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Money Demand in the euro area, the US and the UK: Assessing the Role of Nonlinearity

Fredj Jawadi[*]　　　　Ricardo M. Sousa[$]

Abstract

This paper estimates money demand equations for the euro area, the US and the UK using three different econometric methodologies: (i) a linear model based on a dynamic ordinary least squares (DOLS); (ii) a nonlinear technique based on a quantile regression framework; and (iii) a nonlinear model relying on a smooth-transition regression. The linear model shows that the elasticity of money demand with respect to income is positive and large in magnitude, while the elasticity of money demand with respect to the interest rate is negative and generally small. The quantile regression technique highlights that: (i) the income and the interest rate semi-elasticities are significantly different from the OLS estimates at the tails of the distribution of real money holdings; and (ii) the sensitivity of money demand with respect to inflation tends to be larger when real money holdings are extremely low. Finally, the smooth transition model provides two interesting findings. On the one hand, they capture reasonably well the dynamics of the money demand function. On the other hand, they show that the elasticity of money demand with respect to inflation rate, interest rate and GDP varies not only in accordance with the regime considered, but also across the countries under consideration.

Keywords: money demand, dynamic OLS, smooth transition, quantile regression.
JEL classification: C2, E21, E44, D12.

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1. Introduction

The role of money for the purpose of achieving medium-to-long term price stability in major central banks such as the European Central Bank (ECB), the Fed Reserve Board (Fed) or the Bank of England (BoE) is not the same. In fact, while the ECB uses M_3 as an indicator of inflationary risks and has an explicit target for inflation, the Fed and the BoE focus on M_2 and M_4, respectively, and, despite following an inflation-targeting strategy, they do not have such explicit figure for what price stability means.

However, the developments in money markets, in particular, over the most recent financial turmoil have highlighted that in order to understand the importance of money in the conduct of central banks' policy, one needs to pay a special attention to the dynamics of the money demand.[1] Indeed, although the transmission of monetary policy to real variables such as output and employment operates via the impact on asset prices, firms' balance sheets, interest rates and exchange rates (Rafiq and Mallick, 2008; Granville and Mallick, 2009; Mallick and Moshin, 2010; Castro, 2010, 2011), the knowledge about the money demand function is crucial, as it helps uncovering risks to long-term price stability.[2]

In the literature, authors have used different econometric techniques to estimate the money demand function in the euro area, the US and the UK, but the existing works typically share a common feature: the money demand displays a linear relationship between real money balances, real GDP and nominal interest rate.[3] Indeed, linear models embodying single equations approaches or error-correction methods are the most commonly used macroeconometric tool for modeling money demand (Sriram, 1999; Duca and van Hoose, 2004). Their relevance relies on a combination of a description of the long-run (linear) equilibrium money demand function and a specification of the short-term (linear) dynamics that allows for the correction of disequilibria.

[1] For an assessment of the relevance of money supply, see Barnett (2008). In the same context, Arouri et al. (2012) provide a (nonlinear) perspective of the linkages between international monetary markets.
[2] Interestingly, Barnett and Chauvet (2011) highlight that better monetary statistics would have provided a good signal for the recent financial crisis. Additionally, Jawadi (2012) presents a time-varying methodology to assess the relationship between the macroeconomy and the dynamics of financial markets.
[3] For euro area, see, for instance, Fase and Winder (1999), Funke (2001), Golinelli and Pastorello (2002) and Hall et al. (2008, 2012); for the US, see Goldfeld (1973), Jain and Moon (1994), Butkiewicz and McConnell (1995) and Ireland (2009); and, for the UK, see Brigden and Mizen (2004) and Chrystal and Mizen (2005a, 2005b).

However, this framework may not be effective if the relationship between the goal of the policy (price stability) and the targeted monetary aggregate varies over time. Similarly, there are a number of good reasons implying that accounting for nonlinearity and regime dependency may provide a better assessment of the dynamics of the behavior of money demand. First, developments in the banking sector and the financial system may play an important role, thereby, reflecting the demand of money as part of a portfolio of assets and the possible impact of financial innovation. Second, in the presence of adjustment costs, agent may find it optimal to adjust their asset holdings only gradually. As a result, buffer stock or target-threshold models may be better at characterizing agents' desire to hold money. Additionally, asymmetry and nonlinearity in the money demand function may be justified for various reasons. For instance, an increase in the elasticity between money and income can be the natural consequence of a slowdown in money velocity due to the monetization process. Moreover, the fall in interest rate and the relatively high level of inflation observed in recent times can be a source of discontinuity and nonlinearity in the dynamics of money demand. Furthermore, the implementation of various measures of unconventional monetary policy such as quantitative easing may affect the structure of money demand.

