# EMPIRICAL EVIDENCE FOR A MONEY DEMAND FUNCTION: A PANEL DATA ANALYSIS OF 27 COUNTRIES 1988-98.

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***Abstract***
The purpose of this paper is to estimate the money demand function of Cagan (1956) using a panel data set covering 27 countries with different economic levels over the period 1988-98. The static and dynamic fixed effects reveal that a money demand equation exists. However, in contrast to the theory proposed by Cagan, estimates of the output elasticity of money demand are in the range from 0.18 to 0.20.

*Keywords:* Money demand, Inflation, Panel data, Dynamic fixed effects
*JEL Classification:* C23 – C52 – E41

## 1. Introduction

Inflation has been the focus of attention of a lot of relevant essays in the economic literature. The analysis of the Money Demand Functions (MDF) is one of the most used approach to examine it. Recent studies analyze the properties of several MDF in different countries. Lütkepohl and Wolters (1998) or Beyer (1998) investigated whether the MDF would remain stable despite the German unification. Dekle and Pradhan (1999) studied the case of some Asian emergent countries, while Torsen (2002) focused his research on developing countries as, for example, Mongolia. Therefore, the analysis of the MDF is an important subject of investigation for both, academic researchers and policy makers. Most of these previous works and recently others like, e.g., Brand and Cassola (2004) or Nielsen (2004), use time series (usually ARMA or VAR) or cross section data procedures in their analyses

The purpose of this paper is to estimate the MDF proposed by Cagan (1956). However, instead of applying usual analysis with data from one country, we use a panel data model covering 27 countries with marked economic differences. Starting from these estimates, a check of the theory is made. In the second part of this paper, we include some lagged variables in the model by performing the fitting, so we study the MDF in a dynamic context. Particular panel data techniques are briefly shown for these aims.

The research is structured as follows. Firstly, we present the MDF theory proposed by Cagan (1956) that originates the main equation of our investigation. Subsequently, we introduce the econometric framework regarding panel data for both, static and dynamic

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models. In Section 3, after a short introduction of the data set employed, we examine the estimation outcomes. Finally, Section 4 discusses previous results and summarizes the basic conclusions.

## 2.The Theoretical Model:

From a conceptual point of view, standard theories of money demand postulate that real money is related to the nominal interest rates, $i$, and the production output, $Y$. Defining the general equation of money demand as $L(i,Y)$, the equilibrium condition for the monetary market is:

$$\frac{M}{P} = L(i,Y) \qquad (1)$$

where $M$ is the money stock and $P$ is the price level. Also, we assume that the function $L(i,Y)$ is decreasing in $i$ and increasing in $Y$.

On the other hand, the Fisher Identity relates the spread between real ($r$) and nominal interest rates ($i$) to the level of future inflation ($p^e$), such as $i = r + p^e$. Whether we are interested in calculating government returns obtained via money creation, hereafter $M$, this would have to be interpreted as the monetary base and $L(i,Y)$ as the monetary-base demand. Looking at this from the point of view of the equilibrium we have that,

$$\frac{M}{P} = L\left(\overline{r} + g_m, \overline{Y}\right) \qquad (2)$$

where $g_m$ is the monetary growth rate which can be defined as:

$$g_m = \frac{\dot{M}}{M} \qquad (3)$$

Ignoring, for simplicity, the growth rate of the product, the real values will remain constant in the static situation. This implies that inflation would be the same as the monetary growth rate.

Thus, the MDF proposed by Cagan (1956) is a good example of the relation between inflation and what it is known as the *seigniorage* equilibrium (see, e.g., Özmen, 1998 or Selcuk, 2001). Specially in an inflation context, it is a useful money demand description that can be expressed mathematically as,

$$\ln\frac{M}{P} = a - bi + \ln y \qquad (4)$$

## 3. Panel Data Econometric Models:

*3.1 The Static Model*

A widespread representation of the panel data models assumes that discrepancies across units can be captured in differences in the constant term. These kinds of models are usually named *fixed effects* models and can be written as,

$$y_{i,t} = a_i + b^T x_{i,t} + u_{i,t} \tag{5}$$

where $y_{i,t}$ is the observable output, $x_{i,t}$ is a $k$-regressor vector and $u_{i,t}$ is a random error such that: $E\left[u_i\right] = 0$, $E\left[u_i^T u_i\right] = s_u^2 I_T$ and $E\left[u_i^T u_j\right] = 0$ (for all $i \neq j$)

Equation (5) may be interpreted as a classical regression model and can be estimated by ordinary least squares. One may obtain estimates of $b$ in (5) in three possible ways:

*Pool estimation*

$$\hat{b}_t = \left[S_{xx}^t\right]^{-1}\left[S_{xy}^t\right] \tag{6}$$

*Within estimation*

$$\hat{b}_t = \left[S_{xx}^w\right]^{-1}\left[S_{xy}^w\right] \tag{7}$$

*Between estimation*

$$\hat{b}_t = \left[S_{xx}^b\right]^{-1}\left[S_{xy}^b\right] \tag{8}$$

where $S_{xx}^t$, $S_{xy}^t$, $S_{xx}^w$, $S_{xy}^w$, $S_{xx}^b$ and $S_{xy}^b$ are the matrices of sum-of-squares and cross-products and are suitably defined in Appendix A.

