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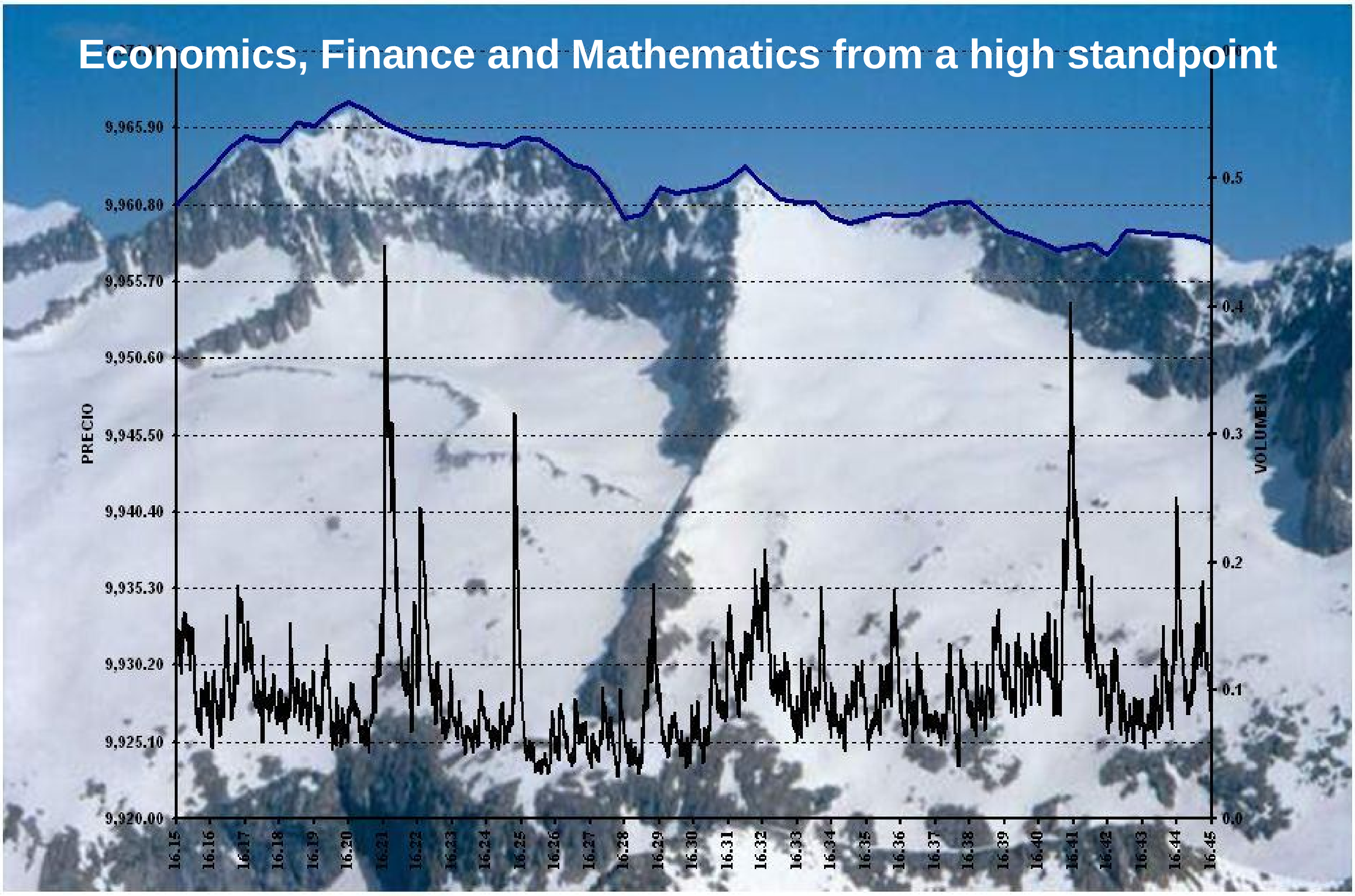

Private Productive Investment in Spain and the United States (1964-2007)

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PRIVATE PRODUCTIVE INVESTMENT IN SPAIN AND THE UNITED STATES (1964-2007).

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Abstract

Private productive investment is, or should be, the key variable of any macroeconomic and growth model. Surprisingly enough, after a two-century long discussion, economists are far from reaching any theoretical agreement, while empirical studies do not confirm and, in fact, reject any particular model, although the best results are generally associated to those based on the *acceleration principle*. In this paper we estimate, using cointegration techniques, a model of capital accumulation whose independent variables are: (a) the expected rate of growth of the economy proxied by the past rate; (b) deviations of capacity utilization from its "normal" level; (c) deviations of the long-term real interest rate from its "conventional" rate. We examine the empirical evidence in Spain and the USA during the period 1964-2007. Econometric results support our "flexible accelerator" model of investment.

Keywords: Keynesian and Kaleckian macroeconomic models, fixed capital investment, accelerator, capacity utilization, cointegration techniques.

