Corporate Liquidity Demand in the US: Evidence from Panel Data*

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Abstract

In this paper we estimate the demand for liquidity by US business firms using COMPUSTAT database. In contrast to the previous literature, we consider firm-specific effects, such as cost-of-capital and wages. From the balanced and unbalanced panel estimations we infer that there are economies of scale in money demand by US business firms, because estimated sales elasticities are smaller than unity. In particular, they are lower than in previous papers, suggesting that economies of scales in the demand for money are even bigger than formerly thought. In addition, it emerges that labor is not a substitute for money.

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1 Introduction

Since the seminal work by Keynes (1936) the focus of the empirical investigations on the properties of money demand has shifted from the aggregate to the individual level.

The keynesian approach to the demand for money distinguishes according to three different motives: economic agents hold cash either for transaction or for precautionary purposes on one side, while on the other they can demand money for speculative reasons. The models that are used to explain the demand for money and other liquid assets held by firms are: (i) transactions, (ii) wealth, and (iii) portfolio balance. In the transaction approach one considers the interest rates paid on alternative liquid assets and the transaction costs related to the management and exchange of these assets, as well as assumptions on the possible time patterns of receipts and payments, to arrive to the theoretical conclusion that cash balances should increase less than proportionately with transactions. The wealth model, instead, lies upon the assumption that business firms will distribute their total assets among various categories by equating their marginal rates of return. The portfolio balance view explicitly adds the risk factor, as firms should balance risk and rate of return. In practice, the firm must compare the interest rate earned on government securities with the risk of not holding money, that is the possibility of forced liquidation of some assets with sure capital losses.

The aim of this paper is to shed some light on the mechanism that governs the demand for money by business firms. This can be helpful in understanding and explaining the patterns of money velocity or in predicting inflation and interest rates. A quantitative determination of the demand for money by the agents in the economy, might be crucial to assess the impact of monetary policies on the most relevant macroeconomic variables. At a micro level, instead, a quantitative assessment of the demand for money by firms can be important for financial intermediaries.

The main contribution of the paper is twofold: from a theoretical point of view we organize the previous models of money demand by firms in such a way to incorporate the typical heterogeneity that characterizes firms. Actually, firms may exhibit different organizational structures or industry specific aspects that can affect cash holdings and therefore must be taken into account. On the empirical side, we analyze firms' money demand using balanced and unbalanced panel data with firm-specific effects.

In the previous literature many studies only focus on aggregate data rather than individual data, and sometimes they do not distinguish among different sectors. Many other papers just concentrate on cross-sections and very few highlight the importance of the dynamics, by using panel data. Another problem of most of the previous works is the usual assumption of constant cost-of-capital across firms, which is highly inconsistent with the theory of finance, for which the cost of borrowing crucially depends on each firm's characteristics.

Therefore, in sharp contrast with the previous literature we use firm-specific effects for all the variables that are assumed to affect cash holdings by corporations. Using COMPUSTAT database, we select data on firms in the Manufacturing and in the Wholesale and Retailing industries to then estimate the demand for liquidity only by firms belonging to such sectors. Very few papers in the previous literature consider different sectors, and many authors just analyze the whole sample of firms that, nevertheless, can give misleading results, since firms in different industries are subject to different rules and accounting procedures. To get more robust estimates, we compare different panel data estimators, while, to our knowledge, so far in the literature only Fixed Effects have been considered. The results suggest that there are economies of scale in the demand for money by the US business firms that are even stronger than formerly thought. Actually, the estimated sales elasticities we find (which are between 0.5 and 0.7) are quite lower than those usually found in the previous literature (between 0.8 and 0.9).

The paper is organized as follows: in Section 2 some previous empirical studies about the liquidity demand are reviewed. In Section 3 our model specification, in a Baumol-Tobin spirit, is described, while in Section 4 the econometric specification is discussed. In Section 5 a description of the data used is given, while in the subsequent Section 6 the empirical results are presented and discussed. Then, in Section 7, some conclusions are drawn.

2 Previous Empirical Studies

Before introducing the theoretical model that will constitute the framework for our empirical analysis, we present a brief review of the previous literature that has dealt with the estimation of the demand for cash and other liquid assets by firms.

One of the first to analyze quantitatively the demand for money is Selden (1961): he studies the postwar velocity of money by sectors. In his study, he uses cross-section data from the IRS (Internal Revenue Service) and finds that the velocity falls as firm size increases. Such a result is due to the ratio of sales relative to the total assets which declines at a faster rate than the ratio of firm's cash. Furthermore, he points out a consistent substitution effect between government securities and cash and other liquid assets. Such effect seems to directly increase with firm size. In his argumentation, Selden emphasizes that the main reason for substituting cash and other assets with government securities is the cost of holding money, which is definitely higher for smaller firms because of the higher cost that they face to raise money.

Frazer (1964) explores the corporate demand for money by using cross-section regression methods. He applies such techniques on quarterly cross-sections from the FTC-SEC Quarterly Financial Report for Manufacturing Corporations for the period 1956-1961. He finds that, whereas cash falls relative to total assets, the corporate liquidity - defined as the ratio of cash and government securities to current liabilities - rises with firm size. In this way he asserts the importance of the precautionary motive for holding money and the possibility of economies of scale. As highlighted by Vogel and Maddala (1967), Frazer's findings are to be interpreted with extreme care, because he doesn't give other possible explanations for firm's behavior and completely ignores the problems of estimating cross-sections in a dynamic context and the bias he introduces by using the ratios.

Meltzer (1963) gives a great contribution on the cross-section investigations of business demand for money, trying to reconciliate the Baumol-Tobin's inventory model and Friedman's (1959) model. His evidence, based on data from 14 industries spanned over 9 years taken from the IRS's Statistics of Income, shows that neither economies nor diseconomies of scale in holding money predominate. Moreover, "...as a first approximation, the data suggest that the cross-section demand for money by firms is a function of sales and is linear in logarithms and unit-elastic".[1]

Whalen (1965) reformulates Meltzer's approach by adding to the regressions the ratio of total assets to sales, in order to allow for differences according to firms' size. He assumes

[1] As pointed out by Maddala and Vogel (1965), there is still an open question with the definition of money as implied in the Baumol-Tobin model.

that, within each industry, at any given time, firms are identical in all respects except for the size of their business operation: the crucial assumption here is that the only factors operating to influence the size of firms' cash balances are the volume of their sales and the amount of their investment portfolios. Using IRS data for the single year[2] 1958-59 he tests a Baumol-Tobin like model and the reformulated Meltzer's model to see if there are economies of scale for business transactions and precautionary cash balances. The results are not conclusive to assert the presence of economies of scale, since it's not possible to separate out the motivation for holding the money for every industry under exam.

