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MONEY AND BUSINESS CYCLE IN A SMALL OPEN ECONOMY

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Money and Business Cycle in a Small Open Economy.

An study of the Spanish case *

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Abstract

This paper examines the consequences of introducing a cash-in-advance constraint in a small open economy business cycle model for the Spanish economy. A business cycle model is built extending Correia, Neves and Rebelo (1995) small open economy framework and Cooley and Hansen (1995) monetary economy. Money is introduced through a cash-in-advance constraint. The stochastic simulation of the model and its comparation with Spanish data shows that the model is able to mimic the real dimension of the business cycle. In particular the high volatility of consumption for the Spanish economy is greatly reproduced. Some features of the nominal dimension are also reproduced. As a negative result the high correlation between money and output, and labor market relations are not reproduced.

Keywords: Business Cycle, Cash-in-Advance Constraint, Small Open Economy.

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1 Introduction

The high correlation among monetary aggregates and ouput, the weak correlation between hours worked and labor productivity and the high volatility of consumption relative to the volatility of output, are three highlight features of the Spanish business cycle. First, the high correlation among monetary aggregates with GDP (about 0.6, see Table 1) is higher than in other economies.[1] Second, the weak correlation between hours worked and wages, the so-called Dunlop-Tarshis observation, suggests comovements on the labor supply and demand in the economy. Real Business Cycles theory, on Kydland and Prescott (1982) tradition, sets technology shocks as the source of fluctuations in the economy. Since these shocks only shift labor demand, models of this type finds a high positive correlation between hours worked and labor productivity. Christiano and Eichenbaum (1992) for US economy introduced into an indivisible labor Real Business Cycle model a goverment shock that affects individual preferences.[2] This modelization allows shifts of labor supply due government shocks, as well as shifts of labor demand due technological shocks. However, it is still a challenge to find alternative modelizations where shocks on preferences are not present.

Third, the high relative volatility of consumption, sometimes called the "Spanish consumption puzzle",[3] seems to be inconsistent with economic theory of consumption. Theories like life-cycle (Modigliani, 1966) or permanent income (Friedman, 1956) suggest that households smooth consumption over the cycle. Hence volatility of consumption relative to volatility of output should be low. The fact that Spanish consumption is highly volatile relative to output may indicate a large elasticity of intertemporal substitution together with strong wealth effect, See Dolado *et al* (1993). However, some authors (e.g., Puch and Licandro, 1997) or Martín-Moreno, 1998) suggested that the distinction between durable and non-

[1]For example, for a correlation between M1 and GDP: Japan, 0.26%; Germany, 0.31%; UK, 0.39%; Canada, 0.09% (see Kollmann, 1997).

[2]Puch and Licandro (1997) uses the same modelization for the Spanish economy.

[3]Quarterly National Accounts data in per capita terms 1.13 (1970:I-1991:IV, Dolado et al, 1993); 1.07 (1970:I-1994:IV, Puch and Licandro, 1997); 1.22 (1975:III-1995:IV, Martín-Moreno, 1998).

durable consumption could help to explain this puzzle.[4] That is, the behaviour of durable goods over the cycle is very close to investment.[5] So the higher volatility of durable goods distorts the volatility of aggregate consumption. However, Spanish non-durable consumption data still exhibit a high volatility.[6] Models dealing with this issue could not explain enough this fact. Further modellization seems necessary to take into account some features of the Spanish economy. For example Dolado et al (1993) suggest the relevance of the effects of financial contraints (i.e., liquidity constraints) or the frequent changes in tax transfers schemes.

This paper examines the consequences of introducing a cash-in-advance constraint in a small open economy business cycle model for the Spanish economy. A monetary business cycle model is built for the Spanish economy extending Correia, Neves and Rebelo (1995) small open economy framework and Cooley and Hansen (1995) monetary economy. This model is a first attempt to explain the high relative volatility of consumption in the Spanish economy with the introduction of the monetary side of the economy. In particular how the introduction of liquidity restrictions in the economy may help to explain this volatility. We are also interested if the responses to a monetary shock of key macro-variables, both real and nominal, mimic empirical studies. We are particular interested if we can reproduce the high correlation between money and output, and the weak correlation of hours worked and wages. To answer these questions we compute a monetary dynamic stochastic general equilibrium model for a small open economy. This model will be parametrized, simulated and calibrated with Spanish economy data, to evaluate the consistency with the aggregate macroeconomic fluctuations associated to the Spanish business cycle in the period 1976:III-1995:IV.

The framework is a monetary intertemporal general equilibrium growth model for a small open economy. There are four agents in the economy: a representative infinite lived

[4] That is, the distinction between "expenditure" in goods and "consumption", see Deaton (1992)

[5] Durable Consumption and Non-Durable Consumption series are not supply by National Accounts. Then, both can be constructed making use the methodology by Estrada and Sebastián (1993).

[6] Quarterly National Accounts data in per capita: 0.91 (1970:I-1994:IV) in the case of a closed economy; 0.99 for the case of open economy (1974:III-1995:IV, see Martín-Moreno, 1998, and Table 1).

household, a firm, a domestic government, and the foreign sector. There are three assets in the economy: two financial assets -international traded bonds and money- and a real asset capital. Household has an infinite period separable utility on consumption and leisure. A particular utility function is assumed, where the intertemporal substitution elasticity of leisure is zero. Representative household is endowed with a unit of time and she is also the owner of capital. Household's income is her wages and the return of her asset holdings. She consume, invest, buy financial assets and pay taxes. Investment is not directly transformed in the real asset capital, since an adjustment cost on capital is present.

Firms produce a perisable composite good with a constant return of scale technology. Labor and capital are the required inputs, hired to household. This composite good is transformed at zero cost on two kind of goods: a cash-good (consumption, government expenditure and a foreign good) and a non-cash good (investment). Government collects taxes from household and creates money to finance public expenditure. Foreign Sector supplies and demands inelastically a cash-good and an international traded bonds. These bonds have a positive constant return, an exogenous international real interest rate. They are bought or sold to offset trade balance deficits or surpluses.

In addition to deposit value purpose, money is exogenously required to buy some goods, the cash-goods. We also assume that investment is a good that can be bought without money requirement. So a demand of money for transaction purpose is created and then money has positive value in equilibrium. The introduction of a liquidity constraint (a cash-in-advance constraint) and a particular market timing due a spacially separated markets departure our model from standard Arrow-Radner economy. This makes that competitive equilibrium (instead of social planner problem) has to be computed.

Economy grows at an exogenous constant rate associated with technological progress. This exogenous rate coincides with the steady state growth rate of the economy. In order household preferences to be consistent with steady-state growth we will assume that the disutility of work in the market has to increase with the level of technical progress. Hence endogenous growing variables can be transformed at per capita stationary levels, corrected by the exogenous steady-state growth rate of economy.

This stochastic economy presents three sources of fluctuation. Shocks on productivity, on government expenditure and on monetary growth. Then, a quantitative analysis can be carried out. We can compute the steady-state and a calibration for Spanish data can be done. We make use quarterly series for the period 1976:III to 1995:IV. All series but prices are transformed into per capita terms. Finally, we can run simulations with different shocks in this calibrated economy. These results allow us to analyze if this model can reproduce the Spanish nominal and real business cycle.

The study of the effects of monetary shocks on real economy in the business cycles framework starts with King and Plosser (1984) work who extends the original models by Kydland and Prescott (1982) and Long and Plosser (1983) to incorporate money and banking. One can distinguish two main lines of improvement of the standard real business cycle model. The first enriches the seminal model without denying the essential role of the technological disturbance. The second adds nominal disturbances to account for the role of monetary shocks in the business cycle. In this paper we follow this second line and we add public expenditure and monetary shocks to the standard neoclassical growth model.

The relevance of the relationship between money and output suggested by the data is also pointed out by Cooley and Hansen (1995) for US economy and by Dolado, Sebastián and Vallés (1993) for the Spanish economy. However, there is no applications to the introduction of money setup in the real business cycle framework for the Spanish economy.[7] We follow Cooley and Hansen (1995) and Hairault and Portier (1995), who extend Hansen (1985) to be a monetary economy, where money is demanded by its transaction purpose. Then to give a role to money we do not assume any non-walrasian features as nominal rigidities, quantity rationing or non-rational expectations. In respect with these papers our work departures in two points. First we introduce an stochastic process for government expenditure, in

[7]Here it is worth of commenting the work by Andrés, López-Salido and Vallés (1999) in which through a model in a small open economy with nominal and real rigidities they study the mechanism of monetary transmission on the liquidity effect and the exchange rate behavior for the largest European economies.

addition to productivity shock and monetary growth shock.[8] Second, we work in a small open economy setup. Our point is that the small open economy offers a convenient framework for isolation the relative importance of exogenously given terms of trade, as well as domestic aggregate demand and supply disturbances in generating the observed interaction between real and nominal variables. In this respect, we can think that Spain can be considered as a small open economy because, firstly, its volume of exports and imports in terms of GDP is significant; and secondly, the world interest rate is not set in the economy.

