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Felicitas Nowak-Lehmann

Was there Endogenous Growth in Chile (1960-1998)? A Test of the AK-Model.

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Die Autorin:

Dr. Felicitas Nowak-Lehmann
Universität Göttingen
Ibero-Amerika Institut
e-mail: fnowak@gwdg.de

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CENTER FOR GLOBALIZATION AND EUROPEANIZATION OF THE ECONOMY
ZENTRUM FÜR GLOBALISIERUNG UND EUROPÄISIERUNG DER WIRTSCHAFT
an der Georg-August-Universität Göttingen
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1. Introduction

Basically all (development) economists emphasize the fostering of savings and investment as crucial to successful economic development and economic growth.

Although the role of savings and investment - not neglecting the importance of an undistorted incentive system, good institutions, the protection of property and human rights, social and political stability ...- is widely recognised, the 'key' question certainly remains whether a policy, which pushes savings and investment, will lead to a one-time increase of the rate of economic growth or, whether savings and investment will have a permanent (long-term) impact on the rate of growth. This issue is directly linked to the relevance/irrelevance of the neoclassical growth theory versus the endogenous growth theory.

In this study the author's model of choice within the endogenous growth framework is the AK model[1]. This model takes output to be a linear function of the accumulable factor capital (in a broad sense). Broad capital encompasses physical and human capital and is assumed to have constant returns to scale. In the AK model approach capital is the only determinant of the long-term growth rate.

The cornerstones of the neoclassical and endogenous growth models will be summarized in Chap. 2.

In order to bring more light onto the theoretical debate outlined above, the main empirical findings of Jones (1995) who analyzed the US and 14 OECD economies, will be highlighted in Chap. 3.

An empirical test of an endogenous growth model, run by the author, will follow in Chap. 4. The AK model - taken as a representative of an endogenous growth model - will be applied to the Chilean data and tested. The Chilean economy showed quite a successful growth path that could either be characterized as endogenous or as neoclassical (transitional[2] or steady state). Since Chile is often treated as a 'success story' (especially since 1985), it is important to get some hints on whether Chile can be considered a country that was capable and able to generate endogenous (long-run) growth in the period under scrutiny. For this purpose the Chilean growth experience in the period of 1960-1998 will be analyzed in very general terms (Chap. 4.1 and 4.2). The AK model will be applied to two sets (unfiltered and filtered) of Chilean data (Chap. 4.3 and Chap. 4.4). Statistical methods will be presented to gain insights into the duration of the impact of economic policies, which produce an upward shift of savings and investment. This procedure has the purpose to determine whether economic policy has (had) a permanent or only transitory impact on economic growth.

In Chap. 5 conclusions concerning the relevance of the endogenous growth model, and more specifically the AK model, will be drawn. It will be pointed out that the conclusions depend largely on the definition of the long-run. Finally a future line of research will be referred to. This 'in between approach' puts emphasis on dynamic modelling, which allows to determine the duration of impact of certain policy variables in terms of years, months etc.

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1 R. Harrod (1939) and E. Domar (1946) propagated a first version (labor surplus version) of the AK model. P. Romer rediscovered and modernized its basic idea of constant returns to capital in 1986.

2 I. e. being in the process of transition and moving towards a new steady state equilibrium.

2. Transitory versus permanent effects of savings and investment

The effects of a rise in savings and investment ratios on growth can be very different, depending on the growth theories one chooses to look at. According to the neoclassical growth model a positive shift of savings and investment rates will only have a temporary effect on the rate of growth, whereas according to the endogenous growth theory (in its AK version) it will have a long-run impact on the rate of growth.

2.1 The neoclassical growth model

Neoclassical growth theory goes back to Solow (1956) and Swan (1956) and has not yet lost its attraction (see studies of Mankiw, Romer, Weil, 1992; Barro and Sala-i-Martin, 1992, 1995).

According to the neoclassical growth theory a policy that promotes savings and investment will lead to an increase of output (level effect), but only to a short-run increase in the rate of growth (growth effect). The time-limited increase in the rate of growth is due to diminishing returns of the input factor: capital. Therefore, a rise in the savings rate which translates into investment will raise the level of per capita income and its growth rate only temporarily, up until the point at which the available savings is only sufficient to cover depreciation and growth in the labor force. Capital per worker stops increasing, although savings and investment continue to take place. This means that growth in per capita income would also stop, if there were no technological change. Viewed another way, during transition (most probably in the short and medium run) growth in per capita income is possible even without technological change, but in the long-run the growth in per capita income is just equal to the rate of technological change, and is entirely dependent on technological change which is exogenous.

2.2 The endogenous growth model

The beginnings of endogenous growth theory are associated with Romer (1986, 1990), Lucas (1988), Rebelo (1991), Rivera-Batiz and Romer (1991) as well as Grossman and Helpman (1991a, 1991b) and Grossman (1992).

Endogenous growth theory can explain long-run increases in output growth rates because of three phenomena (Rebelo, 1991, 1998):

First, endogenous technical progress makes the long-run growth permanent. Innovation, imitation and adaptation are driven by the profit-maximizing behavior of firms. Even though externalities might be connected with those activities, the costs of innovating, imitating or adapting new products and/or new technologies are covered by temporary profits that allow to set prices correspondingly (mark-up pricing), an idea already propagated by Schumpeter (Judd, 1985; Romer, 1990; Aghion and Howitt, 1992; Grossman and Helpman, 1991; Young, 1993).

Second, according to the AK model that assumes constant returns to scale of the accumulable factor capital[3] (which comprises physical and human capital) and that abstracts from

[3] Constant returns of capital can be justified in two ways, either surplus labor (Harrod and Domar) or positive externalities linked to capital accumulation (Romer).

nonreproducible factors, such as land[4], an increase in savings and investment does therefore not curb the incentives to accumulate capital. Capital accumulation becomes thus a profitable long-run business (Jones and Manuelli, 1990; Rebelo, 1991; Jones, 1995).