Vogel and Maddala (1967) criticize all the previous works because they do not take into account the possibility of cross-section estimates in a dynamic context, as highlighted by Kuh (1959). Kuh (1959) points out the difficulties of using cross-section regressions in a dynamic situation, since the variance of an array of data is attributable both to differences among individuals and to variability over time. Therefore, from his point of view, it is necessary to employ what he calls a 'rectangular data array' (that is a panel data) with observations on the same individuals through time, so that the estimated coefficients from the cross-section part and the time series part, can drive to a better interpretation of the phenomenon under study. Vogel and Maddala (1967) verify the usefulness of all the preceding cross-section analysis for understanding and analyzing the determinants of the demand for cash and liquid assets by manufacturing corporations. They try to test (i) if either a model of wealth or a model of transactions demand better explains the liquid asset holdings; (ii) if there exist economies of scale in the demand for cash by businesses; (iii) if there are patterns of substitution between cash and government security balances; (iv) if interest rates and other variables affect firms' portfolios. They highlight the important statistical issue that makes the previous cross-section analysis a little controversial: in the context of liquidity demand there might be some dynamic factors such as expectations or lagged adjustments that remain completely excluded in a cross-section analysis. The real innovation in their analysis is given by their modern approach, for which they study patterns of variation by industry, by year and by asset size class. Their results confirm Kuh's warnings for which cross-section estimates should be viewed with considerable caution in a dynamic context.

[2] Whalen claims that in a cross-section approach, there is a better control over "extraneous" variables affecting the demand for cash.

Among the various conclusions, Vogel and Maddala (1967) find that it is extremely hard to distinguish between transactions and wealth models for the money demand by corporations. They find substantial economies of scale in the demand for liquid assets by firms and evidence that firms substitute government securities for cash at an increasing rate as their size grows.

Ben-Zion (1974) argues that the cross-section estimates for firms' demand for cash reported in the literature have two main difficulties. First of all, those studies do not use a variable cost-of-capital in their analysis, assuming implicitly that all firms in a given cross-section have the same cost-of-capital. Such an assumption is inconsistent with the theory of finance, for which that cost should depend on each firm's appropriate risk class. Secondly, all those previous studies use data of firms in different industries, rather than data on individual firms. Actually, using data on individual firms enables to find a much more coherent measure of the cost-of-capital, as is typically assumed in the theory of firm valuation, based on the Modigliani and Miller's approach (Modigliani and Miller, 1958 and Miller and Modigliani 1966). Ben-Zion (1974) proposes a simple extension of Baumol's (1952) model, where money also enters into the firm's production function. From his model, Ben-Zion is able to isolate two opposite situations: (i) a case which resembles the classical Baumol solutions (demand elasticities for cash of a half) and (ii) a case in which there are no transaction costs and the demand elasticity with respect to size is unity. Clearly, the general solution falls in between those extreme cases. The substantial contribution by Ben-Zion is to consider as a proxy for the firms' cost-of-capital a function of the earning per share, the price of the corporate share and the long-run growth of the earning per share. With such specification for the cost-of-capital, Ben-Zion estimates, from the COMPUSTAT file for the years 1964 and 1965, money demand elasticities between 0.866 and 0.889, suggesting some economies of scale in holding money. All his coefficients have the predicted sign and show the importance of the concept of cost-of-capital derived by Miller and Modigliani (1966).

Karathanassis and Tzoannos (1977) test the ability of two alternative monetary theories such as the transactions model and the wealth adjustment model in order to explain the demand for money by business firms. They point out the relevance of having micro data instead of aggregate data, since aggregation can lead to inaccurate results. In particular, they emphasize the huge differences in the demand for money among the various industries, by focusing on two different sectors, such as the retailing and distribution industry and the electrical engineering industry. They use data from the U.K. Board of Trade, for the period 1965-72. Their estimation procedure combines the cross-section analysis with the time series data available, in such a way that "...the effects of transitory phenomena on the coefficients will be removed and biases avoided", using an error component model. They find economies of scale in cash holding in electrical engineering industry, but not in the retailing and distribution industry. Moreover, they show how the choice of the statistical methods and the estimation procedures can be crucial for discovering economies of scale, pointing out the necessity of conducing this kind of analysis on a disaggregated basis.

Fujiki and Mulligan (1996) (hereinafter FM) propose a model of demand for money by firms and households: their model is general enough to encompass the "money in production function" approach by Fisher (1974) and the "inventory-like" models proposed by Allais (1947), Baumol (1952), Tobin (1956), Miller and Orr (1966). This framework is very useful to interpret and to compare the various empirical specifications and estimates of individual money demand that can be found in the literature; moreover, due to its peculiar specification, multiple monetary assets are admissible and the degree of financial sophistication can be modeled both as endogenous and exogenous.

In particular, FM define the demand for money in three complementary ways: (i) as a Hicksian or derived demand in the case of firms, (ii) as a Marshallian demand in which money is seen as a function of income and prices if we refer to households, and (iii) as an expansion path that relates money balances to its opportunity cost and the demand for another input to production. For our purposes, we will restrict our attention to the analysis of firms' behavior.

Let's consider the production of firm i at date t, y_{it}, as a function of a vector of inputs X_{it} as well as of the quantity of transaction services used at that day, T_{it}

$$y_{it} = f\left(X_{it}, T_{it}, \lambda_f\right)$$

where λ_f is a parameter of the production function which is assumed to be constant over time and across firms.

Without loss of generality, we can consider a simplified version of the model in which there is only one input x_{it}

$$y_{it} = f\left(x_{it}, T_{it}, \lambda_f\right)$$

Then, a production function for the transaction services T_{it} is needed. FM assume that such transaction services are produced with real money balances held by the firm and, for simplicity, a certain type of labor (or generally another input different from x_{it}) that can be used to get more services:

$$T_{it} = \phi\left(m_{it}, l_{it}, A_{it}, \lambda_\phi\right)$$

where λ_ϕ is a parameter of the production function assumed to be constant across firms and m_{it} is the stock of real money balances held by the firm i at time t. The quantity l_{it} represents the units of labor used by the firm to produce transaction services, while A_{it} represents a sort of productivity parameter that can be thought of as an indicator of the firm's degree of financial sophistication. Moreover, it is assumed that firms rent the inputs so as to minimize the following cost function:

$$c_{it} = p_{it}x_{it} + w_{it}l_{it} + R_{it}m_{it} \tag{1}$$

which represents the total cost of the rental expenditures. The variable p_{it} represents the price of the composite input, while R_{it} is the nominal opportunity cost of money and w_{it} is the wage of the workers who are involved in the production of transaction services. In Mulligan (1997b) and Fujiki and Mulligan (1996) it is assumed that the interest rate is the same across firms, R_t, and this turns out to be a very strong assumption.
In order to get the optimal choice of inputs, as shown in Fujiki and Mulligan (1996) and Mulligan (1997b), firms have to minimize the total rental expenditures, with respect to the specific inputs, subject to the two production functions, that is:

$$\Gamma\left(y_{it}, R_{it}, p_{it}, w_{it}, A_{it}\right) \equiv \min_{x_{it}, m_{it}} \left(p_{it}x_{it} + w_{it}l_{it} + R_t m_{it}\right) \tag{2}$$
$$\text{s.t. } y_{it} = f\left(x_{it}, \phi\left(m_{it}, l_{it}, A_{it}, \lambda_\phi\right), \lambda_f\right)$$

where we can see that the minimum cost achieved is a function of the production level y_{it} and the rental prices. Among the assumptions that are necessary in the present framework, we recall that the production function f is continuous, nondecreasing in all arguments and increasing in T and that the production of transactions services T is continuous, nondecreasing in all arguments and strictly increasing in A and m. Consequently the cost function is homogeneous of degree one in prices, increasing in y_{it} and nondecreasing in the rental rates. Γ is also continuous and concave in p, R, and w. In addition, other two assumptions are necessary to restrict the production functions. First, for given rental rates, level of production, and level of financial technology, the elasticity of the production function with respect to transactions services approaches zero as $\lambda_f \to 0$. Then, the returns to scale of the production function ϕ are bounded from above for any positive level of the two inputs.

In his empirical investigation of the determinants of money demand, using COMPUSTAT data with a total of 102,088 firm-years for the period 1961-92, Mulligan (1997a and 1997b) finds that large firms hold less cash, as a percentage of sales, than their smaller counterparts. Moreover, he points out that his estimates are consistent with both scale economies in the holding of money and the observed decline in money velocity.

With a demand model in the Baumol-Tobin tradition, Adão and Mata (1999) find substantial economies of scale in the use of money, and argue that the decline of money velocity observed in many OECD countries is due to the increased presence of small firms. They use data from a yearly survey conducted by the Bank of Portugal, for the period 1986-95, carrying out an estimate with year and firm-specific dummies, which corresponds to a panel data analysis with fixed effects. Their methodology differs significatively from the ones of the previous studies, since they allow firms to differ in terms of risk and of cost-of-capital, using a different interest rate per firm. Their main result is that economies of scale are larger than what found in the previous empirical investigations, once fixed effects are taken into account.

In the present paper, we follow the Baumol-Tobin tradition to derive the demand for money, taking into account both firms' heterogeneity and industry-specific effects.

3 The Model

As pointed out by Miller and Orr (1966), the so called inventory model proposed by Baumol is less satisfactory if applied to business firms, since their pattern of cash management is not "saw-tooth"[3], but it fluctuates irregularly, and sometimes unpredictably, over time. This suggests the presence of randomness in such process. The weakness of their model lies in the set of underlying assumptions: some of them are just technical simplifications, while others hardly affect the features of the model. Miller and Orr classify their hypothesis in 4 groups. (i) *The Baumol like assumptions*: namely, the two-asset setting, the constant marginal cost per transfer and the absence of lead-time. (ii) *The minimum balance hypothesis*: i.e. the presence of a definite threshold below which the firm's cash is not allowed to fall. This minimum level is set to be zero. (iii) *The stochastic process*: here the nature of the stochastic process is defined. They assume that the net cash flows are completely stochastic and are generated by a stationary random walk and this allows them to assume that the random behavior of the cash flow is characterized as a sequence of independent, symmetric Bernoulli trials[4]. (iv) *Firm's objective function*: here Miller and Orr assume that the firm seeks to minimize the long-run average cost of managing the cash balance[5]. In their framework, they derive a "transaction technology" $T = Bml$, where B is constant over time and across firms and represents the time cost of cash management, and l is the cost of getting the money, which is assumed to be independent from the amount of money demanded.

Even if this model represents an elegant analytic tool to describe the patterns of money demand, what we do observe in reality is fairly different. Firms are heterogeneous, due to several reasons: different organizational structures, different objective functions, and industry-specific aspects which can affect cash management. Following Adão and Mata (1999), we try to incorporate this heterogeneity into the model of money demand.

Let's assume a firm faces a random flow of transactions c, with some distribution with mean $\hat{c}$ and variance $\sigma_c^2 < \infty$. During each period a firm's employee gets the money at intervals of length t, bringing back from the bank an amount of money equal to $\hat{c}t$. The money reserves (MR) are defined as a function[6]:

[3] As it might be for households.

[4] This is not a very restrictive hypothesis, as Miller and Orr show: "... any of other familiar generating processes with these features might equally well have been used, all leading to the same solution".

[5] The policy used in their paper is a two-parameter control-limit: the cash is allowed to wander until it reaches either the lower bound zero, or an upper bound at which the portfolio transfer takes place to restore the balance to a lower level.

[6] The function f should be increasing in both its arguments.

$$MR = f\left(\hat{c}t, \sigma_c\right) \tag{3}$$

and we assume the employee goes to the bank when the amount (3) approaches to zero[7]. In the relevant period, the firm will hold, on average, an amount of money equal to:

$$m = \frac{\hat{c}t}{2} + MR \tag{4}$$

The choice of the functional form in equation (3) turns out to be crucial, since it will affect the tractability of the aggregate money demand function. Adão and Mata (1999) use a specification that allows the derivation of a Cobb-Douglas functional form for the transaction technology. We set:

$$f\left(\hat{c}t, \sigma_c\right) = \frac{\left(\hat{c}t\right)^{g(\sigma_c)} - \hat{c}t}{2} \tag{5}$$

with the function $g(\cdot)$ increasing[8] in σ_c and such that $g(0) = 1$ and $g(\cdot) \geq 1$. We assume that there might be some economies of scale in the demand for money: this specification will allow us to test it directly. Unlike in Tobin's model, the cost of getting the cash l is not constant, but proportional to the inverse of the intervals at which the cash is demanded, i.e. $l \propto (1/t)^n$ which implies $t \propto l^{-1/n}$. Substituting the latter into equation (4) we get $m \propto \left(\hat{c}l^{-1/n}\right)^{g(\sigma_c)}$. One should keep this proportionalities in mind while commenting the results. We borrow the general framework from Miller and Orr (1966), with a transaction technology in the same spirit, but allowing the degree of financial sophistication B to be different across firms and over time. In particular, we let the transaction technology of firm i at time t be equal to:

$$T_{i,t} = B_{i,t} m_{i,t}^{a} l_{i,t}^{b} \tag{6}$$

The spirit of the theoretical model from now on, resembles the one by Fujiki and Mulligan (1996): the firm solves the minimization problem as in equation (2), with the transaction

[7] As in Adão and Mata, we assume this threshold is a positive number. Otherwise, if it were zero, the firm would not be able to meet its flow of transactions.

[8] Of course, a higher volatility of the cash out-flow implies a higher level of money reserves.

technology specified in equation (6). Solving for $m_{i,t}$ the first order condition of the problem defined in equation (2), we get the demand for money which can be linearized as:

$$\log m_{i,t} = \log \Phi_{i,t} - \frac{b}{a+b} \log R_{i,t} + \frac{b}{a+b} \log w_{i,t} + \frac{1}{a+b} \log y_{i,t} \tag{7}$$

where $\Phi_{i,t}$ is a function of B.