The present work relies on Licandro and Puch (1997) and Martín-Moreno (1998) articles. Both articles analyze the Spanish business cycle, evaluating the empirical behaviour of a general equilibrium model in a closed and open economy, respectively. A shortcut of these papers is that they are not able to explain the high volatility private consumption shown in Spanish data. In consequence one goal of this work is to study if a monetary model in a small open economy can reproduce this particular features of the Spanish economy.

The main results of this analysis show that the proposed model with a liquidity constraint is able to reproduce in general terms the different correlations and the relative variability of real variables. In particular, the modelization presented here improves the previous work applied to the Spanish economy by Puch and Licandro (1997) and Martín-Moreno (1998), in a real model framework, in what respects the volatility of private consumption.

The effect of money appears to be important. When money is introduced by a liquidity requirement, monetary growth shocks do contribute to explain some cyclical features of nominal variables. Here non-neutralities on real variables will arise only because anticipated inflation acts as a distorting tax on activities involving the use of cash. In response to this, agents substitute away from activities that involve the use of cash in favor of activities that do not require cash. However, the economy is neutral with respect to unanticipated changes in the money supply. That is, this monetary shock does not reproduce money and output

[8]Christiano and Eichenbaum (1992) and Puch and Licandro (1997) also introduce this source of fluctuation in a related model. However, households derive direct welfare on per-capita government consumption. This has implication in the labor market, since the supply of labor is affected. In the present paper we follow Martín-Moreno (1998) where exogenous government expenditure does not contribute to households welfare.

correlations found in data. In this line we can understand why a cash-in-advance constraint is not a suitable modelization to reproduce money-output correlation when the liquidity constraint is introduced in the standard business cycle model in a small open framework.

Finally the labor market dimension is not fully reproduced. Although procyclicity of hours worked are found, the correlation of hours worked and labor productivity is poorly reproduced. Some intuitions are given on why this happens.

The paper is organized as follows. In section 2 the data and the Spanish styled facts. Section 3 describes the model are presented. Section 4 discusses calibration. We report the main results in section 5. In section 6 we present the impulse response functions for a temporary technological and monetary shock. In the last section we present the conclusions and extentions.

2 The data

2.1 Measuring the variables of the model

The National Accounts of the Spanish Economy (Contabilidad Nacional de España) are somewhat inconsistent in their treatment of consumers durables, as Puch and Licandro (1997) and Martín-Moreno (1998) point out. This has some effects on the measures of output, consumption and investment.[9] Hence, the measurement of the capital stock, output and the components of the aggregate demand are taken from Martín-Moreno (1998) appendix.[10] Monetary variables are taken from the Bank of Spain source.[11] All series are quarterly for

[9]Cooley and Prescott (1995) discussed in detail the imperfections of the National Income and Product Accounts (NIPA) of the US. This imperfections are also present at the Contabilidad Nacional de España.

[10]In that study a detailed built of these series is presented for a small open economy, the same used at the present paper.

[11]The source of monetary series from Bank of Spain are monthly and data are at the end of the month. Even the data are stocks, an average of every quarterly was taken. We follow Repullo (1990) p.119 when he points out that the average monthly series are prefered than the end of the month data, since this has a very erratic behavior.

the period 1976:III to 1995:IV. To conform the data with our non-population growing model we transform the series, except inflation and prices, to per capita terms using a measure of population between 16 and 65.

2.2 The Spanish stylized facts

In this section we compute a set of statistics that characterizes the cyclical pattern of the Spanish economy. A first and extensive description of the cyclical regularities of the Spanish economy was achieved by Dolado, Sebastián and Vallés (1993). Their descriptive study of Spanish business cycle facts makes use the quarterly raw data of National Accounts for a length of 1970:I to 1991:IV.

In the present paper a model is displayed. We make use a quantitative analysis with data consistent with the model, in the line of Cooley and Prescott (1995) and Puch and Licandro (1997). Although the statistical methodology used here is the same than in Dolado et al (1993), the different data sets is what may make their results and conclusions may different from ours.

Table 1 presents the main features of the cycle both real and monetary, for the range 1976:III-1995:IV.[12] All variables are in logaritms except the trade balance (net exports), which are a percentage of the GDP, the inflation rate and money growth.[13]

[Insert Table 1]

In Martín-Moreno (1998) it is characterized and highlighted the main features of the volatility and comovements among real variables associated with the business cycles for the Spanish economy in an open economy. Hence, in this section we focus only on the labor market and the monetary features of the Spanish cycle. Table 1 shows the standard deviations, cross-correlations with Spanish real GDP. The table includes the most important

[12] We follow Puch and Licandro (1997) when choosing the range 1976:I-1994:IV since "this sample approximates the long run properties of the Spanish economy" (p.365)

[13] The trend component of the series was suppressed by the Hodrick-Prescott filter, with a penalization factor $\lambda = 1600$.

real variables as well as nominal and labor market variables. Several features are important in characterizing the business cycle. Next we present nominal stylized facts.

- *Monetary aggregates and velocity are procyclical.*

  The correlation shows that virtually all the monetary aggregates and money velocities are procyclical, except for Monetary Base.[14] Broad monetary aggregates, such as M1 or M2 which includes aspects on financial intermediation, are more closely correlated with output than is a narrow aggregate, such as the monetary base or currency.[15] In addition, M1 is four times more volatile than output and three times in M2. All these results are similar than those found by Dolado et al (1993). Finally, the statistics in Table 1 show that broader definitions of money exhibit lower correlations with GDP, and lower relative volatility. Both happens the opposite in US economy.[16] However, this low relative volatility could be hardly surprising since the broader aggregates the more internalized are most of the flows in and out of the narrower aggregates as a result of financial deregulation. Table 1 presents that velocity is more volatile than output. However the correlation with the output follows an opposite pattern. Our findings are that the velocity of money, both M1 and M2, are procyclical.[17]

  There is no phase shift in the correlation between output and monetary aggregates.

  We find that GDP and the monetary correlation shows that output is more highly correlated with contemporaneous values of aggregates, implying the monetary aggre-

[14]Spanish financial regulation and policy usually affect directly the Monetary Base (e.g., through reserve requirements changes and Open Market Operation in 80's).

[15]The strong association between monetary and real variables over the cycle is such that many economists view the cycle as a purely monetary phenomenon. Since financial intermediation is endogenous to economic activity, this finding suggests, as argued by King and Plosser (1984), that reverse causation may be important. The observed positive correlation between money and output may reflect primarily the impact of economic activity on the quantity of money, rather than vice versa.

[16]Cooley and Hansen (1995) even suggest that this distinction may be an important one to explore. So US and Spanish economies are two opposite cases.

[17]This is also found in other countries. See Cooley and Hansen (1995) for the US, or Dolado et al (1993), Table 4, for UK, Germany, France and US.

gates peak at the same time of output. Only MB is found with leads.[18] Our results are similar than those found by Dolado et al (1993) where the monetary variables are synchronical with output. The monetary aggregates (M1 and M2) do not lead real GDP. Here we take up the statement by at Dolado et al (1993) who support the neutrality of money claimed by Real Business Cycles models. this neutrality challenges the monetarist view that shocks in the money supply are an important source of business cycle fluctuations. However this result is contrary to Cooley and Hansen (1995) styled facts for US economy, and other countries (United Kingdom, France Germany and Italy) reviewed by Dolado et al (1993). Both found a pronounced lead phase shift in output and the monetary aggregates correlation. The ability to capture this dynamic response pattern of output to monetary innovations is an important challenge for macroeconomists.

– *There is no correlation between output and prices.*

  Table 1 shows that prices are acyclical. This fact differs from the findings by Cooley and Hansen (1995) for the US economy and by Dolado et al (1993) for the Spanish economy. The latter may be explained because our range starts on from 1976:III instead of theirs 1970:I beginning and without a per capita transformation.[19] The non-procyclicity of prices was also dicussed in Kydland and Prescott (1990) and Wolf (1991) in some detail.

– *There is no correlation between output and inflation.*

  The data shown in Table 1 indicate that, like prices, the detrended inflation rate is acyclical over the period.[20] A stronger contemporaneous correlation is found by

[18]This finding may support the statement to convert the Monetary Base in the centerpiece of the Monetary Policy made by Meltzer (1984), McCallum (1984), Haslag and Hein (19??). For more empirical evidence of this issue also see Giménez-Fernández (1996, Ch.6).

[19]If our range would start in 1970:I, and the data would not be in per capita terms, the cross correlation of prices with output would be -0.27 for the Deflactor of the GDP and -0.35 for the Consumer Prices Index, very close to -0.29 correlation for Dolado et al (1993).

[20]This feature keeps the same even if our range would start in 1970:I, and the data would not be in per capita terms.

Hairault and Portier (1995) for French and US economy, and by Cooley and Hansen (1995) for US economy.

