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## Article

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# Modelling accumulation: A theoretical and empirical application of the accelerator principle under uncertainty

*Philip Arestis\**, *Ana Rosa González\*\** and *Óscar Dejuán\*\**

*In this paper we derive a theoretical macro accumulation function, which relies on the accelerator principle and is complemented by utilizing capacity and profits. This investigation also accounts for several sources and kinds of uncertainty: exchange rates for financial uncertainty, oil prices for political uncertainty and interest rates for stock market uncertainty. The latter purports to account for the relationship between physical and financial investment. We also take on board the role of conventions in an attempt to account fully for uncertainty. In doing so, we include the relevant variables as deviations from their conventional levels. In the second part of the paper we estimate the investment function, by means of the system GMM in a panel of 12 OECD economies over the period 1970–2010.*

*JEL classifications: B22, C23, E22*

*Keywords: Accumulation, accelerator, uncertainty, conventions, Keynesian economics*

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## 1. Introduction

Private investment is a key macroeconomic variable since it affects both the demand and the supply side of the economy. Still there is no straightforward way the investment function is formulated. Even in *The General Theory*, Keynes (1936) postulates two theories of investment. In chapter 11, Keynes presents the *marginal efficiency of capital* that gives prominence to the rate of interest in the way advanced by Irving Fisher (1930) and other neoclassical economists. In chapter 12, Keynes (1936), claims that the key determinant of investment is the state of long-term expectations, which are formed in an atmosphere of uncertainty. New variables, such as *animal spirits*, *state of confidence* and *conventions*, come to the stage for the first time, displacing the traditional interest rate variable.

In this paper we estimate a Post Keynesian investment function based on the *acceleration principle* but flexible enough to account for the influence of distributive and financial variables, accounting for uncertainty and conventions. The introduction of conventional values as a way to deal with uncertainty has a significant role to play in the empirical literature, which is not always acknowledged. Using panel data, we apply the *within-groups* estimator, the Least Square Dummy Variable (LSDV) estimator and the *system* Generalized Method of Moments (GMM) in an attempt to find a dynamic model, which captures the common structure among different economies that supposedly globalization brings about (Alexiou 2010, Servén 2003).

We proceed after this short introduction, section 1, to the theoretical formulation of the problem in hand as in section 2, where we discuss the Post Keynesian investment function, and in section 3 where we elaborate on extensions of the Post Keynesian investment function. We discuss in section 4 our particular formulation of the investment relationship to be empirically tested subsequently. We elaborate and justify in section 5 the econometric methodology utilised for the empirical analysis. The data employed along with their sources is presented in section 6. The empirical results derived, along with a discussion of them, are provided in section 7. Finally, we summarise and conclude in section 8.

## 2. The Post Keynesian investment function

There is an important controversy in terms of the specification of the investment function, which is evident not only among different schools of thought, but even within the same paradigm. The Post Keynesian controversies are a typical example. In view of this in what follows we begin with a brief discussion of the alternatives, in an attempt to account for them in our ultimate specification that is subsequently tested against real data.

Our starting point is the basic Post Keynesian investment function, which shows how accumulation,  $a = I/K$ , where  $I$  is investment and  $K$  is capital stock, is linked to capacity utilization,  $u$ , as in equation (1):

$$a = \frac{I}{K} = \alpha_0 + \alpha_1 u \quad , \quad (1)$$

where capacity utilization is measured as in (2):

$$u = \frac{Y}{K} , \quad (2)$$

where  $Y$  stands for output.

However, and from our perspective, the alternative version of this traditional model that accounts for the *normal* or *conventional* capacity utilization,  $u^*$ , is more relevant. This is so, we would suggest, in that it accounts for the gap between current capacity and its *normal* level as the main explanatory variable, as in equation (3):

$$a = \frac{I}{K} = \beta_0 + \beta_1(u - u^*) . \quad (3)$$

This particular view assumes that the *normal* rate of capacity utilization is determined endogenously and indicates that excess capacity plays a role even in the long run, due to the presence of uncertainty. The latter induces businessmen to maintain idle capacity in an attempt to anticipate unexpected increases in demand (Lavoie et al. 2004).

Another important approach, which elaborates on the initial function is the model introduced by Bhaduri and Marglin (1990), where the profit share,  $\pi$ , is argued to be the main determinant of investment. The inclusion of the profit share in the model accounts for a new path of growth, the profit-led growth, where growth and capital accumulation move in the same way (Dutt 2011). Moreover, the profit share can be considered as an indicator of the amount of internal resources, which are available to finance future investment projects. Equation (4) summarizes this particular proposition:

$$a = \frac{I}{K} = \chi_0 + \chi_1 u + \chi_2 \pi . \quad (4)$$

Nevertheless, this new relationship could be enhanced by considering the accelerator hypothesis, which relies heavily on expectations about future demand as the key variable in investment decisions. According to this principle (introduced by Clark 1917), the rate of accumulation will evolve in parallel to the expected rate of growth of demand; and production adjusts.<sup>1</sup> The main shortcoming of the accelerator mechanism emerges from the presence of uncertainty and the lack of perfect information. As a result, entrepreneurs' errors of prediction are frequent in a non-ergodic world. This compels us to reject a pure accelerator model as the unique explanatory element of investment. Under these circumstances businessmen cannot foresee precisely expected demand and have to assume that in the short-run consumers will demand a similar amount as in the recent past. However, even under these conditions the role of expected demand is strong, since it influences businessmen's expectations about other variables like profits or capacity utilization. Specifically, our function accounts for the accelerator principle by approximating the expected rate of growth of demand through the rate of growth of production,  $g$ . The extended version of model (4) is displayed in equation (5):

1 Investment in year  $t$  is a flow that increases the stock of capital. After dividing this flow by the stock of capital in  $t-1$  we obtain the rate of growth of capital, i.e. the accumulation rate,  $a_t$ .

$$a = \frac{I}{K} = \lambda_0 + \lambda_1 g + \lambda_2 u + \lambda_3 \pi , \quad (5)$$

where all the variables are as in equation (4), with the exception of  $g$ , which is the accelerator term.