Third, positive externalities linked to capital (in a broader sense) accumulation lead to constant or even increasing returns of the accumulable factor (Romer, 1986, 1987). Positive externalities suspend the assumption of diminishing returns to capital (in the neoclassical model) and thus make permanent increases in the growth rate of output possible. Romer refers to the positive externalities of physical investment and knowledge, whereas Lucas points to the positive externalities of human capital accumulation. (Romer, 1986; Lucas, 1988; Azariadis and Drazen, 1990; Murphy, Shleifer and Vishny, 1989).

2.3 The mediation approach

According to the neoclassical growth model, savings and investment have only a level effect on per capita income. 'Good' economic policy does increase the long-run level of per capita income but not its long-run rate of growth. It has to be pointed out, however, that the growth rate in the neoclassical model during transition is in fact an endogenous function of underlying parameters, and actual economies spend most or all of the time in a transitional state. In contrast, the endogenous growth model shows that economic policies which enhance the rate of saving and investment have an impact on the long-run rate of growth.

This is meant to say that - after all - the differences between the neoclassical model and the endogenous model are not that big, if the transitional state is the rule or lasts for years. Under comparable time intervals, capital accumulation, the rate of depreciation, the rate of population growth/labor force growth and - of course- the rate of technological progress have a similar impact on the growth rate of output.

The only difference would be that in the endogenous growth model the rate of technological advance is explained by profit-maximizing firm decisions to imitate and/or to innovate. Besides, the existence of externalities (spillovers) makes the accumulation of physical and human capital and knowledge more attractive, thus enabling higher rates of output growth if certain positive conditions are fulfilled. Therefore, the issue of the impact of 'good' economic policies on economic growth remains a matter for empirical testing.

3. Jones' test of the AK model: findings for the U.S.A and 14 OECD countries

In order to clarify the role of good economic policies empirical analyses become necessary. Jones (1995) studied the relevance of endogenous growth for the U.S.A. and 14 OECD countries. Even though his results are clear, they remain primarily country specific. However, Jones' findings may even be distorted and misleading because the data have not been purged from short-run fluctuations. This point will be picked up in Chap. 4.2 and 4.4.

Jones (1995) was the first who did time series tests of endogenous growth models. He examined the growth rate of the US economy (1880-1987) and of 14 OECD countries (1900-1987) by applying time series tests. He looked at the time series properties of the per capita GDP growth in the United States and concluded from its constant mean and its stationarity (in

[4] Rebelo (1991) proved that perpetual growth can be consistent with the presence of capital goods produced with nonreproducible factors.

the statistical sense) that "either nothing in the U.S. experience since 1880 has had a large, persistent effect on the growth rate, or whatever persistent effects have occurred have miraculously been offsetting". The same applied to the fourteen OECD countries[5] when looking at the ADF-test[6] which proved the growth rates to be stationary. These results call into question the implicit prediction of many endogenous growth models for the countries under investigation that growth rates should exhibit large permanent increases (Jones, 1995).

However, if one examined the period of 1950-1988, the picture is mixed. One would realize a positive mean shift after World War II. The countries with significant mean shifts are Australia, Austria, Germany, Italy, Japan and the United Kingdom. With the exception of Australia, these were all countries that were severely affected by the war and where the recovery in the ensuing decades was tremendous due to the Marshall Plan which facilitated the inflow of capital.

Then Jones moved on to test the **AK model** which can be referred to in Romer (1987), Rebelo (1991), Barro (1991) and Benhabib and Jovanovic (1991). The idea of the AK models is that a permanent increase in the investment rate should be reflected in a permanent increase of the growth rate if the endogenous growth theory is true. When looking at the data for the period of 1950-1988 one realizes a long-lasting increase in the investment rate for the majority of the 14 OECD countries and a significant and positive time trend for the investment rate in the United States, but no permanent increase in the growth rate of output. This would imply that for those countries the endogenous growth theory is not a good approximation of reality.

To sum up: Endogenous growth could not be detected for the US and the OECD economies over periods of about 100 years. The AK model had to be rejected (with the exception of the economies most destroyed by the war) when analysing the period of 1950-1988.

4. An analysis of Chilean growth : Does the AK model apply to the Chilean economy?

4.1 The Chilean growth experience and growth prospects

The Chilean growth experience is well documented in the book 'Análisis empírico del crecimiento en Chile' edited by Morandé and Vergara (1997). Some stylized facts and main findings shall be gathered in the following paragraphs.

Lefort (1997) points out that Chile was the only economy in Latin America that increased its growth rate in the period of 1975-1990 compared to the period of 1960-1975. Per capita income growth in 1975-1990 surpassed the growth rate in 196-1975 by 2.3 percentage points. Growth in the 1975-1990 period was made possible by the economic reforms that positively affected the fundamental growth determinants (investment, efficiency of production, efficiency of the financial system).

According to Rojas, López and Jiménez (1997) GDP growth in Chile averaged 3.9% in the period of 1961 to 1996. Capital growth contributed ~40%, labor growth contributed ~60% to GDP growth and TFP growth contributed close to nothing or even a bit negatively to output growth. In the period of 1991-96, GDP growth averaged 7.4%. In that period capital growth

[5] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden and the United Kingdom.

[6] ADF-test = Augmented Dickey Fuller - test (a unit root test; test on non-stationarity/stationarity of time series.

caused 30%, labor growth caused 39% and TFP growth caused 31% of this tremendous output growth (Vergara, 1997). The question of course is whether this impressing growth of the early nineties can go on forever.

Camhi, Engel and Micco (1997) observed a strong increase in TFP growth in the Chilean manufacturing sector in the exportable branch from 1991 to 1996. This upswing in TFP growth was paralleled by a 30%-fall (appreciation) in the real exchange rate (Vergara, 1997). However, it has also to be questioned whether such a continous real appreciation is sustainable in the long-run (forcing producers of tradeables to become more and more productive). At least the recessionary experience of 1998/99 seems to contradict the view of those long-lasting appreciations not being harmful to the real side of the economy.

De Gregorio (1997) predicts potential growth in Chile to be in the range of 6.5% to 7% in the long term, depending on some optimistic assumptions on the rate of investment (more than 20%) and the rate of productivity growth (3%).

Roldós (1997) comes to very similar projections concerning Chile's growth potential and points to the importance of the quality of the input factors for enhancing growth. The percentages of (imported) machinery and equipment (standing for capital goods) and learning-by-doing (standing for labor) are considered to be growth promoting factors.

