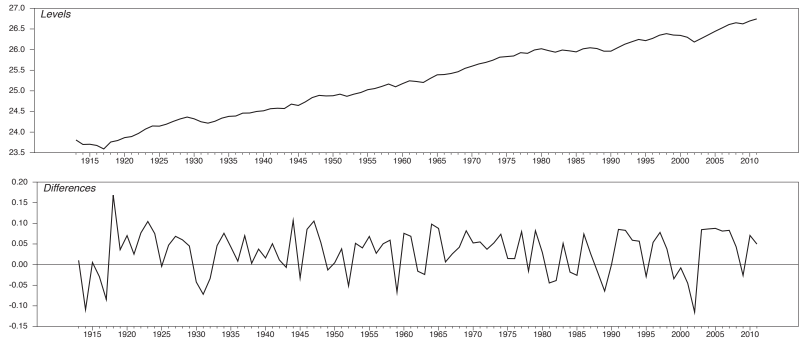
It should be noted that inconsistencies were found when joining GDP series based on 1970 prices with GDP series based on 1986 prices. In fact, there is some 30% discrepancy between the nominal values in both series over the first half of the 1980s. The inconsistency was corrected by assuming it had been originated in the existence of a shadow economy, using, then, a quantity adjustment and assuming that the values in the base years 1970 and 1986 were correct, and distributing the discrepancy proportionally over the 16 years. Dagnino Pastore (1995) already warned about this problem when joining Argentinean output series. This correction slightly modifies the view concerning the growth performance of the period and smoothes out the sustained sharp fall in total factor productivity estimated by other authors. However, the 1980s will continue to be a lost decade, although a little less so.

Figure 1 shows that the growth rate of the economy has been highly variable, specially before 1919 and after 1975.

Total capital stock was calculated following the perpetual inventory method at a disaggregated level for each component of investment. Capital stock was calculated in a given period as the sum of the different types of investments made to date, adjusted for the respective depreciations. Specifically, capital series done by Maia and Nicholson (2001) for the 1960-2000 period were completed backwards.[5] The calculations allowed to obtain two types of capital

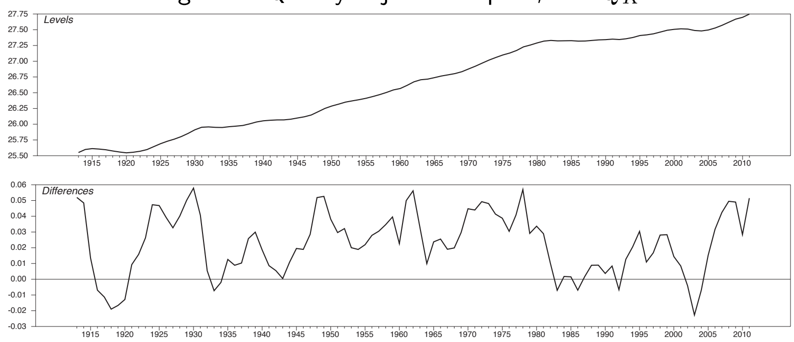
[5] In this task of reconstruction, the values used for the initial capital stock of 1900 were: Total Construction

Figure 1: Output, lnY



series: total capital and reproductive capital (residential buildings not included); total capital is used in the estimation.

Figure 2: Quality-adjusted Capital, $lnKQ_K$



The quality index which serves to correct capital shows a unit value in 1993. Appendix, describes the methodology, although it must be said that quality adjustments were not made in periods prior to the 1940s given the lack of reliable data of prices of the different capital stock components.

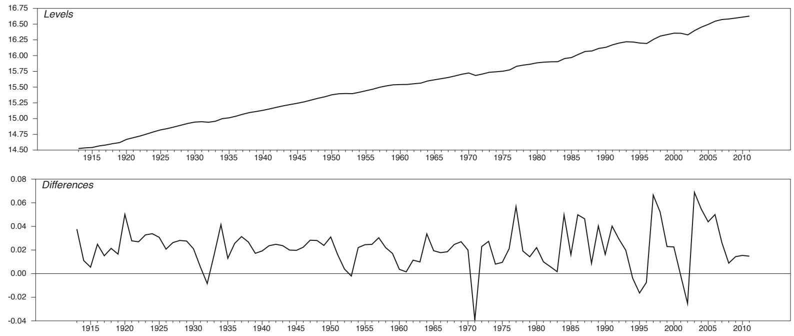
Figure 2 shows that the capital does not grow during the 1980s. Capital growth returns during the Convertibility Plan until the collapse of the currency board, and then again starts growing. It can be seen that the capital stock appears to be a variable that has some I(2) behavior, given that it's first difference is not a clear stationary variable. In fact by construction, capital stock is the result of accumulating investment, an I(1) variable, over time.

Employment is expressed in the number of people corrected by the quality index which holds a unit value in 1993. Appendix describes the processing methodology of the quality index. It must be stated that the adjustments of labor quality were not made, in the period before 1940, given the absence of census data. Quality-adjusted employment grew at an average rate of 2.2% per year in the period. It can be seen in figure 3 that after 1991 the growth rate becomes more unstable.

The factor land is represented by millions of hectares cultivated with grains and oilseeds. Figure 4 shows the strong negative impact that the agricultural policy of the first Peronist

29817, Machinery and Equipment 2425 and Transport 585, expressed in millions of pesos (national currency) of 1950, according to CEPAL (1959). The capital stock for the period 1990-2010 was taken from the National Institute of Statistics and Censuses (INDEC, by the acronym).

Figure 3: Quality-adjusted Labor, $lnLQ_L$



Administration caused on the number of hectares cultivated. At the end of the sample, in the past two decades the agricultural frontier has expanded at an average rate of 2.8% per year.

Figure 5 shows the evolution of the terms of trade corrected by commercial policy, i.e. the price of exports includes the effects of taxes or differential exchange rates, and the import price includes the effect of tariffs or differential exchange rates. Notice that between 1934 and 1954 the nominal exports exchange rate was lower than the nominal imports exchange rate.