4 The Econometric Specification

Once specified the money demand model we have to choose the appropriate panel data estimator to obtain consistent estimates of the parameters involved.

The presence of firm-specific effects may be due to technological and financial heterogeneity or to non-random sampling. Such effects might be correlated with the exogenous variables as well, leading to consistency problems for the estimators. Thus, one of the main econometric issues is the possible non-zero correlation between the exogenous variables and the contemporaneous disturbances that would undermine the assumption of strict exogeneity.

A further important issue when one uses a panel of firms is that of non-random entry and exit. However, we can say that this selection problem is not so relevant as when one tries to model and estimate investments. Actually, it might be quite unlikely that a firm exits from the sample only because it has liquidity problems. The reasons for possible exit are deeper and involve firms' investment strategies, of which the demand for liquidity only represents a tiny part.

Another concern is the possible measurement error. Actually, according to the theory, sales elasticities should be around unity, but in reality they are usually smaller (even much smaller). This might be related to possible measurement errors in the sales and in the other variables examined. With such measurement error, the estimates would be downward biased, but as highlighted by Mairesse (1990) such problem would be similar to the possible endogeneity problem with the Within estimator. The Between estimator is not affected so much by the endogeneity problem, because the fixed effects are usually averaged and then wiped out for large T. Instead, the Within estimator would be inconsistent. Moreover, with measurement errors, the Between estimator tends to minimize their importance, while the Within estimator tends to magnify their effects, with an increased resulting bias.

In the empirical specification we need to assume that all differences between companies in the cash-flow structure and in the degree of financial sophistication are persistent over time, so that they can be captured by the individual fixed effects. Furthermore, we allow for possible changes in the degree of financial sophistication over time, imposing that such movements have the same effects on all firms at each point in time. To control for such economy-wide changes in financial sophistication, we include time effects in the empirical specification. However we leave all the firm-specific changes in the financial technology as residuals.

In sum, we mainly model time and firm-specific effects as fixed effects, and the empirical specification of equation (7) turns out to be:

$$\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \epsilon_{i,t} \tag{8}$$

where α_i are the firm-specific effects and β_t are the time effects. In practice, we assume a two-way error component regression model where the disturbances are composed by an unobservable individual effect, an unobservable time effect and a purely stochastic disturbance[9].

This particular specification is very useful because removes the effects of all the persistent differences among firms from the estimates. In practice, the estimated demand elasticity, θ, will be immune from any difference in money holding between small and large firms. We have to consider that normally small and large firms differ not only on the size, but also on many other aspects of their business, such as the cash-flow structure and the degree of financial sophistication.

Introducing time effects in the empirical specification, the variable R_{it} reflects the deviations of each firm's cost-of-capital from its average level over time, rather than the evolution of the overall level of the interest rates. The effects of the entire evolution of the interest rates and the changes in financial technology and wages are captured by the time effects.

We also consider the assumption that the α_i's , that is the firm heterogeneity, are *i.i.d.*

[9]See Baltagi (2001) for a comprehensive treatment.

random variables. In this way, we can test the eventual endogeneity by the Hausman test and see if the Fixed Effects estimator is also consistent. To our knowledge, so far in the literature only Fixed Effects have been considered. Therefore, it will be very informative to compare the results from such different estimators.

5 The Data

The data used in the present study are obtained from the COMPUSTAT Industrial Annual Expanded files for the period 1982-2000. COMPUSTAT is a database of financial, statistical and market information which provides annual and quarterly Income Statement, Balance Sheet, Statement of Cash Flows and supplemental data items on more than 15,000 publicly held companies. The firms in this database are all the companies listed on the New York Stock Exchange and the American Stock Exchange. Moreover, U.S. firms that file, or have filed, either 10-K or 10-Q forms with the Securities and Exchange Commission (SEC) are also included[10].

The variable that we use as our proxy for money holdings by business firms m_{it} is given by 'cash' (balances at the end of the year), which includes bank deposits and some kinds of short-term investments[11].

The other variables used in the empirical analysis are:

- y_{it} - total "net sales" for firm i during year t;
- w_{it} - average wage for firm i, computed as the total payroll (given by "labor and related expense") divided by the number of employees at the end of the year t;
- R_{it} - cost-of-capital for firm i at year t, computed as the total financial expenditures during the year (given by "interest expense"), divided by the total debt (given by "total liabilities") at the end of the year[12].

[10] Some Canadian companies are also reported in the COMPUSTAT database, but they are excluded from the present work.

[11] We also used a broader definition of money holdings given by 'cash and short-term investments' in order to accomplish a different definition of money. The results are quite consistent with the previous definition of money with negligible differences and we decided not to report them for the sake of brevity. However they are available from the authors upon request.

[12] We want to emphasize the possible problems that can arise when one deals with this kind of data. Since

All the variables are in millions of dollars and have been converted in 1996 dollars by using the GNP implicit price deflator.

We focus our analysis on firms belonging to manufacturing sector (SIC codes: 2000-3999) and in the wholesale and retail sector (SIC codes: 5000-5999). This choice is due to the great economic relevance of these two industries, and to their importance in the particular question we are trying to answer, that is the determinants of the demand for money by corporations. The firm behavior in other sectors may differ substantially giving misleading results. For example, government regulation influences the public utilities, transportation and farming industries, while the firms in the Financial Insurance and Real Estate (FIRE) industry often use different accounting procedures and have different constraints for their cash holdings.

We have included firm i in our data set for year t if the variables cash (m) and sales (y) are both reported for that particular year and are greater than zero. In other studies, such as in Mulligan (1997a and 1997b) another selection criterion is to pick the firms with sales of at least $1 million. Such a choice is justified by the possible quantitative problems that might arise because Standard & Poor COMPUSTAT rounds[13] cash to the nearest $1,000. We think that such a criterion can induce a serious censoring problem and for this reason in our empirical study we only consider all firms.[14] Further, we can argue that usually smaller firms have bigger financial constraints than their bigger counterparts, and therefore their demand for liquidity is crucial to fully understand the entire issue.

In the sample (when we consider only firms' net sales and cash) there are 59,951 firm-years. Table 1 displays the summary statistics for each one of the selected variables. We can

in the firm's Statement of Income we usually have flow variables, that is variables that relate to all the period of interest, whereas in the firm's Balance Sheet we find stock variables, that is variables that are measured at a certain moment, a compatibility problem may arise. For instance, we can think that the interest paid on loans during the year may not entirely correspond to the real level of loans observed at the end of the year, date to which the balance sheet is referred, because some of those loans might have been liquidated during the year considered. Thus, typically, flow variables are much more reliable in measuring the true average value than the stock variables, but it is not possible to overcome this problem.