1. INTRODUCTION.

This papers aims to model and estimate productive private investment, i.e. investment in buildings, equipment and vehicles undertaken by companies in order to increase or modernize its productive capacity. In *section 2* we review the traditional Keynesian and Kaleckian functions based on the *accelerator principle*. In *section 3* we present our "flexible accelerator model" which explains productive investment as a function of the expected rate of growth of the economy (proxied by the past rate) and two ancillary variables: deviations of capacity utilization from its "normal" level; deviations of the long-term real interest rate from its "conventional" rate. In *section 4* we test the model against Spanish data from 1964 to 2007 applying cointegration techniques, error-correction and first differences. In *section 5* we repeat the estimation for the USA during the same period. In *section 6* we conclude that our flexible accelerator model of investment goes a bit further than other models.

2. MODELS OF INVESTMENT: THE ACCELERATOR PRINCIPLE.

The cornerstone of the Neoclassical Revolution after 1870 was the marginalist theory of distribution (Walras, 1874; Marshall, 1890; Fisher, 1930). This theory translates graphically in a downward-sloping demand function for capital. Entrepreneurs are supposed to invest up to the value of the output derived from giving additional machines to the existing number of workers coinciding with the real interest rate they have to pay for them. After Jorgenson (1963), neoclassical economists usually refer to the rental price or user cost of capital which, in addition to the real interest rate, includes depreciation allowances and taxes. The new model was prepared to be tested, although the results were quite poor.

As a matter of fact, genuine neoclassical models do not worry about the investment function. Investment is supposed to absorb all the savings which are explained in a process of (individual) utility maximization where the interest rate regulates the allocation of income between actual consumption and future consumption. This Walrasian idea is still alive in the "dynamic stochastic general equilibrium models" used by central banks (Clarida, Galí and Gertler, 1999) and also in the "applied and computable general equilibrium models" (Scarf and Shoven, 1984).

Keynes (1936) tried to show that investment does not depend on savings. In equilibrium both variables coincide, but it is investment which creates savings through the multiplier mechanism. What does investment depend on? In *The General Theory*

Keynes offers two alternative (and probably incoherent) explanations. In Chapter 11 he refers to the *marginal efficiency of capital* where the interest rate continues to be the key determinant of investment, although it is now a monetary phenomenon (instead of being determined in the capital market as a result of the forces of productivity and thrift). In chapter 12 he highlights the importance of entrepreneurs' long term expectations (*animal spirits*), without providing a clear-cut explanation of how expectations are formed.

The principle of effective demand and the multiplier was used, a couple of years before the *General Theory* by the Polish economist Kalecki (Kalecki, 1933 reprinted in 1971). Kalecki refused to accept Keynes' investment function. In his opinion firms adjust to changes in demand via capacity utilization. When the actual degree of capacity utilization is above the normal level, then they speed up investment in order to increase capacity.

The different Keynesian strands in the second half of the 20th century can be defined in relation to the investment function. Hicks' ISLM model is based on the marginal efficiency of investment and was a preparation for the first *Keynesian-Neoclassical synthesis* (Hicks, 1937). The closest disciples of Keynes and his American followers emphasized the *animal spirits* (Robinson, 1962; Minsky, 1975). Another group of postKeynesian economists base their ideas on those of Kalecki (Lavoie, 1992).

The *acceleration principle* constitutes an approach to investment. The idea is as simple as it is compelling: in order to produce efficiently, entrepreneurs try to keep the desired "capital/output" ratio, and so they invest whenever they forecast permanent increases in demand. This can be called the "prospective accelerator". When expectations of future demand are based on past increases we are using a "retrospective accelerator", which is the usual procedure in applied studies. The accelerator has proved to be superior to other theories of investment on empirical grounds (Baddeley, 2003). This paper develops and tests a particular model of "flexible accelerator". Before we present it, we shall revise the formation of the concept.

The origins of the *acceleration principle* go back to the early 20th century: Carver (1903), Aftalion (1909), Bickerdike (1914) y Clark (1917). Shortly after *The General Theory*, Harrod (1939) tried to add strength to Keynes' principle of effective demand by joining the multiplier and the accelerator mechanisms. He discovered that given technology (represented by the desired "capital/output" ratio = k) and the propensity to save ($s=1$-c, "c" being the propensity to consume) the system exhibits a “potential” or “warranted” rate of growth” defined as g_w=s/k. He called it “the warranted rate” because if the expected rate of growth envisaged by entrepreneurs coincides with g_w a macroeconomic equilibrium is warranted. But (and this is a big “but”) whenever the expected rate was slightly above (or below) g_w the economy would accelerate (decelerate) itself until it would explode (or disappear). This unstable pattern became known as the “knife edge”. Samuelson (1939) adds mathematical precision to show that depending on the values of the parameters the dynamics can be cyclical. After Chenery (1952) economists developed a “flexible accelerator” where the adjustment to the optimal capacity occurs step by step. Despite these efforts, the instability of the multiplier-accelerator model deterred most researchers.