Moreover, there are other relevant variables, such as monetary elements like the rate of interest,  $i$ , for example, which are ignored by the previous specification of the investment function. Although internal resources can be used to finance investment, in practice the presence of shareholders imposes a limit to finance new projects by using this avenue and the bulk of investment is financed externally, i.e. by bank loans and corporate bonds. Although the rate of interest is not the corner stone of the Post Keynesian investment function, it is relevant to include this variable because it plays a double role in capital accumulation. On the one hand, movements in the rate of interest are associated with income redistribution between rentiers and firms; in other words, consumption decisions are affected, and eventually expectations about future aggregate demand and thus investment follow. On the other hand, increases in interest rates dampen investment as has been demonstrated by Kaleckian and Kaldorian/Robinsonian models of growth and distribution (Lavoie 1995, Hein 2007). We may, therefore, account for it by introducing the rate of interest as in equation (6):

$$a = \frac{I}{K} = \delta_0 + \delta_1 g + \delta_2 u + \delta_3 \pi - \delta_4 i . \quad (6)$$

Furthermore, we would argue that uncertainty is an important variable, which should also be present in all Keynesian explanations of investment (see, for example, Ferderer 1993a and 1993b). According to this notion, entrepreneurs form their expectations about the future in an environment where there is no perfect information and they cannot apply probability in order to predict expected profitability, future demand, developments in financial markets, etc. So, uncertainty could emerge from different sources; some relevant examples are: political regimes, natural disasters, the development of the markets, or the weight that individuals give to their arguments. This variety also has its reflection in the empirical literature, which offers plenty of different proxies of this phenomenon (see, for example, Littleboy 1990, Stockhammer/Grafl 2010; see, also, Baddeley 2003, who provides an overview of the main empirical contributions that account for uncertainty in the investment analysis). We may refer to some examples here to make the point: aggregate demand, inflation, interest rate, unemployment, international trade, profit, technology, sales, stock market index, taxes, oil prices and the possibility of a crisis are the most popular proxies. Post Keynesian economists emphasize that fundamental uncertainty cannot be measured by statistical methods. It will show up via liquidity preference as Davidson (1991 and 2002) has persistently emphasized. In the Post Keynesian framework the influence of uncertainty on accumulation is crucial, since entrepreneurs have to consider a long-term horizon in order to decide how and where to invest. They also have to take into account the presence of sunk costs due to investment, which are often irreversible and imply the purchase of very specific capital goods. So, conventions become the skeleton of businessmen's rational behaviour, whereas the state of confidence helps individuals to define their expectations and decide accordingly.

In view of these arguments, equation (6) above could be enriched to give equation (7), which contains all the different determinants of accumulation that have been suggested by the different approaches as above:

$$a = \frac{I}{K} = \varphi_0 + \varphi_1 g + \varphi_2 u + \varphi_3 \pi - \varphi_4 i - \varphi_5 U, \quad (7)$$

where all the variables are as in equation (6), with the exception of  $U$ , which stands for uncertainty.

### 3. Extending the Post Keynesian investment function

Considering equation (7), the kernel of a Post Keynesian investment function, it could still be extended further, and in several ways. First, by introducing conventions in a way that entrepreneurs take investment decisions in a world dominated by fundamental uncertainty. It is what has prevailed in the recent past and whether people expect it to be maintained in the future (Keynes 1936). If, for any reason whatsoever, expectations change and are kept at the new level long enough, they may become the new convention. This is an example of hysteresis, which is widely used in macroeconomic analysis. More specifically, some of the variables have been defined as deviations from their *normal* or *conventional* levels, which is what permits one to identify further variables to be included in equation (7). Lavoie et al. (2004) is an important contribution in this sense, since it includes conventions in its investment function. Specifically, this study models the *normal* rate of capacity utilization by applying the HP filter (Hodrick/Prescott 1980) in an attempt to define the *normal* and *conventional* variables.<sup>2</sup> However, our approach goes beyond Lavoie et al. (2004) in

2 The Hodrick and Prescott (Hodrick/Prescott 1980) filter permits to isolate the trend component,  $p_t$ , and the cyclical component,  $c_t$ , which compose a time series,  $x_t$ , in the following way:

$$x_t = p_t + c_t. \quad (8)$$

To capture the cyclical component, the HP filter solves the next minimization problem:

$$\min \sum_{t=1}^T \left[ (x_t - p_t)^2 + \lambda ((p_{t+1} - p_t) - (p_t - p_{t-1}))^2 \right]. \quad (9)$$

The trend component measures the fitness of the time series while the cyclical component is a measure of its smoothness. This minimization problem introduces a *trade-off* parameter,  $\lambda$ , which helps to separate *goodness of fit* and *smoothness*; thereby, isolating the trend from the cyclical component.

For our empirical exercise the time series which are obtained as a result of applying the HP filter,  $p_t$ , are used to measure the following variables: a) the *normal* rate of capacity utilization,  $u^*$ ; b) the *conventional* long-term interest rate,  $i^*$ ; c) the *conventional* exchange rate,  $e^*$ ; and d) the *conventional* oil price,  $v^*$ . In that sense, the conventional level collects the long-run stable trend of the variable through the past, a fact which is relevant in the investment decision, since the presence of sunk costs related to investment in fixed assets compels entrepreneurs to invest only in responses to permanent changes in the economic situation.

that it accounts for this *normal* rate and extends the notion of conventions to the rate of interest and those variables that capture the presence of uncertainty in the model.<sup>3</sup> This is so simply because conventions become really important if they are related to uncertainty. In fact, the role of conventions becomes even more relevant when businessmen have to take investment decisions in a world with imperfect information. The way in which we determine conventional levels is perfectly compatible with expectations that change through time.

