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Revisiting the empirical evidence on firms' money demand

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REVISITING THE EMPIRICAL EVIDENCE ON FIRMS' MONEY DEMAND

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Abstract

In this paper we estimate the demand for liquidity by US non financial firms using data from 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 empirical studies, suggesting that economies of scale in the demand for money are even bigger than formerly thought. In addition, it emerges that labor is not a substitute for money.

Keywords: Panel Data, Liquidity, Demand for Money, COMPUSTAT.
JEL classification: E41, L60, C23.

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1. Introduction[1]

Since the seminal work by Keynes (1936) the focus of 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 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 used to explain the demand for money and other liquid assets held by firms are based on transactions, wealth, and portfolio balance. In the transaction approach one considers the interest rates paid on alternative liquid assets and the transaction costs related to their management, concluding that cash balances should increase less than proportionately with transactions. The wealth model, instead, relies on 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 mechanisms that govern 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. Although recent macroeconomic theories tend to de-emphasize the importance of monetary aggregates in the monetary transmission mechanism,[2] a quantitative determination of the demand for money by the agents in the economy is 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 and policy-makers to acquire more up-to-date information about portfolio behavior and attitudes to risk.

The main contribution of the paper is twofold: from a theoretical point of view we organize the previous models of money demand by firms so as 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 not only a balanced panel with firm-specific effects, but also an unbalanced panel to obtain more precise estimates that also consider its incompleteness.

In the previous literature many studies focus only on aggregate data rather than individual data, and sometimes they do not distinguish among different sectors. Many other papers just

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[2] See for example the review of the theoretical and empirical literature on the demand for money by Duca and VanHoose (2004).

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 firms' 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 non-financial firms. Using the COMPUSTAT database, we select data on firms in the manufacturing and in the wholesale and retailing industries to estimate their demand for liquidity. Very few papers in the previous literature consider different sectors, and many authors just analyze the whole sample of firms, which can, however, give misleading results because 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 only fixed effects have been considered in the literature. The results suggest that the economies of scale in the demand for money by US non-financial firms are even stronger than formerly thought. Indeed, the estimated sales elasticities we find (which are between 0.5 and 0.7) are much lower than those usually obtained in the previous literature (between 0.8 and 0.9).

The paper is organized as follows: in Section 2. some previous empirical studies on 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 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 non-financial firms.

One of the first to analyze quantitatively the demand for money was Selden (1961), who studied the postwar velocity of money by sectors. In his study, he uses cross-section data from the IRS (Internal Revenue Service) and finds that velocity falls as firm size increases. This result is due to the ratio of sales to total assets, which declines at a faster rate than the ratio of a firm's cash. Furthermore, he points to a consistent substitution effect between government securities and cash and other liquid assets. This effect seems to increase directly with firm size. In his argument, 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 they face to raise money.

Frazer (1964) explores the corporate demand for money by using cross-section regression methods. He applies these 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, 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 does not give other possible explanations for firms' behavior and completely ignores both the problems of estimating cross-sections in a dynamic context and the bias introduced by using ratios.

Meltzer (1963) makes a great contribution to the cross-section analysis of business demand for money, trying to reconcile Baumol-Tobin's inventory model and Friedman's (1959) model. His evidence, based on data from 14 industries spanning 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."[3]

Whalen (1965) reformulates Meltzer's approach by adding to the regressions the ratio of total assets to sales, in order to allow for differences in firms' size. He assumes that, within each industry, at any given time, firms are identical in all respects but for the magnitude of their business operation. The crucial assumption here is that the only factors that 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[4] 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 in asserting the presence of economies of scale because it is not possible to separate out the motivation for holding money for every industry under examination.

Vogel and Maddala (1967) criticize previous studies 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, the variance of an array of data being 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 lead to a better interpretation of the phenomenon under study. Vogel and Maddala

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

[4] Whalen (1965) claims that in a cross-section approach, there is a better control over "extraneous" variables affecting the demand for cash.