Figure 4: Land, lnT

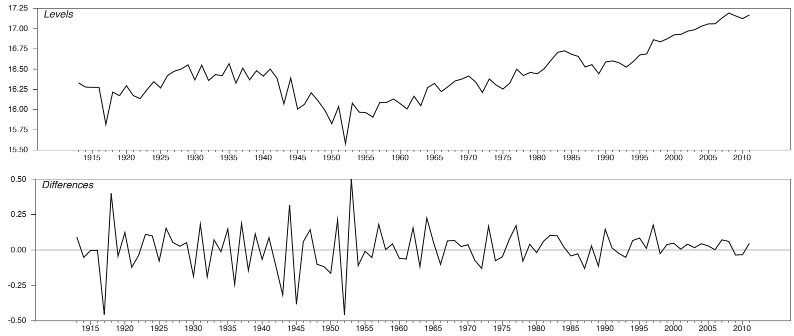
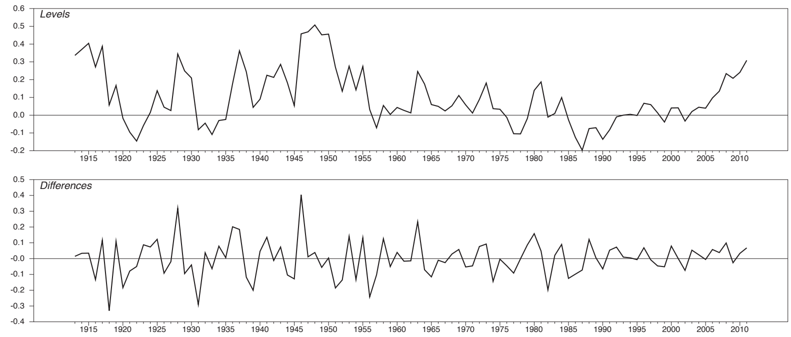


Figure 5: Internal Terms of Trade, $lnToT$



Exports taxes were introduced in 1955, and the exchange rate market for commercial activities was unified. In 1991-2001, despite the elimination of export taxes, the terms of trade corrected by commercial policy did not recover because of the low prices of the agricultural products in international markets. With the collapse of Convertibility in 2002, export taxes were introduced back again. Despite the aforementioned, in following years the situation turned very much favorable to the agro-exporting sector thanks to the high price of grains and oilseeds in international markets.

5. Empirical Estimation

5.1. Model Specification

The model used here starts at the endogenous variable vector X_t, to which certain deterministic components have been added. In order to understand how the deterministic components enter the system, it is necessary to rewrite the equilibrium correction model given in (6) as follows:

$$Z_{0t} = \alpha\beta' Z_{1t} + \Psi Z_{2t} + \varepsilon_t \tag{6}$$

where $Z_{0t} = X_t$, $Z'_{1t} = \left(X_{t-1}, D^R_{t-1}\right)$ and $Z'_{2t} = \left(\{\Delta X_{t-i}\}_{i=1}^{k-1}, D^U_t\right)$. In this specification, D^R_t is a vector with deterministic components restricted to the cointegration space, while D^U_t involves the components which are not restricted to that space.

The basic model used in this work allows the cointegration relations to be trend-stationary and to possess a non zero intercept. This specification should be used whenever it is suspected that one or more variables are stationary in trend. The model is characterised, then, for having a linear trend t restricted to the cointegration space and integrated into the vector D^R_t with a constant c included in the vector D^U_t with the other unrestricted variables of the system.

In order to correct anomalies in the data and/or shocks, transitory blip dummy variables in 1917, 1943, 1952, 1971, 1991, 1995 and 2002, and permanent blip dummies in 1961, 1977 and 1997 have been incorporated, among the non-restricted components of the model. Transitory blip dummies assume a value of 1 in the corresponding period and a value of -1 in the immediate following period. The permanent blip dummy variable assumes a unit value in the corresponding period and none for all other t. Transitory blip dummy variables corresponds to years of macroeconomic crises, and the 1977 permanent blip dummy to the year of the financial reform.

A break in trend is also introduced, in 1972, to estimate the model satisfactorily. Because this break is found in the trend and the latter one is found in the group of variables constrained to the cointegration space, the break must be included in vector D^R_t.

When looking at the variables more closely, tests indicate that the terms of trade should be considered as a weak exogenous variable, as economic theory suggests. To complete the model specification, the use of two lags to describe the dynamic behaviour of the system must be mentioned.

5.2. Results of the Estimation

The Johansen trace test and the analysis of the roots that describe the dynamic properties of the system indicates that there is one cointegration relationship.

The different tests are available in Appendix.[6] Graphical analysis of possible cointegration relationships seem to confirm that there is only one cointegration relationship. The results of the estimation under this assumption are presented in Table 1.

The estimated coefficients bear the expected signs and magnitudes, however not all of them are significant.

The step that followed tested the existence of constant returns to scale in the production function.

[6] All model estimates were performed with the program CATS in RATS, Dennis et al. (2005).

Table 1: Cointegrated VAR model estimation ($r = 1$)

The eigenvector (transposed)							
	LY	LKQ	LN	LT	LTOT	T(1972:01)	TREND
Beta(1)	-26.270	10.606	9.347	2.445	2.755	-0.243	0.360

The matrices based on 1 cointegrating vector:

β'							
	LY	LKQ	LN	LT	LTOT	T(1972:01)	TREND
Beta(1)	1.000 [NA]	-0.404 [-2.841]	-0.356 [-1.113]	-0.093 [-2.108]	-0.105 [-1.935]	0.009 [4.206]	-0.014 [-1.556]

α	
	Alpha(1)
DLY	-0.217 [-2.191]
DLKQ	0.073 [5.153]
DLN	-0.004 [-0.124]
DLT	0.264 [1.148]

Π							
	LY	LKQ	LN	LT	LTOT	T(1972:01)	TREND
DLY	-0.217 [-2.191]	0.087 [2.191]	0.077 [2.191]	0.020 [2.191]	0.023 [2.191]	-0.002 [-2.191]	0.003 [2.191]
DLKQ	0.073 [5.153]	-0.030 [-5.153]	-0.026 [-5.153]	-0.007 [-5.153]	-0.008 [-5.153]	0.001 [5.153]	-0.001 [-5.153]
DLN	-0.004 [-0.124]	0.001 [0.124]	0.001 [0.124]	0.000 [0.124]	0.000 [0.124]	-0.000 [-0.124]	0.000 [0.124]
DLT	0.264 [1.148]	-0.107 [-1.148]	-0.094 [-1.148]	-0.025 [-1.148]	-0.028 [-1.148]	0.002 [1.148]	-0.004 [-1.148]

Table 2: The estimation of the restricted model

Test of restricted model: $\chi^2(2)$ = 0.130 [0.937]

Bartlett correction: $\chi^2(2)$ = 0.070 [0.966] (Correction Factor: 1.854)

The eigenvector (transposed)							
	LY	LKQ	LN	LT	LTOT	T(1972:01)	TREND
Beta(1)	-26.271	11.487	12.242	2.542	2.542	-0.246	0.278

The matrices based on 1 cointegrating vector:

β'							
	LY	LKQ	LN	LT	LTOT	T(1972:01)	TREND
Beta(1)	1.000 [NA]	-0.437 [-4.302]	-0.466 [-4.679]	-0.097 [-2.626]	-0.097 [-2.626]	0.009 [4.466]	-0.011 [-8.974]