Second, the existence of several sources of uncertainty, as mentioned above, is accounted for in our model through three different proxies: deviations of oil prices and its conventional level,  $dv$ , which approximates geo-political uncertainty; and deviations of the interest rates and the current exchange rate from their conventional levels, denoted respectively as  $di$  and  $de$ , which capture financial uncertainty. The explanation of this choice emerges from the fact that under globalization all the economies are open systems exposed to foreign trade. So that, the most relevant sources of uncertainty that we could consider are those which relate to domestic and foreign markets. One of the key variables that satisfy this requirement is the exchange rate, which relates to different currencies, different financial and monetary markets and different goods markets. The second one is oil prices, due to the fact that the production of this basic commodity is located in some countries where political problems are frequent and have a reflection in its production and subsequently in its price.

Although the volatility of the exchange rate has been used as a proxy of financial uncertainty by previous Post Keynesian empirical studies (Stockhammer/Grafl 2010, for example), our approach is different. It introduces the notion of *convention* as a way to deal with uncertainty. So, our model approximates at the same time financial and political instability and accounts for businessmen's expectations about them, which constitutes a novelty of the analysis undertaken.

Our approach also takes into account the influence of stock markets,  $X$ , in order to clarify the role that these markets play in the investment-decision process instead of using the volatility of this market as a proxy of financial uncertainty as in other studies (Episcopos 1995, Baum et al. 2008). We suggest that this is more appropriate since our purpose is to study the possibility of a close relationship between physical and financial investment in order to analyze if both are competing for the same kind of resources. Moreover, financial markets cannot be ignored because they contain those conventions, which embrace the essence of the political, social and economic atmosphere that also affect *animal spirits* (Dow/Dow 2011). We may note at this stage that there is a conflicting relationship between investment

3 Moreover, the way in which the deviations are defined is different between Lavoie et al. (2004) and our approach. Specifically, Lavoie et al. built the deviation of capacity utilization as the discrepancy between actual and *normal* rates of capacity utilization, while for the purpose of this study all the deviations under consideration are calculated according to the following general expression:

$$d\tau_{i,t-1} = \frac{\tau_{i,t-1} - \tau^*}{\tau^*}, \quad (10)$$

where  $\tau$  is the current rate of the variable (for instance, the rate of interest rate,  $i$ ) and  $\tau^*$  is its *normal* or *conventional* rate (e.g. *conventional* interest rate,  $i^*$ ).

and stock markets, which has been studied since Keynes (1936). Keynes suggests a positive relationship between these two variables, since the stock market permits investors to revise their expectations about the profitability of a particular investment project when they turn out to be disappointing. So, businessmen are willing to invest more since this market gives them the opportunity to save their capital when calculations are proved wrong. Apart from this idea, Keynes points to an inverse relationship by considering the presence of financial bubbles in the market place. Under such case, the stock market increases the volatility of investment since the role of *animal spirits* becomes prominent.<sup>4</sup> Following Keynes' (1936) ideas, Brainard and Tobin (1968 and 1977) consider this market as a source of external funding. Theoretically, a firm which receives a positive valuation from the market could obtain resources easily and finance new investment projects with a lower cost.

The analysis of this section would suggest modifying equation (7) in order to account for the variables suggested by this section. This is undertaken in section 4.

#### 4. *The Post Keynesian investment function in the context of uncertainty and financial markets*

In order to study the impact of finance and explore the role of conventions and uncertainty, it is necessary to provide a new investment function, which modifies equation (7) by considering appropriately additional explanatory variables. So in addition to the variables included in equation (7), a number of variables follow from the discussion in section 3: the deviation between the effective capacity utilization and its *normal* level,  $du$ ; the deviation of the real interest rate from its *conventional* rate,  $di$ ; the deviation between the real exchange rate based on labour unit cost and its *conventional* rate,  $de$ ; the deviation of oil prices from its *conventional* level,  $dv$ ; and the stock market index,  $X$ .<sup>5</sup> In the rest of this section, we elaborate, and justify, the inclusion of these extra variables in equation (7).

As we have justified above, the Bhaduri and Marglin (1990) approach needs to be amended by including monetary elements, like the rate of interest, in order to account for the cost of external finance and the redistribution process between rentiers and firms. However, our proposal includes not only this financial element but also businessmen's expectations about its evolution. As a result, we insert the deviation of the rate of interest from its conventional level,  $di$ , instead of the rate of interest as in equation (6). This new variable permits to cope with the uncertainty, which emerges from the banking sector, and related to the lack of perfect information in the credit market about borrowers. The latter influences the risk premium of a loan and with unexpected changes in the main instrument of monetary policy in order to achieve its objectives. Expectations about the cost of external

4 The *animal spirits* reflect how under the presence of uncertainty, which characterizes financial markets, individuals cope with this phenomenon in an optimistic way, and finally, take risks (Dequech 1999, Dow/Dow 2011).

5 In the Appendix we explain how the variables mentioned in the text are defined.



finance also play an important role in the investment decision since expectations about relevant changes in the future rate of interest can induce businessmen to undertake a project today in order to obtain more affordable financial resources.