[13]Standard&Poor COMPUSTAT rounds all the data items (most of which are expressed in million of dollars) to the nearest thousand dollars.

[14]In order to make a useful comparison of our results with those by Mulligan's (1997a), in a previous version of the paper we also considered all firms with sales of at least one million dollars. For both models estimated in the empirical exercise, the estimated sales elasticities are much higher than those for all the firms. Therefore, we might argue that one of the possible reasons for introducing such a constraint by Mulligan (1997a)(Mulligan 1997a) might be due not really to the fact that COMPUSTAT rounds all the figures to the nearest $1,000, but rather to the fact that we can get estimated sales elasticities closer to the umbers appearing in the literature. The corresponding tables are available upon request.

Table 1: Summary Statistics

Variable	N. of Valid Obs.	Mean	Std. Dev.	Min	Max
	All Industries				
m	60226	37.736	254.537	0.00093	13320.0
y	67259	1179.162	6093.778	0.00096	192618.9
w	3612	43.978	513.726	0.03633	30880.5
R	64320	0.052	0.114	0.00002	12.7
	Retailing				
m	13505	22.214	106.809	0.00097	5186.0
y	14907	1277.159	4751.483	0.00231	178828.9
w	1139	45.708	914.626	0.48512	30880.5
R	14422	0.052	0.099	0.00003	9.0
	Manufacturing				
m	46721	42.222	283.072	0.00093	13320.0
y	52352	1151.258	6424.665	0.00096	192618.9
w	2473	43.181	20.183	0.03633	274.3
R	49898	0.052	0.118	0.00002	12.7

Note: m is our proxy for the cash holdings by business firms and represents 'cash'. y represents the firm's "net sales", w is our proxy for the wages and R is the firm's cost-of-capital.
The GNP implicit price deflator is used to convert all current dollars in 1996 dollars.

immediately notice that the number of valid observations for all the selected industries is around 64,000 except for the variable w. In this case the problem is due to the huge number of firms in the database that do not report the value for their labor expenses[15]. From Table 1 we can see that both the scale of operation and cash vary dramatically across firm-years. Furthermore, we can notice a very pronounced variation in all variables but the wages for the Manufacturing industry. The variable w is the only one that has the hugest variation across firm-years for the Retailing industry. Probably, such finding is due to the extreme sensitivity, typical of this sector, to the overall economic conditions and to consumers' confidence.

[15]In the two industries considered only the 6% of the firms that report their number of employees by the end of the year also report their labor expenses.

6 Empirical Evidence and Discussion

In this section we present the various estimates from the regressions performed and we provide some comments. All the empirical part focuses on two alternative derivations of the demand for money given in (8). In the first derivation we consider only the sales as explanatory variable. This is what we call the 'basic model', that is the regression

$$\log m_{i,t} = \alpha + \beta \log y_{i,t} + \epsilon_{i,t} \tag{9}$$

In the second specification we take into account other determinants of the demand for liquidity by firms, such as the cost-of-capital and the wages. The estimated regression for the 'large model' becomes

$$\log m_{i,t} = \alpha + \beta \log y_{i,t} + \gamma \log R_{i,t} + \delta \log w_{i,t} + \epsilon_{i,t} \tag{10}$$

We analyze both models in a typical cross-section context by considering first the OLS regressions year by year and then the pooled regressions. In this way, it is possible to highlight the gains from the panel data analysis that follows, where we also take into account for possible unbalanced-ness.

6.1 Preliminary Estimates

We initially estimate a series of cross-section OLS regressions year by year, whose results are displayed in Figure 1.

The top-left panel of Figure 1 shows the sales elasticities when we consider the basic model as in (9). We can see the great differences between the estimated sales elasticities when industries are considered altogether and when they are considered separately. For all the firms selected (continuous line) the sales elasticities vary from 0.58 to 0.77, while for the Manufacturing firms (short-dashed line) they vary from 0.58 to 0.79 and for the Retailing businesses (long-dashed line) elasticities vary from 0.63 to 0.79. When we consider the 'large model', from the top-right panel of Figure 1 we can notice very similar patterns, but now the variation across years is even higher. Looking at all firms (continuous line), the elasticities (β) vary from 0.64 to 0.87, while with the Manufacturing corporations (short-dashed line) the parameters β's vary from 0.58 to 0.92 and for the Retailing businesses (long-dashed line) the elasticities go from 0.61 to 1.07. The two figures show the inadequacy of cross-sections that cannot capture the dynamics in the data and the usefulness of a panel data analysis, as highlighted by Vogel and Maddala's (1967) critique.

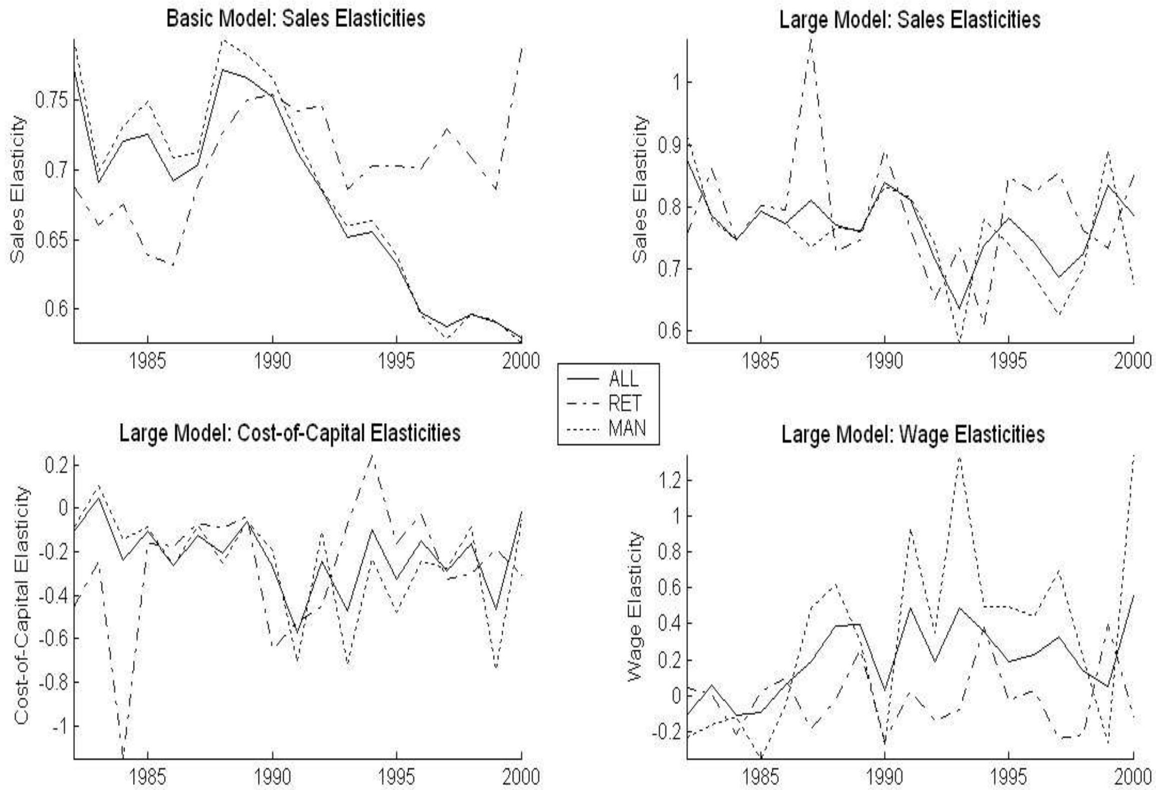

Figure 1: Estimated Elasticities for Basic Model and Large Model from cross-section regressions.