α	
	Alpha(1)
DLY	-0.205 [-2.073]
DLKQ	0.073 [5.169]
DLN	0.000 [0.012]
DLT	0.273 [1.185]

Π							
	LY	LKQ	LN	LT	LTOT	T(1972:01)	TREND
DLY	-0.205 [-2.073]	0.090 [2.073]	0.096 [2.073]	0.020 [2.073]	0.020 [2.073]	-0.002 [-2.073]	0.002 [2.073]
DLKQ	0.073 [5.169]	-0.032 [-5.169]	-0.034 [-5.169]	-0.007 [-5.169]	-0.007 [-5.169]	0.001 [5.169]	-0.001 [-5.169]
DLN	0.000 [0.012]	-0.000 [-0.012]	-0.000 [-0.012]	-0.000 [-0.012]	-0.000 [-0.012]	0.000 [0.012]	-0.000 [-0.012]
DLT	0.273 [1.185]	-0.119 [-1.185]	-0.127 [-1.185]	-0.026 [-1.185]	-0.026 [-1.185]	0.003 [1.185]	-0.003 [-1.185]

Table 2 shows the results of the restricted model, and it is confirmed that we can not reject the validity of the hypothesis $\beta_1 + \beta_2 + \beta_3 = 1$ and that β_3 is the coefficient of both variables (land and terms of trade), with a p-value of 0.97.[7]

It can also be seen that the trend changes are significant and that the coefficients of the production function have the expected signs and are all significant. Capital share is 0.44, labor share is 0.46 and that of land and terms of trade are 0.10. The estimate would indicate that in the long-term relationship, the annual growth in total factor productivity (TFP) is 1% in the period before 1972, and virtually nil (0.1%) as from 1972.

The analysis of the adjustment coefficients (α) to equilibrium indicates that variables that adjust are output and capital. If at some point, effective output is above potential output, the equilibrium correction term of the model will induce a reduction of output and an increase

[7] imposing only $\beta_1 + \beta_2 + \beta_3 = 1$, the results are $\beta_1 = 0.444$, $\beta_2 = 0.464$, $\beta_3 = 0.092$, and $\beta_4 = 0.105$, with a p-value of 0.83

of capital stock in the next period. The amounts of these changes are express in percentage of the imbalance, that is -20.5% and 7.3% respectively, and both movements will reduce the output gap. Recursive graphs show that these adjustment coefficients are always significant.

The analysis of the residuals is presented in Appendix, test do not reject the null hypothesis of normality.

6. Potential output and output gap

6.1. Cointegrated VAR Model Forecast

Figure 6 shows the observed output and the potential output estimated by the equilibrium correction model.[8] The dotted line stands for the output level estimated by the model, using the equation 5. The inputs required for the forecast are: the estimated parameters of the model, the values of all the variables for the year 1915 and lags (1914 y 1913), and the exogenous variable (terms of trade) for each year of the 1913-2011 period.

Figure 6: Output and Potential Output

It should be noted that before the crash of 1930, output evolved above its potential, the same as during the 1970s. During hyperinflation at the end of the 1980s and during the collapse of Convertibility Plan in 2001, output is found well below its potential.

To analyze in greater degree of detail what happened in the last decades, let us plot the actual and the potential output since 1970. In 2011, the actual output is well above potential, which indicates that the economy is overheated. In Figure 7, the evolution of the potential output up to 2015 has been forecasted, assuming that the terms of trade remain constant at 2011 levels. It is seen, that the potential output will reach the level of the 2011 observed output, only during 2015, showing a big disequilibrium in the goods market (7.1% above potential output in 2011). Historical data show that the observed output never grew beyond 10% above the potential output. This would be saying that the latitude for growth between 2012 and 2015 is limited and that it will be difficult for the economy to grow more than potential output does; as a matter of fact, it would be better if it grew less so that the actual output may converge to the potential.

To make forecasts about potential output growth for 2012-2015, we can use equation 4, but it is necessary to make assumptions regarding the evolution of the terms of trade. In this sense, Table 3 shows forecasts about potential output growth under three scenarios: (1) terms of trade (ToT) fall 5% each year in the period 2012-2015, (2) terms of trade remain constant

[8] The equations of the equilibrium correction model are detailed in the Appendix

Figure 7: Output and Potential Output (1970-2015)

at 2011 values (the scenario plotted in Figure 7); (3) terms of trade grow 5% per year in the period. Under the intermediate assumption, the potential output would grow around 1.9% annually.

Table 3: Growth Forecasts under different scenarios of ToT growth

	$d(lnY)$	$d(lnY^*)(1)$	$d(lnY^*)(2)$	$d(lnY^*)(3)$
2010	7.1%	1.9%	2.0%	2.1%
2011	5.0%	2.6%	2.8%	2.8%
2012		1.9%	2.2%	2.9%
2013		1.2%	1.9%	3.0%
2014		1.1%	1.9%	3.0%
2015		1.1%	1.8%	3.0%

6.2. Quantifying the output gap

Figure 8 shows the output gap of Argentina's economy in recent decades. The 2011 value is 8.8%, close to the gaps observed during the mid 1970 crisis. In addition, you may notice some asymmetry in the figure between positive and negative gaps, the positive not exceed 10% while the negative ones can reach 16%, as during the hyperinflation and the collapse of convertibility plan.

The evolution of the output gap (GAP) can be analysed with this equation:

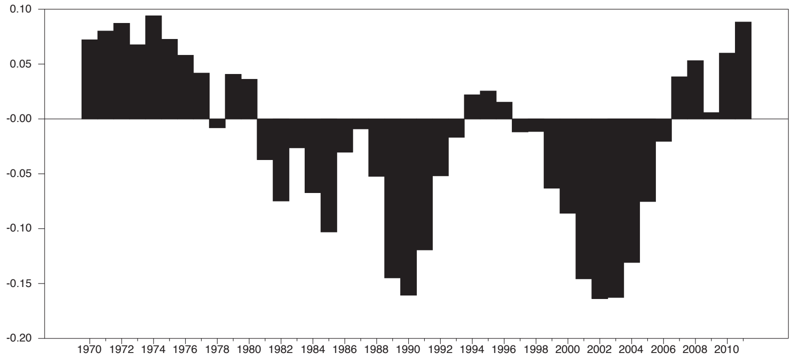
$$GAP_t = GAP_{t-1} + d(lnY_t) - d(lnY_t^*) \tag{7}$$

The output gap at any given time, is the sum of the gap of the former period, plus the observed growth in the period, minus the growth of the potential output. Table 4 helps with the accounting, the first column shows the growth rate of GDP, the second the growth rate of potential output and the last column the evolution of the output gap.[9].

