Does money have a role in shaping domestic business cycles? An international investigation

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Abstract

We study the contribution of money to business cycle fluctuations in the US, the UK, Japan, and the Euro are using a small scale structural monetary business cycle model. Likelihood-based estimates of the parameters are provided and time instabilities analyzed. Real balances are statistically important for output and inflation fluctuations in all countries but Japan, and their contribution changes over time only in the UK. Models which give money no role give a distorted representation of the sources of cyclical fluctuations, of the transmission of policy shocks and, in general, of the events of the last 40 years.

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1 Introduction

There has been a considerable interest in analyzing the monetary aspects of the business cycle in recent years. Stylized facts about the transmission of monetary shocks have been collected for more than a decade (see Christiano et al. (1999) for an early summary of the evidence) and theorists have devoted considerable time to developing dynamic stochastic general equilibrium (DSGE) models which fit these facts and help in evaluating the optimality of monetary policy decisions.

The majority of the monetary models nowadays employed in academics and in policy circles share similar microfundations and similar New-Keynesian frictions in their structure and differ primarily in accessory assumptions needed to bring lagged dynamics in the equations of the model - some use ad-hoc delay mechanisms, other employ similarly ad-hoc informational constraints. One feature which is shared by essentially all models within this class is the minimal role that theory assigns to the stock of money. It is, in fact, often the case that models make no reference whatsoever to monetary aggregates, and when they do, they use a specification where a money demand function determines how much money needs to be supplied, given predetermined levels of output, inflation and the nominal rate. In general, changes in the quantity of money play no role in shaping the dynamics of output and inflation.

For those trained in the orthodoxy of the 1970s-1980s or involved in the decision making process over the last 40 years, such models are hard to accept as a working paradigm for monetary practice. The recent emphasis given in Japan to monetary aggregates as instruments to escape the prolonged deflation (see e.g. Ito and Mishkin (2004)), is also hard to reconcile with the basic assumptions of these models. Moreover, their structure seems to go against the accumulated wisdom that has made e.g. the Bundesbank and the Swiss National Bank successful in controlling inflation at times where double digit levels were the norm. Are these models providing an accurate description of the role of money in the monetary business cycle? What is the empirical evidence in favour of such a setup?

In a seminal paper, Ireland (2004) has constructed a general specification within this class of models, where money potentially plays an important role in directly affecting the dynamics of output and inflation. He estimated the structural parameters by maximum likelihood (ML) techniques using post 1980 US data and assessed the importance of money in propagating monetary business cycles by testing restrictions on the basic specification. He found that money plays a minimal role, thus supporting current theoretical models. Despite the relevance of the topic for monetary policy discussions, no other paper has attempted to investigate whether Ireland's conclusions are robust to the ancillary assumptions made and/or to minor changes in the empirical specification of the model. Furthermore, it is unclear whether data of other countries or of different periods will confirm or disproof the conclusions he obtained.

This paper attempts to fill this gap. We are concerned with three main questions. First, what is the role of money in transmitting business cycle fluctuations in the four largest industrialized countries (the US, Japan, the Euro area and the UK)? Can we safely neglect money when studying domestic business cycles and designing monetary policy rules? Second, are there subsample instabilities? In particular, does the importance of money change over time? Can money explain certain changes we observed in advanced economies over the last 30 years? Does money have anything to do with the Japanese experience of the 1990s-2000s, when deflation set in, the nominal rate reached the zero bound and output stagnated? Third, is the evidence similar across countries? Do policies, institutions or idiosyncratic features explain the differences?

In our analysis we employ a small scale New-Keynesian model, similar to the one of Ireland, and estimate its parameters using the same ML technique. The model provides important cross equation restrictions which give econometric content to the exercise. For example, the model implies that if changes in the real money balances have any direct impact on the dynamics of output and inflation, then this effect must come contemporaneously through both the Euler equation and the Phillips curve. Maximum likelihood techniques are preferable to GMM or similar methods in our context because they take into account the whole system of equations in the estimation and provide a natural framework to test restrictions on the general specification we employ. We refrain from employing a-priori restrictions on the parameter space to make the information content of the data and its ability to distinguish theoretical specifications we propose as alternative, as transparent as possible. While it is common to restrict the ML search with a prior, the constraints used are often so tight and so data-based that formal testing is difficult, if not impossible (see Canova (2007)).

Our results are as follows. First, in all countries but Japan, money matters for cyclical fluctuations in output and inflation. The role of money is roughly unchanged over time in the US and the Euro area, while in the UK money matters only prior to the inflation targeting experience.

Second, when money matters, it typically matters both directly, through its effects on the Euler equation and the Phillips curve, and indirectly, through its effects on the nominal interest rate. Money is important because it alters both the marginal rate of substitution between consumption and leisure and the intertemporal rate of substitution of consumption at different points in time and because, when reacting to nominal balances, the monetary authority indirectly reacts to inflation. Both channels represent an important and up to now unexplored mechanism which may amplify the magnitude of cyclical fluctuations and stretch their persistence over time.

Third, the importance of money as a vehicle to propagate cyclical fluctuations differs across countries, but the differences relate more to the significance of the estimates than to their absolute magnitude. Since the model fits equally well the data of different countries, and since the distribution from which shocks are drawn has important idiosyncratic features, we do not have to appeal to government policies or institutional changes (such as the creation of the ECB) to explain the cross country evidence. To our surprise, money has nothing to do with the events in Japan over the last 15 years and the recent role that the monetary aggregates have acquired, as tools to escape deflation, has not yet materialized in the data.

Finally, important conclusions about the sources of cyclical fluctuations in output and the interpretation of inflation responses to policy shocks in the US; the reasons behind the large decline in the inflation rate in the Euro area after the implementation of the Maastricht treaty and those driving the variations in output and inflation dynamics in the UK differ when money is allowed to have a role. Hence, neglecting monetary aggregates may create inferential mistakes, not only when trying to interpret the 1970s, but also current events.

The rest of the paper is organized as follows. The next section presents the theoretical model used to organize the data. Section 3 describes the data and its sources. Section 4 presents the full sample estimates, test restrictions and studies subsample evidence. Section 5 examines the role of money in interpreting the events of the last 40 years. Section 6 concludes.

2 The model

We builds on the basic New-Keynesian model without capital accumulation described in Gali (2008). We extend this simple structure in three ways. First, we allow for habit in consumption - a feature which is now standard in models of this type. Second, we allow but do not require the stock of money to play a role in the determination of output and inflation, by making real balances enter non-additively in utility. Third, we permit the growth rate of nominal balances to be a potentially important determinant of the nominal interest rate.

Since the economy is quite standard, we only briefly describe its features. There is a representative household, a representative final good producing firm, a continuum of intermediate goods firms each producing a differentiated good $i \in [0, 1]$ and a monetary authority. At each t the representative household maximizes

$$E_t \sum_t \beta^t a_t \left[U\left(x_t, \frac{M_t}{p_t e_t} \right) - \eta n_t \right] \tag{1}$$

where $x_t = c_t - hc_{t-1}$, $0 < \beta < 1$, $h, \eta > 0$ subject to the sequence of constraints

$$M_{t-1} + T_t + B_{t-1} + W_t n_t + D_t = p_t c_t + \frac{B_t}{R_t} + M_t \tag{2}$$

where c_t is consumption, n_t are hours worked, p_t is the price level, M_t are nominal balances, W_t is the nominal wage, B_t are one period nominal bonds with gross nominal interest rate R_t, T_t are lump sum nominal transfers from the monetary authority at the beginning of each t and D_t are dividends distributed by the intermediate firms. a_t and e_t are disturbances to preferences and to the money demand, whose properties will be described below. Let $m_t \equiv \frac{M_t}{p_t}$ denote real balances and $\pi_t \equiv \frac{p_t}{p_{t-1}}$ the gross inflation rate during period t.

The representative final good producing firm uses y_t^i units of intermediate good i, purchased at the price p_t^i to manufacture y_t units of the final good according to the constant returns to scale technology $y_t = [\int_0^1 (y_t^i)^{(\theta-1)/\theta} di]^{\theta/(1-\theta)}$ with $\theta > 1$. Profit maximization by these firms yields demand functions of the form

$$y_t^i = \left(\frac{p_t^i}{p_t} \right)^{-\theta} y_t \tag{3}$$

so that θ measures the constant price elasticity of demand for each intermediate good. Competition within the sector implies that $p_t = (\int_0^1 (p_t^i)^{1-\theta} di)^{1/(1-\theta)}$.