4.2 Overview of Chilean growth in the period of 1960-1998

In this section a quick look shall be taken at the data such as computed by the author. The dataset underlying the statistical analysis comprises GDP, capital stock and occupation data for the period of 1960-1998. The data ,Y and K, have been taken from statistics of Chile's Central Bank, and L has been provided by Prof. Coeymans; Universidad Católica de Chile, Santiago (see **Appendix: Table 1 - 4** for the data) .

Some time series properties, such as stationarity/non-stationarity of the series and tests on it will be referred to and discussed. These issues and tests can be looked up in Darnell (1994), Harvey (1995), Hendry (1995), Lüthkepohl (1993) and many other statistical books. The test results concerning the statistical properties of the time series are summarized in the **Appendix: Table 5-6**.

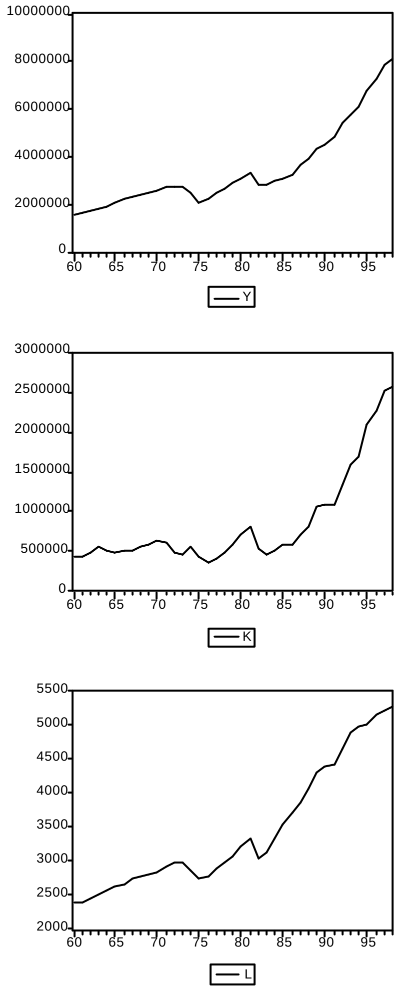
First, the line graphs of Y, K, L in **Figure 1** will be looked at.

Y stands for GDP in real terms measured in millions of 1986 pesos. The variable K indicates the capital stock in real terms (millions of 1986 pesos). It stands for gross capital formation (in analogy to the Jones' data) and is composed of change in stock and gross fixed capital formation. And finally L is an indicator of the number of occupied persons, measured in thousands of persons. The data with the prefix LN are logarithms of Y, K and L. Both data sets reveal a decline in the 1973-75 period (first recession). In the year 1982 the country was hit by a second recession, which was reinforced by the debt crisis. Starting in 1985 the economy recovered steadily. A third recession occurred in 1999 which, however, is not covered by the data. Both the Y-K-L-series and the LNY-LNK-LNL-series (see **Appendix : Table 1-2 and 5**) were non-stationary, i. e. they exhibited clear upward and downward trends.[7]

[7] Non-stationarity makes the application of the wide-spread regression analysis at least questionable.

Second, the growth rates WY, WK and WL in **Appendix: Table 3** show a tremendous amount of oscillation, but no increasing or decreasing trend. They seem to fluctuate around a

Figure 1: The development of Y, K, L



Note:

Y, K and L are non-stationary. The Johansen cointegration test indicated cointegration between them. However, the existence of a long-run equilibrium between those series is nothing exceptional. Besides, it does not allow conclusions on whether a neoclassical or an endogenous growth process prevails.

constant mean. Stationarity was confirmed by the Phillips-Perron test. The growth rates were created the following way:

$WY_t = LNY_t - LNY_{t-1}$

$WK_t = LNK_t - LNK_{t-1}$

$WL_t = LNL_t - LNL_{t-1}$

Third, these growth rates were purged from short-run fluctuations so that a possible trend became visible, generating HPWY, HPWK and HPWL. **(Appendix: Table 4)**. The method used for purging the data was the Hodrick-Prescott (HP) filter, which is available in the time series program EViews. HP, therefore, is the abbreviation for 'filtered'.

Fourth, TFP growth (WTFP resp. HPWTFP; **Appendix: Table 3 and 4**) were computed as a residual. For this purpose the values for the output elasticities were taken from Coeymans (1999a) and Coeymans (1999b). Coeymans estimated the output elasticity of capital to be 0.35 and the output elasticity of labor (employment) to be 0.65. Constant returns to scale were assumed and 'confirmed' by a test on this restriction (Coeymans, 1999b).

$WTFP_t = WY_t - 0.35\ WK_t - 0.65\ WL_t$

$HPWTFP_t = HPWY_t - 0.35\ HPWK_t - 0.65\ HPWL_t = HP(WTFP)$

Fifth, the statistical properties of the series, which become important in the analysis of the AK model, were checked by statistical tests. All series were subject to a test of stationarity (Phillips-Perron test) and when possible to a cointegration test. The results are summarized in **Appendix : Table 5-6.**

4.3 Test of the AK model using non-filtered data

Let us now look at the **AK model** such as outlined by Jones (1995) and its implications concerning long-run growth (see eq. (1)).

Households maximize their utility by choosing $i_t^{\,k}$, $i_t^{\,h}$

(1) max $\int_{t?0}^{?} e^{??t} u(c_t)dt$

subject to:

$c_t = (1 - i_t^{\,k} - i_t^{\,h})\, y_t$

$y_t = A\, k_t^{\,?}\, h_t^{\,1-?}$

$\dot{k}_t = i_t^{\,k}\, y_t - ?\ k_t$

$\dot{h}_t = i_t^{\,h}\, y_t - ?\ h_t$

where:

u ( ) = CRRA utility function with intertemporal elasticity of substitution ?

c = consumption

? = rate of depreciation (assumed to be the same for both types of capital)

? = rate of time preference

i^k, i^h investment ratios of physical and human capital, respectively

Constant returns to the accumulable factors are assumed, which will generate endogenous growth.