– *Acyclical behavior between M1 growth and output.*

  There is very low and positive correlation between monetary growth and GDP. Cooley and Hansen (1995) find for US economy that this correlation is also small but negative.

In what respects labor market stylized facts, we present the following:

– *Hours worked are procyclical with lag phase shift.*

  Table 1 shows that the hours worked are very procyclical, lags the cycle by two periods and is as volatile as real GDP. This is analogous as what was found by Dolado et al in what respect Total Employment. This finding may supports some statements on rigidity of Spanish labor market claimed by some authors. Cooley and Hansen (1995), for US economy, also found that hours worked exhibts high procyclity but peak contemporaneously.

  Weak correlation between hours worked and productivity of labor.

  We observe for this sample data the so-called Dunlop-Tarshis observation. That is, a weak correlation between hours worked and wages.

3 The model

The model is a monetary extention of Correia, Neves and Rebelo (1995) small open economy with perfect international mobility of capital framework. Following Cooley and Hansen (1995) we describe an economy in which money is held as a requirement to purchase consumption goods.[21] That is, we introduce the cash-in-advance motive for holding money into the "indivisible labor" real business cycle model for a small open economy described by

[21]There are several approaches to introduce money into the neoclassical growth framework, e.g., real money balances in the utility function (see Farmer, 1996), money can be assumed to save on the transaction cost associated with purchasing goods, etc. The theoretical foundations of the basic cash-in-advance model of money are carefully laid out in Lucas and Stokey (1983, 1987), Svensson (1985) and Sargent (1987, Ch.5).

Martín-Moreno (1998).

We must have in mind that the competitive equilibrium is no longer Pareto optimal because of the distortion introduced by forcing agents to hold money. Therefore we can not simply solve a social planning problem to obtain the competitive equilibrium allocations. Hence we solve the decentralized equilibrium for the extended monetary economy.

The economy consists of a representative infinitely lived agent and a representative firm. There is a government that finances its public deficit with money emission. The foreign sector supplies and demands inelastically a cash-good and an international traded bonds, which are bought and sold to offset trade balance. The labor supply is endogenous and there is capital accummulation. There are two financial securities in the economy, and a real productive factor capital. The financial securities are a real an international traded foreign good and domestic money. For the sake of simplicity we will assume that population is constant along time, so all variables are represented on per capita ratios.

3.1 The households

The economy is populated by a large number of identical infinitely lived consumers, who derive utility from consumption and leisure. They take prices as given at the markets they participate. For simplicity the number of consumers is normalized to one. The representative household maximizes her expected utility defined on the stochastic sequences of consumption C_t and the percentage of her available time dedicated to labor N_t:

$$\mathcal{U} = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \right\}$$

where $0 < \beta < 1$ is the subjective rate of intertemporal discount, and where E_0 represents the expectation based on the information set available at period zero (which includes all present and past values of all variables). We assume that at every period the separable utility is identical and equal to:

$$U(C_t, N_t) = \frac{1}{1-\sigma} \left[(C_t - \psi X_t N_t^{\nu})^{1-\sigma} - 1 \right]$$

where $\sigma > 0$ is the parameter of relative risk aversion, $\frac{1}{\nu-1}$ is the intertemporal elasticity substitution of labor supply and $\psi > 0$ is the disutility of labor. In order household preferences to be consistent with steady state growth the disutility of labor must increase at the level of technical progress X_t. This technical progress is supposed to be associated with the efficiency of labor factor that grows at a constant rate (labor-augmenting technical progress Harrod-neutral):[22]

$$X_{t+1} = \gamma_x X_t$$

where the constant $\gamma_x > 1$ denotes the steady-state growth of the economy. The growth-side of the model is, therefore, exogenous. To ensure that utility is finite, we assume that $\beta\gamma_x^{1-\sigma} < 1$.

Households are endowed at each period with one unit of time that are allocated between work and leisure. They supply work to firms, and they also accumulate physical capital which is rented to firms.

Finally, there are two securities in the economy: an international traded real bonds B and domestic money M. The representative agent has accessed to a perfectly competitive international capital market, where she can buy and sell foreign bonds at an (exogenous) international real interest rate. Foreign Sector supplies and demands inelastically a cash-good and an international traded bonds. Then, at any level for the current account of the economy a deficit in the trade balance can be offset with sales of foreign bonds:

$$B_{t+1} = TB_t + (1+r^*)B_t \qquad (1)$$

where r^* is the (exogenous) international real interest rate[23] and TB_t is the real balance of

[22]Since this is a first order difference equation, we take as given $X_0 = 1$ at $t = 0$.

[23]We deal with a small open economy where the Interest Parity Condition and the Purchasing Power Parity both hold. The former implies that domestic and foreign securities returns are equal:

$$1 + i_t = \frac{e_{t+1}}{e_t}(1 + i_t^*)$$

where i and i^* are the domestic and foreign nominal net interest rates and e_t is the exchange rate at period t. Assuming the latter holds, i.e. $e_t = \frac{P_t}{P_t^*}$, and defining the inflation rate as $1 + \pi_{t+1} \equiv \frac{P_{t+1}}{P_t}$, then

$$1 + r_t \equiv \frac{1 + i_t}{1 + \pi_{t+1}} = \frac{1 + i_t^*}{1 + \pi_{t+1}^*} \equiv 1 + r_t^*$$

trade.

3.2 The Firms

The economy produces an international tradable good which will be denoted as Y_t. This production takes place by combining the two non-international mobile production factors labor N_t and aggregate capital stock K_t, according to a constant returns-to-scale technology. Given this assumption of constant returns we may assume, without loss of generality, that there is only one competitive firm, which maximizes their benefits subject to their own technology. In addition, the firm will make zero benefits in equilibrium. The aggregate level technology can be described by a Cobb-Douglas production function:

$$Y_t = F\left(Z_t, K_t, N_t\right) = Z_t K_t^{1-\alpha} (X_t N_t)^{\alpha}$$

where $\alpha \in (0,1)$. The production level is affected by the level of the technical progress X_t and by the productivity shock represented by Z_t. The technology shock consists of a single persistent component that evolves according to the law of motion that, in logaritms, follows an autoregresive of first order, AR(1):

$$lnZ_t = \rho lnZ_{t-1} + \varepsilon_{Zt}, \qquad 0 < \rho < 1$$

The random variable ε_Z is normally distributed with mean zero and standard deviation σ_{ε_Z}.

The production can be transforme at zero cost to a non-cash good (investment, I_t), and to a cash-good (private consumption, C_t, and to public consumption, G_t). The difference between production and domestic cash-good absortion is the cash-good trade balance TB_t:

$$Y_t = C_t + I_t + G_t + TB_t$$

The resources not consumed at each period are dedicated to increase the stock of private physical capital next period. The investment in period t produces productive capital in

hence the domestic and foreign real net interest rates equalize: $r_t = r_t^*$. That is, if the economy is a small open economy, domestic real interest rate is set at foreign level.

period $t+1$, and there is a cost of adjustment that depends on net investment. The capital acummulation is given by the equation:

$$K_{t+1} = I_t + (1-\delta)K_t - \Phi(K_t, K_{t+1})$$

where I_t is the gross investment; δ the constant rate of depretiation, so δK_t is the fixed capital consumption; and Φ is the adjustment cost function of the stock of capital as a function of the net investment. This adjustment cost function is assumed to be homogeneous of degree zero (i.e., $\Phi(\lambda K_t, \lambda K_{t+1}) = \Phi(K_t, K_{t+1})$). This assumption allow us to transform the law of accumutation of capital into a per-capita individual restriction. In particular we take the following quadratic functional form:

$$\Phi(K_t, K_{t+1}) = \frac{\phi}{2}\left(\frac{K_{t+1} - K_t}{K_t}\right)^2$$

3.3 The government

The government uses the lump-sum real transfer revenue, real government bonds and money emission to finance its expenditure. Real government consumption G_t and the per capita stock of money M_t are assumed to be realizations of two independent exogenous stochastic processes. In addition, a government policy also includes sequences of real transfers net of taxes, T_t, and nominal government debt B_{gt}, that satisfies the following government budget constraint for each period t:

$$P_t G_t + P_t T_t = M_{t+1} - M_t + B_{gt+1} - (1 + R_{gt-1})B_{gt}$$

where the initial stock of government debt, B_{g0} is given. In addition, the government policy must satisfy the condition that $(1+R_{g-1})B_{g0}$ plus the expected present value of government purchases and net transfer payments equals the expected present value of seignorage revenues.