We continue with our analysis of uncertainty by accounting for the effect of oil prices in view of its importance. In this sense, it is necessary to study some conflicting effects, which arise from the impact this variable can have on the real economy. On the one hand, high volatility of oil prices and constant increases in its price, induce firms to invest in other productive processes, which are less intensive in oil than the current equipment. Also, higher profitability in order to compensate for increases in the cost of this particular commodity, as it happened in Spain after the crisis in 1973 (Mendizabal et al. 1986), is a further inducement. However, is this effect exceptional or so strong to operate throughout time and in different countries? Or is it the case that if the price of this basic input rises frequently, should we expect a reduction in the short-run profitability, since the manufacturing sector will have problems in terms of transferring this cost to consumers? Indeed, they may be compelled to accept a decrease in the amount of their profits, and so, a reduction in the amount of financial resources available to invest would take place. In the event that the business sector manages to transfer this increase to their clients, the presence of inflation will depress expectations about future demand, and a negative impact on accumulation emerges.<sup>6</sup>

Furthermore, this variable has a relevant role in the financial sector of the economy. A high and unexpected increase in oil prices will be understood as a negative sign by financial markets, in which case they would be advancing the presence of cost-push inflation, increases in interest rates and its negative effects. As a result instability and losses arise in the stock markets, which make it more difficult to obtain external resources. So, our approach deals with these effects by computing the deviation between the current oil price and its conventional level,  $dv$ .

Finally, the financial crisis of August 2007 highlighted the necessity of involving financial markets in economic analysis, since the effects that emanate from them play an important role in the development of the real economy. Two facts compel us to think that firms have had incentives to *play* with their profits in financial markets rather than invest them in fixed assets: the deceleration of the accumulation pace, which was evident in the majority of the OECD countries; and the increasing trend of profits during the period under consideration. Moreover, this market is a source of uncertainty and instability to the remainder of the economy, since every day huge capital flows are moving to speculate following expectations about profits. Our hypothesis assumes a depressive impact of stock markets on accumulation, since the stock market is attractive to investors due to the fact that it offers possibilities of speculation, which may provide quick gains of capital without necessarily long-term commitments. Specifically, we add the term  $X$  to our equation, which registers the evolution of the main real stock indices in order to account for the sign of the relationship between accumulation and the stock market.

6 Moreover the evolution of the oil price reflects energy/peak oil crisis, whose impact not only affects business activities, but also other macroeconomic aggregates, like households consumption.

Including the expected rate of growth of demand, the deviations between the effective level and the *conventional* one (capacity utilization, interest rates, oil prices, exchange rate) and the stock market indices, in equation (11) we obtain our investment function, which can be described as follows:

$$a = \gamma_0 + \gamma_1 g + \gamma_2 du + \gamma_3 \pi - \gamma_4 di - \gamma_5 de - \gamma_6 dv - \gamma_7 X + \varepsilon \quad (11)$$

where the symbols are as defined above;  $\gamma_i$  are the coefficients, which will be estimated below, and  $\varepsilon$  is a random error term.

### 5. *Econometric methodology*

This study treats the data as a panel, which permits us to simultaneously analyze the development of the rate of accumulation of capital through time for a number of different countries. The main objective of this kind of methodology is to collect the individual-specific, time-invariant, unobserved heterogeneity, which appears among the data. In other words, those features that are common among the different individual countries and whose impact is maintained through time could be collected and utilised, although they cannot be measured directly in spite of the fact that they are correlated with the explanatory variables included in the model. So, we control for individual effects and temporary effects at the same time.<sup>7</sup>

Panel data analysis offers several advantages over cross-section or time-series data sets due to the fact that modeling this kind of data allows us to utilise a wider sample of information. Thereby, the variability and the degrees of freedom of the model are higher than in the case of an analysis, which considers time series data or cross-sectional-data (Baltagi 1995). Modeling longitudinal data reduces the collinearity of the model, due to the fact that it is possible to use the interindividual differences of the explanatory variables.<sup>8</sup> In this way it is not necessary to apply the usual approach of constraining the coefficients of lagged variables. As a result, we can estimate an unconstrained distributed-lag model (Hsiao 2003). Moreover, the results of panel data estimations also reduce the bias of the estimators since it is possible to use all the available observations at the same time without having to aggregate the information (Gujarati/Porter 2010). Finally, this kind of data offers a new possibility because the behavior of a particular individual country can be foreseen more accurately than when time-series data is used. The reason is that this method permits the acquisition of knowledge about the behavior of the rest of countries included in the sample and utilizes it to build their predictions (Hsiao/Mountain 1994).

<sup>7</sup> These effects are different for each individual case but do not change through time. At the same time, though, the same effects exert similar influence on each individual case in period  $t$ .

<sup>8</sup> In this way, the efficiency of the estimators clearly increases.

Due to reasons of robustness, the described relationship in equation (7) is going to be estimated by means of three techniques: the *within-groups* estimator to model fixed-country effects, the LSDV estimator, and the *system* GMM.<sup>9</sup>

However, some peculiarities of these econometric methods have to be highlighted. First of all, since the relationship under consideration is a dynamic one, both fixed effects and LSDV estimations have to include the lagged dependent variable as a regressor. Second, we may note that the GMM estimator was developed for cases with a large number of cross sections. Due to the twelve countries we utilize is not such a big number, we have estimated the model by using fixed country effects. Nickell (1981) points to the fact that the results are biased for short-sample applications. However, in our exercise the time series are long enough, but if any problems arose, they would be rather minor. We also estimate the proposed accumulation function by applying the LSDV estimator, which performs comparably well in applications based on unbalanced panels (Judson/Owen 1999). Finally, the preferred technique is the *system* GMM, which provides efficient estimators under additional assumptions, like the presence of autocorrelation between errors and individual effects through time among the analyzed units (Alonso-Borrego/Arellano 1996).<sup>10</sup> This last method also accounts for simultaneity among the variables.