When solving eq. (1), one can prove that the ratio h/k is constant and equal to (1-?)/? . Since adjustment costs are assumed to be non-existent, the model instantaneously adjusts the initial amounts of k and h so that this ratio is always achieved. Therefore, the two types of capital can be said to develop in a parallel way. This leads one to rewrite the production function in terms of a simplified production technology (see eq. (2)):

(2) $Y_t = \tilde{A} K_t^1$

with:

Y = GDP in real terms

$\tilde{A} = A\,(h/k)^{1-?}$

K = physical and human capital, represented by physical capital k

t = time/years (1960-1998)

Production in this model exhibits constant returns to the accumulable factor: K, which will generate endogenous growth. The equilibrium growth conditions imply that physical and human capital grow at the same rate such that the development of physical capital can be taken as synonymous with the development of human capital. Since reliable data on the development of human capital are often lacking, they are replaced by data on physical capital. k is thus treated as representative of K.

To analyze the steady state relationship between the growth rate (WY) and the investment rate (WK), one has to take logs and differentiate (2) to get to (3)

(3) $Wk = -\,? + \tilde{A}\, i^k = Wh = WK = WY$

with:

Wk = rate of growth of the physical capital stock

Wh = rate of growth of human capital

WK = rate of growth of the total capital stock

WY = growth rate of real GDP

? = rate of depreciation, assumed to be the same for physical and human capital

$\tilde{A} = A\,(h/k)^{1-?}$ = production technology; productivity parameter

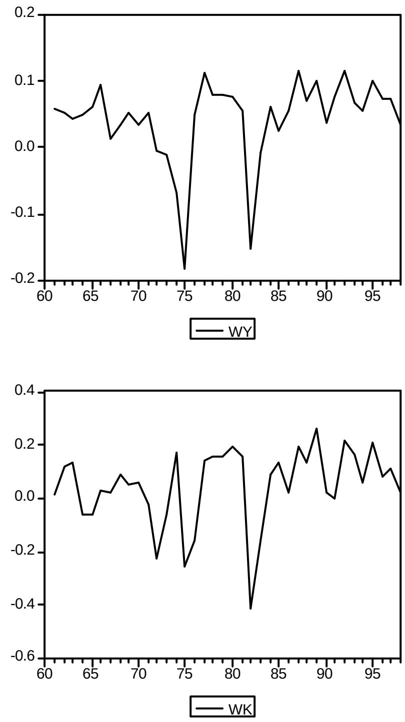
i^k = investment rate for physical capital

Jones (1995) concludes from eq. (3) that in the AK model the dynamics of the growth rate should be similar to the dynamics of the investment rate (i. e. growth rate of the physical capital stock).

Following this line of thought the AK model will be tested. Endogenous growth - according to the AK model - requires that an increase of the growth of the physical capital stock (Wk=WK[8]) is paralleled by an increase in output growth (WY) over the long run.

By doing this, one will recognize the stationarity of both WY and WK. Both series oscillate around a constant mean, but do not increase. Stationarity can be derived from the line graphs in **Figure 2** and is confirmed by the results of the unit-root test in **Appendix: Table 5**.

Figure 2: The development of WY and WK (visualization of the AK model)



Note:

WY and WK are stationary. They oscillate around a constant mean.

Since WY is clearly stationary and oscillates around a constant mean, one can conclude that either nothing in the Chilean experience has had a large, persistent effect on the growth rate (implying the absence of endogenous growth during 1960 to 1998) or whatever persistent effects have occurred have been offsetting (in line with Jones' argumentation concerning the United States and 14 OECD countries).

8 In EViews the names of series appear in capital letters, i.e. Wk the growth rate of physical capital is written as WK. This might be confusing, but in any case the growth rate of Wk (physical capital) and WK (human and physical capital) are the same under equilibrium growth conditions.

It is interesting to note that the growth rate of the GDP in the period of 1975 to 1998 (WY75) or alternatively the one in the period of 1985 to 1998 (WY85) were also tested to be stationary implying the same conclusion as above, namely not even the slightest hint to an increase in output growth in the period of 1975-98 or 1985-98.

Furthermore, when looking at WK there is no clue of a permanent increase either. This implies that a long-run increase in the growth of the capital stock did not take place.

To sum up: The annual, non-filtered growth rates: WY and WK were both stationary. They exhibited a similar development. Judging visually, this fact does not allow one to reject the AK model.

4.4 Test of the AK model using smoothed/filtered growth rates

However, following Coeymans (1999a, 1999b) one has to be aware of the tremendous short-run fluctuations of these growth rates which are mainly due to fluctuations in capacity utilization, to changes in the real exchange rate and in the terms of trade (see also Easterly et al. 1993).

Therefore, it was decided to purge the annual growth rates from those short-run fluctutions, by applying the Hodrick-Prescott filter and thus generating new series: HPWY, HPWK, HPWL, HPWTFP. These new series are depicted in **Appendix 1: Table 4** and certainly show some downward and upward movements after short-run fluctuations have been eliminated. These movements point to non-stationarity in the series. Non-stationarity was 'confirmed' by applying the Phillips-Perron test.

This result takes us one step further. Given the fact that these series are non-stationary (integrated of order I(1)), it can now be tested whether they are cointegrated, i. e. whether there exists a long-run equilibrium between HPWY and HPWK as the AK model would suggest.[9]

If the question of a cointegrating relationship between HPWY and HPWK is answered with 'yes', then we would have a hint that increasing growth rates are sustainable in the 'long-run', provided that a period of approximately forty years can be called the 'long-run'. If the answer is 'no', then we would have to conclude that rather the neoclassical growth model applies where no 'long-run' relationship between the growth of the capital stock and the output growth exists.

Therefore, the endogenous growth model[10] is applied to the **smoothed series HPWY and HPWK** which is in contrast to Jones (1995), but certainly makes much more sense from an economic point of view (see **Figure 3** for the interplay between HPWY and HPWK).