During 2007, GDP reached full employment level, which at the end of the year was 3.8% above potential output. The 2007 output gap is the result of adding the economy's growth rate (8.3%) to the 2006 output gap (-2%) and subtracting the potential output growth (2.6%).

[9]All rates have been calculated as the difference of logarithms, including the output gap

Figure 8: Output Gap (1970-2011)



From that year onwards, GDP evolved above potential output, boosting the inflationary process. The 2011 output gap (8.8%) is the result of taking the 2010 gap and the growth rate of real GDP and potential output (6% + 5.4% - 2.6%).

Table 4: Growth and Output Gap

	$d(lnY)$	$d(lnY^*)$	$lnY - lnY^*$
2000	-0.8%	1.5%	-8.6%
2001	-4.5%	1.5%	-14.6%
2002	-11.5%	-9.7%	-16.4%
2003	8.5%	8.4%	-16.3%
2004	8.6%	5.5%	-13.1%
2005	8.8%	3.2%	-7.5%
2006	8.1%	2.6%	-2.0%
2007	8.3%	2.4%	3.8%
2008	4.3%	2.8%	5.3%
2009	-2.6%	2.1%	0.6%
2010	7.3%	1.9%	6.0%
2011	5.4%	2.6%	8.8%
2012		2.2%	
2013		1.9%	
2014		1.9%	
2015		1.8%	

This kind of exercise tends to show that the growth rate of 5.1% which is found in the Budget Bill 2012 will quite improbably be effective. In fact, if the economy grew 5.1% in 2012, the GDP would be 11.7% higher than the potential output (8.8% + 5.1% - 2.2%), which seems unlikely in historical terms. No discrepancies of such magnitude have been recorded in the analyzed century between GDP and potential output, except before the 1930 and the 1975 crises.

Additionally, even if the growth rate turns to be zero until 2015, the economy could not fully absorb the output gap, and the 2015 GDP would be 1% above potential (8.8% - 2.2% - 1.9% - 1.9% - 1.8%). In short, it's time to pay the costs of the expansionary policies implemented after 2007.

The average growth rate in the years 2004-2011 was 6%, when the optimal value would have been 4.9% (2.9% annually given potential output growth, plus 2% per year to absorb the initial output gap along 8 years).

7. Conclusion

An equilibrium correction model has been build in order to estimate Argentina's potential output. The long-term equilibrium is represented by an aggregate Cobb-Douglas production function with three factors: capital, labor and land. Capital and labor inputs have been adjusted for quality, in the case of land; the terms of trade have been exogenously introduced in the production function as we assume they affect the quality of land. In fact, an increase in the terms of trade encourages the use of more fertilizers and other improvements (irrigation) which enhance the land quality.

The two distinctive features of the work, the use of an equilibrium correction model to perform the estimation and the inclusion of the terms of trade in the model, have interesting policy implications. If the data generating process is that of an equilibrium correction model, expansionary demand policies that attempt to push the GDP beyond the level of potential output have no medium-term effects, given that adjustment mechanisms to balance will work. For the same reason, the economy will neither evolve systematically at a level well below potential output.

Given a disequilibium between effective and potential ouput, the variables that adjust are output and capital. The equilibrium correction term will reduce output in an amount that equals 20.5% of the imbalance, and will increase capital in an amount that equals 7.3% of the imbalance.

The introduction of the terms of trade as an exogenous variable in the production function and the empirical validation of the results obtained also brings about relevant consequences. Indeed, we have established a link between shocks to the terms of trade and movements in productivity. Empirical support was found for the hypothesis that shocks in the terms of trade shift the aggregate production function in the Argentine case. It is also surprising that the whole growth and capital accumulation dynamics is led by the terms of trade, an exogenous variable, which is beyond the control of policy-makers.

The forecasts about the growth of potential output over the next four years also show the key role of this variable in macroeconomic performance. Indeed, if the terms of trade remain constant, potential output in the coming years will grow at a rate of 1.9% per year. If the terms of trade increase 5% per year, the potential output growth rate will be 3%, whereas if the terms of trade fell by 5% per year, potential output will grow at 1.1% per year.

The analysis of the output gap indicates that full employment was reached during 2007 and that towards the end of that year output was 3.8% above its potential. The fall in GDP during 2009 allowed a reduction in output gap, aligning GDP with potential output; however, the expansionary monetary and fiscal policies in 2010 and 2011 regenerate again a positive gap. In 2011, the GDP is 8.8% above potential output, fueling inflation.

The introduction of the terms of trade represents a small progress in the direction of introducing open economy variables in the estimation of the production function. It could be more interesting to estimate a production function resulting from adding two sectors, a tradable goods sector and a non-tradable one, the former being directly affected by changes in the terms of trade and sectoral productivities. Unfortunately, there are no sectoral capital series in Argentina, a fact which apparently blocks the possibility to make progress in that direction.

Returning to the idea present in Solow's quote that econometrics has to perform its task and help to solve the aggregation issue, the equilibrium correction model introduced here represents an initial step in accomplishing that goal. However, a general equilibrium framework is still needed to isolate demand shocks, so that total factor productivity could be estimated more accurately.

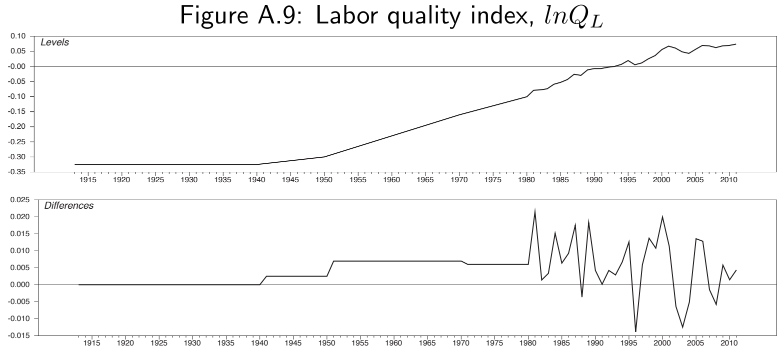
AppendixA. Capital and Labour Quality Indices

The labor quality index is defined as a weighted average of labor with different education levels, where the weights are the relative wages of each category with respect to the mean wages in the workforce. The formula for calculating the growth rate of the index is:

$$\frac{\dot{Q}_L}{Q_L} = \Sigma_1^5 \frac{w_i}{w} \left(\frac{\dot{L}_i}{L} \right) \tag{A.1}$$

where the dot over a variable stands for its differential. Labor quality increases when the composition of labor changes in favor of workers with higher productivity, measured by the received salary. To develop this index, a number of employees and the income received in return for declared work as the main occupation were recorded for the Greater Buenos Aires in the period 1980-2010. The series were obtained from the Household Survey conducted by the National Institute of Statistics and Censuses (INDEC, by the acronym). The workforce was classified into five categories: incomplete primary school cycle, complete primary schooling and incomplete high school, completed high school and incomplete college education, completed college studies and a residual category characterized by very low wages.