The validity of the GMM regression can be checked by using: a) the Sargan test of orthogonality between the instruments and the residuals, which permits to test the validity of the instruments (Sargan 1958, Hansen 1982); and b) the Arellano and Bond test for first- and second-order serial correlation (Arellano/Bond 1991).<sup>11</sup>

## 6. Data

As mentioned above, panel data estimation is utilised for the purposes of our empirical investigation and estimation. Our sample spans from 1970 to 2010 and includes annual data for the following economies: Australia, Belgium, Canada, Denmark, France, Germany, Italy, Norway, Austria, Spain, the United Kingdom and the United States. Consequently, our sample includes the main European economies and others like the United States and Canada, which are relevant due to their size. It also includes Australia because the empirical

9 See Baltagi (1995) for a discussion of the fixed effect approach, Kiviet (1995) for a description of the LSDV estimator, and Arellano/Bover (1995) and Blundell/Bond (1998) for details on the *system* GMM technique.

10 To solve these problems the *system* GMM computes the equation in differences and in levels. In the case of the equation in levels the relevant instruments are the lagged differences of the variables, while in the case of the equation in differences the instruments are the lagged values of the levels of the variables.

11 In the event that the models are estimated by applying *system* GMM, the way in which they are constructed, namely, by differencing the original equation to obtain the equation in differences and the lagged variables to use them as the instruments of the equation in levels, will produce first-order autocorrelation terms but of no higher-order (Arellano/Bond 1991).

literature about this country is scarce. These economies differ in terms of size, openness to international trade and their financial institutions. The rest of this section attempts to justify the period chosen for the empirical investigation aspects of this contribution.

The main source of data is the *AMECO* databank, where annual data availability exists since 1960 for some of the economies included in the sample. However, we have to reduce this period to 1970–2010 in order to balance the panel and use the most complete and homogenous data as possible.<sup>12</sup> More specifically, the following time series have been provided by this source: operating surplus, real long term interest rates and real exchange rates based on labour unit cost. Moreover, these data series have had to be enhanced by resorting to additional information as follows. Capacity utilization series are provided by the OECD database *Business Tendency and Consumer Opinion Surveys*. However, there is some missing information about this series in the case of Australia and the United States.<sup>13</sup> Annual oil prices are published by the *U.S. Energy Information Administration (EIA)* since 1861.

The lack of data about the stock of capital in the business sector in *AMECO* databank compels us to consider additional sources as in Kamps (2005), which provides them for all the countries included in our sample until 2002. In order to complete these time series until 2010 and for the rate of capital accumulation of the business sector, we also use the *Eurostat* databank (*Cross-classification of fixed assets by industry and by non-financial fixed asset*) which provides statistics of fixed assets by type and industry over the period under consideration.<sup>14</sup>

The main difficulty in obtaining the required data appears in the case of the stock exchange indices. The majority of this information is daily and in the best case it only covers the last 25 years. Another problem is the fact that there are often changes in the composition of the indices. In view of this, we only consider those indices for which it is possible to find long-run series and are also consistent with our sample. Specifically, we include the DAX

12 Although the LSDV estimator can be applied in those cases in which the panel is not balanced, we have nonetheless balanced our panel in order to apply all the unit root tests that can be implemented by means of STATA 11. Balancing the panel enabled us to employ the following tests: the Breitung (Breitung 2000) test, the Levin-Lin-Chu (Levin et al. 2002) test and the Harris-Tzavalis (Harris/Tzavalis 1999) test.

13 Australian capacity utilization information comes from the Australian Chamber of Commerce and Industry (*ACCI Westpac Survey of Industrial Trends*), which publishes quarterly data since 1961. The United States capacity utilization data comes from the Federal Reserve website, which provides monthly data since 1967 (*G.17 Industrial Production and Capacity Utilization, Capacity utilization: Total Industry*).

14 In the case of some economies it was necessary to consult other additional sources. Specifically, the Bureau of Economic Analysis (BEA) in the case of the United States (*Current-Cost Net Stock of Fixed Assets and Consumer Durable Goods*), the Australian Bureau of Statistics for the Australian economy (*Capital Stock, by Institutional sector*), the Instituto Valenciano de Investigaciones Económicas (IVIE) in the Spanish case (*Stock de capital en España y su distribución territorial, 1964–2002*), Statistics Norway for the Norwegian data (*Gross fixed capital formation and capital stocks, by type and industry*), Statistics Canada for the Canadian observations (*Investment, capital stock and capital services of physical assets*), and the Office for National Statistics (*National Non-Financial Balance Sheet: by Asset and Sector*) for the United Kingdom information.

index as the most representative one for the *Old World* stock market and use it for all the European countries except for Spain and the United Kingdom. The latter two countries incorporate their own indices (IGBM in the former case and FTSE 100 in the latter one). In the Australian case we compute the AXS index, and finally, we consider the Standard & Poor's index for the United States and Canada. DAX index is calculated by the *Deutsche Bundesbank*, which publishes relevant historical data since 1960. Standard & Poor's index is provided by *Standard & Poor's website*, which offers information since 1957. AXS and FTSE index are published by *Wren Investment Advisers* since 1875 in the case of the first one and since 1970 in the second case.<sup>15</sup> IGBM index is provided by the *IESE Business School University of Navarra* from 1940 to 2003. Since 2003 this information comes from *Bolsa de Madrid* website.<sup>16</sup>

## 7. Empirical results

We begin by reporting those unit root tests, which have been undertaken before any estimation, in an attempt to make sure that spurious regressions are avoided. More specifically, we have applied the Im-Pesaran-Shin (2003) tests, which assume an individual unit root process; the Breitung (2000) test and the Levin-Lin-Chu (2002) test, both of which assume a common unit process; and the Harris-Tzavalis (1999) test, which is similar to the previous ones, although the Harris-Tzavalis test assumes that the number of time periods under consideration is fixed. Moreover, we also check the absence of unit roots by means of the Fisher-augmented Dickey-Fuller (Choi 2001) test and the Fisher-Phillips-Perron (Choi 2001) test, which were applied to the observations of each variable as a set by considering an individual unit root process. The results derived clearly show that the panel data tests

15 FTSE time series consider the development of the FT 30 index from 1970 till 1984. Previous daily data about the FT 30 are provided by Loughborough University databank since 1935.