Since the purpose of this paper consists in checking a particular acceleration model of investment, it may be of interest to review other papers with a similar purpose. Epstein and Denny (1983) analyzed investment in the US manufacturing sector during the period 1947-1976. Fazzari and Mott (1986-87) checked empirically Keynesian and Kaleckian theories of investment using the United States manufacturing panel data from the period between 1970-80. Acemoglu (1993) applied the accelerator model to the American and British economies with quarterly data from 1965 till 1990. He introduced imperfect information and distinguished between investment accelerator and employment accelerator. Hay and Louri (1995) analyzed UK firms during the years 1960-1985 and found a trade-off between the level of stocks of the company and its investment in capital. Hein and Ochsen (2003) added a term with the interest rate to analyze its impact on capital accumulation during the period 1960-1995 in France, Germany, United Kingdom and USA. Surprisingly enough, they found a positive influence on the real interest rate in the rate of accumulation between 1983 and 1995 in in the United States. Atesoglu (2004) applied cointegration analysis to the United States data during the period 1947-2001. He obtained a positive relationship between investment and fiscal and monetary policy, although he found a greater impact for public spending than changes in interest rates. Iyoda (2005) estimated Japanese investment from 1973 till 2001. His model is based on Davidson and Minsky´s ideas about a monetary production economy. Cámara (2008) shows an investment model whose endogenous variables are the rate of capacity utilization and gross profits of the United States firms in the years 1950-2006. Profits turned out to be the only significant variable. This paper used an error-correction model, as we are going to do. Falls and Natke (2007) analyzed the investment in Brazilian firms using panel data. They showed how a Keynesian frame is useful to explain investment development in this country between 1973-1976. Singh (2008-9) applied cointegration techniques to study the investment effect in the development of the economic growth in the years 1950-2001. He stated the importance of accelerating investment processes.

Now, for the Spanish economy. Andrés *et al.* (1990), using cointegration, estimated an accelerator model which included the rate of capacity utilization and the user cost of capital. This analysis covered the period 1964-1986. Espasa and Senra (1993) improved the previous model by introducing two additional variables and were successful in reducing the residuals. Estrada *et al.* (1997) estimated a model similar to Andrés *et al.* (1990) extending the number of observations until 1995. Raymond *et al.* (1999) estimated an accelerator model, a *q* model and a cash flow model using Spanish firm data from 1991 to 1997.

The results of econometric models are ambivalent. The good news is that investment models based on the acceleration principle are clearly superior to the alternative ones. The bad news is that one gets a sense of unease on finding a determination coefficient (R^2) below 0,5, while the simplest Keynesian consumption function gets R^2 above 0,9. Baddeley (2003) and Argitis (2008) showed that R^2 could rise dramatically using autoregressive models that explain investment, in the first case, and the accumulation rate, in the second one, in year *t* by investment and accumulation in year *t-1* respectively. In Spain, the models with the highest R^2 are also characterized by including the last year's investment among the determinants (Andrés *et al.* 1990 and Estrada *et al.* 1997). Of course, this implies not knowing the true independent variables that influence investment. As in the previous studies we are going to use cointegration techniques plus error correction models, but without including the past level of investment as a determinant variable.

3. An alternative Post Keynesian accelerator model accounting for changes in capacity utilization and interest rates.

As we have seen the multiplier-accelerator model was miscarried because of the extreme instability it conveyed according to Harrod (1939). Dejuán (2005) shows that the Harrodian "knife edge" was not the natural outcome of the interrelationship between the multiplier and the accelerator but the result of the strange reaction function that Harrod attributed to entrepreneurs. The paper proves that the model is stable and converges to fully adjusted positions of stability if two simple conditions are fulfilled:

(1) autonomous demand is truly autonomous; (2) entrepreneurs use the investment function to adjust capacity which is the short term bumper against unexpected changes in demand. This will be the theoretical basis of our empirical work, partially shared by authors like Shaikh (1991), Serrano (1995) and Trezzini (1995, 1998).

In our model we are going to estimate the key determinant of investment as the expected growth of autonomous demand that can be proxied by recent increases in aggregate demand. This is nothing other than the acceleration mechanism that relies on an optimal "capital/output" ratio, corresponding to the "normal" degree of capacity utilization. To smooth out the peaks of the investment series we shall refer to the accumulation present in the stock of capital (*K*) in natural logarithms. The accumulation rate that appears as the dependent variable of our regression will be defined as:

$$a_t \approx \ln\left(\frac{K_t}{K_{t-1}}\right) \approx \ln K_t - \ln K_{t-1}$$

Its main determinant will be the growth of gross domestic output, lagged by one period. In logarithms we get:

$$g_{t-1} \approx \ln GDP_{t-1} - \ln GDP_{t-2}$$

In a market economy, errors of prediction about the evolution of demand result in overutilization or underutilization of capacity. In the first case (overutilization) entrepreneurs will speed up investment, over and above the level that derives from the strict application of the *acceleration principle*. Firms will rush to build capacity in order to attend efficiently the new increases in demand and to make up for the past gaps. If entrepreneurs face underutilization of capacity they will slow down the investment decisions demanded by the strict *acceleration principle*.