Contrary to Cooley and Hansen (1995) and Hairault and Portier (1995) we will assume that G_t is not equal to a constant for all $t \geq 0$. In this case, a money injection can be used to directly finance public deficit or to retire existing government debt. The first of these is analogous to the "helicopter drop" and the second is a standard open market operation. An implication of Ricardian equivalence in this economy is that given B_{g0} and a particular realization of the government expenditure and money supply processes, as long as the present-value government budget constraint is satisfied, the time path of B_{gt}, with $t \geq 0$, and T_t, with $t \geq 0$, does not matter for the equilibrium allocations. Thus, these two methods for injecting new money are equivalent in this economy. Hence, with no loss in generality, we assume that $B_{gt} = 0$ for all $t \geq 1$. In addition, we assume that B_{g0} is equal to zero. Together these assumptions imply that no government debt is held in this economy and that

$$G_t + T_t \;=\; \frac{M_{t+1}}{P_t} - \frac{M_t}{P_t} \tag{2}$$

The government expenditure is considered exogenous by the private sector and it has a stochastic component. The public consumption path is assumed to be known by all agents in the economy and can be represented by:

$$ln\left(\frac{G_t}{X_t}\right) = g + \zeta ln\left(\frac{G_{t-1}}{X_{t-1}}\right) + \varepsilon_{gt} \tag{3}$$

where $0 < \zeta < 1$, and $\bar{g} = \mathrm{e}^{\frac{g}{1-\zeta}}$ is the median of the stationary component of public expenditure. The random variable ε_g is normally distributed with mean 0 and standard deviation σ_{ε_g}.

In what respect the monetary shock, the per capita money supply is assumed to grow at the rate $\mu_t - 1$ in period t. That is $M_{t+1} = \mu_t M_t$, where μ_t is revealed at the beginning of period t. The random variable μ_t is assumed to evolve according to the autoregressive process AR(1):

$$ln\mu_t = \mu + \eta ln\mu_{t-1} + \varepsilon_{\mu t} \tag{4}$$

where $0 < \eta < 1$. The random variable ε_μ is normally distributed with mean 0 and standard deviation σ_{ε_μ}. The average growth rate of money is equal to $\bar{\mu} = \mathrm{e}^{\frac{\mu}{1-\eta}}$. With this specification μ_t is guaranteed to be positive in every period, thus the cash-in-advance contraint is always binding.[24]

[24] This also holds in the steady state, since real return of money $\frac{\bar{\mu}}{\gamma_x}$ is lower than the real return of bonds $1 + r^*$.

3.4 The markets timing

A new period appears when every agents' set of information incorporates the simultaneous stochastic shocks (technological, monetary and public expenditure). In every period four markets are open: the securities (bonds and money) market, the cash-good market, the investment non-cash-good market, and the factor (labor and capital) market. The cash-in-advance framework allows the use of money in some markets. Cash-good market is the only market where money is required. Within every period markets open and then close following a timing. Time is divided in a sequence of discrete periods.

The realization of the shocks are known at the beginning of any period t. Households receive the returns of securities carried from previous period (i.e., money M_t and real bonds B_t). Money has no nominal returns and bonds have a real interest rate r^*. Real transfers from government T_t are also given at the beginning of the period. Monetary and public expenditure shocks are introduced into the economy through these real transfers. The factor markets open and firms hire labor and capital to produce a perisable good.

First securities market opens. Households share their wealth between bonds and money. Bonds are demanded to transfer wealth into the future. Money is demanded to purchase goods at the cash-good market and to transfer wealth to the future, the latter depending on its real return. Next security market closes and cash-good market opens. Households and government exchange goods to domestic firms and to the foreign sector for (domestic) money. So the cash-in-advance constraint is the following:

$$P_t\left(C_t + G_t + TB_t\right) \quad \leq \quad M_{t+1} \tag{5}$$

The inequality comes from the fact that households can demand money for other uses rather than transaction. As we will see later, in this model money only affects the equilibrium if this restriction is operative. However this restriction will be always binding. Otherwise money should have a higher real return than bonds, i.e. $E\frac{P_t}{P_{t+1}} > 1 + r^*$, and then bonds will never be demanded. The introduction of the liquidity constraint, and several subperiods within each period, separates financial market into two markets: monetary market and foreign bonds market. The main results presented here rely on this fact.[25]

Finally non-cash good market opens, after cash-goods market closes. Household collects her working income from input factors, compensation of employees W_tN_t, and gross operating surplus R_tK_t, where W_t and R_t are, respectively, the nominal wage and the nominal interest rate of capital. Then households purchase the investment non-cash good I_t with their nominal income -in nominal terms- and money not spent on consumption at t cash-goods market, i.e. $[M_{t+1} - P_t(G_t + TB_t)] - P_tC_t$. The remaining money is held to the next period

$$P_tI_t + M_{t+1} = W_tN_t + R_tK_t + [M_{t+1} - P_t(C_t + G_t + TB_t)] \tag{6}$$

Hence, substitution of (1) and (2) into (6) yields the representative household's budget constraint (in real terms):

$$B_{t+1} + \frac{M_{t+1}}{P_t} + C_t + I_t = w_tN_t + r_tK_t + \frac{M_t}{P_t} + B_t(1 + r^*) + T_t \tag{7}$$

where w_t and r_t are now real variables. Analogously, substitution of (1) and (2) into (5) gets the cash-in-advance constraint

$$C_t \leq \frac{M_t}{P_t} + B_t(1 + r^*) + T_t - B_{t+1} \tag{8}$$

3.5 The steady state

In order to study the properties of the model we first describe the deterministic steady state, i.e., without the presence of stochastic shocks. This steady-state will characterize the economy long run properties. It provides us the parametric value of the variables without growth. We will find the solution of competitive equilibrium around these stationary variables, once we will introduce the stochastic shocks.

It is worth of writing the decentralized problem and the steady state as a function

[25] In Martín-Moreno (1998), since no cash-in-advance constraint existed, there was a supply of lending funds from households savings (i.e., $Y_t + T_t - C_t$) and the demand of lending funds came from investment and foreign sector (i.e., $I_t + TB_t$). The setup was a small open economy so the price of the financial market was exogenous given by r^*.

of the stationary variables in the convergence direction in a non-stochastic setup, i.e., $h_t = \frac{H_t}{\gamma_x}$, where h_t will represent any variable without growth. Then, a steady state equilibrium is an equilibrium in which it is supposed the absence of uncertainty, and where $\{K_{t+1}, B_{t+1}, C_t, W_t, \frac{M_t}{P_t}\}$ grow at the same rate γ_x and the other variables $\{N_t, r_t, r^*\}$ are constant. ¿From the optimality conditions of the described problem the steady state of the economy can be found from the following equations:

$$
\begin{aligned}
1 &= \beta\gamma_x^{-\sigma}(1+r^*) &(9)\\
N &= \left[\frac{\alpha Z N^{\alpha-1}k^{1-\alpha}}{\psi\nu}\frac{\gamma_x}{\bar{\mu}}\frac{1}{1+r^*}\right]^{\frac{1}{\nu-1}} &(10)\\
1+\phi\left(\frac{\gamma_x-1}{k}\right) &= \beta\gamma_x^{-\sigma}\left[(r+1-\delta)+\phi\left(\frac{\gamma_x-1}{k}\right)(1+\gamma_x)\right] &(11)\\
c &= \frac{m}{p}-g-tb &(12)\\
c+(\gamma_x-1+\delta)k+(\gamma_x-1)^2\frac{\phi}{2}+g+tb &= ZN^{\alpha}k^{1-\alpha} &(13)\\
tb &= -(1+r^*-\gamma_x)b &(14)
\end{aligned}
$$

The first equation is a condition to be hold by the parameters of the model. It relates the growth rate of the economy with the subjective rate of the intertemporal discount of consumers, This condition can be justified from the general equilibrium perspective: if the real world would be several little and identical economies as the described here, the interest rate at equilibrium on world markets would be endogenous and it could be found at (9). The number of working hours to be supply by the representative agent at every period can be found on equation (10). Equation (11) relates the ratio capital-labor with the international interest rate. The cash-in-advance constraint at the steady state is given by equation (12). The resource restrictions and the accummulation of foreign securities, equations (13) and (14) respectively, set the private consumption and the trade balance. Observe that the steady state of the economy is compatible with any amount of international bonds. Economies with high holdings of foreign bonds will have a high trade balance deficit at the steady state. This will mean a higher level of private consumption (in respect to its tendence).

4 Calibration

The model described above, under the assumption of rational expectations, presents conditions of stochastic optimality and non linearities that make imposible to have an analytical solution of the variables. Then we must find a numerical solution to characterize a stochastic realization of such variables from the realization of the structural shocks. Later, this will allow us to analyze the economic relations among the variables of the model in a stochastic dynamic competitive equilibrium.

To calibrate the model we follow the methodology described in Cooley and Prescott (1995). Once we defined the set of measures of the economic variables consistent with the specified model at section 3, a value of the structural parameters and those that characterize the distributions of the exogenous shocks to get a numerical solution are chosen so that the model economy produces the stationary variables which match the corresponding averages of actual data. This principle is based on the assumption that the Spanish economy is moving during the period around its balanced growth path, which implies that stationary variables move around the observed averages.[26]

Table 2 reports the parameter values from the quarterly data of reference for the Spanish economy at the considered period.