(1967) verify the usefulness of all the preceding cross-section analyses in understanding and analyzing the determinants of the demand for cash and liquid assets by manufacturing corporations. They try to test (i) whether a model of wealth or a model of transactions demand offers the best explanation of the liquid asset holdings; (ii) whether there exist economies of scale in the demand for cash by businesses; (iii) whether there are patterns of substitution between cash and government security balances; and (iv) whether 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 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 that cross-section estimates should be viewed with considerable caution in a dynamic context. Among the various conclusions, Vogel and Maddala (1967) find that it is extremely hard to distinguish between transactions and wealth models for 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, the 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. This assumption is inconsistent with the finance theory, according to which this cost should depend on each firm's appropriate risk class. Second, all the previous studies use data of firms in different industries, rather than data on individual firms. Actually, using data on individual firms makes it possible to obtain a much more coherent measure of the cost-of-capital, as is typically assumed in the theory of firm valuation based on the approach of Modigliani and Miller (1958 and 1966) (1958 and 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 0.5) 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 between these extreme cases. The substantial contribution by Ben-Zion is to consider as a proxy for 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 this specification for the cost-of-capital, using the COMPUSTAT file for the years 1964 and 1965, Ben-Zion estimates 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, to explain the demand for money by business firms. They point out the relevance of using micro data instead of aggregate data because 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 UK 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 the electrical engineering industry, but not in the retailing and distribution industry. Moreover, they show how the choice of statistical methods and 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) 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), and Miller and Orr (1966). This framework is very useful for interpreting and comparing 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, Fujiki and Mulligan (1996) 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 us 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. Fujiki and Mulligan (1996) 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 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 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:

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

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 estimation with year and firm-specific dummies, which corresponds to a panel data analysis with fixed effects. Their methodology differs significatively from those of previous studies, since they allow firms to differ in terms of risk and cost-of-capital, using a different interest rate per firm. Their main result is that economies of scale are larger than what was 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 industry-specific effects and firms' heterogeneity.

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, because their pattern of cash management is not "saw-tooth" - as it might be for households - but fluctuates irregularly, and sometimes unpredictably, over time. This suggests the presence of a certain degree of randomness in money management. 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 firms 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.[5] (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.[6] 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 obtaining the money, which is assumed to be independent from the amount of money demanded.

Even if this model represents an elegant analytical tool to describe the patterns of money demand, what we observe in reality is fairly different. Firms are heterogeneous for several

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[5] 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".

[6] The policy used in their paper is a two-parameter control-limit: 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.

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 us assume a firm faces a random flow of transactions, with some distribution with mean $\hat{c}$ and variance $\sigma_c^2 < \infty$. During each period a firm's employee obtains 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:[7]

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

and we assume the employee goes to the bank when the amount (3) approaches zero.[8] Therefore, we can think of wages as a proxy for a firm's 'shoe-leather costs', i.e. the inflation-hedging activities in which agents try to protect the value of their money balances in periods of high inflation and that may also be at work for corporate money holdings.

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 as 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:

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

with the function $g(\cdot)$ increasing[9] 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 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 $m \propto \left(\hat{c}l^{-1/n}\right)^{g(\sigma_c)}$.

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

[8] 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.

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

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 differ 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 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 the money demand model has been specified, 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. These 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 as relevant as when one tries to model and estimate investments. Actually, a firm might be very unlikely to exit from the sample only because it has liquidity problems. The reasons for a possible exit are deeper and involve firms' investment strategies, of which the demand for liquidity only represents a small part.

Another concern is possible measurement error. According to the theory, sales elasticities should in fact be around unity, but in reality they are usually smaller (even much smaller). This might be related to possible measurement errors in sales data and in the other variables examined. With such a measurement error, the estimates would be downwardly biased, but as highlighted by Mairesse (1990) these problems 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, yielding greater 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:

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

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.[10]

This particular specification is very useful because it 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 in terms of size, but also in many other aspects, for example cash-flow structure and 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 interest rates. The effects of the entire evolution of interest rates and 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.* random variables. In this way, we can test any 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.

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

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 companies listed on the New York Stock Exchange and the American Stock Exchange. Moreover, US firms that file, or have filed, either 10-K or 10-Q forms with the Securities and Exchange Commission (SEC) are also included.[11]

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.[12] Since January 1994, many commercial banks and other depository institutions have adopted sweep programs to avoid statutory requirements on transaction deposits.