Figure A.9: Labor quality index, lnQ_L



Using equation A.1, the labor quality index was derived starting in 1980. For the years 1940-1970, the computations by Elías (1978) based on census data were used; that is, an annual 0.25% increase for the 1940s, an annual 0.7% for the 1950s and 1960s. For the 1970s, an annual 0.6% was assumed. There were no quality adjustments prior to 1940, as data were not available.

The index shows a clear positive trend, reflecting improvements in human capital and the shift towards more skilled jobs.

The change in the capital quality index Q_K is calculated as the weighted average of investment in machinery and tools on the one hand and investments in buildings and structures on the other, where the weights are the relative rates of return.

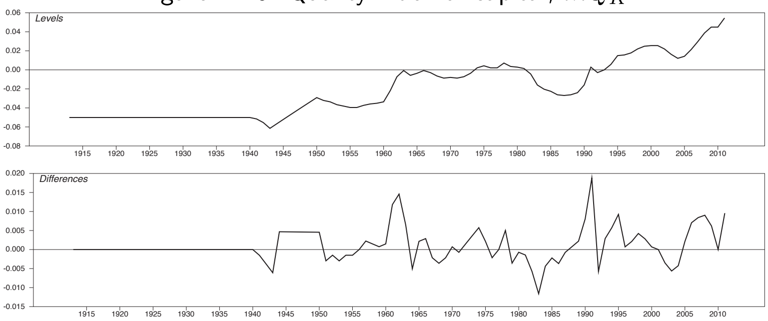
$$\frac{\dot{Q}_K}{Q_K} = \Sigma_1^3 \frac{r_j}{r} \left(\frac{\dot{K}_j}{K} \right) \tag{A.2}$$

While data on investment and capital in machines, equipment and buildings are available and can be reworked, data on rates of return for different types of capital are not available and were estimated by an arbitrage relationship:

$$r_j = P_{j(t-1)} r_{(t)} + \delta_j P_{j(t)} - (P_{j(t)} - P_{j(t-1)}) \tag{A.3}$$

where r_j is the price of capital service of j, $P_{j(t)}$ is the price of capital goods j, $r_{(t)}$ is the overall return rate of the economy, δ_j is the rate of depreciation of capital assets j. The first term represents the (general) return on the capital valued in the capital price j. The second term stands for the amount of the depreciation on capital assets j and the third term represents the capital gains on capital assets j.

Figure A.10: Quality index of capital, lnQ_K



The capital quality index shows a very small increasing trend with ups and downs; in particular, a deterioration of the quality of capital can be seen over the 1980's.

AppendixB. The cointegration rank

To determine the number of cointegration relations (r) present in this system, i.e. the rank of matrix Π, three tests are available.

The first one is based on the maximum likelihood procedure proposed in Johansen (1995). The test LR to determine the cointegration rank, also known as the Johansen trace test, is based on the VAR model expressed in concentrated form ($R_{0t} = \alpha\beta' R_{1t} + error$, being R_{0t} and R_{1t} the residual vectors resulting from a pair of auxiliary regressions derived from implementing the Frisch-Waugh theorem on the VAR model, where all the short-term dynamics and dummies variables have been concentrated outside the model. According to Johansen (1995), the likelihood ratio test of the null hypothesis of the r cointegrating relations against the unrestricted alternative is given by the trace statistic defined as:

$$-2logQ(H(r)|H(p)) = -T \sum_{i=r+1}^{p} log(\hat{\lambda}_i) \quad \text{(B.1)}$$

where $H(r)$ is the hypothesis that introduces the existence of r cointegration relations and $p - r$ unit roots; $H(p)$ raises the hypothesis of absence of unit roots in the system (vector X_t is stationary); T is the number of observations and $\hat{\lambda}_i$ are the eigenvalues that result from maximizing the log-likelihood function.

It is important to consider that the trace statistic and its asymptotic distribution may be affected by the sample size when the sample is small. That is why CATS incorporate a small sample correction in the test.

The results of the Johansen trace test are shown in Table B.5.

It seems that there is one cointegration relation, however the critical/P-values in table B.5 correspond to the basic model with no dummies, no breaks and no exogenous variable. To take into account these features which influence the shape of the distribution we need to simulate the critical values as done in Table B.6.

Table B.5: I(1) Analysis - Rank Test Statistics

p-r	r	Eig.Value	Trace	Trace*	Frac95	P-Value	P-Value*
4	0	0.298	77.431	70.146	63.659	0.002	0.012
3	1	0.215	43.071	39.053	42.770	0.046	0.115
2	2	0.126	19.586	18.064	25.731	0.253	0.347
1	3	0.065	6.506	5.763	12.448	0.409	0.501

The fact that there is no cointegration cannot be rejected according to Table B.6. However, if we omit the 1997 blip dummy (only to perform the test), results change, see Table B.7. The hypothesis that there is no cointegration can be rejected (P-value=0.086), and we cannot reject the hypothesis that there is at most one cointegrated relation (P-value=0.36).

A second approach to determining the number of cointegrated relations is to analyze the estimated roots of the process, which are shown in Table B.8.

Following the information in the table, the largest non-restricted roots are: 0.593 for $r = 1$, 0.692 for $r = 2$, 0.866 for $r = 3$, 0.837 for $r = 4$. The proximity of the last two figures to value one is an indicator of the presence of two unit roots in the system. This would suggest that there may be two cointegration relationships.

Another element to take into account emerges from the graphical analysis of the cointegration relationships. In that sense, the possibility of having many cointegration relationships may be ruled out. The graphs do not show stationary behavior except in the case of the first cointegration relationship. The graphical analysis would indicate that there is only one cointegration relationship.

In brief, the trace test can not reject that there is at most one cointegration relation in the model, and the other tests say that there are one or two relations; it seems, therefore, that we should bow to the existence of one cointegrating relation in the model.

Table B.6: Simulation of the rank test distribution

Report of the simulated quantiles for the asymptotic distribution of the rank test.