16 The websites which provide the data are:

<http://www.bolsamadrid.es/comun/empresas/infigbm.asp?id=esp&tinf=igbm>

[http://ec.europa.eu/economy\\_finance/db\\_indicators/ameco/index\\_en.htm](http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm)

<http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WTOTUSA&f=W>

<http://stats.oecd.org/index.aspx>

<http://www.wrenresearch.com.au/downloads/>

[http://www.bundesbank.de/statistik/statistik\\_zeitreihen.php?func=row&tr=wu3140&year=](http://www.bundesbank.de/statistik/statistik_zeitreihen.php?func=row&tr=wu3140&year=)

<http://www.ifw-kiel.de/forschung/datenbanken/netcap>

[http://epp.eurostat.ec.europa.eu/portal/page/portal/national\\_accounts/data/database](http://epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/data/database)

<http://www.bea.gov/>

<http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1350.0May%202012?OpenDocument>

<http://w3.grupobbva.com/TLFU/tlfu/esp/areas/econosoc/bbdd/capital.jsp#1>

<http://statbank.ssb.no/statistikkbanken/>

<http://www.statcan.gc.ca/>

<http://www.ons.gov.uk>

undertaken for cointegration prove stationarity so that the regressions presented below are not spurious.<sup>17</sup>

Table I reports the estimation of our investment function by applying the three different techniques briefly explained above: a) the *system* GMM; b) the *within-groups* estimator for fixed effects; and c) the LSDV estimator. All the explanatory variables that we introduce in our model are lagged one and two periods, since the expectation variables are based on the recent past. This assumption permits us to consider the notion of the value of waiting and the impact of hysteresis, which surrounds the development of the economic system (Dixit 1992). Under this premise businessmen have to decide between investment in the current period, or waiting in order to obtain more information, which helps them to take an irreversible decision that means sunk costs in the context of uncertainty and the lack of perfect information.<sup>18</sup>

The first column (Model I) shows the estimated parameters of the unrestricted version of our proposed relationship, which includes all the variables two periods lagged and was estimated by the *system* GMM. The final lag structure is based on the application the econometric methodology of general-to-specific modelling (Hendry 1986), Model II was estimated by means of the same technique, but omitting the insignificant variables of Model I. It thereby provides the coefficients of the restricted model and reports the final specification of our investment function. The following Models (III–IV) report the results of the restricted version of the accumulation model but estimated by the *within-groups* and LSDV estimators respectively.<sup>19</sup> It should be noted that the LSDV estimation requires a set of dummy variables that represent each one of the countries included in our sample. In Table I these country dummies are denoted as follows: FR (France), GE (Germany), IT (Italy), AU (Australia), BE (Belgium), DEN (Denmark), CA (Canada), AUS (Austria), SP (Spain), US (the United States), NO (Norway), UK (the United Kingdom). The inclusion of these variables permits us to separate the total impact of the intercept in Model IV among the units analysed, instead of having a single intercept as in Model III.

The bottom part of Table I displays the diagnostics/statistics utilised. The Wald test reported in the case of Models I and II permits us to accept the estimated coefficients, since the null hypothesis is that all the considered parameters in the regression are simultaneously equal to zero. In the case of Models III and IV, the F-test is reported, which allows us to accept the significance of the explanatory variables of the model. We also apply the Sargan test in order to study the validity of the instruments, which are included in the model. This test

17 The results of these tests are not reported in the paper but can be obtained from the authors upon request.

18 STATA 9.2 is the econometric software utilised. In order to estimate the models it was necessary to apply the following commands: *xtreg* to implement the *within-groups* estimator, *regress* in the case of LSDV estimator, and *xtabond2* to estimate the *system* GMM model.

19 The kind of data that we employ compels us to consider a minimum delay of one year. The lengths of the lags, which are considered are in line with previous empirical investigations (see, for example, Evans 1969, Baddeley 2003).

Table 1: Estimated coefficients for the macro accumulation function (1970-2010)

| Dependent    | Model               |                     |                     |                     |
|--------------|---------------------|---------------------|---------------------|---------------------|
|              | I                   | II                  | III                 | IV                  |
| Constant     | a                   | a                   | a                   | a                   |
| a (1)        | 0.00583 (0.91)      | 0.00418 (0.79)      | -0.00716 (-1.05)    |                     |
| g (1)        | 0.76309* (16.49)    | 0.77921* (19.05)    | 0.73200* (26.53)    | 0.73200* (26.53)    |
| g (2)        | 0.15886* (3.85)     |                     |                     |                     |
| du (1)       | 0.05438*** (1.83)   | 0.06625* (2.68)     | 0.12716* (6.13)     | 0.12716* (6.13)     |
| du (2)       | 0.04827** (2.20)    | 0.07822* (4.15)     | 0.04169* (4.59)     | 0.04169* (4.59)     |
| $\varpi$ (1) | 0.01531 (1.33)      |                     |                     |                     |
| $\varpi$ (2) | -0.00094 (-0.01)    | 0.01885*** (1.66)   | 0.04495** (2.31)    | 0.04495** (2.31)    |
| di (1)       | -0.00332 (-0.04)    |                     |                     |                     |
| di (2)       | -0.00012 (-0.84)    | -0.00021*** (-1.68) | -0.00003 (-0.54)    | -0.00003 (-0.54)    |
| de (1)       | 0.00019 (0.89)      |                     |                     |                     |
| de (2)       | 0.00003 (0.39)      | -0.00010*** (-1.79) | -0.00003*** (-1.76) | -0.00003*** (-1.76) |
| dv (1)       | -0.00002 (-0.10)    |                     |                     |                     |
| dv (2)       | -0.00048 (-0.16)    |                     |                     |                     |
| X (1)        | -0.00517*** (-1.85) | -0.00560** (-2.39)  | -0.00282*** (-1.72) | -0.00282*** (-1.72) |
| X (2)        | -0.00037 (-0.13)    |                     |                     |                     |
| FR           | -0.00021 (-0.07)    | -0.00105*** (-2.11) | -0.00089** (-1.97)  | -0.00089** (-1.97)  |
| GE           |                     |                     |                     | -0.00638 (-1.00)    |
| IT           |                     |                     |                     | -0.00895 (-1.33)    |
| AU           |                     |                     |                     | -0.01208 (-1.44)    |
|              |                     |                     |                     | -0.00734 (-1.02)    |