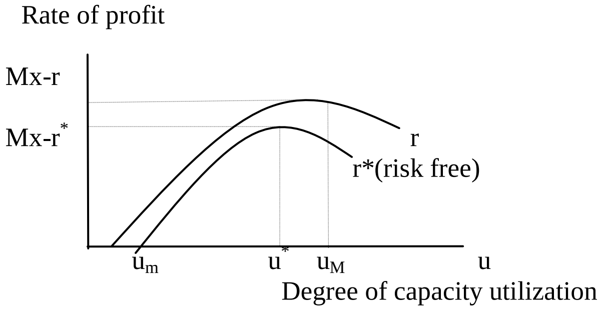
The degree of capacity utilization may be defined by the ratio between the number of hours per day firms use the installed capacity (h_t) and the number of hours they considered optimal at the moment of investment: $u=h_t/h^*$. The definition of the "normal", "desired" or "optimal" degree of capacity utilization continues to be a source of controversy (Kurz, 1986; Lavoie et al, 2004). Mixing Sraffian and Kaleckian arguments we shall define it as the rate that maximizes the rate of profit (adjusted to risk). The actual profit rate could grow a little by enlarging the working day several hours. But this behaviour may cause a loss of customers if there is a peak in demand that firms are not ready to attend immediately.

Figure 1 summarizes the argument. The maximum degree of capacity utilization is set at u_M. The maximum absolute rate of profit associated to it is *Mx-r*. The optimal rate is fixed at u^*. This conveys the maximum rate of profit in the economic sense, i.e. free of the risk of loosing customers (*Mx-r**). Point u_m stands for the so called "minimum of exploitation"; below it, firms do not cover variable costs, so they would have to shut doors.

Nowadays most national agencies conduct a survey asking entrepreneurs about their operating capacity rate. Even in boom periods they say they operate between 80 and 85% of the installed capacity. This indicates that they associate "full capacity" ($u=1$ or 100%) to our point Mx-r. In our regressions, the normal rate (u^*) will be identified with the average rate during boom periods. What actually matters in our model, however, is the deviation of the effective rate of utilization from the "normal" one that we can formalize as follows:

$$Du_t = \frac{u_t - u^*}{u^*} \quad \text{or} \quad Du_t \approx \ln u_t - \ln u^*$$

FIGURE 1. DEGREE OF CAPACITY UTILIZATION.



What about financial conditions? As we have seen, most investment models consider the real interest rate as the main determinant of investment, if not the only one. The empirical evidence plainly refutes this claim. At the end of boom periods, investment rockets despite high interest rates. At the beginning of a recession, investment falls dramatically despite low (even nil) real interest rates. Of course this does not mean that investment is positively related to the interest rate; it only means that the main determinants lie somewhere else. A more plausible formulation will relate investment and changes in the accumulation rate not with the level of interest rates but with the deviation of current real interest rate (i_t) from the "conventional" level (i^*). We can write:

$$Di_t = \frac{i_t - i^*}{i^*} \quad \text{or} \quad Di_t \approx \ln i_t - \ln i^*$$

Following Keynes (1936) the "conventional" rate is the one that has ruled in the recent past and entrepreneurs expect to prevail in the near future. It can be altered by a persistent monetary policy. The "conventional" rate exhibits hysteresis in the sense that once people get accustomed to the new rate (higher or lower) it becomes the reference for investment decisions. This approach is in clear contrast to the doctrine of "natural" rate of interest nowadays introduced into the monetary rules of most central banks. This, in turn, is related to the "natural" rate of employment (or unemployment) that makes no sense from a postKeynesian perspective (Dejuán, 2007).

Financial conditions involve many other issues: degree of indebtedness and leverage of firms; liquidity problems and so on. All of them have been included into the independent term which also accounts for the "state of confidence of entrepreneurs", and for "modernization investment", (i.e. the part of investment that does not try to increase capacity but to change it in order to produce different goods or the same goods with different methods).

We are ready to concrete the equations to be estimated. The general form of the model makes the accumulation rate (a_t) a function of the rate of growth of output (g_t), the deviation of capacity utilization from the normal level (du_t) and the deviations of interest rates from its conventional level (di_t):

$$a_t = f\,(g_t, du_t, di_t) \qquad (1)$$

These variables have been approximated by means of logarithmic differences, as indicated above. We must remember that K_t is the private stock of capital; u_t, the rate of capacity utilization; i_t, the long term interest rate. The asterisks (*) identify the "conventional" or "normal" levels.

After introducing logarithms, the model (1) becomes:

$$a_t = lnK_t - lnK_{t-1} = c(1) + c(2)(lnY_{t-1} - lnY_{t-2})$$
$$+ c(3)(lnu_t - lnu^*) + c(4)(lni_t - lni^*) + \varepsilon_t \qquad (2)$$

If the variables have a unit root (I(1)) OLS cannot be applied to estimate the model, because the variables are not stationary, and the regression could be spurious. To avoid the problem we shall use the Engle and Granger' two stage procedure (Engle and Granger, 1987). Firstly we apply an augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test to check the nonstationarity of the time series, secondly we estimate the long run model, if their residuals are "white noise", we estimate the parameters of the "error correction model". The error correction model has the same variables that have been differentiated once to obtain stationary series and the residual of the previous model as in (3):