Deterministic specification: Restricted Linear Trend (CIDRIFT)

Partial Model: 1 weakly exogenous variable

Trend Breaks (1): 1972:01 (0.598)

Number of Replications (N): 2500

Length of Random Walks (T): 400

Quantiles of the Simulated Rank Test Distribution									
p-r	r	50%	75%	80%	85%	90%	95%	97.5%	99%
4	0	62.660	10.173	62.192	68.944	70.949	73.160	76.158	80.703
3	1	41.201	8.339	40.694	46.378	47.713	49.500	52.022	56.107
2	2	23.805	6.395	23.192	27.997	29.310	30.574	32.322	35.186
1	3	10.114	4.425	9.306	12.636	13.457	14.472	15.965	18.539

I (1) Analysis based on simulated critical values:

I(1) Analysis							
p-r	r	Eig.Value	Trace	Trace*	Frac95	P-Value	P-Value*
4	0	0.298	77.431	70.146	80.703	0.080	0.223
3	1	0.215	43.071	39.053	56.107	0.387	0.577
2	2	0.126	19.586	18.064	35.186	0.730	0.813
1	3	0.065	6.506	5.763	18.539	0.785	0.847

Table B.7: Simulation of the rank test distribution (1997 blip dummy omitted)

Report of simulated quantiles for the asymptotic distribution of the rank test.

Deterministic specification: Restricted Linear Trend (CIDRIFT)

Partial Model: 1 weakly exogenous variable

Trend Breaks (1): 1972:01 (0.598)

Number of Replications (N): 2500

Length of Random Walks (T): 400

Quantiles of the Simulated Rank Test Distribution									
p-r	r	50%	75%	80%	85%	90%	95%	97.5%	99%
4	0	62.999	10.002	62.472	69.499	71.184	73.303	76.281	80.315
3	1	41.665	8.334	41.058	47.049	48.588	50.582	53.137	56.522
2	2	23.843	6.457	23.152	27.963	28.965	30.414	32.213	35.153
1	3	10.107	4.300	9.499	12.495	13.362	14.381	15.750	18.203

I (1) Analysis based on simulated critical values:

I(1) Analysis							
p-r	r	Eig.Value	Trace	Trace*	Frac95	P-Value	P-Value*
4	0	0.311	84.910	77.072	80.315	0.021	0.086
3	1	0.218	48.765	44.144	56.522	0.191	0.360
2	2	0.159	24.870	22.692	35.153	0.403	0.536
1	3	0.080	8.088	7.491	18.203	0.641	0.700

Warning: The Bartlett Corrections correspond to the “Basic Model”.

Table B.8: Module of the roots of the process

r=0	1.000	1.000	1.000	1.000
r=1	1.000	1.000	1.000	0.593
r=2	1.000	1.000	0.692	0.692
r=3	1.000	0.866	0.741	0.741
r=4	0.837	0.837	0.719	0.719

AppendixC. Residual Analysis

The analysis of the residuals is quite important when examining the goodness of fit of the model. The most relevant information is shown in table C.9.

Both the first and the second order autocorrelation tests do not reject the null hypothesis of no autocorrelation. Test do not reject the null hypothesis of normality in the residuals, nor the null hypothesis of no heteroscedasticity.

Table C.9: Multivariate tests

Test	Statistics	p-value
Autocorrelation of residuals:		
$LM(1)$	$\chi^2(16) = 8.307$	0.939
$LM(2)$	$\chi^2(16) = 17.920$	0.329
Normality of residuals:		
$TestforNormality$	$\chi^2(8) = 5.365$	0.718
ARCH effects:		
$LM(1)$	$\chi^2(100) = 78.231$	0.947
$LM(2)$	$\chi^2(200) = 193.881$	0.609

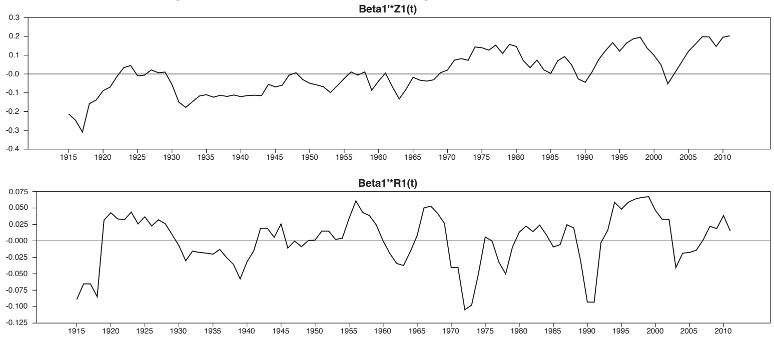
Table C.10: Univariate Statistics

	Mean	Std.Dev	Skewness	Kurtosis	Maximum	Minimum
DLY	-0.000	0.037	-0.201	2.517	0.074	-0.096
DLK	0.000	0.005	0.072	2.823	0.013	-0.014
DLN	-0.000	0.011	0.068	3.485	0.032	-0.026
DLT	0.000	0.086	-0.309	3.146	0.184	-0.268

	ARCH(2)		Normality		R-Squared
DLY	1.494	[0.474]	1.593	[0.451]	0.462
DLKQ	1.863	[0.394]	0.104	[0.949]	0.924
DLN	14.079	[0.001]	2.557	[0.278]	0.605
DLT	1.701	[0.427]	1.812	[0.404]	0.652

AppendixD. The cointegration relationship

Figure D.11: The cointegration relationship



AppendixE. Max Test of constant β

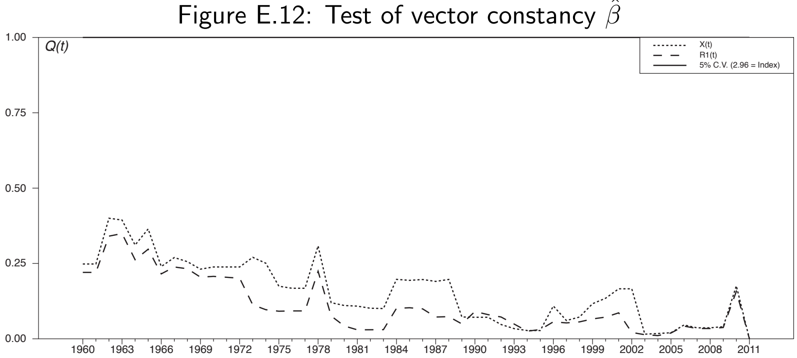
The test focuses on testing changes in β. The max test essentially test the hypothesis:

$$H_\beta : \hat{\beta}_{t_1} = \beta_0 \tag{E.1}$$

for $t_1 = T_1, ..., T$, where we use $\beta_0 = \hat{\beta}_T$.

The distribution of this test is generated by CATS via simulation. Figure E.12 shows that the recursively calculated max test of a constant β does not reject constancy in the sample period.