An intermediate goods producing firm i hires n_t^i units of labor to produce y_t^i units of intermediate good using the production function $y_t^i = z_t n_t^i$, where z_t is an aggregate productivity shock. Since intermediate goods substitute imperfectly for one another in producing finished goods, the intermediate firms act as monopolistic competitors in their pricing decisions. We assume that, when firms change prices, they face the following cost of adjustment, measured in terms of finished goods:

$$\frac{\phi}{2}\left(\frac{p_t^i}{\pi^s p_{t-1}^i}-1\right)^2 y_t \tag{4}$$

where $\phi > 0$ and π^s measures steady state inflation. The problem faced by the representative firm in setting its price is therefore to maximize

$$E_t \sum_t \beta^t a_t \left[U_1\left(x_t, \frac{M_t}{p_t e_t}\right)\left(\frac{D_t^i}{p_t}\right)\right] \tag{5}$$

subject to (3), where $\beta^t a_t U_1(x_t, \frac{M_t}{p_t e_t})$ measures the marginal utility value to the household of an additional unit of profits received at t and real dividends are

$$\frac{D_t^i}{p_t} = \left(\frac{p_t^i}{p_t}\right)^{1-\theta} y_t - \left(\frac{p_t^i}{p_t}\right)^{-\theta}\left(\frac{w_t y_t}{z_t}\right) - \frac{\phi}{2}\left(\frac{p_t^i}{\pi^s p_{t-1}^i}-1\right)^2 y_t \tag{6}$$

The monetary authority is characterized by a set of rules, normalized on the nominal rate, which allows it to respond to past values of the interest rate and to either current or past values of output, inflation and the growth rate of nominal balances:

$$R_t = R_{t-1}^{\rho_r} y_{t-p}^{(1-\rho_r)\rho_y} \pi_{t-p}^{(1-\rho_r)\rho_\pi} \Delta M_{t-p}^{(1-\rho_r)\rho_m} \epsilon_t \tag{7}$$

where ϵ_t is a monetary policy shock and p is either zero or one.

The four disturbances of the model $v_t = (a_t, e_t, z_t, \epsilon_t)$ are characterized by $\log v_t = \bar{v} + N \log v_{t-1} + u_t$, where N is a diagonal matrix with entries $(\rho_a, \rho_e, \rho_z, 0)$, respectively. The covariance matrix Σ of the structural shocks u_t is diagonal, with entries $\sigma_a^2, \sigma_e^2, \sigma_z^2, \sigma_\epsilon^2$. In a symmetric equilibrium all the firms make identical choices so $y_t^i = y_t$, $n_t^i = n_t$, $p_t^i = p_t$, and $D_t^i = D_t$.

Log-linearizing the equilibrium conditions around the steady states leads to:

$$\begin{aligned}
\hat{y}_t &= \frac{1}{1+h}E_t\hat{y}_{t+1} + \frac{h}{1+h}\hat{y}_{t-1} - \omega_1\frac{1-h}{1+h}((\hat{R}_t - E_t\hat{\pi}_{t+1}) - (\hat{a}_t - E_t\hat{a}_{t+1})) \\
&+ \omega_2\frac{1-h}{1+h}((\hat{m}_t - \hat{e}_t) - (E_t\hat{m}_{t+1} - E_t\hat{e}_{t+1})) \qquad (8)\\
\hat{m}_t &= \gamma_1\hat{y}_t - \gamma_2\hat{R}_t + (1-(R^s-1)\gamma_2)\hat{e}_t \qquad (9)\\
\hat{\pi}_t &= \beta E_t\hat{\pi}_{t+1} + \psi(\frac{1}{\omega_1}\hat{y}_t - \frac{\omega_2}{\omega_1}(\hat{m}_t - \hat{e}_t) - \hat{z}_t) \qquad (10)
\end{aligned}$$

$$\hat{R}_t = \rho_r\hat{R}_{t-1} + (1-\rho_r)\rho_y\hat{y}_{t-p} + (1-\rho_r)\rho_\pi\hat{\pi}_{t-p} + (1-\rho_r)\rho_m\Delta(\hat{m}_{t-p} + \pi_{t-p}) + \hat{\epsilon}_t \tag{11}$$

where

$$\omega_1 = -\frac{U_1(x_t, \frac{m_t}{e_t})}{y^s U_{11}(x^s, \frac{m^s}{e^s})} \tag{12}$$

$$\omega_2 = -\frac{m^s}{e^s} \frac{U_{12}(x^s, \frac{m^s}{e^s})}{y^s U_{11}(x^s, \frac{m^s}{e^s})} \tag{13}$$

$$\gamma_2 = \frac{R^s}{(R^s-1)(m^s/e^s)} \left(\frac{U_2(x^s, \frac{m^s}{e^s})}{(R^s-1)e^s U_{12}(x^s, \frac{m^s}{e^s}) - R^s U_{22}(x^s, \frac{m^s}{e^s})} \right) \tag{14}$$

$$\gamma_1 = (R^s - 1 + R^s \omega_2 \frac{y^s}{m^s})(\frac{\gamma_2}{\omega_1}) \tag{15}$$

$$\psi = \frac{\theta - 1}{\phi} \tag{16}$$

The superscript s denotes steady state values of the variables, U_j is the first derivative of U with respect to argument $j = 1, 2$ and U_{ij} is the second order derivative of the utility function, $i, j = 1, 2$.

The log-linearized Euler condition (equation (8)) includes, in addition to standard arguments, terms involving real money balances and the money demand shocks. These terms are irrelevant for output determination if and only if the utility function is separable in consumption and real balances, i.e. $U_{12} = 0$ (see equation (13)). Equation (9) is a money demand equation: real balances positively depend on output and negatively depend on the nominal rate. There are important cross coefficient restrictions in this equation and, for example, the output elasticity of money demand depends on the interest semi-elasticity of money demand. Equation (10) is a forward looking Phillips curve. Real balances enter this equation as long as $\omega_2 \neq 0$, so that $U_{12} \neq 0$ is again necessary for real balances to play a role in the determination of the inflation rate. Intuitively, real balances matter in the Phillips curve because they affect the marginal rate of substitution between consumption and leisure which, in equilibrium, is equal to the real wage and the real wage is a crucial component of the marginal costs of the model. Equations (8)-(10) also indicate that whenever real balances enter the Euler equation and Phillips curve, the money demand shock also enters. Finally, the policy rule allows, but does not require, the growth rate of real balances to be an important determinant of interest rate decisions. The specification we have chosen in (11) allows for either a backward looking or a contemporaneously looking policy rule. We allow this flexibility for three reasons. First, the conventional contemporaneous specification has no clear theoretical advantages relative to a backward looking one. Second, a model featuring a backward looking relationship is superior, both in terms of fit and properties of the estimated shocks (see Canova (2008)), to one which considers a contemporaneously looking or even a forward looking specification for US data. Third, since we consider samples which include the 1970s, allowing for the possibility that monetary policy was backward looking avoids important specification errors.

In this paper, we focus attention on the estimates of ω_2, of $\lambda_m = (1 - \rho_r)\rho_m$ and of ρ_m. The first measures the direct role of money in determining the magnitude and the persistence of output and inflation fluctuations; the other two, the short and long run indirect effects that money has on these two variables through the nominal rate.

When ω_2, is zero utility is separable and real balances have no direct role in propagating monetary business cycles. When both ω_2 and ρ_m are zero, money could be totally omitted from business cycle and monetary policy analyses without statistical or interpretation loss. Our a-priori expectation is that both ω_2 and ρ_m vary across countries and time periods. Our empirical analysis intends to shed some light on the cross country and cross time heterogeneities in these two effects.

2.1 Inflation and output dynamics and the role of money: an overview

Before estimating the model, it is useful to highlight what difference money may make in the model and along which dimensions we should expect giving money a role may help us understand certain real world phenomena.