– [**Insert Table 2**]

Following Christiano and Eichenbaum (1992) we fix the individual's productive time endowment to 1369 hours per quarter. To calibrate the labor share α, we follow Puch and Licandro (1997) when correcting the National Accounts date to take into account the correction carried out by the *European Economy* (1994). The labor share after this correction is $\alpha = 0.6565$ in the period 1976-1995. The quarterly world interest rate $r^* = 0.01$ is taken from the value suggested by Kydland and Prescott (1982). The parametrization of

[26]This is one of the reasons why the range 1976:III-1995:IV is chosen. Puch and Licandro (1997) pointed out that Spanish data are able to reproduce better the long run properties of the Spanish economy from 1976 on.

preferences is borrowed from Greenwood et al (1988), $\nu = 1.7$, and from Mendoza (1991), $\sigma = 1.001$.[27] All other parameters, except ϕ, were chosen in order that the balanced growth path conditions of each model should hold for the average data for the period 1976:III-1995:IV. That is, the quarterly gross growth rate γ_x, the depreciation rate δ, the subjective rate of discount β, the disutility of labor ψ and the international foreign bonds b. Parameter ϕ is chosen so that the variability of investment relative to output would be suited reproduced by the model.

To complete the calibration, the parameters corresponding to technology, government expenditure and monetary growth stochastic processes have to be set. Given the level of technical progress X_t, the stationary components of the government expenditure and the growth of money are computed. Then, the corresponding parameters are estimated using (3) and (4). Finally, to calibrate the corresponding technological stochastic process parameters we follow Martín-Moreno (1998). It is worth of saying that the Solow residual found from our reference data shows too high volatility and serial correlation in order the model to be consistent with the stylized facts shown in Section 2.2. Hence we calibrate ρ and σ_Z in such way that the model reproduces the volatility of our production measurement in the presence of technology shocks only.[28]

5 Main findings

In this section we dicuss our empirical results for the model under consideration. Tables 3, 4 and 5 show the results of simulating this economy. These are averages of statistics computed from 100 simulations of 78 periods in length, taken logarithms, and filter each simulated

[27] This parameter of relative risk aversion is usually taken in the literature. See, in example, Mendoza (1991). In other hand, Prescott (1986) points that this parameter might not be much higher than 1.

[28] Kollintzas and Vassilatos (1996), Correia et al (1995) and Mendoza (1991) do the same in their own work. Another possibility is to reproduce this volatility in the presence of the three shocks together. In other hand, McCallum (1989, p.28-29) pointed out that when the adjustment costs and the fluctuations in the terms of trade are taken into account, the Solow residual is not a suitable proxy for the productivity shocks.

time series using H-P filter.[29]

In Table 3 we displayed a summary of statistics for an economy with only technology shocks operating; in Table 4 we present the results for the economy with public expenditure and technology shocks. Finally in Table 5 we present the results with monetary, technology and public expenditure shocks.

[Insert Table 3, 4 and 5]

5.1 Productivity shock and public expenditure shock

The behavior of the variables is shown in Table 3 –with only a productivity shock– is very similar to the behavior of the real variables shown at Table 4 –with productivity and public expenditure shocks. The reason is the following: if the monetary growth is constant we can understand from (2) that the (e.g., positive) public expenditure shock affects (decrease) government transfers, T_t. As this variable enters only at the supply of foreing bonds market, i.e. $\left[\frac{P_{t-1}}{P_t}(Y_{t-1} - I_{t-1}) + T_t\right] - C_t = TB_t$, the lower this transfer, the lower agents' aggregate lending funds. But since the interest rate of the economy is fixed by r^*, the trade balance –the demand of this market– is backwards adjusted. To sum up, increases of public expenditure are mainly offset by decreasing in the trade balance.[30] Then with a constant growth rate of money. The introduction of a stochastic process for public expenditure the correlation with output and the relative volatility of all variables will be about the same –except, perhaps for trade balance. Finally, since public shock does not affect productivity public expenditure and GDP variables have a very low correlation and government consumption is acyclical, as

[29] The variables that are expressed as rates are not logged. This includes trade balance, inflation rate and money growth rate.

[30] That is, we disagree with Correia et al's (1995) statement that "[for the preferences used] a permanent shock to government expenditures generates solely a permanent decline in consumption; there are no effects on trade balance or on any macroeconomic variable" (p.1101). We believe that trade balance is the only variable affected. This result is the same they found for a permanent government shock in the case that a different utility function is assumed (i.e., the same as in Hansen, 1985).

it is reported in Table 4.[31]

A first result is that the artificial economy modelled in the presence of only productivity shock reproduces, in general terms, the behavior of real variables and its correlations with the output for the Spanish economy (see Table 3).

In this line, the volatility of private consumption in this monetary framework improves the previous results found in other models applied to the Spanish economy like Puch and Licandro (1997) and Martín-Moreno (1998). See table 6.

[**Insert Table 6**]

The present modelization is a monetary extention of Martín-Moreno (1998) small open economy set-up. hence this result suggest that the increase of relative volatility of consumption with respect Martín-Moreno calibrated economy is caused by the introduction of the cash-in-advance modelization. The model also do reasonably well at matching of the relative volatility of investment (i.e., σ_i/σ_y) and the relative volatility of the trade balance (i.e., σ_{tb}/σ_y).

Nevertheless, the simulation of the artificial economy in the presence of both shocks does not reproduce appropiate the behavior of all nominal variables. This is analogous to Cooley and Hansen (1995) and Hairault and Portier (1995) results for similar technology shock and constant monetary growth experiment. The price level in this model economy and the velocity are both procyclical, with positive contemporaneous correlations with output higher than in the Spanish economy. But both variables in the model economy are considerably less volatile than those presented in Table 1. The reason is that neither productivity nor public expenditure shocks affect strongly on the cash-goods market, so price level keeps almost unchanged. Likewise, as in Cooley and Hansen (1995) close experiment, the inflation rate in the artificial economy is negatively correlated with output in contrast to what is observed

[31] In data both variables are procyclical, see Table 1. One reason of the low correlation between them in the artificial economy is that technology shock and public expenditure shock are incorrelated. Obviously a way to improve this correlation in the model would be present a joinly stochastic autorregresive process for both shocks.

in the Spanish economic series.

In what respects labor market, hours worked are also highly procyclical and peak contemporaneously. In addition the hours worked fluctuates less than output. The other stylized fact, the weak correlation between hours worked and labor productivity, is poorly reproduced. This result is standard in Real Business Cycle models. Due the technological shock is the only source of fluctuation in the economy only the demand of labor shifts, keeping the supply of labor unchanged. This result suggests that technology shocks can not be the only impulse for aggregate fluctuations in the labor market.

5.2 Monetary shock

Table 5 summarizes the behavior of this monetary economy under the assumption that the money supply follows an autoregresive stochastic process. Analogous to Cooley and Hansen (1995) model, changes in the growth rate of money affect real variables only to the extent that they signal changes in the inflation tax. That is, increases in the growth rate of money lead agents to expect higher inflation in the future. In response of this, agents substitute away from activities that involve the use of cahs in favor of activities that do not require cash. Then a monetary shock increases the relative volatility of investment and trade balance (from 4.27 to 5.89 and 0.85 to 1.41, respectively), and reduces their correlation with output, mimicing better the correlation of trade balance with output in what respects Tables 3 and 4. The reason is double. After a (e.g. positive) monetary shock there are two effects. First there is an contemporaneous non-anticipated shock effect that only affects the price level. Since neither labor supply nor technology is affected by this monetary shock the aggregate output and investment are unchanged. Hence the monetary shock affects only prices. The second effect is an anticipated shock effect that relies mainly on expectations. Since there was a positive monetary shock in the same period t (so prices tends to increase) agents expect a future positive monetary shock in $t+1$. Then, as higher prices are expected in the future, agents prefer to transfer wealth in real terms, i.e. I_t, and not in nominal terms, i.e. $\frac{M_{t+1}}{P_t}$. Finally, given that monetary shock does not affect output, the increase of investment affects prices in t. So there is a further increasing on prices. Then expectations increase volatility of investment.

Moreover, as price level increases, the aggregate supply of lending funds in the foreign bonds market shift leftwards as the real money holdings decrease. Then, as international interest rate is fixed r^*, agents endebt further on foreign bonds to smooth consumption. This increases volatility of trade balance and decreases its correlation with output.

To sum up, a monetary shock produces an increasing relative volatility of investment and the trade balance, since agents' expectations realize that future monetary shocks affect real money holdings transfered to the future through prices.

The introduction of monetary shocks in the artificial economy improves the statistical properties of the nominal variables. Although the behavior of velocity is about the same in Table 4 and 5, which suggests that monetary shocks affects mainly prices, the price level and inflation are more volatile in this economy. In fact, the model displays significantly more variability in the price level than what it is observed in the Spanish economy (3.26% versus 1.26%). As far as we have just argued, the reason of this increase of the volatility of prices is both monetary shock and expectations. The variability of inflation is also higher than in the data, this difference is not too high (1.91% versus 0.86%).