Therefore, some authors have started to assess the existence of nonlinearity in the short-run dynamics of monetary demand. Lütkepohl et al. (1999), Teräsvirta and Eliasson (2001), Khadaroo (2003) and Sarno et al. (2003) model such nonlinearities for various European countries and the US, while Delatte and Fouquau (2009) provide evidence for China. This has been typically done by using regime-dependent models, such as smooth-transition regressions or Markov switching error-correction models. That is, the approaches are based on a stable long-run money demand function and the nonlinearity is assessed in terms of the adjustment of the residuals of the error-correction models.[4]

In the current paper, we estimate the long-run money demand equation by making use of three different econometric methodologies: 1) a linear model based on a dynamic ordinary least squares (DOLS) estimation; and 2) two nonlinear frameworks (i.e. a quantile regression and a smooth transition (STR) model). This is particularly interesting as it enables us to capture different paths for the money demand and its interactions with output, interest rate and inflation rate through various specifications. In

[4] Barnett et al. (2009a, 2009b) investigate the issue of measurement error in monetary aggregates using nonlinear approaches.

addition, it allows us to specify the type of nonlinearity that is inherent to the function of money demand, in particular, in the case of the STR model. As a result, this piece of research defines a comprehensive and exhaustive linear and nonlinear analysis of the behaviour of money demand function in the three abovementioned market economies.

Furthermore, while previous studies focus on modeling money demand for particular area or country, our study is distinguished by estimating money demand functions for three important regions: the euro area, the US and the UK. This, in turn, enables us to investigate different money demand functions in these three benchmark economies and provides another important adding value to the existing literature.

Overall, the linear model shows that elasticity of money demand with respect to income is positive and large in magnitude (in particular, for the UK) and negative and generally small for the interest rate. In what concerns the inflation elasticity, it is also small and: (i) negative for the euro area and the UK; and (ii) positive for the US.

As for the quantile regression technique, it shows that, for the euro area, the income semi-elasticity tends to be lower at the left tail of the distribution of money demand, while the interest rate semi-elasticity is smaller in magnitude at the right tail of the distribution of money demand. In what concerns the elasticity with respect to inflation, it is typically smaller for the lowest quantiles of the distribution of money demand. A much stronger nonlinearity in the money demand function can be found for the US and the UK. More specifically: (i) the income and the interest rate semi-elasticities are significantly different from the OLS estimates at the tails of the distribution of real money holdings; and (ii) the sensitivity of money demand with respect to inflation tends to be larger when real money holdings are extremely low. The results also highlight that the OLS regression can be a reasonably good way of describing the money demand function during “normal” times, but completely looses track of the link between real money holdings, income, interest rate and inflation during “extreme” periods. Such conclusion is confirmed by the STR modelling as our findings show that the money demand elasticities vary according to the regime considered and the relationship between money demand and output, interest rate and inflation rate exhibits asymmetry and nonlinearity.

What is the economic intuition for these findings? The quantitative theory of money suggests that both money velocity and nominal GDP rise in booms and fall during recessions. By compensating each other, these forces have an ambiguous impact on real money holdings. As for the real business cycle (RBC) model, it argues that money responds endogenously to the cycle, rising during booms and falling at times of recession. Our findings show that money demand is less responsive to income at the left tail of the distribution (i.e. when real money holdings are extremely lows) and more sensitive to income at the right tail of the distribution (i.e. when real money holding are very large). This evidence is also corroborated by the STR model, which suggests that the elasticity of money demand with respect to income substantially changes according to the regime considered. Therefore, the evidence seems to give support to the implications of the RBC model. Alternatively and in the context of the quantitative theory of money, the effect of the increase nominal GDP on real money holdings more than compensates for the effect of the fall in velocity.

The rest of the paper is organized as follows. Section 2 presents the econometric methodology, Section 3 describes the data and discusses the main results. Section 4 concludes.

2. Estimation methodology

2.1. A linear framework: the Dynamic Ordinary Least Squares (DOLS)

The money demand function is typically estimated in accordance with the work of Stock and Watson (1993) and, therefore, using the dynamic ordinary least squares (DOLS) technique,[5] one can specify the following equation

$$m_t^d = c + \beta_y y_t + \beta_i i_t + \sum_{i=-k}^{k} \Delta y_{t+i} + \sum_{i=-k}^{k} \Delta i_{t+i} + \varepsilon_t, \quad (1)$$

where m_t^d is the demand for real balances, y_t denotes real GDP, i_t is the nominal opportunity cost of holding money which is proxied by the central bank rate, Δ denotes the first difference operator, c is a constant and ε_t is the error term. The parameters of interest, β_y and β_i, represent, respectively, the long-run output and interest semi-elasticities of money demand, and, from a theoretical point of view, they are expected to be positive and negative, respectively. The terms $\sum_{i=-k}^{k} \Delta y_{t+i}$ and $\sum_{i=-k}^{k} \Delta i_{t+i}$ correspond to the sum of the leads and lags of the first differences of the regressors and are included in the model to correct for endogeneity.

[5] This is close in spirit to the estimation of consumption functions. See, for instance, Davidson and Hendry (1981) and Blinder and Deaton (1985).

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