These programs reduce the required reserves by sweeping demand deposits, ATS, NOW and other checkable deposits into saving deposits, in particular money market deposit accounts (MMDAs). Sweep accounts may distort firms' holding of money, but Anderson and Rasche (2001) and Anderson (2002, 2003) argue that deposit-sweeping programs create a shadow MMDA deposit which is not visible to customers and, therefore, to them it appears as if their transaction account deposits are unaltered. For this reason, although COMPUSTAT does not collect information about MMDAs, any balances swept into MMDAs during business hours are likely to be included in the item 'cash'.

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[13] as in Adão and Mata (1999). Actually, this measure represents the cost of credit and has the advantage of being firm-specific. In addition, it is a weighted average of interest rates paid on short- and long-term loans.

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

[12] We have 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 have decided not to report them for the sake of brevity. However they are available from the authors upon request.

[13] We emphasize the possible problems that can arise when dealing with this kind of data. Because the firm's

All the variables are in million dollars and have been converted in 1996 dollars using the GDP implicit price deflator.

We focus our analysis on firms in the manufacturing sector (SIC codes: 2000-3999) and in the wholesale and retail sector (SIC codes: 5000-5999). This choice is based on the great economic role of these two industries and their importance in the particular question we are trying to answer, that is the determinants of the demand for money by corporations. 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 affecting their cash holdings.

We include a 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. This choice is justified by the possible quantitative problems that might arise because Standard & Poor COMPUSTAT rounds[14] cash to the nearest $1,000. We think that such a criterion can induce a serious censoring problem and for this reason we consider all the sample of firms.[15] Further, we can argue that usually smaller firms have more financial constraints than their bigger counterparts, and therefore their demand for liquidity is crucial to analyzing money demand by firms.

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 of the selected variables. We notice immediately 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.[16] From Table 1 we see that both the scale of operation and cash vary dramatically across firm-years. Furthermore, we notice a

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Statement of Income usually contains flow variables, that is variables relating to all the period of interest, whereas in the firm's Balance Sheet we find stock variables, that is variables 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, the date at which the balance sheet is measured, 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.

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

[15] To make a useful comparison of our results with those by Mulligan's (1997a), in a previous version of the paper we have also considered all firms with sales greater than one million dollars. For both models estimated in the empirical exercise, the estimated sales elasticities are much higher than those from the complete sample. Therefore, we might argue that one of the possible reasons for introducing such a constraint by 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 he gets estimated sales elasticities closer to the numbers appearing in the literature.

very pronounced variation in all variables except the wages for the manufacturing industry. The variable w is the one displaying the greatest variation across firm-years for the retailing industry. Probably, this reflects this industry's extreme sensitivity to overall economic conditions and consumers confidence.

6. Empirical Evidence and Discussion

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

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

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

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

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

6.1 Preliminary Estimates

We initially estimate a series of cross-section OLS regressions year by year, whose results are shown in Figure 1. The upper-left panel of Figure 1 displays the sales elasticities when we consider the basic model 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 (dashed line) they vary from 0.58 to 0.79 and for the retailing businesses (line with circles) elasticities vary from 0.63 to 0.79. When we consider the 'large model', from the upper-right panel of Figure 1 we can notice very similar patterns, but now the

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[16] 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.

variation across years is even higher. Looking at all firms (continuous line), the elasticities (β) range from 0.64 to 0.87, while with the manufacturing corporations (dashed line) the parameters β's vary from 0.58 to 0.92 and for the retailing businesses (line with circles) the elasticities go from 0.61 to 1.07. The upper panels 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.[17]

The lower-left and the lower-right panels 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 range 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 estimated elasticities 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 range 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 elasticities with a counter-intuitive sign.

Table 2 presents the results from the pooled regressions when year effects are taken into account. The table shows the estimated sales elasticities for the basic and 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, 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.[18]

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[17] To check the robustness of our results, we have run some additional regressions by adding the logarithm of the variation in total inventories to all our models. The resulting estimated inventory elasticities are always insignificant and the other estimated elasticities do not change considerably. The same results hold when we add the log of the inventories.

[18] In these and in the following estimates the wage elasticities are almost always insignificant. Thus, we have also estimated all the large models by dropping the wage variable. All the remaining estimated elasticities are slightly lower than in the full model, whereas most retail regressions present the same estimates.