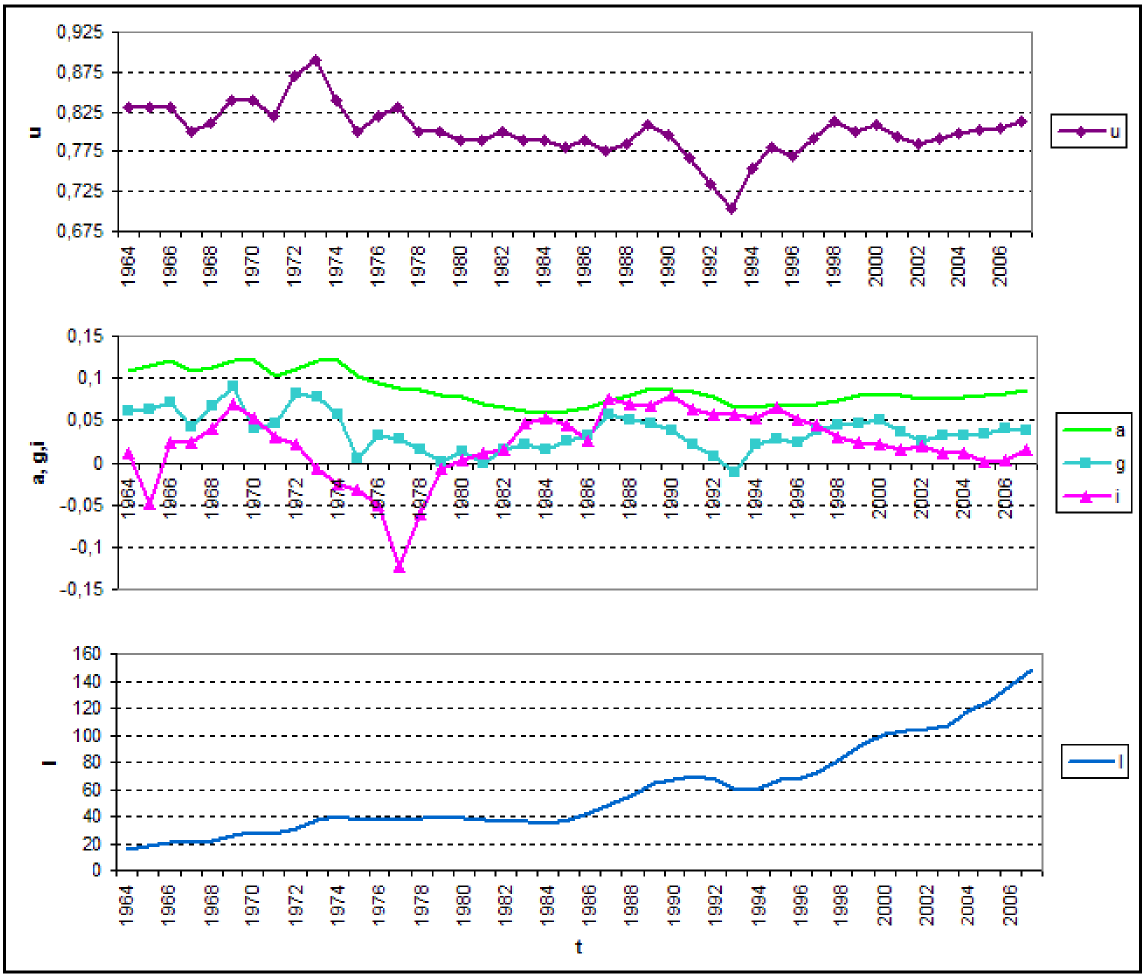
$$\Delta a_t = c'(1) + c'(2)\,\Delta g_{t-1} + c'(3)\,\Delta du_t + c'(4)\,\Delta di_t + c(5)\varepsilon_{t-1} + \mu_t \qquad (3)$$

4. AN EMPIRICAL ANALYSIS OF INVESTMENT IN SPAIN (1964-2007).

The data for the analysis of the productive investment of the Spanish firms come from the Instituto Valenciano de Investigaciones Económicas (IVIE), Instituto Nacional de Estadística (INE), Ministry of Industry, Trade and Tourism, Eurostat and Organization for Economic Co-operation and Development (OECD).

Figure 2 shows the time series which have been analysed. All the variables appear in logarithmic differences, except private productive investment, which is expressed in thousands of millions euros.

FIGURE 2. PRIVATE PRODUCTIVE INVESTMENT, RATE OF ACCUMULATION OF CAPITAL, RATE OF GROWTH OF REAL GDP, RATE OF CAPACITY UTILIZATION AND LONG TERM INTEREST RATE IN SPAIN (1964-2007).



Source: IVIE; INE; Ministry of Industry, Trade and Tourism; Eurostat and OECD.

The period 1964-2007 seems too long and diverse to be treated in one study. The economy has experienced a number of institutional changes, particularly, the entrance in the European Union in 1986 which causes a clear break in the series of capital accumulation. Note that the sample 1964-86 coincides with the period analyzed by Andrés *et al.* (1990). To the best of our knowledge, the period 1987-2007 has not been analyzed yet.

TABLE I. LONG-RUN EQUILIBRIUM RELATIONSHIP 1964-1986.

$$a_t = c(1) + c(2)g_{t-1} + c(3)du_t + \varepsilon_t$$

	Coefficient	t-Statistic [p-value]
c(1)	0,084448	10,23524 [0,0000]
c(2)	0,516791	4,297952 [0,0004]
c(3)	0,247826	2,640124 [0,0166]
R-squared	0,803177	

TABLE II. LONG-RUN EQUILIBRIUM RELATIONSHIP 1987-2007.

$$a_t = c(1) + c(2)g_{t-1} + c(3)du_{t-2} + c(4)di_t + \varepsilon_t$$

	Coefficient	t-Statistic [p-value]
c(1)	0,075383	17,52436 [0,0000]
c(2)	0,288554	4,379806 [0,0004]
c(3)	0,076317	2,565939 [0,0200]
c(4)	-0,000323	-2,245986 [0,0383]
R-squared	0,762989	

Table I and II show the coefficients of the long run equilibrium, estimated using OLS. This is the straight application of our flexible accelerator model of investment. The results look good enough. All the variables have the sign expected on theoretical grounds. All of them are significant, except the interest rate in the first period that has dropped out. The goodness of fit is reasonable, relative to the usual results of investment functions. R^2 is 0,80 in the first period and 0,76 in the second one.