It is well known that the US went through considerable structural changes over the last 30 years and this phenomena has been termed the Great Moderation (see e.g. Stock and Watson, 2002). These changes include a significant decline in the volatility of output and inflation since the early mid-1980s and a considerable fall in the persistence of inflation. Canova et al. (2007) show that such a phenomena is present also in the UK and, to a smaller extent, in Europe. Various explanations have been offered for these changes running from better monetary policy (see e.g. Clarida, et. al (2000)), to changes in the stochastic process from which shocks are drawn (see e.g. Sims and Zha (2006)), to changes in the parameters regulating private sector behavior (see e.g. Campbell and Herkowitz (2006)). Here we want to investigate two issues: first, whether allowing ω_2 and ρ_m to be different from zero makes a difference for the variability and the persistence of output and inflation; and, second, whether changes in these two parameters have any hope to account for the changes in these moments.

To give an idea of the range of possibilities of the model, we consider two different parameterizations. In both cases, the rule is specified to be backward looking and we set $\beta = .99, \psi = 0.1, \omega_1 = 2.0, \gamma_2 = 0.72, \sigma_a = 0.31, \sigma_z = 0.059, \sigma_e = 0.009, \sigma_\epsilon = 0.007$ which are close to the values estimated or calibrated by Ireland. We also set $h = 0.95, \rho_r = 0.56, \rho_y = 0.37, \rho_\pi = 3.71$, and $\rho_a = 0.40, \rho_z = 0.50, \rho_e = 0.60$ in the first case and $h = 0.8, \rho_r = 0.4, \rho_y = 0.2, \rho_\pi = 1.52$, and $\rho_a = 0.40, \rho_z = 0.70, \rho_e = 0.80$ in the second, which are close to the values we obtain below with US and Euro data. Note that in the first setting the habit parameter is large and the persistence of the shocks low; in the second, the habit parameter is more moderate and the persistence of the shocks higher. For each parameterization, we let ω_2 and ρ_m vary within a range of values and trace out how the variability of output and inflation and the persistence of inflation change: for ω_2 the interval is [-0.5,2.0], which allows for complementarity and substitutability of consumption and real balances in utility; for ρ_m the interval is [-0.2,1.0], where negative values are intended to capture the possibility that reacting to nominal balances is a way to temper a possibly too strong policy reaction to inflation.

Figure 1 shows that variations in both parameters could be important to account for the level and the variations in the unconditional moments of output and inflation over time. For example, ρ_m positively affects the variance of both output and inflation and the AR(1) coefficient of inflation with both parameterizations. Changes in ω_2 positively affect the variance of output but the effect on the variance and the persistence of inflation is non-linear and depends on the parameter configuration used. Since changes in nominal balances are partially determined by economic conditions via the money demand function, a lower reaction of interest rates to nominal balances may reduce the feedbacks from money to economic conditions and therefore help to dampen output and inflation fluctuations. The relationship between ω_2 and the unconditional moments of inflation is non-linear because two mechanisms are contemporaneously at work: a higher ω_2 implies higher inflation variability; and a higher inflation variability implies a larger induced interest rate effect. Whether the first or the second effect dominates depends on the parameter configuration and, in particular, on how strong is the reaction of interest rates to deviations of inflation from its steady state value.

In sum, while the range of variations in the variability and persistence of inflation in figure 1 is small relative, for example, to what has been observed in the US, it is clear that setting ρ_m and ω_2 to zero may be restrictive. In addition, time variations in the values of these two parameters represent an unexplored channel which may help us to understand better the changes that advanced economies displayed over time.

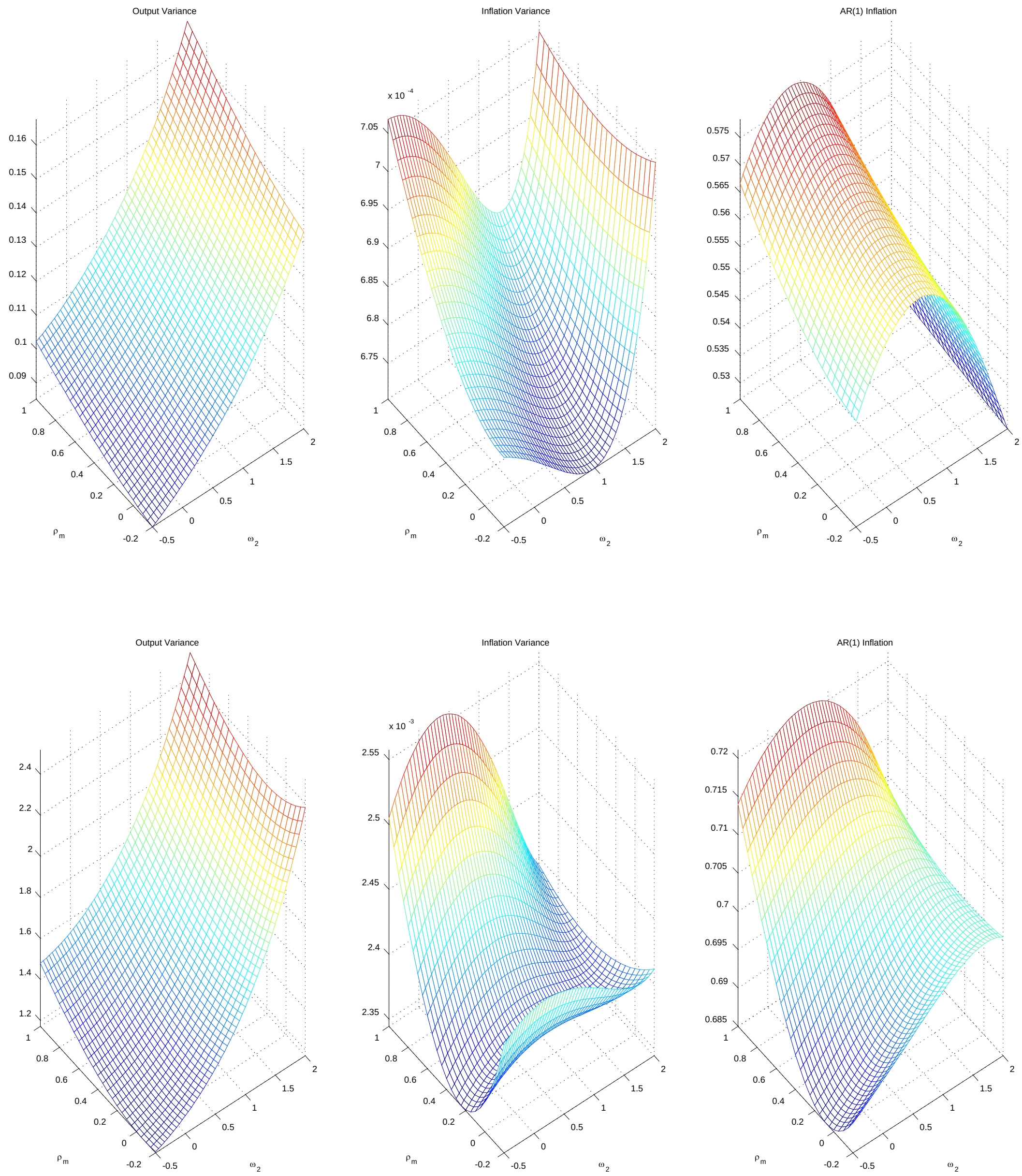

Figure 1: Surface plots. Top panel first parameterization; bottom panel second parameterization.

3 The data and the estimation approach

We assume that the investigator observes data for output, the inflation rate, the nominal rate and real balances. The sample we use differs across countries: it goes from 1959:1 to 2008:2 for the US, from 1970:1 to 2007:4 for the Euro area, from 1965:1 to 2008:2 for the UK and from 1980:1 to 2007:4 for Japan. US data is obtained from the FRED database at the Federal Reserve Bank of St. Louis; Euro data is from the Eurowide model dataset (update 7) and from the ECB web page; UK data comes from the Bank of England, while data for Japan is collected from IMF and OECD data bases. The inflation rate in all four countries is measured by the growth rate of the GDP deflator; the nominal rate is the three month T-bill rate in the US and the UK, the call rate in Japan, and three month rate in the Euro area. For money we use the M2 stock in the US and the Euro area, M2 plus certificate of deposits in Japan and the M4 stock in the UK. GDP and nominal monetary aggregates are scaled by the GDP deflator and by civilian population in the 16-65 group to transform them in real per-capita terms.