The bottom-left and bottom-right panel of Figure 1 depict the results from the cross-section estimates for the cost-of-capital and wage elasticities respectively. In these figures the variation across years is stronger than in the previous pictures and particularly among different sectors. Overall, the interest rate elasticities vary from -0.57 to 0.05, while in Manufacturing they go from -0.74 to 0.10 and in Retailing they range between -1.15 and 0.24. Since the interest rate represents the opportunity cost of holding cash balances, we should expect that a higher cost-of-capital will lower the demand for money. From these cross section estimates we can see that the estimates have a wide range and may inconsistently end up being positive.

Considering wage elasticities, we notice that overall, their range is between -0.11 and 0.55, while for the Manufacturing firms they vary from -0.35 to 1.34 and for the Retailing businesses the estimates go from -0.25 to 0.40. If we think that labor is a substitute for money, we should expect that wages increase the demand for money. Therefore, cross section estimates may give estimates with the wrong sign.

Table 2: Results from Pooled Regressions With 'Cash'

Dependent Variable log(m)	Basic Model			Large Model		
	All	Man	Ret	All	Man	Ret
log(y)	0.6691	0.6761	0.7086	0.7659	0.7561	0.7706
	(0.0029)	(0.0033)	(0.0061)	(0.0092)	(0.0110)	(0.0181)
log(R)	-	-	-	-0.2054	-0.2029	-0.2053
	-	-	-	(0.0319)	(0.0408)	(0.0507)
log(w)	-	-	-	0.2240	0.3259	*-0.0037*
	-	-	-	(0.0350)	(0.0614)	(0.0558)
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.492	0.497	0.518	0.751	0.758	0.665
N	59953	46524	13429	2934	1937	997

Notes: The Basic Model is: $\log m_{i,t} = \alpha_i + \beta_t + \theta \log y_{i,t} + \epsilon_{i,t}$. The Large Model is: $\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \epsilon_{i,t}$. Standard errors in parentheses. The figures in Italic represents the coefficients that are not significant at 5%.

Table 2 presents instead the results from the pooled regressions when year effects are taken into account. The table shows the estimated sales elasticities for the basic and for the large model. For the former we have sales elasticities around 0.65, while for the latter we obtain slightly higher estimates around 0.75. The estimated interest rate elasticities are all significant and around -0.20, so that the estimates are consistent with the model predictions. The estimated wage elasticities present different values: the estimates range from 0.22 to 0.33 and are consistently positive and significant for all the firms in the sample and for the Manufacturing businesses, but not for the Retailing companies.

Table 3: Results from Panel Data Analysis: Basic Model with 'Cash' as the Dependent Variable.

Basic Model: $\log m_{i,t} = \alpha_i + \beta_t + \theta \log y_{i,t} + \epsilon_{i,t}$

	Between			Fixed Effects			Random Effects		
	All	Man	Ret	All	Man	Ret	All	Man	Ret
log(y)	0.600	0.598	0.659	0.589	0.595	0.569	0.600	0.602	0.626
	(0.007)	(0.009)	(0.014)	(0.007)	(0.009)	(0.015)	(0.005)	(0.006)	(0.010)
Y.E.	No	No	No	No	No	No	No	No	No
H.T.	-	-	-	-	-	-	4.16*	1.29	27.49**
R^2	0.462	0.460	0.510	0.462	0.460	0.510	0.462	0.460	0.510
N	59951	46524	13427	59951	46524	13427	59951	46524	13427
log(y)	0.597	0.601	0.652	0.507	0.507	0.516	0.556	0.557	0.599
	(0.007)	(0.008)	(0.014)	(0.008)	(0.009)	(0.017)	(0.005)	(0.006)	(0.011)
Y.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
H.T.	-	-	-	-	-	-	977.93**	834.48**	984.61**
R^2	0.427	0.418	0.405	0.491	0.495	0.518	0.491	0.496	0.518
N	59951	46524	13427	59951	46524	13427	59951	46524	13427

Notes: Standard errors in parentheses. The figures in Italic represents the coefficients that are not significant at 5%. Y.E. indicates year effects and H.T. is the Hausman test to test the null of absence of correlation between the individual effects and the regressors. * indicates significance at 5% and ** shows significance at 1%.

6.2 Balanced Panel Data Analysis

Tables 3 depicts the results from the panel data estimation of the basic model in (9). The upper panel shows the estimates without year effects, while the lower panel depicts the same estimates with year effects. The table displays the Between, the Fixed Effects (Within) and the Random Effects estimates for the sales elasticities, which indicate significant values around 0.60 for both panels. As can be seen, the estimated sales elasticities for the three models do not differ substantially. This means that the possible measurement error is less important when we do not consider year effects.

The Hausman Test is also given and we can see that we reject the null hypothesis of absence of correlation between the individual effects and the regressors for all the firms at the 5% level, while for the Retailing industry the rejection is at the 1% level. However, in the case of Manufacturing firms, we cannot reject the null of absence of correlation between the individual effects and the regressor in (9).

Once we take into account year effects (lower panel in Table 3), the estimated sales elasticities are also significant and do not change considerably (they are around 0.57), except for the Within Estimates which are around 0.51. Thus, in this case, it might be that the measurement error plays a major role, biasing downward the Within estimates.

The Hausman Test leads us to reject the null of no correlation between individual effects and the explanatory variables at any confidence level.

Table 4 presents the estimation results for the large model with and without year effects. With no year effects the Between estimated sales elasticities are around 0.67; the same estimates are around 0.69 when we consider year effects. The Fixed Effects estimated sales elasticities range from 0.32 to 0.48 in the upper panel, while with year effects they vary from 0.23 to 0.49. The estimated sales elasticities from Random Effects are quite stable, being around 0.62 with no year effects and around 0.64 in the lower panel. As can be seen, the differences in the estimated sales elasticities from the Between and the Fixed Effects estimators are remarkably high, indicating that the latter ones are amplifying possible measurement errors[16]. In both panels all the elasticities are significant, except for some of them, in particular those related to wages and the cost-of-capital. In particular, the sign of the significant wage elasticities is positive as expected from the theoretical model, and the sign for the interest rate elasticities is consistently negative. The Hausman tests show the presence of endogeneity for all the cases at 1% significance level, but the Retailing firms when year effects are considered.