| Model  | I              | II             | III            | IV                  |
|--|----------------|----------------|----------------|---------------------|
| BE   |                |                |                | -0.00797 (-1.15)    |
| DEN  |                |                |                | -0.00422 (-0.69)    |
| CA   |                |                |                | -0.00492 (-0.72)    |
| AUS  |                |                |                | -0.00513 (-0.77)    |
| SP   |                |                |                | -0.00684 (-0.86)    |
| US   |                |                |                | -0.00661 (-1.01)    |
| NO   |                |                |                | -0.01245*** (-1.67) |
| UK   |                |                |                | -0.00304 (-0.49)    |
| Method   |                | GMM-sys        | Within-Groups  | LSDV                |
| Number of observations (countries)               | 475 (12)       | 479 (12)       | 479 (12)       | 479                 |
| Wald test of joint significance (p-value)        | 936.75 (0.000) | 867.69 (0.000) |                |                     |
| F test (p-value)                                 |                |                | 150.12 (0.000) | 446.1 (0.000)       |
| Sargan test (p-value)                            | 59.05 (0.652)  | 79.11 (0.238)  |                |                     |
| 1 <sup>st</sup> -order autocorrelation (p-value) | -8.21 (0.000)  | -9.26 (0.000)  |                |                     |
| 2 <sup>nd</sup> -order autocorrelation (p-value) | 1.39 (0.164)   | 1.57 (0.117)   |                |                     |

Note: \*, \*\* and \*\*\* indicate the statistical significance and the rejection of the null hypothesis at the 1, 5 and 10 percent levels, respectively. Numbers in parentheses next to the variables show the lags of the variable. Numbers in parentheses next to the estimated coefficients display the value of the t-statistics. Otherwise, numbers in parentheses show the p-values of the test as indicated.



assumes that the instruments are truly exogenous only when the residuals are uncorrelated with the set of exogenous variables.<sup>20</sup> All the Sargan tests display no evidence to invalidate the inclusion of the relevant instruments in the estimated relationship. We also test for the absence of autocorrelation between the residuals, since its presence does not permit the use of lagged independent variables and the lagged dependent variable as instruments in the regression. Models I and II, which were estimated by applying the *system* GMM, exhibit no trace of second-order autocorrelation but show strong first-order autocorrelation. The presence of second-order autocorrelation is the only evidence of misspecification of the model, since the process of differencing the original equation and the lagged variables preclude first-order autocorrelation terms.<sup>21</sup>

Model I shows how the two lags of the rate of growth of GDP and the deviation of capacity utilization in  $t-1$  have a positive impact on accumulation (0.15886, 0.05438 and 0.04827 respectively). This specification also shows how the presence of political instability, as captured by deviations of oil prices, lagged two periods depresses investment (-0.00517). The selected estimation is captured by Model II, which widens Model I by adding several variables. Specifically, this specification shows a positive incidence of the accelerator term (0.06625), deviations of capacity utilization (0.07822) and profit shares (0.01885) on business investment. This estimation also finds a negative impact on accumulation, which mainly emerges from the financial side of the economy; more precisely, it emerges from the stock market (-0.00105), deviations of exchange rates (-0.0001) and deviations of the interest rates (-0.00021). As our testable hypothesis suggests, increases in oil prices also dampen investment (-0.0056).

Models III and IV exhibit the same determinants of capital accumulation although the technique employed is different in the two cases. Both models display a positive influence of expectations (0.12716), profit share (0.04495) and deviation of capacity utilization (0.04169) on accumulation. These models report a negative relationship between the stock market (-0.00089), deviations of exchange rates (-0.00003) and deviations of oil prices (-0.00003). These determinants are lagged by one period except the rate of growth of GDP, the evolution of the stock market and deviations of oil prices from its conventional level, which exhibit a two-period lag. However, the deviations of interest rates are not significant when the model is estimated with the *within-groups* and LSDV estimators. In terms of the country dummy variables the only significant dummy variable is for the Norwegian case.

20 Specifically, the Sargan test compares the value of the estimated moments against the value of the sample moments.

21 The presence of  $n$ -order autocorrelation means that the residuals are MA( $n$ ), so that only those variables, which are lagged more than  $n$  periods, are suitable instruments. A MA( $n$ ) process can be expressed as in equation (12):

$$\zeta_t = \mu + \theta_t + \psi_1 \theta_{t-1} + \psi_2 \theta_{t-2} + \dots + \psi_q \theta_{t-n}, \quad (12)$$

where  $\zeta_t$  is a variable,  $\psi_i$  are the estimated parameters,  $E(\zeta_t) = \mu$  and  $\theta_t$  is a succession of independently and identically distributed random variables with  $E(\theta_t) = 0$  and  $Var(\theta_t) = \sigma^2$ .

In general terms, the empirical results obtained confirm our theoretical framework. As we have argued above, expectations about future demand are a crucial element in terms of what supports the relevance of the accelerator principle in order to explain the path of accumulation. Regardless of the econometric technique employed and the exogenous variables of the model, the estimated coefficient for the rate of growth of GDP lagged one period is positive and higher than the rest of the parameters.