Per-capita real GDP and real money balances display an upward trend which looks almost deterministic in all countries. Since the drift appears to be idiosyncratic, both across variables and countries, we separately eliminate it from the log of the series using either a linear specification or a linear segmented specification. In the latter case, the relationship is allowed to change at 1980:1 for the US; at 1992:4 for the UK and the Euro area and at 1990:4 for Japan. The results we present are not sensitive if we move the break dates within a year (backward or forward) of the selected one. Both transformations produce fluctuations with long periods of oscillation for all countries and appear to be more time homogeneous when the trend is allowed to break. The inverted U-shaped patterns that interest rates and inflation display are much more difficult to deal with. Consistent with the literature, we demean both series using either the full sample mean or the subsample mean, where the chosen break date is the same as the one of per-capita real GDP and real balances.

Trend heterogeneities are not the only form of instabilities that may be present in our samples. In fact, the time varying nature of unconditional inflation and output moments we discussed in the previous section suggest that dynamic heterogeneities could also be severe. Therefore, we also estimate the model allowing both the trend and the cyclical relationships to be sample specific.

One feasible alternative to the strategy we use to match the data to the model's counterparts is to allow the technology shock z_t to be non-stationary and remove the upward trend in per-capita real output and real balances using a model consistent methodology. We do not follow this approach for two reasons. First, when technology shocks have a unit root, per-capita output and real balances share the same trend, which is not the case with the available data. Second, it is unclear whether all non-cyclical fluctuations can be safely attributed to non-stationary technology shocks. Chang et al. (2006) have recently fit a model with non-stationary preference shocks to US data with good results.

The model (8)-(11) contains 19 parameters; 6 structural ones $\eta_1 = (\beta, h, \rho_r, \rho_y, \rho_\pi, \rho_m)$, 4 semi-structural ones $\eta_2 = (\psi, \omega_1, \omega_2, \gamma_2)$ and 7 auxiliary ones, $\eta_3 = (\rho_a, \rho_z, \rho_e, \sigma_a, \sigma_z, \sigma_e, \sigma_\epsilon)$ plus the steady state values of the nominal interest rate and the output to real balance ratio, $\eta_4 = (R^s, \frac{y^s}{m^s})$. Our exercise is geared to obtain likelihood-based estimates of $\eta = (\eta_1, \eta_2, \eta_3)$, conditional on selected values for η_4 [1].

The model can be solved using standard methods. Its solution has the format:

$$x_{1t+1} = A_1(\eta)x_{1t} + A_2(\eta)u_t \tag{17}$$

$$x_{2t} = A_3(\eta)x_{1t} + A_4(\eta)u_t \tag{18}$$

where $x_{2t} = [\hat{y}_t, \hat{\pi}_t, \hat{R}_t, \hat{m}_t]$, $x_{1t} = [\hat{y}_{t-1}, \hat{\pi}_{t-1}, \hat{R}_{t-1}, \hat{m}_{t-1}, \Delta\hat{M}_{t-p-1}, \hat{v}_{1t}, \hat{v}_{2t}, \hat{v}_{3t}, \hat{v}_{4t}]$ and the matrices $A_i(\eta), i = 1, 2$ are complicated nonlinear functions of the parameters η.

Likelihood-based estimation of the parameters entering (17) and (18) is simple: given some η, and a sample $[t, \ldots, T]$, we compute the likelihood, denoted by $f(y_{[t,T]}|\eta)$, by means of the Kalman filter and the prediction error decomposition and update the original η values using gradient methods. The Kalman filter is easy to use since (17) and (18) form a linear state space system where (17) is a transition equation and (18) an observation equation.

Unfortunately, the likelihood function of the model is not well behaved with the data of any of the countries and, in fact, displays multiple peaks, sharp cliffs and large flat areas. This is due, in part, to samples which are not very informative and, in part, to the fact that the model only imprecisely approximates the data generating process of the observables. Thus, to find the maximum of the likelihood function, we employ the following multi-step approach:

[1] We read R^s for each country and each sample off the average level of inflation, once we set $\beta = 0.99$. The value of $\frac{m}{y}$ ratio is constant across countries and samples and fixed to 1.5 (using the calibration of Chari et. al. (2002)). Changing this ratio from 1.5 to 2.5 has minor consequences on the estimates of ω_2 and λ_m we obtain. We do not estimate η_4 jointly with the other parameters because the likelihood has little information for these two parameters

1. For each data set and each country, we randomly draw a set of 20 initial conditions. If the model does not solve with such a draw, the draw is discarded and a new draw is made.

2. For each draw, we numerical maximize the likelihood function of the state space system [2]. We take as estimate for the vector of parameters the one that produces the largest likelihood value across draws, excluding runs where convergence of the optimization routine fails.

3. We repeat the first two steps using an alternative specification of the monetary policy rule. To compare the maximum we obtain with the one of the benchmark specification obtained in 2, we use the Schwarz approximation to the posterior odds ratio (see Canova, 2007). We select as preferred specification the one which optimizes this criteria and results in estimated residuals which deviate less from the mean zero, iid assumption.

4. Since the optimization routine does not know what a reasonable economic value for the parameters is, we screen the output to eliminate specification selected in 3 that violate basic economic principles (e.g. specifications for which the risk aversion or adjustment costs become negative) or produce standard errors for the structural shocks which are unreasonable or non-interpretable.

5. For the specification selected in 4, we then impose parametric restrictions on ω_2 and ρ_m and measure how much they alter the maximized value of the likelihood, as compared either to a χ^2 distribution, or to a penalty function, which is proportional to the number of restricted parameters times the sample size as in the Schwarz approximation to the posterior odds ratio.

6. We iterate on steps 1-5 for each country and each data set by changing the values of η_4 within a reasonable range and compare how much parameter estimates change when these conditioning parameters are altered.

It is well known that Bayesian methods have an edge over classical likelihood methods in situations like ours where the likelihood function is poorly behaved. However, the choice of priors is problematic since the standard priors employed in the literature

[2] We use the csminwel.m routine written by Chris Sims since it appears to be able to explore reasonably well the function of interest. Standard Matlab routines fail to move from the initial conditions in many cases.

make the posterior of the parameters look very different from the likelihood. In other words, when the likelihood has problematic features, inference may crucially depend on the shape, the location and the spread of the multivariate prior density. Our choice of letting the data speak and of employing an ex-post criteria to eliminate economically non-interpretable estimates is equivalent to assuming that the prior on the parameter vector is multivariate uniform with truncation in the area of the parameter space which does not produce a determinate solution or that gives economically unreasonable results.

4 The results

4.1 Full sample evidence

We start by analyzing the estimates in the four countries for the full sample. Table 1 reports the estimates of ω_2, the direct effect of real balances on output and inflation fluctuations, of $\lambda_m = (1-\rho_r) * \rho_m$, the short term indirect effect of real balances growth (via interest rates determination) on output and inflation fluctuations, of ρ_m, the long term indirect effect of real balances growth, and of their standard errors, computed from the Hessian of the function at the maximum. The first two columns contain estimates for the US, the third and fourth estimates for the Japan, and the fifth and sixth for the Euro area and the last two estimates for the UK. The row labeled "Linear" refers to estimates obtained when per-capita GDP and per-capita real balances are linearly and separately detrended; the row labeled "Segmented" when the drift in these two variables is eliminated with a segmented linear trend.

The sign of the coefficient measuring the direct impact of money in the model is positive in all cases, indicating that consumption and real balances are complements in utility, as any theory which give money a transaction role would predict. However, the magnitude and the significance of the effect depends on both the preliminary transformation used and the country considered: ω_2 is large and statistically significant in all countries when a linear trend is eliminated from per-capita output and pre-capita real balances; and it is somewhat smaller and significant only in the US when a segmented trend is eliminated from these two variables.