All the series presented in *Figure 2* are I(1), i.e. they exhibit a unit root, they have an inherent trend. To cope with this problem we apply the cointegration procedures. Table III shows the results of the augmented Dickey-Fuller test and the Phillips-Perron test, Then, the residuals of our model are stationary, i.e. they behave as "white noise".

TABLE III. UNIT ROOT TESTS.

Series	ADF	PP
Level series		
Model 1964-1986	-2,906826*	-2,906826*
Model 1987-2007	-3,807195*	-3,738058*

Note: *, ** and *** indicate the statistical significance and the rejection of the null at the 1, 5 and 10 percent levels, respectively.

After applying the typical error-correction procedures, the equations to be estimated are the ones contained in table IV and table V. (Variables which have been proved to be non significant have been dropped)

TABLE IV. ERROR-CORRECTION MODEL 1964-1986.

$$\Delta a_t = c'(1) + c'(2)\,\Delta g_{t-1} + c'(3)\,\Delta du_t + c'(5)\,\varepsilon_{t-1} + \mu_t$$

	Coefficient	t-Statistic [p-value]
c'(1)	-0,001801	-1,635397 [0,1215]
c'(2)	0,157096	3,062250 [0,0074]
c'(3)	0,187279	4,370420 [0,0005]
c'(5)	-0,352539	-2,854782 [0,0115]
R-squared	0,674265	

TABLE V. ERROR-CORRECTION MODEL 1987-2007.

$$\Delta a_t = c'(1) + c'(2)\,\Delta g_{t-1} + c'(5)\,\varepsilon_{t-1} + \mu_t$$

	Coefficient	t-Statistic [p-value]
c'(1)	0,000308	0,398782 [0,6950]
c'(2)	0,260834	4,271737 [0,0005]
c'(5)	-0,622356	-2,586857 [0,0192]
R-squared	0,561124	

The accuracy of the short-term predictions in the first period (1964-1986) is lower than the long-term ones, but still acceptable (R^2=0,67). All the estimated parameters of this period turn out to be relevant and present the signs expected on theoretical grounds. Such results reinforce the validity of the long-term model presented in Table I.

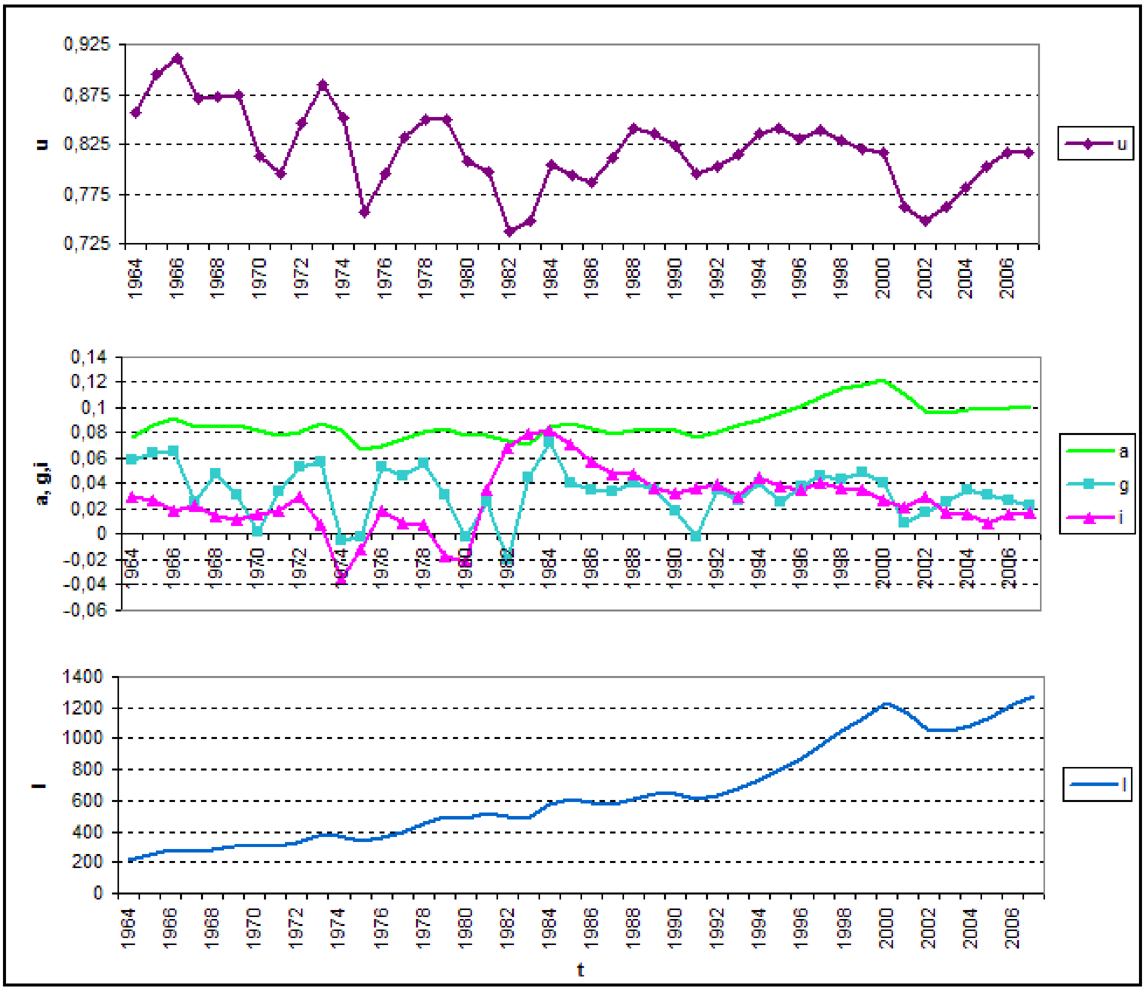
The story is not very different since 1987. The most important determinant continues to be the increase of production, which, in fact, in the short run analysis is the only significant variable. Both deviations are relevant in the long run but not in the short run.