6.2 Balanced Panel Data Analysis

Table 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 sales elasticities from the three estimators without year effects do not differ substantially, meaning that the possible measurement error is less important when we do not consider year effects.

From the Hausman test 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 of 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 these 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 large, indicating that the latter ones are amplifying possible measurement errors.[19] In both panels all the elasticities are significant, except for some, such as those related to wages and 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, except for the retailing firms when year effects are considered.

We have seen that according to the Hausman test, the null hypothesis of absence of correlation between individual effects and the regressors is almost always rejected. Therefore, we

[19] 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.

have decided 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 log values of net sales ($\log(y_{t-1})$), the cost-of-capital ($\log(R_{t-1})$) and 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, the 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, except for the model with all firms without year effects. 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.[20]

In sum, all the results so far have confirmed that the estimated sales elasticities range between 0.60 and 0.70 even after accounting for possible endogeneity problems.

6.3 Unbalanced Panel Data Analysis

In the data we have selected from COMPUSTAT, many firms are not observed over the entire sample period: this leads to an unbalanced (or incomplete) panel. 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 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 yield more precise estimates of the money demand by COMPUSTAT firms.[21]

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[20] We have performed the same analysis using only the lagged net sales as an instrument. The results for the large model are quite similar, but the estimated elasticities are in general slightly lower than those obtained by considering all the instruments.

[21] In order to test the sensitivity of our data to the sweep account issue, we have split the sample into two subperiods: from 1982 to 1993 and from 1994 to 2000, the sweep account era. Our estimated elasticities do not change substantially over the two subperiods. Moreover, we have employed the Chow test for the null of hypothesis of

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,[22] with estimated sales elasticities around 0.5-0.7. A summary of the estimated sales elasticities of all the models considered is depicted in Figure 2. These results are lower than the 0.8 value of Mulligan (1997a) and the 0.9 value of Ben-Zion (1974) and in general all the other estimates in the literature, except 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, can we obtain estimates that are in line with the previous literature, even though, doing so gives rise to a serious censoring problem.

7. Conclusions

Our paper first organizes the previous theoretical models of money demand by firms taking into account firms' heterogeneity and then we estimate the demand for money by US non-financial firms using balanced and unbalanced panel data with firm-specific effects. We use the COMPUSTAT database and select the item 'cash' to describe cash holdings by corporations. Our focus is on two particular industries that best reflect the demand for money by firms: manufacturing, and 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 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 sometimes 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 firms. Our estimated sales elasticities are between 0.50 and 0.70, depending on the assumptions used. These are much lower than the ones 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

structural stability which is not rejected in most specifications.

[22] The economies of scale are measured by the reciprocal of the parameter θ in (8), because it represents $a+b$ in (7). Therefore, the lower the estimated sales elasticities, the greater the economies of scale in the demand for money by COMPUSTAT firms.

thought. This observation leads to the conclusion that small and large firms differ in terms of their demand for money; this issue, although important, goes beyond the scope of this paper. Furthermore, we find negligible and statistically insignificant effects of labor in cash holdings by firms, implying that labor is not a substitute for money as the theoretical model predicts. Probably, this result is due to our proxy of wages, that is the ratio of labor and related expenses to the number of employees at the end of each fiscal year. This 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. In contrast, the cost-of-capital elasticities are all significant and consistent with the fact that the interest rate represents the opportunity cost of holding money.

Our results suggest further research is needed to understand the possible effects of sample attrition and measurement errors in the determinants of demand for money by firms.

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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 GDP implicit price deflator is used to convert all current dollars in 1996 dollars.

Table 2: Results from pooled regressions

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

With Year Effects

	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: Standard errors are in parentheses. *, ** and *** indicate significance at 10, 5 and 1% respectively.

Table 3: Results from panel data analysis: basic model

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

Without Year Effects

	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)
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

With Year Effects

	Between			Fixed Effects			Random Effects		
	All	Man	Ret	All	Man	Ret	All	Man	Ret
$\log(y)$	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)
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 are in parentheses. H.T. is the Hausman test to test the null of absence of correlation between the individual effects and the regressors. *, ** and *** indicate significance at 10, 5 and 1% respectively.