The coefficient measuring the indirect short run effect of real money is generally estimated to be moderate in all countries except, the UK when a linear trend is eliminated from per-capita output and per-capita real balances. The reason for why the

	US				Japan				Euro area				UK			
	p	ω_2	ρ_m	λ_m	p	ω_2	ρ_m	λ_m	p	ω_2	ρ_m	λ_m	p	ω_2	ρ_m	λ_m
Linear	1	2.69	1.14	0.15	0	1.74	1.51	0.27	0	1.74	2.80	0.40	0	1.01	3.98	1.80
		(0.69)	(0.70)	(0.01)		(0.50)	(0.64)	(0.02)		(0.34)	(0.21)	(0.00)		(0.07)	(0.40)	(0.08)
Segmented	0	1.86	2.23	0.49	0	1.19	2.34	0.32	0	1.14	4.52	0.57	1	2.52	0.71	0.07
		(0.24)	(0.25)	(0.01)		(2.51)	(2.91)	(0.06)		(0.79)	(0.87)	(0.01)		(6.04)	(2.81)	(0.03)
Sample 1	0	1.12	3.81	0.49	0	1.48	1.01	0.13	0	2.37	3.95	0.14	0	2.56	3.94	0.54
		(0.32)	(0.72)	(0.01)		(3.81)	(2.95)	(0.05)		(0.60)	(1.02)	(0.00)		(1.93)	(0.65)	(0.01)
Sample 2	0	1.86	2.68	0.75	0	0.24	1.18	0.20	0	1.81	3.46	0.19	0	1.08	-1.29	-0.09
		(0.50)	(0.69)	(0.05)		(2.74)	(2.62)	(0.07)		(0.29)	(0.76)	(0.00)		(0.76)	(1.51)	(0.01)

Table 1: Parameters Estimates for restricted model, different countries, different samples. Linear indicates that a linear trend is removed from per-capita real GDP and real balances and Segmented that a linear trend is separately eliminated from two subsamples in both variables. Standard errors are in parenthesis. ω_2 is the coefficient on real balances in the Euler equation and the Phillips curve; ρ_m is the long run coefficient on real balances in the Taylor rule and λ_m the short run coefficient on real balances in the Taylor rule.

UK is an outlier here is relatively simple: recall that for the UK we have used M4 (rather than M2), and that this series appears to display a strong break around the 1992:4. Since when a segmented trend is removed, the estimated value of λ_m is instead small, the large estimate we obtain when removing a linear trend reflects the upward bias that this unaccounted trend heterogeneity creates in the estimated parameters. Nevertheless, regardless of the preliminary transformation used, estimates of λ_m are strongly significant in all four countries.

The evidence concerning the long run coefficient on real balances in the policy rule is little more mixed. ρ_m is estimated to be relatively large and significant in Japan, the Euro area and the UK when a linear trend is removed from per-capita output and per-capita real balances. With the segmented trend specification, estimates are generally larger in magnitude but are significant only in the US and the Euro area. Taken literarily, the estimates we obtain imply that a one percent deviation of real balances from their steady state value has long run effects on interest rates which range from one to four percentage points, depending on the country. Thus, while it is difficult to pin down with precision a value, it is clear that this long run effect it is far from negligible in several of the countries we consider.

We have mentioned in the previous section that the monetary policy rule is flexibly chosen to allow both backward looking and contemporaneously looking specifications.

Typically, a contemporaneous rule is specified. However, as Canova (2008) has shown, such a rule induces monetary policy shocks which deviate strongly from the iid assumption, when the drift in per-capita output and per-capita real balances is eliminated with a linear trend. The deviations are much less evident when a backward rule is used. Table 1 confirms that for the US a backward rule is preferable when a linear trend is removed from the real variables, but for the other countries a contemporaneous rule appears to be superior. When a segmented trend specification is used, a contemporaneous rule is superior in all countries but the UK. Overall, a policy rule where the nominal rate responds to current values of output and inflation, seems, by and large, appropriate when the model is estimated at the quarterly frequency.

We test for the joint significance of the direct and indirect effects of money using a likelihood ratio (LR) test and the Schwarz approximation to the log Bayes factor. The specifications we estimate, for each preliminary transformation, allow either all the parameters to be freely set or force ω_2 and ρ_m to be zero, while leaving other parameters unrestricted. Since both statistics take into account the fit of the whole system of equations, they provide a more powerful discriminant than t-statistics to evaluate the role of money. Since Bayes factors take into account potential small sample distortions when evaluating the predictive power of a model, while the LR test does not, differences in the results can be attributed to important small sample biases.

Table 2, which reports the p-value of the LR test and the value of the Schwarz criteria, confirms the main indications of table 1. When a linear trend is used money is statistically important to explain Japanese, UK and the Euro area data and this is true no matter what criteria is used to evaluate the in-sample fit of the model. For the US, instead, the evidence is slightly mixed primarily because the Schwarz criteria give an inconclusive answer. When a segmented trend specification is used, instead, money matters only in the US. Since ρ_m was estimated to be strongly significant, one may be surprised by the fact that money does not seem to matter much in the Euro area. The two results however are not necessarily inconsistent with each other, since the exact value of ρ_m does not change much the likelihood of the model with Euro area data. Interestingly, the LR test and Schwarz criteria give the same conclusions. Thus, small sample biases are relatively unimportant in our full sample estimates.

Since results appear to differ depending on the preliminary transformation used to eliminate the drift in per-capita output and per-capita real balances, which one should be trusted more? There are at least two reasons that make the choice difficult. On the

	P-value LR test		log Bayes Factor	
Country	Linear	Segmented	Linear	Segmented
US	0.001	0.00	1.001	51.26
Japan	0.000	0.08	335.721	-2.28
Euro	0.000	1.00	250.942	-11.10
UK	0.000	1.00	31.025	-20.65

Table 2: The restrictions are $\omega_2 = 0, \rho_m = 0$. The corrected LR test uses $2(\log L_u - \log L_r)$ as statistics. The log Bayes factor is computed using a Schwarz approximation $(\log L_u - \log L_r) - 0.5(k_u - k_r) * \log(T)$ where k_j is the number of parameters used in the specification $j = u, r$.

one hand, if the long run relationships truly display a structural break, the evidence produced with the linear specification is biased. On the other, it is possible that the chosen break date is incorrect; that a linear specification is appropriate for one sample but not another one; that there are additional breaks; or that breaks occur also in the dynamics of the model, in which case results with the segmented specification should not be trusted either. We have checked that the results do not strongly depend on the chosen break date and that no abnormal patterns emerge in the residuals of the model with both specifications. However, we were unable to visually spot any other breaks or test for their presence since samples become too short to make estimates meaningful nor to test if the specification of the trend changed, precisely for the same reason.

In sum, while not completely unidirectional, the evidence we have collected indicates that money matters in shaping monetary business cycles in several of the countries or, to put it more mildly, it seems to matter more than the current literature is willing to assume. Since statistical significance does not necessarily imply large distortions in the economic interpretation of the evidence when designing optimal policies, performing response analysis or conducting conditional forecasting exercises, section 5 examines the economic relevance of our findings.

4.2 Subsample evidence

In the previous subsection we have attempted to account for breaks in the long run trend of the real series and in the level of nominal variables but also mentioned that dynamic heterogeneity is a matter of concern. Output and inflation dynamics have dramatically changed in some of the countries we consider over the last 30 years, meaning that the structural relationship of the model are potentially time-varying. Since the estimates in the first two rows of table 1 neglect these changes, one may suspect that the evidence we have reported is not entirely reliable.

To investigate whether time variations in the structural relationship are important, we have estimated the model over two separate subsamples, allowing both the steady states and the dynamics of the variables to be sample specific. When estimates of the structural parameters do not significantly change over subsamples and are roughly similar to those obtained with the full sample of data, full sample estimates are appropriate and time variations in the structural relationship are likely to be minor. If, on the other hand, estimates differ across subsamples and full sample estimates do not represent any meaningful combination of subsample estimates, the opposite is true. When comparing subsamples and full sample estimates, however, one important caveat must kept in mind. Short subsamples may induce important biases in structural estimates, thus potentially giving the impression that parameters have changed when no variations really exist. To be able to distinguish whether dynamic heterogeneity or small sample biases dominate, it is therefore important to scrutinize not only point estimates but also the size of their standard errors.

Clearly, besides giving us important information about the reliability of full sample estimates, a subsample analysis can shed light on whether the role of money in shaping monetary business cycles has changed over time and whether these changes may account for some of the structural variations that the four economies have displayed.