As a complementary test, a model using stationary time series (as in Lavoie *et al.*, 2004 which computes first differences) has been also estimated. The results of this technique confirms our previous results.

5. An empirical analysis of investment in the United States (1964-2007).

For the USA we rely on data provided by the Bureau of Economic Analysis (BEA), the Federal Reserve (FED) and the OECD. *Figure 3* shows the evolution of the variables we are going to analyze. All of them appear in logarithmic differences, except private productive investment which is expressed in thousands of millions of dollars.

FIGURE 3. PRIVATE PRODUCTIVE INVESTMENT, RATE OF ACCUMULATION OF CAPITAL, RATE OF GROWTH OF REAL GDP, RATE OF CAPACITY UTILIZATION AND LONG TERM INTEREST RATE IN THE UNITED STATES (1964-2007).



Source: BEA; FED and OECD.

We shall also distinguish two periods in the evolution of the rate of accumulation: 1964-1993; and 1994-2007. The reason being that in year 1993 there is a break in the trend of investment: it speeded up.

The variables, which have been shown in *Figure 3* are I(1). They have a unit root as in the Spanish case. For this reason we shall apply cointegration analysis and error correction models.

Table VI and VII show the results of the regression of the original model that can be defined as the "long run model".

TABLE VI. LONG-RUN EQUILIBRIUM RELATIONSHIP 1964-1993.

$$a_t = c(1) + c(2)g_{t-1} + c(4)di_{t-1} + \varepsilon_t$$

	Coefficient	t-Statistic [p-value]
c(1)	0,075341	72,32146 [0,0000]
c(2)	0,142355	4,970750 [0,0000]
c(4)	-0,000187	-3,499856 [0,0018]
R-squared	0,702024	

TABLE VII. LONG-RUN EQUILIBRIUM RELATIONSHIP 1994-2007.

$$a_t = c(1) + c(2)g_{t-1} + c(3)du_t + \varepsilon_t$$

	Coefficient	t-Statistic [p-value]
c(1)	0,089658	16,47931 [0,0000]
c(2)	0,526162	3,496670 [0,0050]
c(3)	0,101225	2,410292 [0,0346]
R-squared	0,698544	

Table VIII shows the results of the unit root tests. The residuals are white noise and the time series become cointegrated.

TABLE VIII. UNIT ROOT TESTS.

Series	ADF	PP
Level series		
Model 1964-1993	-3,625398*	-3,625398*
Model 1994-2007	-2,575511**	-2,633286**

Note: *, ** and *** indicate the statistical significance and the rejection of the null at the 1, 5 and 10 percent levels, respectively.

Table IX and X show the results of the regression of the error-correction model which can be considered a "short term model".

TABLE IX. ERROR-CORRECTION MODEL 1964-1993.

$$\Delta a_t = c'(1) + c'(2)\,\Delta g_{t-1} + c'(4)\,\Delta di_{t-1} + c'(5)\,\varepsilon_{t-1} + \mu_t$$

	Coefficient	t-Statistic [p-value]
c'(1)	-4,06E-05	-0,066495 [0,9476]
c'(2)	0,112147	4,948303 [0,0001]
c'(4)	-0,000194	-3,226282 [0,0037]
c'(5)	-0,612452	-2,835147 [0,0094]
R-squared	0,713536	

TABLE X. ERROR-CORRECTION MODEL 1994-2007.

$$\Delta a_t = c'(1) + c'(2)\,\Delta g_{t-1} + c'(5)\,\varepsilon_{t-1} + \mu_t$$

	Coefficient	t-Statistic [p-value]
c'(1)	0,000639	0,633996 [0,5403]
c'(2)	0,371324	4,046765 [0,0023]
c'(5)	-0,561017	-2,648126 [0,0244]
R-squared	0,68536	

Until 1993 the accumulation process is explained through the annual changes in GDP and the deviation between the effective long term interest rate from its *conventional* level. Both variables are lagged by one period. This structure is independent from the temporary horizon which we could consider. On the contrary the rate of capacity utilization in USA has no impact in the rate of accumulation (as Argitis, 2008, first observed).