We have seen that according to Hausman test, the null hypothesis of absence of correlation between individual effects and the regressors is always rejected, thus we decide to apply a 2SLS method to estimate sales elasticities for the two different models presented, as in Mulligan (1997a) and Adão and Mata (1999). Actually, there might be errors in the measurements of sales that determine downward biased elasticities. To control for such bias, we assume that such errors are serially uncorrelated. Thus, it is possible to obtain consistent estimates of the elasticities with Instrumental Variables (IV), using as instruments lagged

[16]We think that the main source of measurement error is given by our proxy for wages. Actually, in our sample, many firms do not report either 'labor and related expense' or 'number of employees' at the end of the year.

Table 4: Results from Panel Data Analysis: Large Model with 'Cash' as the Dependent Variable.

Large Model: $\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \epsilon_{i,t}$

	Between			Fixed Effects			Random Effects		
	All	Man	Ret	All	Man	Ret	All	Man	Ret
log(y)	0.676	0.668	0.674	0.383	0.319	0.481	0.641	0.640	0.621
	(0.020)	(0.023)	(0.040)	(0.040)	(0.055)	(0.057)	(0.018)	(0.021)	(0.033)
log(R)	-0.268	*-0.152*	-0.412	-0.144	-0.123	-0.168	-0.163	-0.130	-0.194
	(0.079)	(0.104)	(0.120)	(0.037)	(0.047)	(0.058)	(0.033)	(0.043)	(0.052)
log(w)	0.223	0.428	*-0.113*	*1.4E-4*	*0.089*	*-0.118*	*0.087*	0.198	*-0.125*
	(0.078)	(0.130)	(0.127)	(0.059)	(0.082)	(0.082)	(0.047)	(0.070)	(0.068)
Y.E.	No	No	No	No	No	No	No	No	No
H.T.	-	-	-	-	-	-	63.02**	47.78**	12.25**
R^2	0.736	0.740	0.646	0.733	0.740	0.651	0.736	0.740	0.652
N	2934	1937	997	2934	1937	997	2934	1937	997

	Between			Fixed Effects			Random Effects		
	All	Man	Ret	All	Man	Ret	All	Man	Ret
log(y)	0.694	0.704	0.689	0.331	0.229	0.493	0.647	0.648	0.637
	(0.020)	(0.023)	(0.041)	(0.041)	(0.054)	(0.061)	(0.017)	(0.020)	(0.032)
log(R)	*-0.190*	*-0.093*	*-0.222*	-0.108	-0.092	-0.145	-0.135	-0.105	-0.166
	(0.081)	(0.103)	(0.126)	(0.036)	(0.046)	(0.060)	(0.033)	(0.043)	(0.053)
log(w)	0.363	0.378	*0.019*	*-0.071*	*-0.048*	*-0.108*	*0.063*	*0.116*	*-0.116*
	(0.080)	(0.125)	(0.134)	(0.058)	(0.080)	(0.082)	(0.046)	(0.068)	(0.067)
Y.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
H.T.	-	-	-	-	-	-	89.23**	88.87**	8.8
R^2	0.704	0.520	0.461	0.708	0.657	0.657	0.749	0.755	0.662
N	2934	1937	997	2934	1937	997	2934	1937	997

Notes: Standard errors in parentheses. The figures in Italic represents the coefficients that are not significant at 5%. Y.E. indicates year effects and H.T. is the Hausman test to test the null of absence of correlation between the individual effects and the regressors. * indicates significance at 5% and ** shows significance at 1%.

log values for net sales ($\log(y_{t-1})$), for the cost-of-capital ($\log(R_{t-1})$) and for the wages ($\log(w_{t-1})$).

Table 5 reports the Between and the Within estimated elasticities for the basic and the large model with IV. As can be noticed, Between and Within estimated sales elasticities for the basic model present very small differences, ranging from 0.51 to 0.73, except for the Retailing firms. For the large model there is a slightly bigger difference among the Between and the Fixed Effects estimates. Overall, we can see that there is no difference between considering the year effects or not. The interest rate elasticities are almost all significant and with the right sign, but for the model with all firms without year effects, where the sign is inconsistent with the theory. Very few wage elasticities are significant and with the right sign, but for the model with all firms in the sample without year effects, where the sign is inconsistently negative[17].

In sum, all the results so far have confirmed that the estimated sales elasticities range between 0.60 and 0.70 even when one takes into account possible endogeneity problems.

[17]We performed the same analysis using only the lagged net sales as an instrument. The results (not reported for the sake of brevity) for the large model are quite similar, but the estimated elasticities are in general a little bit lower than those obtained by considering all the instruments.

Table 5: Results from Panel Data Analysis with IV: Dependent Variable is 'Cash'. The instruments are $\log y_{t-1}$ for the basic model and $\log y_{t-1}$, $\log R_{t-1}$ and $\log w_{t-1}$ for the large one.

	Basic Model $\log m_{i,t} = \alpha_i + \beta_t + \theta \log y_{i,t} + \epsilon_{i,t}$						Large Model $\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \epsilon_{i,t}$					
	Between			Fixed Effects			Between			Fixed Effects		
	All	Man	Ret	All	Man	Ret	All	Man	Ret	All	Man	Ret
log(y)	0.630	0.625	0.729	0.571	0.573	0.560	0.770	0.764	0.745	0.555	0.520	0.619
	(0.008)	(0.010)	(0.016)	(0.009)	(0.010)	(0.018)	(0.022)	(0.026)	(0.047)	(0.050)	(0.068)	(0.071)
log(R)	-	-	-	-	-	-	0.141	-0.366	-0.249	-0.223	-0.258	-0.126
	-	-	-	-	-	-	(0.080)	(0.107)	(0.123)	(0.044)	(0.055)	(0.071)
log(w)	-	-	-	-	-	-	-0.328	0.314	*-0.095*	*0.001*	*0.058*	*-0.093*
	-	-	-	-	-	-	(0.080)	(0.143)	(0.124)	(0.065)	(0.092)	(0.086)
Y.E.	No	No	No	No	No	No	No	No	No	No	No	No
R^2	0.480	0.481	0.523	0.480	0.481	0.523	0.768	0.771	0.683	0.766	0.768	0.683
N	51930	40404	11526	51930	40404	11526	2427	1638	789	2427	1638	789
	Between			Fixed Effects			Between			Fixed Effects		
	All	Man	Ret	All	Man	Ret	All	Man	Ret	All	Man	Ret
log(y)	0.627	0.628	0.706	0.510	0.507	0.529	0.781	0.771	0.794	0.514	0.429	0.648
	(0.008)	(0.009)	(0.015)	(0.009)	(0.010)	(0.020)	(0.021)	(0.024)	(0.049)	(0.052)	(0.068)	(0.076)
log(R)	-	-	-	-	-	-	-0.283	-0.229	*-0.211*	-0.207	-0.250	*-0.116*
	-	-	-	-	-	-	(0.079)	(0.104)	(0.127)	(0.044)	(0.054)	(0.074)
log(w)	-	-	-	-	-	-	0.228	0.415	*-0.025*	*-0.050*	*-0.060*	*-0.067*
	-	-	-	-	-	-	(0.083)	(0.144)	(0.141)	(0.064)	(0.091)	(0.087)
Y.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.443	0.458	0.422	0.503	0.509	0.530	0.668	0.574	0.506	0.769	0.760	0.688
N	51930	40404	11526	51930	40404	11526	2427	1638	789	2427	1638	789

Notes: Standard errors in parentheses. The figures in Italic represents the coefficients that are not significant at 5%.