The third and fourth rows of table 1 present estimates of the parameters of interest obtained using the samples 1959:1-1979:4 and 1980:1-2008:2 for the US, the samples 1980:1-1990:4 and 1991:1-2007:4 for Japan, the samples 1970:1-1992:4 and 1993:1-2007:4 for the Euro area, and the samples 1965:1-1992:4 and 1993:1-2008:2 for the UK. The location of the breaks reflect the history of the individual countries: for the US, 1980 was the year when inflation and the nominal rate started declining from their peak levels; for the Euro area, the break roughly corresponds to the time when the Maastricht Treaty was implemented and to the beginning of the decline of inflation and the nominal rate from the 1980s levels. For the UK, the break is selected to separate the inflation targeting period from previous monetary policy experiences. Finally, the second subsample in Japan starts in correspondence with the explosion of the land bubble which, by many, was considered the trigger of the so-called "lost decade"[3].

[3]We have also considered a second sample split for Japan around the end of 1997 - the time when the Bank of Japan become independent of the Ministry of Finance. Estimates obtained with this split are unfortunately non-interpretable.

Before describing our estimates, it is worth discussing why we a-priori select a date for the break (and analyze the sensitivity of the estimates moving the break date backward and forward), rather than formally test for breaks in the dynamics. There are two main reasons for our choice. First, standard break tests are of univariate nature and when applied to the four variables used here rarely select a single break date. Therefore, a researcher needs to use considerable judgment also after formal testing. Second, since the data we employ does not necessarily fit the assumptions underlying these tests, classical type II errors are likely to make structural estimates meaningless. This type of problems can be in part avoided choosing a sensible break date a-priori and performing careful sensitivity analysis.

The structural relationships of the model do appear to have changed over time in all the countries. Variations are present in the parameters governing the private sector behavior; in the monetary policy rule; and in the variance of certain shocks. Regarding the parameters regulating the role of money in the model, a subsample analysis gives us interesting information. For the US, the conclusions we have previously reached are unchanged: money matters both directly and indirectly, it matters both in the short and in the long run, and it is important in both samples. Interestingly, very little time variations are detected in these parameters and the magnitude of the effects is similar to the one obtained with the segmented specification. In fact, the hypothesis that ω_2 and ρ_m are unchanged over subsamples and similar to the full sample estimates can not be rejected at standard confidence levels.

Money also matters in the Euro area, both directly and indirectly, and the magnitude of the estimates is roughly unchanged over the two subsamples. However, estimates obtained breaking the sample in two are now more similar to those obtained in the full sample after eliminating the drift in per-capita output and real balances with a linear trend. Hence, segmenting the trend of these two variables introduces small sample biases which distort estimates of the structural parameters regulating the role of money. Also for the Euro area, we can not reject the hypothesis that ω_2 and ρ_m are unchanged over subsamples.

In Japan, estimates of ω_2 and ρ_m obtained in the two subsamples are close to those obtained with the segmented specification; are insignificant in both subsamples and, although the point estimate of ω_2 falls in the second subsample, we can not reject the joint hypothesis that both parameters are stable over time. Estimates of λ_m, on the other hand, are significant in both subsamples but the point estimates we obtain are smaller than in the full sample, suggesting that the numbers we have previously reported are probably upward biased. Overall, money does not matter much for cyclical fluctuations in output and inflation in Japan, except perhaps in the short run and indirectly, through the effects it has on the level of the nominal interest rate. To put this conclusion in another way, money does not seem to have any role in explaining either the deflationary period and the slow return of the norm of the last few years or the persistent output stagnation experienced in the 1990s.

The UK appears to be the only country where the role of money has significantly changed over time. In particular, estimates of ω_2 and ρ_m are insignificant in the subsample covering the inflation targeting period, while in the first subsample, at least ρ_m was large and significant. Moreover, since subsample estimates are different from those obtained for the full sample, it is clear that neither the linear nor the segmented specification provide a reasonable characterization of the UK experience of the last 40 years. Notice also that, the estimate of the short run indirect effect λ_m dramatically falls in the second subsample and becomes negative. As mentioned, negative values are economically meaningful, once it is understood that a negative reaction of the nominal interest rate to nominal balances is a way to temper a possibly too strong policy reaction to inflation. In sum, the large changes in the parameters regulating both the short and the long run effects of money in the Taylor rule suggest that monetary aggregates played an important indirect role in explaining cyclical fluctuations in the UK up to the start of the inflation targeting period, but that this role waned afterwards.

4.3 Discussion

What have we learned so far? First, except for Japan, money appears to be statistically important in characterizing cyclical fluctuations in output and inflation. The role that money has is roughly unchanged over time in the US and the Euro area, while in the UK, money was statistically significant only prior to the inflation targeting experience.

Second, when money matters, it typically matters both directly, through its effects on the Euler equation and the Phillips curve, and indirectly, through its effects on the nominal interest rate. Real balances are important directly because they affect both the marginal rate of substitution between consumption and leisure and the intertemporal rate of substitution of consumption at different points in time. In other words, the complementarity between consumption and real balances in the utility of the agents provides an unexplored mechanism which may be able to amplify the magnitude of cyclical fluctuations and to stretch their persistence over time.

The indirect effect of money also appears to be a crucial but neglected mechanism to understand how cyclical fluctuations are propagated to the domestic economies. As far as we know, the typical Taylor rules that are nowadays estimated do not include the growth rate of nominal balance among the regressors. Since reacting to nominal balances is also, indirectly, a way to react to inflation, it is likely that in typical rules the inflation coefficient is overestimated when money is neglected, and the richness of second round dynamics due to money muffled. Since the long run effects we estimate are typically strong, omissions of the money term when analyzing monetary policy decision is important for the interpretation of the evidence.

Perhaps more interestingly, we find that, at least in the US and the Euro area, money is important not only in the 1970s and 1980s, when central banks were explicitly or implicitly using the growth rate of nominal aggregates as the main indicator for monetary policy decisions, but also nowadays, when the Fed refrains to mention monetary aggregates in communication with the public, and when the "second pillar" of the ECB has lost most of its appeal, even inside the institution. We do not know whether this effect is spurious or real. It is possible that money lost importance over the last 15 years, but nominal balances proxy for other factors omitted from the specification, for example, exchange rates, credit, or even asset prices. To ascertain whether this is possible, a much more complicated model with many more features than what we consider here is necessary and we need to understand under what conditions money may capture effects which are instead due to exchange rates or asset prices. While such an investigation is clearly beyond the scope of this paper, we conjecture that we need to engineer a very complex set of circumstances to make nominal balances proxying for the effects of certain variables in one sample but not in another one. Overall, our evidence indicates that neglecting monetary aggregates may create inferential mistakes, not only when trying to interpret phenomena like the "Great Inflation" of the 1970s and the slow return to the norm but also current events.

Third, the importance of money as vehicle to propagate cyclical fluctuations differs across countries, but the differences we obtain seem to relate more to the significance of the estimates than to their magnitude. Since the model fits equally well the data of different countries, we do not have to appeal to government policies or institutional changes (such as the creation of the ECB) to explain the cross country evidence (see also Canova, et. al. (2006)). Rather, we find that the distribution from which shocks are drawn has important idiosyncratic features. Hence, while it is important to recognize the role that national policies may have in characterizing monetary business cycles across countries, it is also crucial not to overemphasize their importance, especially for policy purposes.

Fourth, to our surprise, money has no statistical role in explaining output and inflation fluctuations in Japan and, in particular, it has nothing to do with the events of the last 15 years. Interestingly, the recent emphasis that the Bank of Japan gave to monetary aggregates as tools to escape deflation (see e.g. Ito and Mishkin (2004)), does not seem to have yet materialized in the data and estimates of ρ_m, constructed using the last 8 years of data, are still negative but insignificant.

Fifth, although our results indicate that real balances play an important coincident indicator role for output and inflation in some countries, one should be careful in translating such a fact into a statement concerning the use of real (or nominal) balances in unconditional forecasting regressions of output and inflation. The model we have used is highly stylized and, for forecasting, it is inferior to simple time series specifications which leave real or nominal money out. Our results should be interpreted as giving money a role, conditional on the model. In other words, conditional on this model, policy exercises conducted giving or not giving money a role may lead to different conclusions. The next section investigates to what extent this is the case.