Cointegration between HPWY and HPWK can then be tested (see results in **Appendix: Table 6**) in two ways:

First, by the Johansen cointegration test (Johansen, 1987). The test detected two cointegrating vectors, that is cointegration. The computed cointegrating vectors made sense from an

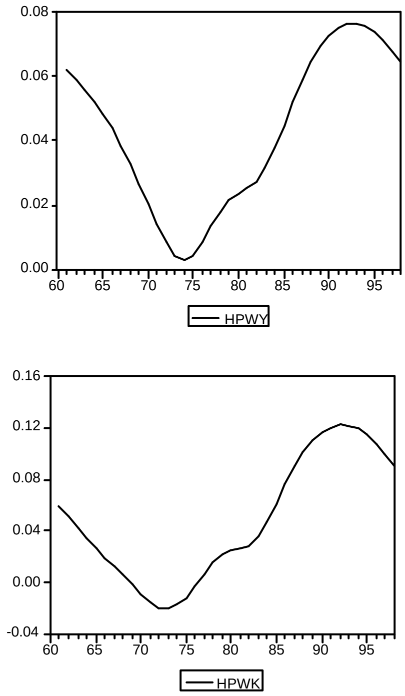
[9] When performing the cointegration test, a requirement is non-stationarity of the series - a feature not fulfilled in the annual series. That is why Jones (1995) did not have to test for cointegration.

[10] The AK model assumes some parallelism (i.e. cointegration in the statistical sense) between WY and WK.

economic point of view. The computed output elasticity of HPWK was 0.35[11] and significant for ? = 1%.

[11] The same output elasticity was calculated by Coeymans using non-filtered data.

Figure 3: The development of HPWY and HPWK (visualization of the AK model)



<u>Note:</u>

HPWY and HPWK are growth rates that have been freed from their short-run fluctuations by means of the Hodrick-Prescott filter. They are non-stationary. According to the Johansen cointegration test, HPWY and HPWK are cointegrated, i. e. in the long-run they move together. Cointegration between HPWY and HPWK gives strong support to the AK model.

Second, to achieve more certainty, the two step Engle-Granger cointegration test was performed. By means of this method cointegration can be examined by testing whether a linear combination of the two series (HPWY and HPWK based on a TSLS-estimation) is stationary or not (Engle and Granger, 1987). Since a test on endogenity of the regressors (the Hausman test) suggested the variable HPWK to be endogenous, TSLS-estimation was applied. Then the residual based on the TSLS-coefficients was computed and subject to the Augmented Dickey Fuller unit root test. The test outcome was that the residual was stationary (for ? = 5%), implying the existence of cointegration and of a long-run co-movement/equilibrium.

It has to be concluded that the tests on cointegration do not allow one to reject the AK model.

The result of cointegration is in line with Jones' (1995) observations on some OECD countries <u>after WWII</u> (1945-1987) who experienced increasing growth rates due to the process of reconstruction. However, over the whole period of 1900-1987, Jones did not observe increasing growth for the very same countries! It has to be kept in mind - of course - that Jones analyzed WY and WK, series which contain all the (misleading!) short-run fluctuations.

5. Conclusions

Since short-run fluctuations tend to conceal important medium- to long-run trends, the author decided - in contrast to Jones (1995) - to purge the annual growth rates WY, WK , WL and WTFP from those swings, thus creating HPWY, HPWK, HPWL and HPWTFP.

As far as Chile is concerned a parallel upward movement between the smoothed growth rate of Y (HPWY) and the smoothed growth rate of K (HPWK) could be detected for the period under consideration (1960-1998). It could even be shown that both series were cointegrated, i.e. in long-run equilibrium (for 39 years).

Jones (1995), in contrast, did not encounter a parallel upward movement between WY and WK (unsmoothed series)[12] for the period of 1950-1988 for the U.S.A and for the majority of the analyzed OECD countries. This led him to reject the endogenous growth model (AK model). However, Jones could detect an upward co-movement of WY and WK for some 'war-destructed' OECD countries, such as Germany, Austria, Italy, Japan and UK.

Arnold (1999), another critic of the endogenous growth model, does not reject the endogenous growth model per se, but makes proposals to modify some of the unrealistic assumptions of endogenous growth theory in order to make the theory fit the facts.

So, where do we stand? Do we have to assume neoclassical or an endogenous growth for Chile? The answer depends on the definition of the long-run. If we consider 39 years as long run, then we would have had endogenous growth in Chile. If we regard the 1960-1998 period too short to be classified as long-run[13], we could say that we are in the stage of transition to a new steady state and that the neoclassical model applies.

Concerning economic policy, one might be induced to say that policy matters for a fairly long period, too long not to worry about its being good or bad! However, in order to make more concrete statements on the impact of certain policies over time one should revert to dynamic macroeconometric models, such as distributed lag models. This should be a line of research to be followed in the future.

[12] It is advisable to take smoothed series in order to avoid biased conclusions which are caused by short-run fluctuations.

[13] Jones would probably agree with that.

6. References

AGHION, Philippe and Peter HOWITT. 1992. 'A model of growth through creative destruction', Econometrica LX, 323-351.

ARNOLD, Lutz. 1997. *Wachstumstheorie*. Verlag Franz Vahlen: München.

ARNOLD, Lutz. 1999. 'Does policy affect growth?', *Finanzarchiv* 56, 141-164.

AZARIADIS, Costas and Allan DRAZEN. 1990. 'Threshold externalities in economic development', Quarterly Journal of Economics CV(2), 501-526.

BARRO, Robert and Xavier SALA-I-MARTIN. 1995. *Economic Growth*. New York: McGraw-Hill, Inc.

BENHABIB, Jess and Boyan JOVANOVIC. 1991. 'Externalities and growth accounting', *American Economic Review* LXXXI, 82-113.

CAMHI, Alexis, Eduardo ENGEL and Alejandro MICCO. 1997. 'Dinámica de empleo y productivitad en manufactureras. evidencia micro y consecuencias macro', in: Morandé and Vergara (eds.). *Análisis empírico del crecimiento en Chile*. Centro de Estudios Publicos. Programa de Postgrado en Economía ILADES/GEORGETOWN UNIVERSITY, 197-225.

COEYMANS, Juan Eduardo. 1999a. 'Ciclos y crecimiento sostenible a mediano plazo en la economía Chilena', *Cuadernos de Economía*, No. 107, 545-596.