6.3 Unbalanced Panel Data Analysis

In the data we select from COMPUSTAT many firms are not observed over the entire sample period. This leads to an unbalanced (or incomplete) panel. In this case we adopt the approach suggested by Baltagi (2001) and use Weighted Least Squares (WLS) which correspond to Generalized Least Squares (GLS). The basic difference in the case of WLS for unbalanced panels is in the crucial dependence of the weights on the lengths of the time series available for each cross-section (i.e. for each firm).

Table 6 shows the estimated sales elasticities for the basic and the large model obtained using the Between estimator with WLS. We can see that the estimated sales elasticities for both models (with and without year effects) are nearly identical and around 0.70. The interest rate elasticities are almost always significant and with the right sign, while only some wage elasticities are significant and with a sign consistent with the theory.

Thus, considering the unbalanced-ness can give more precise estimates of the money demand by COMPUSTAT firms.

Therefore, we can conclude that when we take into account fixed effects, time effects and above all firm-specific cost-of-capital and wages, we find substantial economies of scale[18], with estimated sales elasticities around 0.5-0.7. These results are lower than the 0.8 by Mulligan (1997a) and the 0.9 by Ben-Zion (1974) and in general all the other estimates in the literature, but for Adão and Mata (1999) who also find values around 0.5 by taking into account firm-specific effects for their panel of Portuguese firms. However, if we think that possible measurement errors might bias downward the Fixed Effects estimates, we can conclude that the estimated sales elasticities are around 0.60-0.70. Only by discarding the small companies, as Mulligan (1997a) does, we can obtain estimates that are in line with the previous literature, even though, in this way a serious censoring problem can arise.

[18] The economies of scale are measured by the reciprocal of the parameter θ in (8), because it represents $a + b$ from (6). Therefore, the lower the estimated sales elasticities, the greater the economies of scales in the demand for money by COMPUSTAT firms.

Table 6: Results from Unbalanced Panel Data Analysis: Dependent Variable is 'Cash'. Between Estimator with Weighted Least Squares.

	Basic Model: $\log m_{i,t} = \alpha_i + \beta_t + \theta \log y_{i,t} + \epsilon_{i,t}$			Large Model: $\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \epsilon_{i,t}$		
	All	Man	Ret	All	Man	Ret
log(y)	0.689	0.694	0.735	0.764	0.748	0.776
	(0.007)	(0.008)	(0.013)	(0.017)	(0.022)	(0.032)
log(R)	-	-	-	-0.294	-0.303	-0.288
	-	-	-	(0.075)	(0.098)	(0.112)
log(w)	-	-	-	0.241	0.481	-0.013
	-	-	-	(0.071)	(0.139)	(0.109)
Y.E.	No	No	No	No	No	No
R^2	0.4619	0.4595	0.5101	0.7365	0.7404	0.6533
N	59951	46524	13427	2934	1937	997

	Basic Model: $\log m_{i,t} = \alpha_i + \beta_t + \theta \log y_{i,t} + \epsilon_{i,t}$			Large Model: $\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \epsilon_{i,t}$		
	All	Man	Ret	All	Man	Ret
log(y)	0.687	0.697	0.725	0.772	0.762	0.792
	(0.006)	(0.007)	(0.013)	(0.017)	(0.022)	(0.033)
log(R)	-	-	-	-0.239	-0.244	-0.186
	-	-	-	(0.075)	(0.098)	(0.117)
log(w)	-	-	-	0.319	0.415	0.093
	-	-	-	(0.074)	(0.140)	(0.121)
Y.E.	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.4373	0.4321	0.4348	0.7271	0.6058	0.5348
N	59951	46524	13427	2934	1937	997

Notes: Standard errors are in parentheses. The figures in Italic represents the coefficients that are not significant at 5%.

7 Conclusions

In the present paper we first organize the previous theoretical models of money demand by firms taking into account firms' heterogeneity and then we estimate the demand for money by the US firms, using balanced and unbalanced panel data with firm-specific effects.

We use COMPUSTAT database and select the item ‘Cash’ to describe the cash holdings by corporations. Our focus is on two particular industries that better reflect the money demand by firms: Manufacturing as well as Wholesale and Retailing. In addition, in sharp contrast with the previous literature, we use firm-specific data for the variables that are assumed to affect firms’ money demand, such as the cost-of-capital and wages. We estimate the derived demand for money, both in the basic form (where money balances are regressed only on net sales as a proxy for each firm’s size) and in the large form (where the demand for money is not only a function of firm’s net sales, but also of its cost of borrowing and wages). We first estimate cross sections and find that ignoring the dynamics can be very misleading, as highlighted by Vogel and Maddala (1967), because the estimated elasticities turn out to be very erratic and also inconsistent with the theory. Afterwards, we estimate pooled regressions with year dummies finding quite similar results. Finally, we analyze the whole panel of firms by calculating Between, Fixed Effects and Random Effects estimates of the various elasticities. In this way we can check the robustness of the estimates against possible measurement error problems. We find that there are substantial economies of scale in the use of money by US business firms. Actually, our estimated sales elasticities are between 0.50 and 0.70, depending on the assumptions that are made to perform the estimation. Therefore, they are much lower than those found in the literature (between 0.8 and 0.9), and lead us to conclude that the economies of scale in cash holdings by firms are higher than previously thought. Furthermore, we find negligible and not significant effects of labor in the cash holdings by firms, so that we can argue that labor is not a substitute for money as the theoretical model would predict. Probably, such a result is due to our proxy of wages, that is the ratio of labor and related expense to the number of employees at the end of each fiscal year. Such a measure is firm-specific, but only very few firms report both items in the COMPUSTAT database, leading to conspicuous measurement error problems when we use this variable. On the contrary, the cost-of-capital elasticities are all significant and consistent with the fact that the interest rate represents the opportunity cost of holding money.

The results that we present suggest further research to understand the possible effects of sample attrition and measurement errors in the determinants of the demand of money by firms.

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