*3.2 The Dynamic Model*

To include dynamic effects, we decide to introduce some lagged (endogenous and exogenous) variables into the equation (5). Thus, the new model can be expressed as,

$$y_{i,t} = \sum_{k=1}^{p} g\, y_{i,t-k} + b^T\left(L\right) x_{i,t} + l_t + a_i + n_{i,t} \tag{9}$$

where $l_t$ and $a_i$ are specific temporary and individual effects, respectively, and $x_{it}$ is the regressor vector. Furthermore, $b^T\left(L\right)$ is a polinomial vector that includes the backshift operator *L*.

Usually, in these cases, the time series size of each individual $(T_i)$ is short but the number of individual $(N)$ is large. Here, for simplicity, we present the equation for the *i* individual that can be written as follows:

$$y_t = W_t d + u_t h_t + n_t \tag{10}$$

where $d$ is a parameter vector to be estimated (which comprehends $a_k$, $b$ and $l$ ), $W_t$ is a matrix containing data (lagged endogenous, exogenous and dummy variables) and $u_t$ is an all-ones $T_i \times 1$ vector.

The estimates are calculated using a class of so-called Generalized Methods of the Moments (GMM for short):

$$\hat{d} = \left[\left(\sum_t W_t^{*T} Z_t\right) A_N \left(\sum_t Z_t^T W_t^*\right)\right]^{-1} \left(\sum_t W_t^{*T} Z_t\right) A_N \left(\sum_t W_t^{*T} y_t^*\right) \tag{11}$$

where

$$A_N = \left(\frac{1}{N} \sum_t Z_t^T H_t Z_t\right)^{-1} \tag{12}$$

In equation (11), $W_t^*$ and $y_t^*$ denote some transformation of $W_t$ and $y_t$, respectively, such as levels, first differences, orthogonal deviations, etc. Moreover, $Z_t$ is an instrumental variable matrix and $H_t$ is an individual weight matrix. When the number of columns of $Z_t$ is the same as $W_t^*$, then $A_N$ is irrelevant and $\hat{d}$ simplifies to:

$$\hat{d} = \left(\sum_t Z_t^T W_t^*\right)^{-1} \left(\sum_t Z_t^{*T} y_t^*\right) \tag{13}$$

## 4. Empirical Analysis

In this section we analyze the MDF proposed by Cagan (1956) keeping in mind the negative influence of the nominal interest rate and the unit value of the coefficient that multiplies the production output. In a second stage, taking into account the previous model, we introduce lagged variables in order to study the dynamic of the MDF. We use the panel data tools mentioned above, with a sample of 27 countries and eleven years (since 1988 until 1998), for this purpose. The countries included in the sample are depicted in Table 1. They make up a non-equilibrated panel. Also, variables and data transformations used in the model estimation are defined in Table 2.

Table 1: Countries selected for the analysis

| | | |
|---|---|---|
| Egypt | South Korea | Spain |
| Morocco | The Philippines | France |
| South Africa | Indonesia | Greece |
| Argentina | Japan | Holland |
| Canada | Pakistan | Italy |
| Colombia | Thailand | Portugal |
| USA | Germany | UK |
| Mexico | Australia | Turkey |
| Venezuela | New Zealand | Belgium |

Table 2: Original and Transformed Variables

| | |
|---|---|
| $M_1$ | : Monetary Base, in billions of local currency units. |
| $Y$ | : GDP measured in prices of 1990, in billions. |
| $IPC$ | : Consumer Price Index (base 1990). |
| $TC$ | : Value of the U.S. Dollar in local currency. |
| $i^*$ | : Nominal interest rates (*). |
| | Data transformations: $\frac{m}{p} = \ln\left[\frac{M_1}{IPC}\right]$ $\quad y = \ln\left[\frac{Y}{TC}\right]$ |

Source: National Institute of Statistics except (*), from the International Monetary Found.

### *4.1 Econometric Specification and Estimation*

The fixed-effect model specified for the MDF for the whole panel is as follows,

$$\left[\frac{m}{p}\right]_{i,t} = a_i + b_1 i_{i,t} + b_2 y_{i,t} + e_{i,t} \tag{14}$$

We estimate equation (14), as starting point, by *pool, between* and *within* procedures shown in Section 3.1. However, we only find consistency with the theory in the last case. This is not completely unexpected. Indeed, the fixed-effects model become coherent *a priori* since there are remarkable differences between many countries used in the analysis. Thereby this fact lead us to work with the *within* fixed-effect model in the static regression. The outcomes obtained by fitting this model are presented in Table 3.