Finally, our results for the US stand in sharp contrast with the findings of Ireland (2004), who estimated ω_2 to be small and insignificant using post 1980 data (and set ρ_m identically to zero). There are a few reasons which may account for the differences. The model specification is slightly different - we consider a model with consumption habit, while Ireland does not - and the data is slightly longer, but we have checked that these two features are not responsible for the differences. We believe that the more relevant reason is instead that the likelihood function of the model is poorly behaved and very hard to optimize. During our search for the maximum with US data, we have encountered one or more local peaks where estimates of the effect of real balances in the Euler equation and the Phillips curve is indeed small and setting ρ_m to zero increases the probability that ω_2 is estimated to be negligible. Hence, the optimization routine employed is important to deliver proper conclusions and the one we have outlined in section 3 seems to work reasonably well.

5 The economic relevance of money

So far we have shown that money is statistically significant to explain the data in three of the four countries we consider. But is this effect economically important? Can we safely neglect money when studying domestic business cycles and when designing useful monetary policies? Can money explain the changes observed in advanced economies over the last 30 years? We have seen in figure 1 that variations in both ω_2 and ρ_m have the potential to explain part of the changes in the time profile of output and inflation variability and inflation persistence.Since some of the subsample variations in the estimates we have presented in table 1, although not statistically large, appear to go in the right direction, it is worth investigating this issue in more details.

To study whether the omission of money balances from the model is crucial for understanding the economic phenomena, we present first responses to the four shocks when money is allowed to play a role and when it does not (i.e. ω_2 and ρ_m are identically set to zero). We choose the sample 1959-1979 in the US for illustrative purposes, since these responses can tell something about the causes of the Great Inflation of the 1970s.

There are important differences in the responses to the shocks in the two specifications. For example, it is clear that the effect of technology shocks is amplified when money is allowed to play a role and that a smaller interest rate disturbance can induce similar short run fluctuations in output. Hence, as expected, the transmission mechanism of important shocks is amplified when money is allowed to matter. These differences also show up in terms of variance decomposition. For example, the forecast error variance of output at the 5 years horizon is mainly explained by technology shocks (65 percent) when money plays a role and by preference shocks (68 percent) when money has no role. Two additional features of figure 3 are worth a brief discussion. First, in response to monetary policy shocks, output falls in both specifications but inflation increases when money has a role and decreases when money does not have one. This is due to the negative sign that real balances have in the Phillips curve, see equation (10). Hence, the so-called "price puzzle", which has attracted so much discussion in the literature in the late 1990s and early 2000s, is a reasonable outcome and should be expected to occur when money enters nonseparably in the utility of the agents. Second, monetary policy appears to be more accommodative in response to technology shocks when money is allowed to play a role. This is in part due to the strong procyclical reaction of real balances, a reaction which fails to materialize when

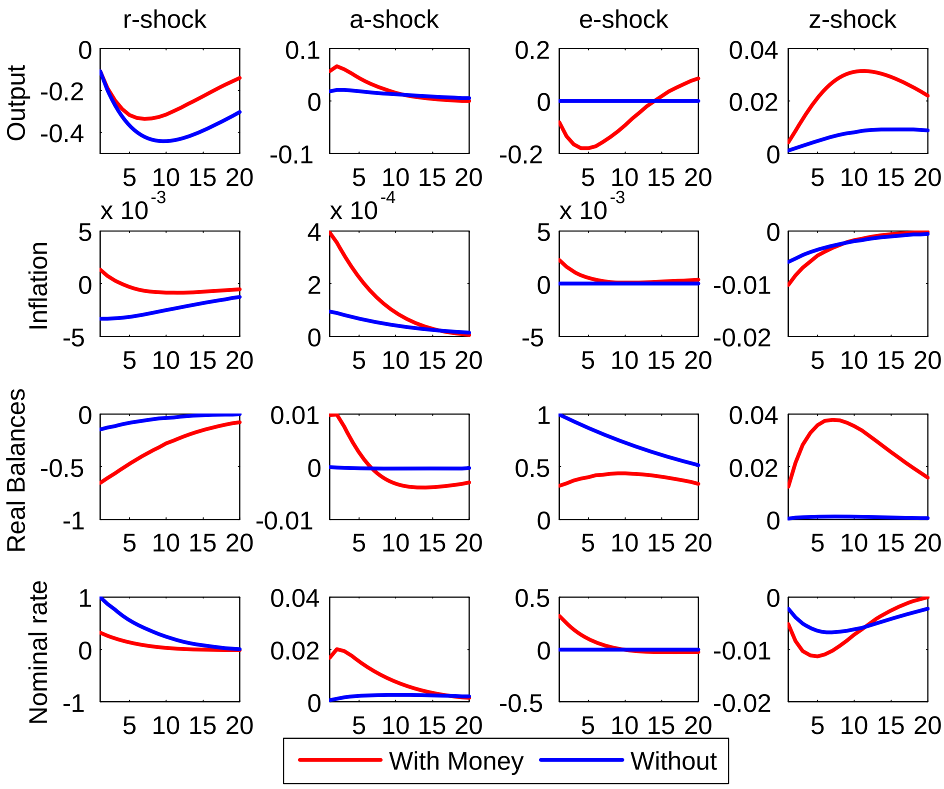

Figure 2: Responses to shocks US, 1959-1979

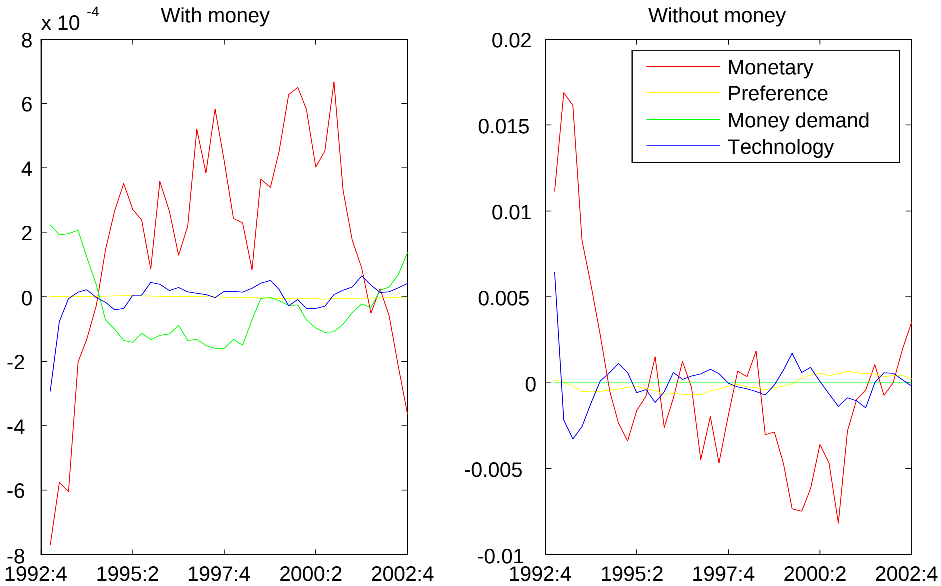

Figure 3: One step ahead historical decomposition of EU inflation

money is not allowed to matter. Interestingly, one important feature of figure 3 is not affected by the role given to money: inflation in the 1970s is not a monetary phenomena. Technology shocks, in fact, dominate the forecast error variance of inflation at the 5 year horizon for both specifications (they explain 95 percent of the forecast error variance when money matters and 97 percent when money does not matter). Since the contribution of money demand or policy shocks to the forecast error variance of inflation is negligible, nominal factors have little importance in explaining the large increase in inflation experienced during this period.

To further examine the distortions induced by the standard practice of not allowing money to play a role in a structural model, we have computed a historical decomposition of EU inflation and examined which factors have contributed most to the fall of the average inflation rate observed after the implementation of the Maastricht treaty. To do this, we have estimated the model with data up to 1992:4 and computed the sequence of one-step ahead forecast errors for the next 10 years using the Kalman filter. These errors are then decomposed into the component attributable to each of the four structural shocks. Figure 3 plots the time path of these forecast errors due to each structural shock, when money has a role and when it does not have one.