COEYMANS, Juan Eduardo. 1999b. 'Determinantes de la productividad en Chile: 1961-1997', *Cuadernos de Economía*, No. 107, 597-637.

DARNELL, Adrian C. 1994. *A dictionary of econometrics*. Edward Elgar: Hants, England.

DE GREGORIO, José. 1997. 'Crecimiento potencial en Chile: una síntesis', in: Morandé and Vergara (eds.). *Análisis empírico del crecimiento en Chile*. Centro de Estudios Publicos. Programa de Postgrado en Economía ILADES/GEORGETOWN UNIVERSITY, 23-37.

DOMAR, Evsey. 1946. 'Capital expansion, rate of growth, and employment'. *Econometrica* 14 (2), 137-147.

EASTERLY, William, Michael KREMER, Lant PRITCHETT and Lawrence H. SUMMERS. 1993. 'Good policy or bad luck? Country growth performance and temporary shocks', *Journal of Monetary Economics* 32 (3), 459-483.

ENGLE, Robert F. and Clive W. J. GRANGER. 1987. 'Co-integration and error correction: Representation, estimation and testing', *Econometrica*, 55, 251-276.

GROSSMAN, Gene and Elhanan HELPMAN. 1991a. Innovation and growth in the global economy, Cambridge, MA.: MIT Press.

GROSSMAN, Gene and Elhanan HELPMAN. 1991b. 'Quality ladders in the theory of growth', *Review of Economic Studies* LVIII, 43-61.

HARROD, Sir Roy. 1939. 'An essay in dynamic theory'. *Economic Journal* 49 (113), 14-33.

HARVEY, Andrew C. 1995. *Zeitreihenmodelle*. R. Oldenbourg Verlag: München, Wien.

HENDRY, David F. 1995. *Dynamic econometrics*. *Advanced texts in econometrics*. Oxford University Press: Oxford, New York.

JOHANSEN, Sören. 1987. 'Statistical analysis of cointegrating vectors', *Journal of Economic Dynamics and Control* 12, 231-254.

JONES, Charles. 1995. 'Time series tests of endogenous growth models', *Quarterly Journal of Economics* 110(2), 495-525.

JONES, Larry and Rodolfo MANUELLI. 1990. 'A convex model of equilibrium growth: theory and policy implications', *Journal of Political Economy* 98(5), 1008-1038.

JUDD, Kenneth L. 1985. 'On the performance of patents', *Econometrica* 53(3), 567-585.

LEFORT, Fernando. 1997. 'Crecimiento económico en chile: evidencia de panel', in: Morandé and Vergara (eds.). *Análisis empírico del crecimiento en Chile*. Centro de Estudios Publicos. Programa de Postgrado en Economía ILADES/GEORGETOWN UNIVERSITY, 101-125.

LUCAS, Robert E. 1988. 'On the mechanics of economic development', Journal of Monetary Economics 22(1), 3-42.

LUCAS, Robert. 1993. 'Making a miracle', *Econometrica* 61 (2), 251-272.

LÜTHKEPOHL, Helmut. 1993. *Introduction to multiple time series analysis*. Second edition. Springer Verlag: Berlin, Heidelberg, New York.

MANKIW, Gregory N:, David ROMER and David N. WEIL. 1992. 'A contribution to the empirics of economic growth', Quarterly Journal of Economics, Vol. CVII (2), 407-437.

MORANDÉ, Felipe G. and Rodrigo VERGARA (eds.). 1997. *Análisis empírico del crecimiento en Chile*. Centro de Estudios Publicos. Programa de Postgrado en Economía ILADES/GEORGETOWN UNIVERSITY.

MURPHY, Kevin, Andrei SHLEIFER and Robert VISHNY. 1989. 'industrialization and the big push', *Journal of Political Economy* 97(5), 1003-1026.

REBELO, Sergio. 1991. 'Long-run policy analysis and long-run growth', *Journal of Political Economy* 99(3), 500-521.

REBELO, Sergio. 1998. 'The role of knowledge and capital in economic growth', *WIDER working papers* 149, Helsinki: World Institute for Development Economics Research.

RIVERA-BATIZ, L. and Paul ROMER. 1991. 'Economic integration and endogenous growth', *Quarterly Journal of Economics* 106, 531-566.

ROJAS, Patricio, Eduardo López and Susana Jiménez. 1997. 'Determinantes del crecimiento y estimación del producto potencial en Chile: el rol del comercio internacional', in: Morandé and Vergara (eds.). *Análisis empírico del crecimiento en Chile*. Centro de Estudios Publicos. Programa de Postgrado en Economía ILADES/GEORGETOWN UNIVERSITY, 67-100.

ROLDÓS, Jorge. 1997. 'El crecimiento del producto potencial en mercados emergentes: el caso de Chile', in: Morandé and Vergara (eds.). *Análisis empírico del crecimiento en Chile*. Centro de Estudios Publicos. Programa de Postgrado en Economía ILADES/GEORGETOWN UNIVERSITY, 39-66.

ROMER, Paul M. 1986. 'Increasing returns and long-run growth', Journal of Political Economy 94(5), 1002-1037.

ROMER, Paul M. 1987. 'Crazy explanations for the productivity slowdown', NBER Macroeconomics Annual, Cambridge: MIT Press.

ROMER, Paul M. 1990. 'Endogenous technological change', *Journal of Political Economy* XCVIII, 71-103.

ROMER, Paul M. 1994. 'The origins of endogenous growth', *Journal of Economic Perspectives* 8(1), 3-22.

SOLOW, Robert M. 1956. 'A contribution to the theory of economic growth', Quarterly Journal of Economics, Vol. LXX, 65-94.

STOLPE, Michael. 1992. 'Ansätze der neuen Wachstumstheorie - ein Literaturüberblick', *Kieler Arbeitspapiere*, Arbeitspapier Nr. 508. The Kiel Institute of World Economics, Germany.

SUMMERS, R. and A. HESTON. 1991. 'The Penn World Table (Mark 5): An expanded set of international comparisons', *Quarterly Journal of Economics*, 106.

SWAN, Trevor W. 1956. 'Economic growth and capital accumulation', *Economic Record* 32, 334-361.