Table 3: Outcomes for the static Fixed-Effects model

| Coefficients | Estimates | t-Statistic | Statistics | |
|---|---|---|---|---|
| $\hat{b}_1$ | -0.004 | 2.9 | $R^2$ | 0.97 |
| $\hat{b}_2$ | 0.180 | 6.8 | DW* | 1.73 |

This Table show that, the Cagan's equation of the MDF is partly validated by the sign of the coefficients. In fact, as in the theory previously described, the real balance demand is decreasing in the nominal interest rate and increasing in the income. Notice, also, that parameters related to both variables are statistically significant. Nevertheless, the coefficient that multiplies the income, $\hat{b}_2$ (known as the income elasticity of the demand), is not equal to one. Further, the null hypothesis $H_0 : b_2 = 1$ is clearly rejected. So, the model predicts that the money demand is affected by the income less than proportionally. This may be caused by the considerable differences between the analyzed countries.

*4.2 The MDF Dynamic Dependence*

Starting from the static relation proposed by Cagan (1956), we introduce dynamic components in the model allowing the existence of lags of endogenous and exogenous variables in the right side of the equation (14).

After carry out some different estimations using the techniques introduced in Section 3.2, we obtain a dynamic model specification that fits reasonably well to the data set. The model representation is as follows:

$$\left[\frac{m}{p}\right]_{i,t} = a_i + b_1 i_{i,t} + b_2 y_{i,t} + b_3 \left[\frac{m}{p}\right]_{i,t-1} + b_4 i_{i,t-1} + e_{i,t} \qquad (15)$$

Equation (15) contains the previous components and also the real balance, $\left[\frac{m}{p}\right]_{i,t-1}$ and the nominal interest rate, $i_{i,t-1}$ , both lagged one period. Any other attempt to introduce another kind of dynamic in the model did not give good results. The final outcomes of the dynamic estimation are shown in Table 4.

Table 4 shows that the coefficients $\hat{b}_1$ and $\hat{b}_2$, that remain from equation (14), do not vary a lot in this new estimation. Moreover, parameters related to the past of both, the real balance and the nominal interest rate, are statistically significant. On the other hand, notice that the negative influence of the one-period lagged interest rate over the money demand is bigger than the contemporaneous influence. This may be explained by the possible existence of a time lag in the composition of asset portfolios.

* The Durbin–Watson statistic value.

Table 4: Outcomes for the dynamic Fixed Effects model

| Coefficients | $\hat{b}_1$ | $\hat{b}_2$ | $\hat{b}_3$ | $\hat{b}_4$ |
|---|---|---|---|---|
| Estimates | -0.005 | 0.202 | 0.573 | -0.017 |
| t-Statistic | 1.7 | 2.0 | 6.1 | 4.2 |
| F –Wald Statistic | | 91.9 | | |
| First order autocorrelation | | -0.064 | | |
| Second order autocorrelation | | -3.610 | | |

## 5. Conclusion

This article presents an empirical analysis of a monetary demand function. Firstly, an estimation of the specific monetary demand function established by Cagan (1956) with panel data techniques is made, testing the theory suggested by the author. The results obtained from this estimation agree in sign with Cagan's theory, since it is observed that the estimated parameters for both, the interest rate coefficient and the income coefficient are negative and positive respectively. However, their magnitudes do not seem to correspond with the expected values. Concretely, the income elasticity of money demand is 0.18, lower than the value suggested by the theory.

In a second stage, motivated by previous results, we improve the model-fitting by introducing dynamic terms. The new model indicates that the money demand depends on its past and the near past of the interest rate. Nevertheless, we find no relation between money demand and income lags.

It is important to emphasize that the possibility to introduce dynamics in these kinds of models not only improves the fit, but also increases the operational capacity of monetary policy. Therefore, the analysis of these models with panel data techniques seems relevant not just in the international aspect, but also in a group of countries with a common monetary policy, such as countries that belong to the European Monetary Union (EMU).

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*Appendix A*

The matrices of sum-of-squares and cross-products are defined as follows:

$$S_{xx}^{t} = \sum_{i=1}^{n}\sum_{t=1}^{T}(x_{it}-\overline{x})(x_{it}-\overline{x})^{T}$$

$$S_{xy}^{t} = \sum_{i=1}^{n}\sum_{t=1}^{T}(x_{it}-\overline{x})(y_{it}-\overline{y})^{T}$$

$$S_{xx}^{w} = \sum_{i=1}^{n}\sum_{t=1}^{T}(x_{it}-\overline{x_{i}})(x_{it}-\overline{x_{i}})^{T}$$

$$S_{xy}^{w} = \sum_{i=1}^{n}\sum_{t=1}^{T}(x_{it}-\overline{x_{i}})(y_{it}-\overline{y_{i}})^{T}$$

$$S_{xx}^{b} = \sum_{i=1}^{n}T\,(x_{it}-\overline{x})(x_{it}-\overline{x})^{T}$$

$$S_{xy}^{b} = \sum_{i=1}^{n}T\,(x_{it}-\overline{x})(y_{it}-\overline{y})^{T}$$