Clearly, the two panels give a very different interpretation of the experience. First, notice that the scale of the graphs is different and the model without money attributes to forecast errors the bulk of the fall. In the model where money plays a role, instead, most of the decline appears to be predictable with the information available at 1992:4. Second, the relative importance of various shocks is altered. In a model where money does not matter, monetary policy shocks are mainly responsible for the fall in inflation and a sequence of restrictive monetary policy shocks would have driven inflation into negative territory in the first few years after the creation of the ECB, had not other shocks positively contributed. In a model where money matters, the contribution of monetary shocks is negative up to the beginning of 1994; positive throughout the rest of the 1990s and negative after the second quarter of 2001 and the fall in inflation is, in part, due to a fall in the contribution of money demand shocks. With the information the model provides, it is hard to say which representation of the evidence is more appropriate. We believe that the consequences of the Maastricht treaty were somewhat predictable. Furthermore, when money is important but it is neglected from the model, one-step ahead forecast errors should have larger variability - which indeed they have - and should be, in part, predictable using real balances - and, again, they are. Hence, we believe the evidence produced in a model where money plays a role is genuinely more appealing.

Finally, we want to see to what extent a specification where money plays a role is better endowed than a specification where money has no role in interpreting the time profile of output and inflation volatility and persistence observed over the last 40 years. As mentioned in section 2.1, variations in ω_2 and ρ_m do affect these unconditional moments. In the UK, changes in the point estimates of these two parameters over the two subsamples are statistically significant and go in the direction of making volatility and persistence fall. In table 3 we therefore quantify the importance of these changes for UK output and inflation volatility and persistence and compare outcomes with those obtained when money does not matter.

When analyzing how certain features of the model affect important functions of the data, it is typical to conduct counterfactuals where, for example, part of the parameters are changed and others are kept fixed at some values. Such a procedure is meaningful when calibration exercises are conducted and parameter selection is based on univariate information, but it is clearly inappropriate when parameters are jointly estimated with system-wide methods. There is in fact a correlation structure among estimates and if

		Output		Inflation	
Specification	Sample	Volatility	Persistence	Volatility	Persistence
With Money	Sample 1	0.146	0.998	0.023	0.986
	Sample 2	0.009	0.962	0.002	0.439
Without Money	Sample 1	0.270	0.998	0.028	0.990
	Sample 2	0.008	0.956	0.002	0.489

Table 3: Volatility is measured by the standard deviation of the variables computed using the solution of the model at the parameter estimates. Sample 1 goes from 1965:1 to 1992:4 and sample 2 from 1993:1-2008:2

some parameters are changed, the remaining parameters must be adjusted using the estimated covariance matrix and standard (asymptotically normal) rules to construct conditional estimates from joint ones. While this latter type of exercise is feasible in our context, it is much easier to directly compare the outcomes when all parameters are unrestrictedly estimated with those obtained when both ω_2 and ρ_m are set to zero, since the other structural parameters are automatically adjusted in the latter case.

Table 3 indicates that our model captures both the decline in the volatility of output and inflation and in the persistence of inflation across the two subsamples and that it does so leaving the structural parameters of the model other than ω_2 and ρ_m and ρ_π roughly unchanged. Thus, it is the decline in the importance of money which mainly accounts for the variations in the unconditional moments of output and inflation.

A model where money does not play any role is also able to capture these variations. Interestingly, apart from the volatility of output, the values we obtain in the two specifications are roughly similar. However, to be able to do this in the first subsample, the model where money has no role needs to considerably increase the standard deviation of the preference shock (from 0.15 to 0.96), decrease the policy parameter on output (from 0.66 to 0.18) and increase the policy parameter on inflation from (1.37 to 3.26). Since money matters in the first sample, there are important omitted variables in this specification. Therefore, the volatility of the preference shock adjusts to capture the effect of real balances and the coefficient on inflation in the policy rule increases to proxy for the missing effect of nominal balances. The importance of money wanes in the second subsample. Thus, a model where money has no role captures the fall in the volatility and persistence with a 10 fold decline in the standard deviation of the preference shock. In other words, the model where money plays no role tells us that it is "good luck" which drives the changes; the model we use instead, suggests that changes in the role of money are responsible for the phenomena.

6 Conclusions

This paper examines the role that money has in shaping monetary business cycles. We study three main questions. First, we want to know whether money helps to transmit cyclical fluctuations to domestic output and inflation in the US, Japan, the Euro area and the UK and whether we can safely neglect money when studying domestic business cycles and designing monetary policy rules. Second, we want to measure whether the importance of money has changed over time. Since advanced economies have displayed important changes over the last thirty years and one (Japan) has experienced an unprecedented deflation spiral, coupled with a prolonged output stagnation, we find it important to study whether money is related to these events or not. Third, we want to examine whether the cross country evidence on the role of money is homogeneous and, if not, whether policies, institutions or idiosyncratic features explain the differences.

We employ a small scale New-Keynesian model and estimate its parameters using a maximum likelihood technique. We find likelihood based techniques preferable to GMM and similar methods because they take into account the whole system of equations in the estimation and provide a natural framework to test restrictions on the specification we employ. We refrain from using a-priori restrictions on the parameter space to make the information content of the data and its ability to distinguish theoretical specifications we propose as alternative, as transparent as possible.

We find that, in all countries but Japan, money matters for cyclical fluctuations in output and inflation. The role of money is roughly unchanged over time in the US and the Euro area, while money was statistically important in the UK only before inflation targeting was introduced. When money matters, it typically matters both directly, through its effects on the Euler equation and the Phillips curve, and indirectly, through its effects on the nominal interest rate. Money is important because it alters both the marginal rate of substitution between consumption and leisure and the intertemporal rate of substitution of consumption at different points and because, when reacting to nominal balances, the monetary authority indirectly reacts to inflation. Both channels represent an important and up to now neglected mechanism which may amplify cyclical fluctuations and stretch their persistence over time.

The importance of money as a vehicle to propagate cyclical fluctuations differs across countries, but the differences relate more to the significance of the estimates than to their magnitude. Since the model fits equally well the data of different countries, and since the distribution from which shocks are drawn has important idiosyncratic features, government policies or institutional changes have little role in explaining the cross country evidence. To our surprise, money has nothing to do with the events occurred in Japan over the last 15 years and the recent emphasis that the Bank of Japan has given to monetary aggregates as tools to escape deflation (see e.g. Ito and Mishkin (2004)), has not yet materialized in the data we have available.

We show that neglecting the importance that monetary aggregates have in explaining output and inflation fluctuations creates inferential mistakes, not only when trying to interpret phenomena like the "Great Inflation" of the 1970s and the slow return to the norm but also current events. In fact, important conclusions about the sources of cyclical fluctuations in output and the interpretation of inflation responses to monetary shocks in the US; the reasons behind the large decline in the inflation rate in the Euro area; and the role of money in accounting for the time profile of output and inflation dynamics in the UK are different when money is allowed to have a role.

While the general lesson to be learned from our investigation is therefore simple - money matters both statistically and in an interesting economic sense - several caveats needs to be mentioned. First, the model we have used to interpret the data is highly stylized and, as we have mentioned, it is possible that money turns out to be important because it proxies for other important omitted influences, such as those due to exchange rates or asset prices. We do not have much experience with larger and less stylized models to confidently embrace one conclusion or the other. As far as we know, in larger scale DSGE models the role of money becomes more transparent and generally stronger (see e.g. Christiano et. al. (2008) or Gerali et. al (2008)). Second, the evidence we have provided concerns only four countries, all of which are large in the world economy. It is therefore possible that in smaller economies or in economies which are still on a development path, conclusions will be different. While it is clear that for these situations the model we use is inappropriate, we find it hard to believe that the mechanisms we emphasize on the utility of the agents and on the policy rule will be vastly different in these countries. Finally, while we have stressed that certain conclusions crucially depend on giving money a proper role in the economy, others are not influenced by this feature. We have mentioned that the Great inflation period of the 1970s in the US is largely attributable to technology shocks, regardless of whether money matters or not. The result that the structural parameters regulating private sector behavior, such as the cost of adjusting prices or the habit persistence parameter, change over time is also independent of whether money plays a role or not.

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