The inflation in Table 5 is acyclical, as in the data (-0.00 versus 0.1). Observe that when there was no monetary shock it was strongly countercyclical (for example -0.78 in Table 4). Prices are also acyclical both in the data and in the model with monetary shocks. The acyclicity here comes from the fact that monetary shock affects mainly prices, and it has no relation with the supply side of the economy. Since monetary and technology shocks are incorrelated, like in data (-0.02 versus 0.1), as no contemporaneous correlation is found between prices and output, a poor result is found in what respects of the almost zero correlation between money and GDP, which it does not found in data (-0.06 versus 0.68). This negative result is also found by Cooley and Hansen (1995) and Hairault and Portier (1995).

Finally monetary growth behavior is well reproduced by the model economy.

The labor market dimension under the introduction of a monetary shock does not improve the results found with only technology shocks. Correlation between hours worked and labor productivity is reduced but it is still highly procyclical. The reason of this reduction, and also the very slight reduction on correlation between output and hours, come from the effect of increasing of prices on the supply of labor. That is a positive monetary shock increases prices and shifts rightwards the supply of labor. As a result an increase in labor hours and a reduction of wages are found. Hence, the introduction of a monetary shock does not help enough to explain this correlation between hours and labor productivity. A further modelization is needed to reproduce this fact. Within our framework we could adopt Christiano and Eichenbaum (1992) framework. They introduced into an indivisible labor Real Business Cycle model a goverment shock that affects individual preferences. This modelization allows shifts of labor supply due government shocks, as well as shifts of labor demand due technological shocks. In addition, other shocks that affect labor supply (e.g., shocks on world interest rate) could be modelled.

6 Impact effects and impulse response functions

We now focus on discussion on responses of the economy to an unexpected productivity shock, holding money growth at the unconditional mean, followed by an analysis of the economy's responses to an unexpected increase in the money stock, holding technology shokcs at the unconditional mean. We do not study the impact of government expenditure due its slight contribution to the cycle in the present small open economy set-up.

These impulse experiments consist of shocking the driving proces once at $t = 0$. Given the autorregresive laws of motion for money growth and technology, the shock is then propagated for a number of periods, and asymptotically returns to the unconditional mean. While the initial shocks is is unanticipated, the future changes in the driving process induced by the initial shock are known with certainty by household. All experiments are initialized with the economy at its deterministic steady state.

The results found are similar, except for the labor market, for the closed economy model by Cooley and Hansen (1995) and Hirault and Portier (1995) and for the two-countries model by Ohanian, Stockman and Kilian (1995).

6.1 Productivity shock and public expenditure shock

A 1% of increase in the unconditional mean of the technology shock is introduced in a stedy state. Figure 1 displays the effect of this shock ion real, nominal and labor market variables.[32]

[Insert Figure 1]

As expected, this shock increases output, consumption and investment. The new aggregate supply of cash-goods $Y_t - I_t$ will depend on the calibration of model parameters. For the present calibration for the Spanish economy the period $t = 1$ new aggregate supply of cash-goods shift leftwards increasing prices in this period, so inflation is positive.[33] Then in data is also positive in $t = 1$. Since prices and consumption increases, the supply of lending funds at the foreign bonds market (i.e., $S_1 \equiv \frac{\bar{M}}{P_1} - \bar{T} - C_1$) shifts upwards so that trade balance decreases below its steady state value. As before this result also depends on parameter calibration.

From this period on, investment decreases, reducing the stock of capital and then output, and consumption decreases and trade balance increases. Consumption and trade balance do not return to their original steady state values. Now steady state consumption is higher and trade balance lower. This result appears also in Correia et al (1995).

In what respects labor market, the technology shock affects the productivity of workers in period $t = 1$, shifting rightwards the demand of labor increasing wages and hours worked along the adjustment dynamics. For the next periods the effect of this shock still is present since investment increases the stock of capital and, then, the labor productivity. Along the dynamics back to steady state labor productivity is lower and lower , since low investment,

[32] All variables are represented by it percentage deviation from its steady state values except inflation. In the steady state inflation is zero, so inflation rate is shown in pictures.

[33] For Cooley and Hansen (1995) calibration for US economy the pattern is the opposite, so prices decreases.

and then low capital, is available in the economy.

6.2 Monetary shock

Figure 2 displays the effect on economic variables when there is an increase in the unconditional mean of the monetary shock is introduced in a stedy state.

[**Insert Figure 2**]

An increase in the stock of money in period $t = 1$ is mainly transmited to prices. Then inflation is positive in $t = 1$. From this period on inflation decreases to almost zero.

Since the price of cash-goods increases there are two ways of smooth consumption. First increase the aggregate supply of cahs-goods through decreasing the demand on investment. This will reduce prices. That is, contrary to the case of a permanent monetary shock, here there is no "anticipated shock effect", since a decrease in prices is expected in the future. Second an increase in the deficit of trade balance. The reason is the leftwards shift of the supply of lending funds of at the foreign goods market. To sum up, investment and trade balance vastly decrease to smooth consumption. This can be seen in figures 2a and 2b.

Several periods after the unexpected shock realization, investment starts increasing, and capital stock and output rises back to their steady state value. Trade balance also rises.

In figure 6 we present the labor market. Surprisingly a monetary shock increases the hours worked. The labor supply depends on prices. The unexpected monetary shock increase prices large enough to shift rightwards the supply of labor in period $t = 1$. That is why wages decreases and hours increases, rising output (and hence mitigate a little the increase of prices). From this period on, capital stock reduces, because of the sharply decrease on investment. Then labor demand shifts leftwards, so workers are less productive. Wages and hours are below their steady state value.[34]

[34] The fact that wages are below its state state is a different result form Hairault and Portier (1995), both for monetary and technological shock. As they deal with a close economy, this could be explained as an efect of endogenous interes rate on labor market.

7 Conclusions

The aim of this paper is a theoretical and empirical study of the consequences of introducing a cash-in-advance constraint in a small open economy business cycle model for the Spanish economy. A business cycle model is built extending Correia, Neves and Rebelo (1995) small open economy framework and Cooley and Hansen (1995) monetary economy. Money is introduced through a cash-in-advance constraint. We try to understand the economic mechanism in an intertemporal stochastic general equilibrium model with cash-in-advance constraint for the Spanish economy. The relevant questions to be answered were the following: can a monetary model in a small open economy framework explain the higher volatility of the private consumption in Spanish economy?; do the responses of key macro-variables to a monetary shock mimic empirical studies?; and can a cash-in-advance constraint explain the role of monetary shocks? In particular we were interested if this model can reproduce the high correlation between moeny and output. To answer these questions the model is parametrized, simulated and calibrated with a set of measurements of the aggregate variables of the Spanish economy we defined.

The results of this analysis shows that the proposed monetary model is able to reproduce in general terms the different correlations and the relative variability of real variables. In particular, the modelization presented here reproduces better the volatility of private consumption from previous works applied to the Spanish economy by Puch and Licandro (1997) and Martín-Moreno (1998), both in a real model framework.

The labor market is badly reproduced in this monetary small open economy set-up. In particular the weak corretation between hours worked and labor productivity. This result is standard in Real Business Cycle modelsd. An extention of the present work is to set a specification that could reproduce this styled feature of labor market. In particular if we keep into the tradition of Real Business Cycle models, a perturbation that affects labor supply is required. One modelization could be the adoption of Christiano an Eichenbaum set-up. Since household does not derive welfare from public consumption in our model, government expenditure shock does not affect labor supply as in Christiano and Eichembaum (1992) or

Puch and Licandro (1997). Hence in our modelization government expenditure shock only affects labor demand.

Another specification could be modelize a shock on international interes rate r^*, assumed fixed in our set-up. It is well known that the interest parity condition and the purchasing power parity do not fully hold in real world. Then a different international interest rate along time for a monetary small open economy can have real effects.[35] In particular this affects the labor supply. That is, a decrease in interest rates increase hours worked due a rightwards shifting of labor supply, see equation (10). This may result in a promising improveness on labor market behavior, and in particular in weak correlation between hours worked and labor productivity.

We have shown here that this monetary shocks are quantitatively important for the real business cycle. The introduction of a monetary growth shock in a small open economy framework is important over the fluctuations in investment and trade balance when money is introduced requiring cash-in-advance. The reason is that this technology separates financial markets into two markets: monetary market and foreign bonds market. We also showed that an unanticipated monetary shock does not affect the real variables in the economy, but an anticipated monetary shock modifies the composition of securities portfolio transfered between periods (in particular, monetary holdings). That is, through expectations, savings, investment and trade balance are modify. The main mechanism for the monetary shock is a change in relative prices which is usually referred as inflation tax effect.

Finally, the monetary economy considered is successful in accounting for some features of the business cycles that are purely monetary. For instance, the behavior of monetary growth, and the acyclical correlation of prices and inflation with the output. Even their volatility are not well reproduced by the model.