VALDÉS, Benigno. 1999. *Economic growth. Theory, empirics and policy*. Edward Elgar: Cheltenham, UK, Northampton, MA, USA.

VERGARA, Rodrigo. 1997. 'Crecimiento en Chile: elementos para el análisis', in: Morandé and Vergara (eds.). *Análisis empírico del crecimiento en Chile*. Centro de Estudios Publicos. Programa de Postgrado en Economía ILADES/GEORGETOWN UNIVERSITY, 11-21.

YOUNG, Alwyn. 1993. 'Invention and bounded learning by doing', *Journal of Political Economy* 101(3), 443-472.

7. Appendix

Table 1: The original data: Y, K, L

obs	Y	K	L
1960	1599874.	420897.8	2380.188
1961	1695669.	426309.9	2400.419
1962	1786247.	478616.5	2446.038
1963	1864170.	549267.9	2499.670
1964	1955303.	517968.7	2556.488
1965	2081513.	486669.5	2616.594
1966	2288199.	502330.0	2668.582
1967	2318502.	513067.3	2752.730
1968	2400311.	561591.9	2784.067
1969	2532403.	589924.2	2797.321
1970	2621427.	628004.8	2842.015
1971	2758959.	613442.0	2934.382
1972	2743418.	490190.7	2987.604
1973	2714225.	460652.1	2970.548
1974	2533861.	548702.7	2861.126
1975	2113474.	423756.0	2733.620
1976	2219192.	360972.9	2782.012
1977	2480256.	416735.4	2887.428
1978	2684069.	489147.4	2994.693
1979	2906350.	571568.5	3081.512
1980	3132501.	696678.3	3226.177
1981	3305784.	813419.8	3336.730
1982	2840122.	537389.4	3039.436
1983	2819928.	457435.2	3120.543
1984	2998736.	498504.5	3336.086
1985	3072177.	572188.0	3524.197
1986	3246107.	586023.0	3709.040
1987	3644681.	713263.0	3867.340
1988	3911154.	814209.0	4059.560
1989	4324181.	1058456.	4293.700
1990	4484071.	1085096.	4398.750
1991	4841447.	1083169.	4421.680
1992	5435881.	1343405.	4643.070
1993	5815646.	1584627.	4894.980
1994	6147610.	1682653.	4969.900
1995	6800952.	2078072.	5018.040
1996	7305141.	2263410.	5141.500
1997	7858481.	2526156.	5194.900
1998	8126506.	2579026.	5257.239

Y = GDP in real terms (millions of 1986 pesos)

K = capital stock in real terms (millions of 1986 pesos)

L = employment (thousands of persons)

Source: Y, K : Boletín Mensual, various issues; Banco Central de Chile
L : Professor Coeymans' data base; Universidad Católica de Chile, Santiago

Table 2: The data in logarithmic form: LNY, LNK, LNL

obs	LNY	LNK	LNL
1960	14.28544	12.95015	7.774935
1961	14.34359	12.96292	7.783399
1962	14.39563	13.07865	7.802225
1963	14.43833	13.21634	7.823914
1964	14.48606	13.15767	7.846390
1965	14.54861	13.09534	7.869629
1966	14.64328	13.12701	7.889303
1967	14.65643	13.14816	7.920348
1968	14.69111	13.23853	7.931668
1969	14.74468	13.28775	7.936417
1970	14.77923	13.35030	7.952269
1971	14.83036	13.32684	7.984252
1972	14.82472	13.10255	8.002227
1973	14.81402	13.04040	7.996502
1974	14.74525	13.21531	7.958971
1975	14.56384	12.95691	7.913382
1976	14.61265	12.79656	7.930930
1977	14.72387	12.94021	7.968121
1978	14.80284	13.10042	8.004597
1979	14.88241	13.25614	8.033176
1980	14.95734	13.45408	8.079053
1981	15.01118	13.60900	8.112747
1982	14.85936	13.19448	8.019427
1983	14.85222	13.03339	8.045762
1984	14.91370	13.11937	8.112554
1985	14.93790	13.25722	8.167408
1986	14.99297	13.28111	8.218528
1987	15.10878	13.47761	8.260322
1988	15.17934	13.60997	8.308830
1989	15.27973	13.87232	8.364904
1990	15.31604	13.89718	8.389076
1991	15.39272	13.89540	8.394275
1992	15.50853	14.11072	8.443131
1993	15.57606	14.27586	8.495965
1994	15.63157	14.33588	8.511155
1995	15.73257	14.54695	8.520795
1996	15.80409	14.63238	8.545100
1997	15.87710	14.74221	8.555433
1998	15.91064	14.76292	8.567361

Note:

LNY, LNK and LNL are non-stationary. The Johansen cointegration test showed those series to be cointegrated as was to be expected (compare also Coeymans (1999b for the period of 1960-1997 and Rojas et al. (1997) for the period of 1960-1996). These findings, however, do not allow conclusions about whether one is confronted with a neoclassical or an endogenous growth model.