Since 1994, the only determinant observed in the short term model is the annual increase of GDP in the period *t-1*. In the long term, two variables are significant, the deviation between the effective rate of capacity utilization from its *normal* level and the increase of the production in the last year. As usual, the key influence derives from production.

When we estimate a model using stationary time series, in the United States (following Lavoie et al, 2004), the only significant variable that we have found is the rate of growth of real GDP in period *t-1*. In this case the long term interest rate has no incidence in the explanation of the rate of accumulation.

6. CONCLUDING REMARKS.

We have tested a postKeynesian model where accumulation of capital accelerates when the rate of growth of GDP speeds up. Our accelerator model is flexible enough to include the positive impact of the deviations of capacity utilization over its normal level and the negative impact of the deviation of the real interest rates over its conventional level. Applying different econometric techniques (cointegration and error correction model) we are able to conclude that the rate of growth of demand (i.e. the accelerator mechanism) is always the key explanatory variable of investment, while the influence of the two ancillary variables (deviations of capacity utilization and of real interest rates) has been significant in some periods.

First we have analyzed the Spanish evidence divided in two series: 1964-1986 and 1987-2007. In both periods, and regardless of the temporal perspective considered, the key variable that explains investment has been the rate of growth of output lagged by one period. In the second period, deviations of capacity utilization have also played a prominent role in a long run perspective. The influence of interest rate deviations went unnoticed most of the time.

Cointegration techniques were also applied to the American data. Again, the annual increase in production (lagged by one period) turns out to be the most important determinant of accumulation. Until 1993, both in long term and short term perspectives, the deviation of the long term interest rate had some relevance. In the second period (1994-2007) the long run results show the influence of the rate of capacity utilization too, which previously went unnoticed.

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APPENDIX.

TABLE XI. UNIT ROOT TESTS SPANISH SERIES.

	SPAIN 1964-1986		SPAIN 1987-2007	
Series	ADF	PP	ADF	PP
Level series				
a	-2,646279	-2,630406	0,139779	-2,189575
g	-3,010548	-2,938414	-1,985026	-2,161966
du	-1,898508	-1,902471	-0,835119	-0,849765
di			-1,698172	-1,633517
First-difference series				
Δa	-3,854488*	-3,810817*	-2,500072**	-2,48512**
Δg	-5,523469*	-6,097300*	-4,037437*	-4,014597*
Δdu	-6,164107*	-6,360971*	-3,859712*	-3,848530*
Δdi			-5,242204*	-5,319516*

Note: *, ** and *** indicate the statistical significance and the rejection of the null at the 1, 5 and 10 percent levels, respectively.

TABLE XII. UNIT ROOT TESTS UNITED STATES SERIES.

	USA 1964-1993		USA 1994-2007	
Series	ADF	PP	ADF	PP
Level series				
a	-0,341229	0,140442	-2,555048	-1,955569
g	-1,759726	-2,047093**	-2,260961	-2,201515
du			-1,183948	-1,310288
di	-3,381491	-3,404121***		
First-difference series				
Δa	-4,473177*	-4,766205*	-1,875115***	-1,906014***
Δg	-4,938763*	-7,769442*	-5,604696*	-4,277391*
Δdu			-2,784712*	-2,807507*
Δdi	-5,819909*	-7,20253*		

Note: *, ** and *** indicate the statistical significance and the rejection of the null at the 1, 5 and 10 percent levels, respectively.

TABLE XIII. DIAGNOSTIC STATISTICS.

Statistic test		
SPAIN	1964-1986	1987-2007
LM (1)	3,710906 [0,054058]	2,933199 [0,086775]
LM (2)	4,225059 [0,120932]	3,042494 [0,218439]
LM (3)	6,613360 [0,085297]	3,539169 [0,315718]
White	6,284018 [0,615451]	2,502671 [0,644158]
White X	15,23053 [0,362580]	3,198456 [0,669420]
ARCH (1)	0,482403 [0,487336]	0,528072 [0,467419]
ARCH (2)	4,003187 [0,135120]	0,438574 [0,803091]
Jarque-Bera	1,062165 [0,587968]	2,130906 [0,344572]
AIC	-7,639218	-8,370859
SC	-7,440072	-8,221499
D-W	1,897044	1,62436
USA	1964-1993	1994-2007
LM (1)	0,987127 [0,320446]	3,808500 [0,050993]
LM (2)	1,846197 [0,397286]	3,124950 [0,209616]
LM (3)	2,359646 [0,501191]	2,894940 [0,408108]
White	14,14629 [0,117216]	4,852200 [0,302802]
White X	14,14629 [0,117216]	11,34390 [0,044972]
ARCH (1)	0,002971 [0,956535]	0,793207 [0,373132]
ARCH (2)	0,054539 [0,973099]	1,412022 [0,493609]
Jarque-Bera	0,478324 [0,787287]	1,205212 [0,547383]
AIC	-8,545818	-8,037882
SC	-8,353842	-7,907509
D-W	1,863884	1,411987