Table 4: Results from panel data analysis: large model

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

Without Year Effects

	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-04	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)
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

With Year Effects

	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)
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 are in parentheses. H.T. is the Hausman test to test the null of absence of correlation between the individual effects and the regressors. *, ** and *** indicate significance at 10, 5 and 1% respectively.

Table 5: Results from panel data analysis with IV

	Basic Model $\log m_{i,t} = \alpha_i + \beta_t + \theta \log y_{i,t} + \varepsilon_{i,t}$						Large Model $\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \varepsilon_{i,t}$					
	Without Year Effects											
	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)
$\log(R)$	-	-	-	-	-	-	-0.328***	-0.366***	-0.249**	-0.223***	-0.258***	-0.126*
	-	-	-	-	-	-	(0.080)	(0.107)	(0.123)	(0.044)	(0.055)	(0.071)
$\log(w)$	-	-	-	-	-	-	0.141*	0.314**	-0.095	0.001	0.058	-0.093
	-	-	-	-	-	-	(0.080)	(0.143)	(0.124)	(0.065)	(0.092)	(0.086)
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
	With Year Effects											
	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)
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 are in parentheses. 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. *, ** and *** indicate significance at 10, 5 and 1% respectively.

Table 6: Results from unbalanced panel data analysis

	Basic Model: $\log m_{i,t} = \alpha_i + \beta_t + \theta \log y_{i,t} + \varepsilon_{i,t}$			Large Model: $\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \varepsilon_{i,t}$		
Without Year Effects						
	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)
R^2	0.462	0.460	0.510	0.737	0.740	0.653
N	59951	46524	13427	2934	1937	997
With Year Effects						
	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)
R^2	0.437	0.432	0.435	0.727	0.606	0.535
N	59951	46524	13427	2934	1937	997

Notes: Standard errors are in parentheses. Between estimator with weighted least squares. *, ** and *** indicate significance at 10, 5 and 1% respectively.