Table 3: Growth rates of Y, K, L, TFP, yielding WY, WK, WL, WTFP

obs	WY	WK	WL	WTFP
1960	NA	NA	NA	NA
1961	0.058152	0.012777	0.008464	0.048179
1962	0.052039	0.115733	0.018826	-0.000704
1963	0.042699	0.137687	0.021689	-0.019589
1964	0.047729	-0.058671	0.022476	0.053655
1965	0.062550	-0.062330	0.023239	0.069260
1966	0.094670	0.031672	0.019674	0.070797
1967	0.013156	0.021150	0.031046	-0.014426
1968	0.034677	0.090368	0.011320	-0.004310
1969	0.053571	0.049219	0.004749	0.033257
1970	0.034550	0.062554	0.015851	0.002353
1971	0.051134	-0.023462	0.031984	0.038557
1972	-0.005649	-0.224291	0.017975	0.061170
1973	-0.010698	-0.062151	-0.005725	0.014776
1974	-0.068762	0.174914	-0.037531	-0.105587
1975	-0.181411	-0.258399	-0.045589	-0.061339
1976	0.048810	-0.160355	0.017548	0.093529
1977	0.111219	0.143649	0.037192	0.036767
1978	0.078972	0.160212	0.036476	-0.000811
1979	0.079564	0.155721	0.028579	0.006486
1980	0.074934	0.197939	0.045877	-0.024165
1981	0.053842	0.154924	0.033693	-0.022282
1982	-0.151826	-0.414524	-0.093319	0.053915
1983	-0.007136	-0.161088	0.026335	0.032127
1984	0.061479	0.085977	0.066791	-0.012027
1985	0.024196	0.137855	0.054854	-0.059709
1986	0.055070	0.023891	0.051120	0.013479
1987	0.115813	0.196491	0.041794	0.019875
1988	0.070564	0.132367	0.048508	-0.007295
1989	0.100390	0.262349	0.056074	-0.027880
1990	0.036309	0.024857	0.024172	0.011897
1991	0.076682	-0.001777	0.005199	0.073925
1992	0.115808	0.215316	0.048856	0.008691
1993	0.067530	0.165142	0.052834	-0.024612
1994	0.055512	0.060023	0.015190	0.024630
1995	0.100999	0.211069	0.009640	0.020859
1996	0.071516	0.085432	0.024305	0.025816
1997	0.073015	0.109826	0.010333	0.027860
1998	0.033538	0.020713	0.011929	0.018535

Note:

WTFP = WY - 0.35 WK - 0.65 WL
WY, WK, WL and WTFP are stationary. They fluctuate around a constant mean.

Table 4: Filtered growth rates, yielding HPWY, HPWK, HPWL, HPWTFP

obs	HPWY	HPWK	HPWL	HPWTFP
1960	NA	NA	NA	NA
1961	0.062288	0.059020	0.019300	0.029086
1962	0.059045	0.050983	0.019333	0.028635
1963	0.055762	0.042482	0.019257	0.028376
1964	0.052325	0.033705	0.018959	0.028205
1965	0.048493	0.025787	0.018350	0.027540
1966	0.043979	0.018942	0.017377	0.026054
1967	0.038634	0.012503	0.016033	0.023837
1968	0.032819	0.005928	0.014338	0.021424
1969	0.026637	-0.001236	0.012459	0.018972
1970	0.020213	-0.008599	0.010533	0.016376
1971	0.013939	-0.015266	0.008623	0.013677
1972	0.008350	-0.019631	0.006841	0.010775
1973	0.004355	-0.020169	0.005535	0.007817
1974	0.002722	-0.017403	0.005165	0.005456
1975	0.004068	-0.012273	0.006076	0.004415
1976	0.008296	-0.003800	0.008187	0.004304
1977	0.013453	0.006537	0.010903	0.004079
1978	0.017992	0.015692	0.013718	0.003584
1979	0.021345	0.021991	0.016392	0.002993
1980	0.023551	0.025204	0.018912	0.002437
1981	0.025232	0.026440	0.021386	0.002077
1982	0.027526	0.028534	0.024193	0.001814
1983	0.031854	0.035606	0.027834	0.001300
1984	0.037847	0.047345	0.031636	0.000713
1985	0.044742	0.061475	0.034909	0.000535
1986	0.052015	0.076105	0.037317	0.001122
1987	0.058936	0.090106	0.038721	0.002230
1988	0.064806	0.101831	0.039123	0.003736
1989	0.069494	0.110693	0.038552	0.005692
1990	0.072926	0.116413	0.037135	0.008044
1991	0.075339	0.120226	0.035171	0.010399
1992	0.076602	0.122454	0.032830	0.012403
1993	0.076598	0.122198	0.029984	0.014339
1994	0.075602	0.119487	0.026663	0.016451
1995	0.073799	0.114779	0.023127	0.018594
1996	0.071172	0.107941	0.019521	0.020704
1997	0.067977	0.099797	0.015854	0.022743
1998	0.064472	0.090952	0.012185	0.024719

Note:

HPWY; HPWK, HPWL and HPWTFP are non-stationary. They were generated by applying the Hodrick-Prescott filter to WY, WK, WL and WTFP.

Table 5: The time series are subject to the Phillips-Perron test[14]

series to be tested	test assumptions[15]	test result	PP test statistics
Y	trend and intercept	non-stationary	1.02
K	trend and intercept	non-stationary	1.06
L	trend and intercept	non-stationary	-0.98
LNY	trend and intercept	non-stationary	-1.02
LNK	trend and intercept	non-stationary	-0.89
LNL	trend and intercept	non-stationary	-1.42
WY	intercept	stationary	-3.95
WY75[16]	intercept	stationary	-5.20
WY85[17]	intercept	stationary	-4.66
WK	intercept	stationary	-4.55
WK75	intercept	stationary	-3.81
WK85	intercept	stationary	-4.50
WL	intercept	stationary	-4.23
WTFP	intercept	stationary	-4.97
HPWY	trend and intercept	non-stationary	-2.02
HPWK	trend and intercept	non-stationary	-2.30
HPWL	trend and intercept	non-stationary	-0.91
HPWTFP	trend and intercept	non-stationary	0.89

[14] The Phillips-Perron test (unit root test) is a test on the stationarity/non-stationarity of the series. The Phillips-Perron test was applied to all series listed in the table. Another possible unit-root test (test on stationarity/non-stationarity) is the augmented Dickey-Fuller test (ADF test).

[15] The test assumptions follow from the line graphs.

[16] WY75 is the annual growth rate in the period of 1975-1998.

[17] WY85 stands for the annual growth rate in the period of 1985-1998.

Table 6: Results of the Johansen cointegration test[18]

series tested	test assumptions [19]	test result
Y, K, L	linear deterministic trend (intercept)	cointegration (2 cointegrating eqs.)
LNY, LNK, LNL	linear deterministic trend (intercept)	cointegration (2 cointegrating eqs.)
WY, WK (test of the AK model)	cointegration test is not indicated	
WY, WTFP	cointegration test is not indicated	
HPWY, HPWK (test of the AK model)	linear deterministic trend (intercept)	cointegration (2 cointegrating eqs.)
HPWY, HPWTFP	linear deterministic trend (intercept)	cointegration (1 cointegrating eq.)

[18] The cointegration test requires non-stationarity of the series!

[19] Assumptions underlying the series.

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