Profit shares and deviations of capacity utilization also have a positive impact on the investment decisions. The impact of the former is slightly superior than the incidence of the latter. Firms always maintain idle capacity, and therefore, the normal rate of capacity utilization is below unity; changes in the rate of capacity utilization enable unexpected increases in demand to be satisfied without undertaking new projects. However, an increase in the rate of capacity utilization over its normal rate would stimulate investment only when this deviation is maintained in the medium to long run. We may note that the impact of a rise in the profit share has a double effect. On the one hand, this is an indicator of higher profitability in the short and the medium run, which attracts new investment. On the other hand, an increase in the profit share enhances the possibility of finance investment with internal resources.

These results reported in Table 1 reinforce the Keynesian idea of the importance of the rate of interest in the investment decision, since investors need to finance externally their new projects. Furthermore, increases in the deviations of the exchange rate dampen accumulation, as implied by our theoretical framework. Instability in the exchange rate reduces trade flows and depresses expectations about external demand. However, the financial cost of a new project is more relevant than the movements of this variable. In those cases in which firms import capital goods it is highly likely that they decide to postpone an investment project in the event that the cost of obtaining financial resources is increasing than in the case that the currency is depreciating. Moreover, this is reinforced by the fact that the weight on the internal trade is bigger than the external one (for instance, the average openness of the United States and Australia over the period under consideration is below 17 per cent).<sup>22</sup> So, the variables that are related to the domestic market have a stronger effect on accumulation than the ones that are not.

The negative impact of the stock market is higher than the previous two indicators. This fact reinforces the idea, as advanced above, that the presence of a speculative bubble in the stock market crowds out investment in fixed assets.

Finally, the deviation of oil prices is the element that exerts the highest negative influence on investment. This proxy of uncertainty has an important role to play mainly in those situations where a crisis is in place and oil prices rise quickly, although its strong impact does not permit to ignore the fact that oil is still a basic commodity whose high volatility affects significantly the real economy.

22 The openness of an economy is measured by the ratio  $(Exports + Imports)/GDP$ .

### 8. *Summary and conclusions*

The aim of this paper is to explain, from an aggregate perspective, capital accumulation. The core of our theoretical framework is the traditional Post Keynesian model, where we introduce several additional variables, which encapsulate the essence of this way of thinking about investment. First, we insert an accelerator term, which plays a key role and captures businessmen's expectations about future demand. However, the presence of uncertainty compels firms to maintain idle capacity in normal conditions, which is reflected in our model with the deviation between current capacity utilization and its *normal* level. Moreover, uncertainty can emerge from different sources and affects investment decisions in a negative way through different channels. Specifically, we highlight the impact of oil prices and exchange rates. The former is a proxy of geo-political uncertainty, while the latter approximates financial uncertainty. Our strategy to deal with uncertainty is to define a *conventional* level for the variable and build a deviation between its effective value and its *conventional* one. Our proposal also introduces expectations about the cost of external finance, since changes in the rate of interest may delay or accelerate the execution of an investment project. Finally, we consider the impact of the stock market in order to account for the relationship between financial and physical investments and test whether the first one crowds out the second one.

We have tested our macro accumulation function with a sample of annual data of 12 OECD economies over the period 1970–2010 by means of the *system* GMM. Our empirical results support our theoretical hypothesis, and specifically, it shows how the key determinant of the accumulation rate is the expected rate of growth of demand. The econometric results find a positive impact of this variable on investment. There are also other positive effects which emanate from profit shares and the deviation between current capacity and its *normal* level. However, and as our theoretical relationship suggests, there is a negative relationship between accumulation and the cost of external finance. Moreover, uncertainty depresses investment, as it is shown by the negative estimated coefficients of deviations of the real exchange rate and oil prices. Finally, an inverse relationship between the development of stock markets and investment accumulation is found. We may note that the depressing effects which arise from the stock market and uncertainty can dampen accumulation more than interest rates. This fact is in line with Stockhammer and Grafl (2010).

The research undertaken and results obtained, both theoretical and empirical, for the purposes of this study imply certain important recommendations for the policymaker. Reducing financial uncertainty by implementing more regulation is paramount. Such policy initiatives improve transparency in the financial markets; also, and in view of the important link between the financial and the real economy, the absence of turbulences in the former avoid distortions in the latter. Moreover, the public sector should maintain a high level of aggregate demand without deep fluctuations, in view of the strong role played by expectations relative to future demand, as shown in this contribution.

## Appendix

Basic definitions of the variables:

$a$ : rate of accumulation of capital.

$$a_{i,t} = \frac{K_{i,t} - K_{i,t-1}}{K_{i,t-1}} = \frac{I_{i,t}}{K_{i,t-1}} . \quad (13)$$

$K$ : stock of productive capital.

$I$ : productive investment.

$g$ : rate of growth of GDP.

$$g_{i,t-1} = \frac{GDP_{i,t-1} - GDP_{i,t-2}}{K_{i,t-2}} . \quad (14)$$

$du$ : deviations between the effective capacity utilization ( $u$ ) and its *normal* level ( $u^*$ ).

$$du_{i,t-1} = \frac{u_{i,t-1} - u^*}{u^*} . \quad (15)$$

$\pi$ : profit share.

$i$ : real long-term interest rate.

$de$ : deviations of the real exchange rate ( $e$ ) from its *conventional* level ( $e^*$ ).

$$de_{i,t-1} = \frac{e_{i,t-1} - e^*}{e^*} . \quad (16)$$

$dv$ : deviations of the current oil price ( $v$ ) from its *conventional* level ( $v^*$ ).

$$dv_{i,t-1} = \frac{v_{i,t-1} - v^*}{v^*} . \quad (17)$$

$X$ : stock market. It is compute by using the logarithm of the variable.

$\alpha_0$ : independent term.

$\alpha_i$ : estimated coefficients.

$\varepsilon_{ij}$ : error term.

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