Nevertheless, the high correlation between monetary aggregates and output found in data could not be explained in this framework. This negative result is the same as in Cooley and

[35]Mendoza (1991) founds neutrality on the economy of shocks to the interest rate. However he points out that this is not a general result. Correia et al (1995) states that with the preferences used in this paper hurs worked increase, raising output. However, any explanation is given on why this happens.

Hansen (1995) and Hirault and Portier (1995). Here, there is no way monetary shocks to affect technology or labor supply. Several extentions have been done up to now. Ohanian, Stockman and Kilian (1995) and Cooley and Hansen (1995) present a model where rigidities in prices affect labor market. There monetary shocks affect prices, and then employment and output. That is, this is consistent with a setup with an aggregate supply of goods with positive slope.

There may be another explanation about this positive correlation between money and output. King and Plosser (1984) suggest the reverse causation: the monetary quantities are endogenous (as broader definitions of money –e.g. M1 and M2– seems to be) and depend on real activity. Hence, a banking sector should be modelled within the business cycle framework to clarify further this question. A first step towards this goal could be the work by Chari, Christiano and Eichenbaum (1995), but there is even lots of work to do to integrate banking theory in macroeconomics. In other hand, if the reverse causation is the explanation, perhaps macroeconomists should focus our attention on narrower definitions of money as monetary policy tools to study their effects, e.g. of monetary base, on economy. (For example Meltzer, 1984, and McCallum, 1984, display several arguments supporting this idea.)

To sum up, if the cash-in-advance constraint is an appropiate way of introducing money in general equilibrium, it does not seem to be a mechanism that can account for the role of monetary shocks in some of the properties the business cycle for the Spanish economy.

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Appendix

TABLE 1.- Data for the Set of reference Data. Range 1976:III - 1995:IV.

Variable	ABS. V.	REL. V.				$\rho_{x_{t\pm j},y_t}$			
	sd(x)	sd(x)/sd(y)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)
GDP	1.09	1.00	0.61	0.77	0.90	1.00	0.90	0.77	0.61
CPRIV	1.09	0.99	0.28	0.44	0.58	0.71	0.78	0.81	0.81
CD	3.85	3.52	0.59	0.65	0.68	0.63	0.50	0.34	0.16
CND	1.09	0.99	0.27	0.42	0.56	0.68	0.76	0.79	0.78
CPUBL	1.18	1.07	0.17	0.26	0.35	0.40	0.40	0.42	0.47
INVEST	4.64	4.24	0.66	0.76	0.82	0.81	0.73	0.60	0.42
TB/GDP	1.02	0.93	-0.35	-0.42	-0.47	-0.45	-0.52	-0.52	-0.49
DEFGDP	1.38	1.26	-0.18	-0.11	-0.03	0.10	0.13	0.16	0.17
CPI	1.26	1.15	-0.21	-0.14	-0.07	0.07	0.05	0.02	0.00
INFLDEF	0.53	0.48	0.04	0.04	0.05	0.10	0.10	0.06	0.01
INFLCPI	0.94	0.86	0.04	0.04	0.02	0.09	-0.02	-0.05	-0.03
MB	8.92	8.16	-0.25	-0.23	-0.18	-0.14	-0.09	-0.03	0.00
M1	3.64	3.32	0.41	0.50	0.62	0.68	0.66	0.64	0.61
M2	2.85	2.61	0.34	0.44	0.56	0.64	0.61	0.59	0.58
VMB	9.14	8.35	-0.32	-0.31	-0.28	-0.24	-0.19	-0.12	-0.07
VM1	3.10	2.83	0.26	0.31	0.42	0.48	0.47	0.50	0.53
VM2	2.42	2.21	0.12	0.17	0.27	0.35	0.34	0.38	0.43
GROWTH M1	2.23	2.13	0.19	0.13	0.18	0.07	-0.05	-0.06	-0.08
HOURS	1.14	1.035	0.31	0.45	0.57	0.64	0.77	0.80	0.78
$\sigma_n/\sigma_{y/n}$		1.045							
Corr(y/n,n)						-0.15			

For every quarterly series x from the Reference Data, the absolute volatility [sd(x)/sd(y)] as a percentage of the standard deviation is shown; $\rho(x(t \pm j), y_t)$ is the correlation of GDP at t with the variable x at $t \pm j$ with $j = 0, 1, 2, 3$. GDP–real GDP, 1986 pts.; CPRIV–private consumption, 1986 pts; CD–consumption of durables, 1986 pts; CND–consumption of non-durables, 1986 pts; CPUBL–public expenditure, 1986 pts; INVEST–gross private domestic investment, 1986 pts; TB–trade balance, 1986 pts; DEFGDP–implicit GDP deflactor, base 1986; CPI–Consumer Price Index, all items, base 1986; INFLDEF–Δ ln(DEFGDP); INFLCPI–Δ ln(CPI); MB–monetary base; M1–money supply 1; M2–money supply 2; VMB–velocity for MB; VM1–velocity for M1; VM2–velocity for M2; GROWTH M1–growth rate for M1; LABOR–number of hours worked.

TABLE 2.- Parameters of the Economy

Preferences		
Individual Endowment of Time [2]		1369
Subjective Discount Rate [1]	β	0.9932
Disutility of labor [1]	ψ	1.9950
Risk Aversion [2]	σ	1.001
Parameter of the Utility Function [2]	ν	1.7
Technology		
Labor Share [2]	α	0.6565
Rate of Depreciation [1]	δ	0.0272
Average gross growth rate [3]	γ_x	1.0031
Adjustment Cost Parameter [4]	ϕ	14.7
World Interest Rate [2]	r^*	0.01
Money		
Average gross monetary growth [3]	$\bar{\mu}$	1.025
Stochastic Processes		
Correlation coefficient, productivity shock [4]	ρ	0.9874
Standard Deviation, Technology shock [4]	σ_Z	0.0045
Correlation coefficient, Public expenditure [5]	ζ	0.9801
Standard Deviation, Public expenditure [5]	σ_g	0.0067
Correlation coefficient, Monetary shock [5]	η	0.1603
Standard Deviation, Monetary shock [5]	σ_M	0.024

Calibration criteria: [1] Set from the model at steady state, [2] External information, [3] Sample average, [4] calibration of the 2nd order moments, and [5] properties of the stochastic process.

TABLE 3.- Monetary Model with productivity shocks, and constant public expenditure and monetary growth. Properties of the second moments of the data filtered with HP.

Variable	ABS. V. sd(x)	REL. V. sd(x)/sd(y)	x(-3)	x(-2)	x(-1)	$\rho_{x_{t\pm j},y_t}$ x(0)	x(+1)	x(+2)	x(+3)
Real Variables									
GDP	1.10	1.00	0.22	0.44	0.70	1.00	0.70	0.44	0.22
CONS.	1.01	0.92	0.26	0.47	0.72	0.99	0.66	0.38	0.15
INVEST	4.63	4.27	0.33	0.51	0.72	0.94	0.53	0.21	-0.03
TB/GDP	0.92	0.85	-0.38	-0.53	-0.68	-0.84	-0.39	-0.05	0.19
Nominal Variables									
PRICES	0.60	0.55	0.39	0.37	0.31	0.21	-0.22	-0.50	-0.65
INFLATION	0.32	0.29	-0.03	-0.10	-0.18	-0.79	-0.51	-0.28	-0.10
VELOC. M.	1.34	1.23	0.36	0.52	0.71	0.89	0.47	0.14	-0.11
Labor Market									
LABOR	0.70	0.69	0.25	0.44	0.69	0.99	0.67	0.41	0.20
$\sigma_n/\sigma_{y/n}$		2.00							
Corr(y/n,n)			0.17	0.31	0.65	0.99	0.72	0.49	0.31

All the statistics for the models are averages, across 100 simulated data sets, each with 78 observations. For each variable x we show the absolute volatility $sd(x)$ and relative volatility $sd(x)/sd(y)$ (as the percentage of the standard deviation); $\rho_{x_{t\pm j},y_t}$ is the correlation of GDP in t with the variables x in $t \pm j$ with $j = 0$, 1, 2, ...

TABLE 4.- Monetary Model with productivity and public expenditure shocks, and constant monetary growth. Properties of the second moments of the data filtered with HP.