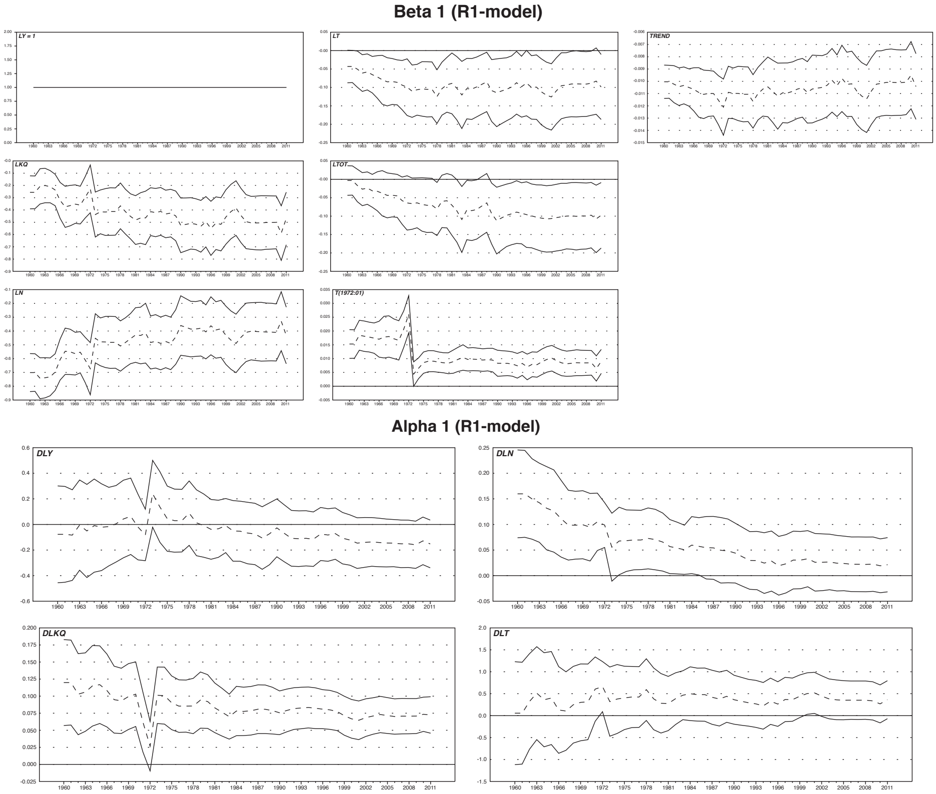
Figure E.12: Test of vector constancy $\hat{\beta}$



The test statistic, which has been divided by the 95% quantile of the distribution under the null of constant parameters, is safely below the rejection line of 1 for all t_1. The parameters obtained in the estimate vector β are constants.

AppendixF. Recursive estimates

Figure F.13: Recursive estimates



AppendixG. Cointegrated VAR Model Equations

Dependent Variable DLY

	Variable	Coeff
	************************************	
1.	LY1	-0.205399041
2.	LKQ1	0.089810581
3.	LN1	0.095717179
4.	LT1	0.019871281
5.	LTOT	0.019871281
6.	T(1972:01)	-0.001920313
7.	DLY1	0.373770403
8.	DLKQ1	0.032157626
9.	DLN1	0.194331354
10.	DLT1	-0.075436949
11.	RTrend	0.002174584
12.	UConst	0.858662108
13.	DLTOT	0.096142714
14.	DLTOT	0.031246419
15.	DT(1972:01)	0.027140323
16.	DUM1917T0	-0.131577585
17.	DUM1943T0	-0.059353606
18.	DUM1952T0	-0.028134768
19.	DUM1961P0	0.022735546
20.	DUM1971T0	0.021654581
21.	DUM1977P0	0.081543311
22.	DUM1991T0	0.021455273
23.	DUM1995T0	-0.051173736
24.	DUM1997P0	0.062633726
25.	DUM2002T0	-0.101753917

Dependent Variable DLK

	Variable	Coeff
1.	LY1	0.073457154
2.	LKQ1	-0.032119087
3.	LN1	-0.034231472
4.	LT1	-0.007106595
5.	LTOT	-0.007106595
6.	T(1972:01)	0.000686764
7.	DLY1	0.135501418
8.	DLKQ1	0.675270803
9.	DLN1	0.092391508
10.	DLT1	-0.015653174
11.	RTrend	-0.000777699
12.	UConst	-0.299592158
13.	DLTOT	-0.006069999
14.	DLTOT	0.007765544
15.	DT(1972:01)	-0.012909060
16.	DUM1917T0	0.001694128
17.	DUM1943T0	-0.005903930
18.	DUM1952T0	0.004106581
19.	DUM1961P0	0.019555029
20.	DUM1971T0	-0.009406601
21.	DUM1977P0	0.014266813
22.	DUM1991T0	0.019425645
23.	DUM1995T0	0.004669000
24.	DUM1997P0	-0.003390863
25.	DUM2002T0	-0.005402453

Dependent Variable DLN

	Variable	Coeff
1.	LY1	0.000333763
2.	LKQ1	-0.000145938
3.	LN1	-0.000155535
4.	LT1	-0.000032290
5.	LTOT	-0.000032290
6.	T(1972:01)	0.000003120
7.	DLY1	0.022283089
8.	DLKQ1	-0.258554089
9.	DLN1	0.314460511
10.	DLT1	0.000416522
11.	RTrend	-0.000003534
12.	UConst	0.018683638
13.	DLTOT	0.009665254
14.	DLTOT	0.023775783
15.	DT(1972:01)	-0.002396071
16.	DUM1917T0	-0.004006959
17.	DUM1943T0	0.002256762
18.	DUM1952T0	0.001476058
19.	DUM1961P0	-0.016291611
20.	DUM1971T0	-0.040921746
21.	DUM1977P0	0.041843913
22.	DUM1991T0	0.011089579
23.	DUM1995T0	-0.008436286
24.	DUM1997P0	0.051181250
25.	DUM2002T0	-0.050213411