Figure 1: Elasticities from cross-section regressions

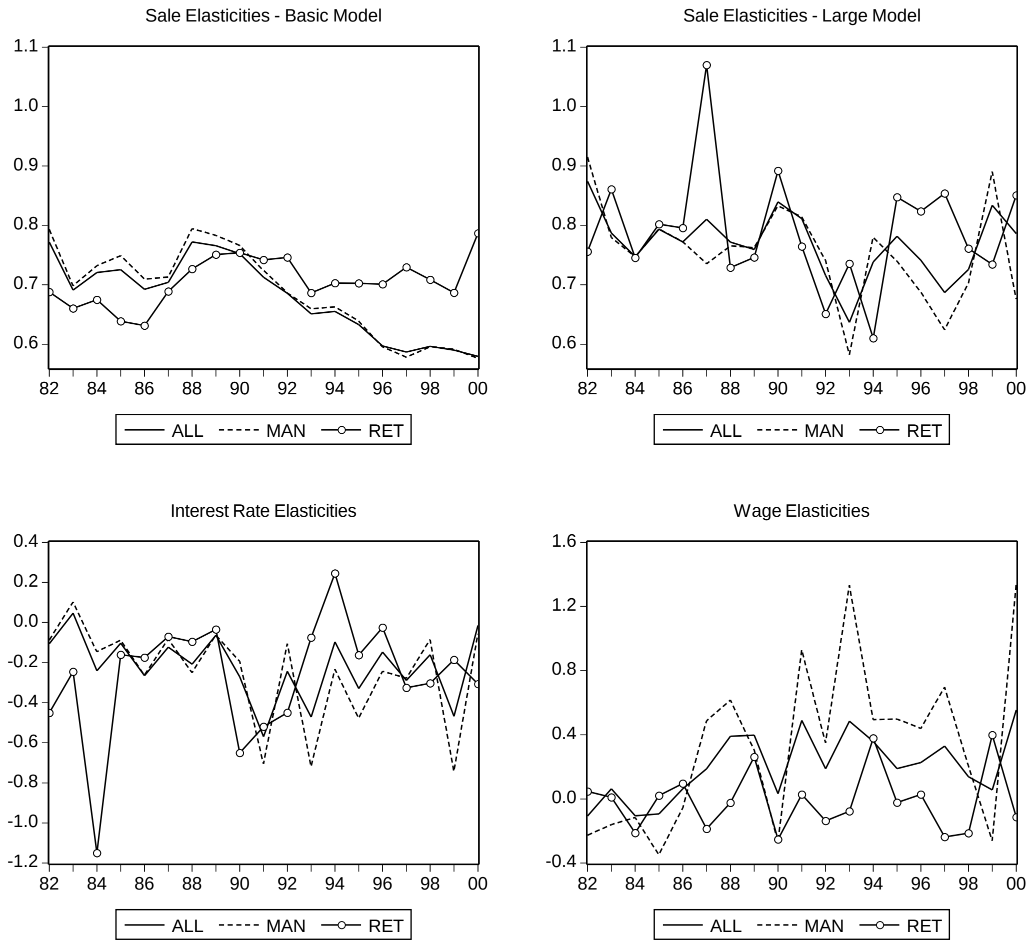
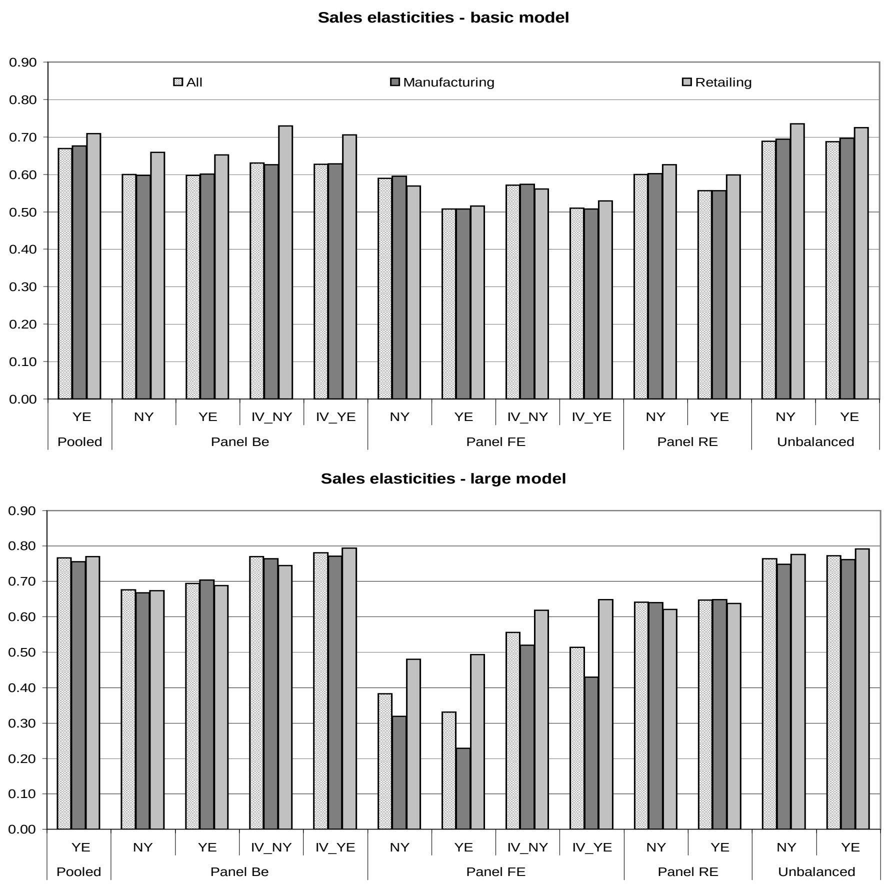


Figure 2: Sale elasticities: Comparison



Notes: Comparison of the estimated sales elasticities from different models with year effects (YE) and without (NY). IV indicates models estimated with instrumental variables. The Basic Model is: $\log m_{i,t} = \alpha_i + \beta_t + \theta \log y_{i,t} + \varepsilon_{i,t}$. The Large Model is: $\log m_{i,t} = \alpha_i + \beta_t + \gamma \log R_{i,t} + \delta \log w_{i,t} + \theta \log y_{i,t} + \varepsilon_{i,t}$. The different estimators are the pooled regressions (Pooled), the between (Be), the fixed effects (FE), the random effects (RE) and the unbalanced (Unbalanced) for panel data.

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