Variable	ABS. V. sd(x)	REL. V. sd(x)/sd(y)	x(-3)	x(-2)	x(-1)	$\rho_{x_{t\pm j},y_t}$ x(0)	x(+1)	x(+2)	x(+3)
Real Variables									
GDP	1.13	1.00	0.26	0.47	0.71	1.00	0.71	0.47	0.26
CONS.	1.04	0.92	0.30	0.50	0.72	0.99	0.67	0.41	0.19
CPUBL	0.85	0.76	0.01	0.02	0.03	0.04	0.03	0.02	0.00
INVEST	4.69	4.17	0.36	0.53	0.71	0.93	0.53	0.23	-0.00
TB/GDP	0.93	0.83	-0.39	-0.53	-0.66	-0.82	-0.38	-0.06	0.18
Nominal Variables									
PRICES	0.64	0.56	0.35	0.36	0.25	0.15	-0.26	-0.51	-0.66
INFLATION	0.32	0.29	-0.05	-0.12	-0.18	-0.78	-0.49	-0.28	-0.10
VELOC. M.	1.36	1.21	0.38	0.53	0.69	0.88	0.46	0.15	-0.09
Labor Market									
LABOR	0.70	0.67	0.26	0.45	0.70	0.99	0.68	0.42	0.22
$\sigma_n/\sigma_{y/n}$		2.01							
Corr(n,y/n)			0.18	0.38	0.65	0.99	0.72	0.49	0.31

All the statistics for the models are averages, across 100 simulated data sets, each with 78 observations. For each variable x we show the absolute volatility $sd(x)$ and relative volatility $sd(x)/sd(y)$ (as the percentage of the standard deviation); $\rho_{x_{t\pm j},y_t}$ is the correlation of GDP in t with the variables x in $t \pm j$ with $j = 0, 1, 2, ...$

TABLE 5.- Monetary Model with productivity, public expenditure, and monetary growth shocks. Properties of the second moments of the data filtered with HP.

Variable	ABS. V. sd(x)	REL. V. sd(x)/sd(y)	x(-3)	x(-2)	x(-1)	$\rho_{x_{t\pm j},y_t}$ x(0)	x(+1)	x(+2)	x(+3)
Real Variables									
GDP	1.14	1.00	0.28	0.47	0.71	1.00	0.71	0.47	0.28
CONS.	1.05	0.93	0.31	0.49	0.71	0.99	0.67	0.41	0.21
CPUBL	0.85	0.77	-0.03	-0.04	-0.04	-0.02	-0.01	0.00	0.02
INVEST	6.58	5.89	0.29	0.41	0.53	0.58	0.36	0.18	0.03
TB/GDP	1.56	1.41	-0.26	-0.34	-0.41	-0.40	-0.21	-0.05	0.08
Nominal Variables									
PRICES	3.58	3.26	0.03	0.02	-0.01	-0.02	-0.02	-0.06	-0.00
INFLATION	2.10	1.91	-0.03	-0.05	-0.02	-0.00	-0.04	-0.04	-0.02
MONEY	3.49	3.18	-0.02	-0.03	-0.05	-0.06	0.01	0.04	0.05
VELOC. M.	1.56	1.39	0.35	0.46	0.60	0.81	0.43	0.16	-0.04
GROWTH M.	2.39	2.18	-0.00	-0.02	-0.02	0.11	0.04	0.00	-0.00
Labor Market									
LABOR	0.78	0.73	0.22	0.38	0.60	0.97	0.60	0.36	0.20
Corr(N,Y/N)			0.19	0.37	0.57	0.70	0.58	0.42	0.27
$\sigma_N/\sigma_{Y/N}$		2.14							

All the statistics for the models are averages, across 100 simulated data sets, each with 78 observations. For each variable x we show the absolute volatility $sd(x)$ and relative volatility $sd(x)/sd(y)$ (as the percentage of the standard deviation); $\rho_{x_{t\pm j},y_t}$ is the correlation of GDP in t with the variables x in $t \pm j$ with $j = 0$, 1, 2, ...

TABLE 6.- Spanish Relative Volatility of Consumption.

	Data	σ_c/σ_y
Puch and Licandro (1997)	0.695	0.500*
Martín-Moreno (1998)	0.99	0.85
Model	0.99	0.92

Data is constructed as a consistent measurement with models.

* This is the value found in a model with divisible labor and government consumption.

FIGURE 1.- Impulse response function to a Technological Shock

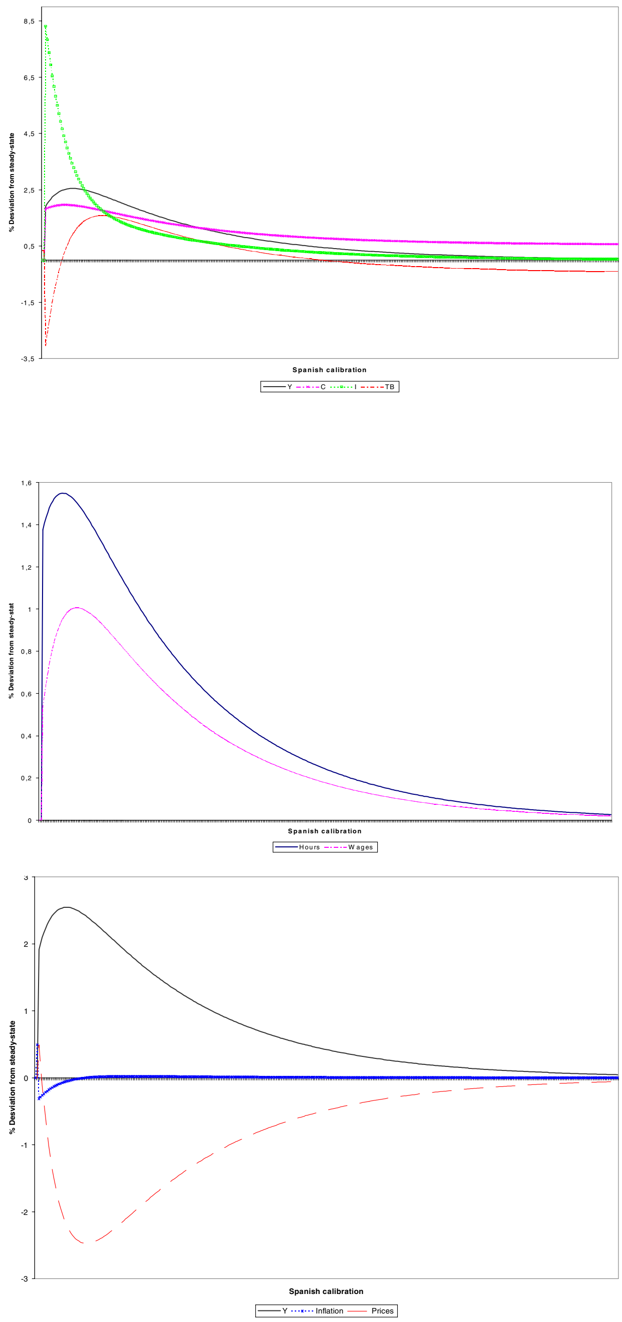
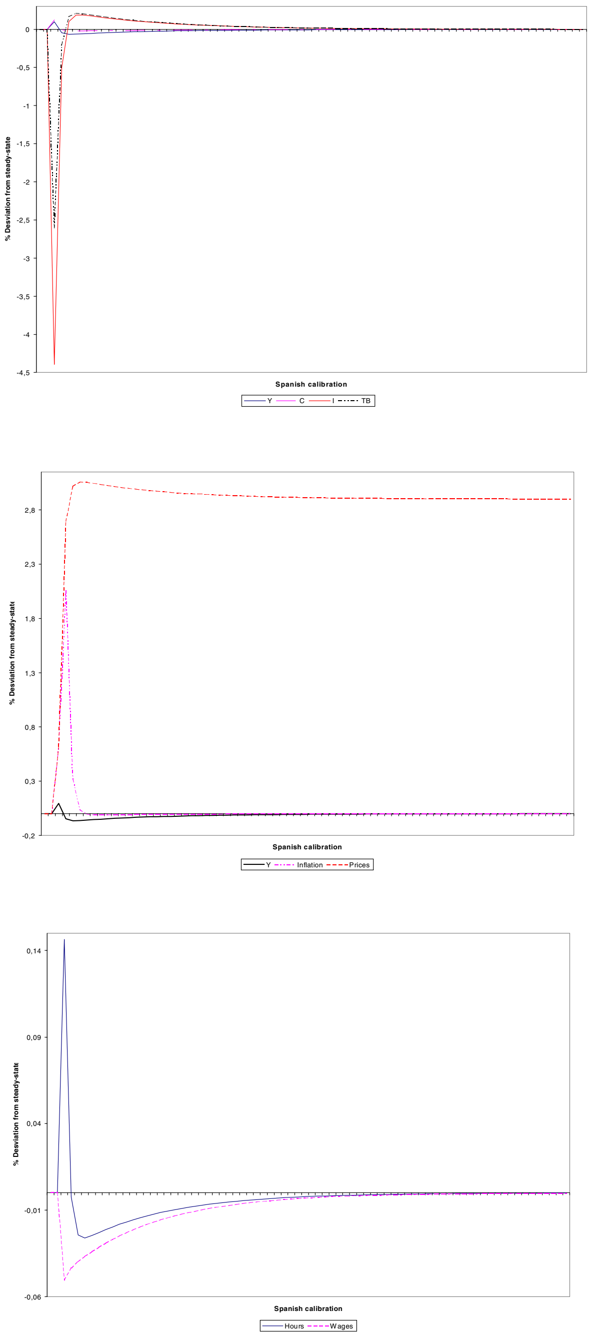


FIGURE 2.- Impulse response function to a Monetary Shock



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