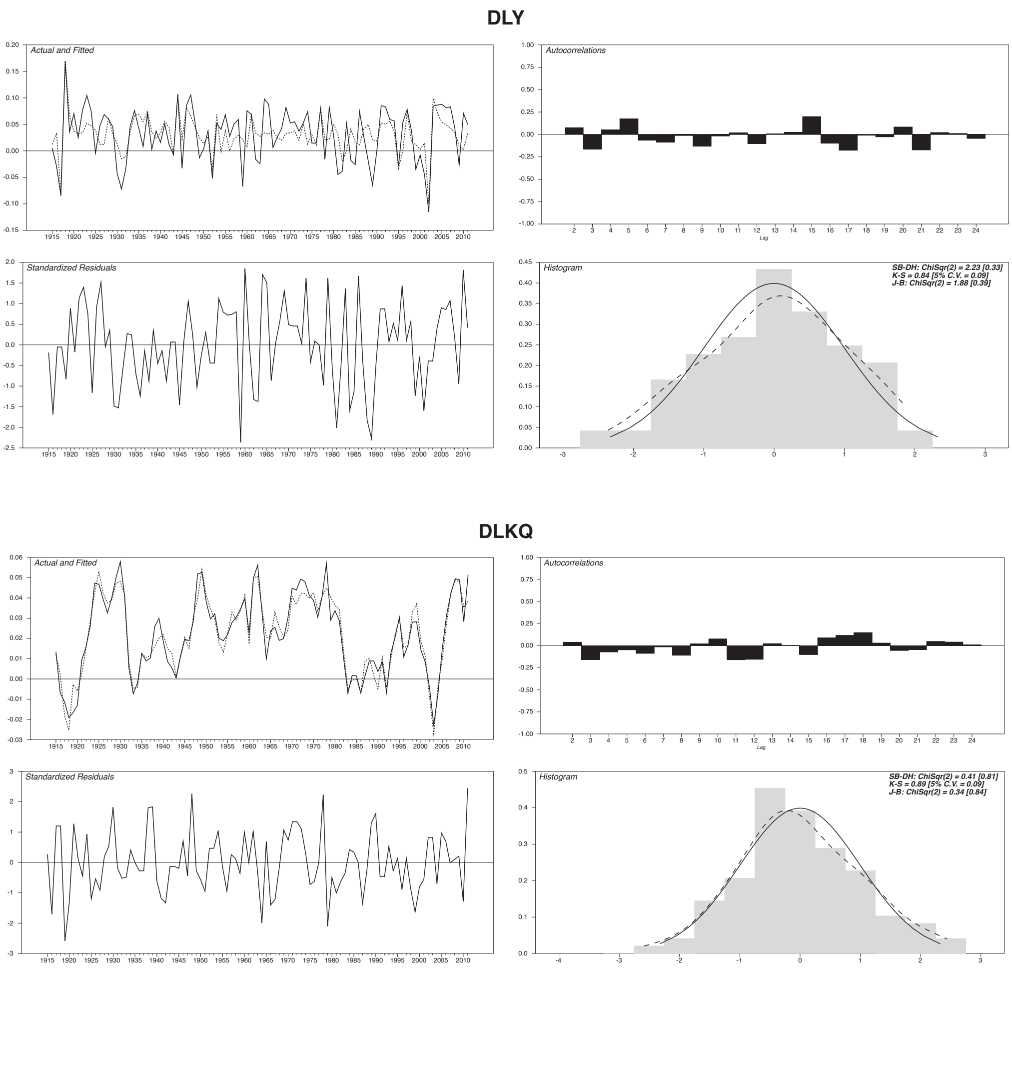
Dependent Variable DLT

	Variable	Coeff
1.	LY1	0.272922021
2.	LKQ1	-0.119334954
3.	LN1	-0.127183291
4.	LT1	-0.026403775
5.	LTOT	-0.026403775
6.	T(1972:01)	0.002551598
7.	DLY1	-0.166917199
8.	DLKQ1	-0.589986084
9.	DLN1	-0.031786927
10.	DLT1	-0.328258054

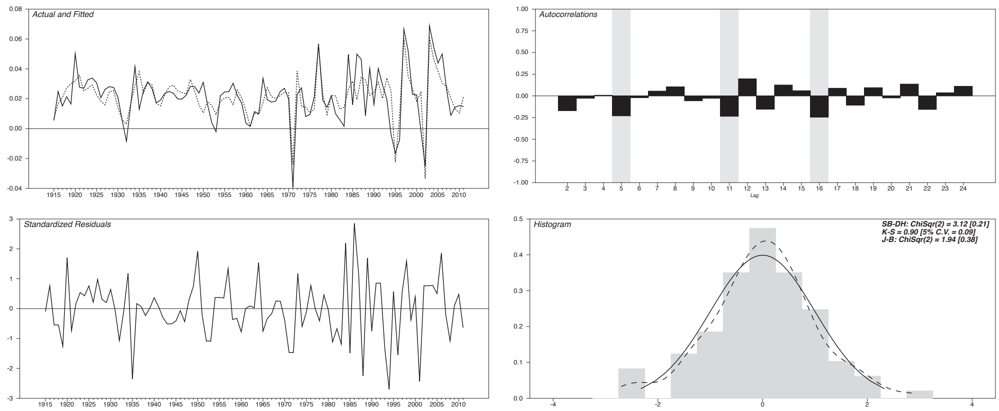
11. RTrend -0.002889457
12. UConst -1.094452356
13. DLTOT -0.047009402
14. DLTOT 0.183468078
15. DT(1972:01) -0.033031117
16. DUM1917T0 -0.322228327
17. DUM1943T0 -0.269981498
18. DUM1952T0 -0.366233848
19. DUM1961P0 -0.095596954
20. DUM1971T0 0.036077025
21. DUM1977P0 0.176075710
22. DUM1991T0 0.050235006
23. DUM1995T0 0.028987891
24. DUM1997P0 0.126701337
25. DUM2002T0 -0.006930471

AppendixH. Graph of the Residuals

Figure H.14: Graph of the Residuals

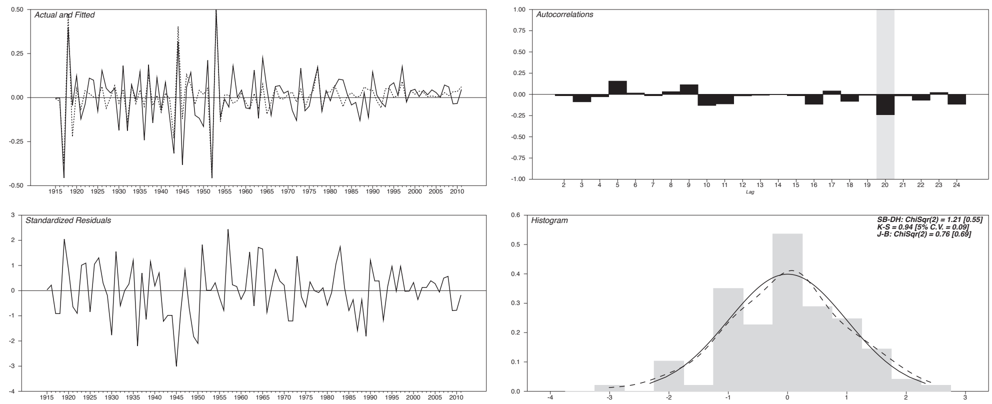


DLN



Actual and Fitted
Autocorrelations
Lag
Standardized Residuals
Histogram
SB-DH: ChiSqr(2) = 3.12 [0.21]
K-S = 0.90 [5% C.V. = 0.09]
J-B: ChiSqr(2) = 1.94 [0.38]

DLT



Actual and Fitted
Autocorrelations
Lag
Standardized Residuals
Histogram
SB-DH: ChiSqr(2) = 1.21 [0.55]
K-S = 0.94 [5% C.V. = 0.09]
J-B: ChiSqr(2) = 0.76 [0.69]

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