Differential Cash Constraints, Financial Leverage and the Demand for Money by Firms in a Developing Country

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Abstract

This paper studies firms' demand for money by developing a differential-cash-constraint framework with firms' entire wage bills requiring cash in advance and a fraction of investment purchases being financed by credits. In addition to conventional scale and opportunity-cost factors, firms' financial status and profitability are crucial determinants for their money demand behavior. Employing a new data set consisting of a panel of Taiwanese firms over 1990-97, our econometric analysis lends empirical support to our theory. The estimates suggest that economies of scale in firms' cash management are present and that lower financial leverage or higher profitability raises money demand significantly.

Keywords: Firms' Transactions Use of Money, Financial Structure, Panel Data Estimation

JEL Classification Numbers: E41, D92, C21

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I. Introduction

Theoretical and empirical studies on money demand have been at the center of the stage of monetary economics. Such issues are not only important for understanding the relationships between money, inflation and growth, but also crucial for conducting monetary policy and evaluating its welfare implications. The majority of previous work focuses on household demand for money, and the literature examining money demand by firms is thin. Our paper contributes to the latter issue both theoretically and empirically. In particular, it develops a generalized differential cash constraint model by taking an explicit account of firms' financial status, and it performs a systematic empirical test of the validity of our theory using a newly available panel data set of reliable quality.

Over thirty years ago, Miller and Orr (1966) extend the Allais-Baumol-Tobin inventory model to study firms' demand for money under uncertainty, suggesting the presence of economies of scale as money serves as a medium of exchange for firm transactions. Although the property of scale economies is empirically supported by Selden (1961) and Frazer (1964), Meltzer (1963) uses cross-section data and finds that the sales elasticity of money demand by firms is very close to unity, thereby implying the absence of economies of scale.[1] Since then, Whalen (1965), Vogel and Maddala (1967), and Falls and Natke (1988) have revisited this issue. By considering the portfolio choice aspect, their cross-sectional analyses reconfirm Selden's finding. Whalen (1965) and Vogel and Maddala (1967) suggest a tendency for cash economization when they incorporate assets as well as transactions into the demand function, obtaining estimates of the sales elasticities ranging from 0.86 to 1.08 (with only four industries below unity). Falls and Natke (1988) find that the sales elasticity of liquid assets of Brazilian manufacturing firms is about 0.9 after controlling for foreign ownership, industry structure, and

[1] The cross-section studies by Selden (1961), Frazer (1964), and De Alessi (1966) are based upon the asset approach in which the wealth of the firm is viewed as a constraint on its money holdings. Selden (1961) relates the velocity of money to the assets of the firms, Frazer (1964) examines the percentage of cash to liquid assets as a fraction of the total assets of firms, and De Alessi (1966) examines the relationship between the cash holdings of British firms and the value of their common stock. While Selden (1961) and Frazer (1964) suggest the presence of sale economies in the holding of money, De Alessi (1966) finds little evidence of economies of scale in cash holdings.

macroeconomic variables. Thus, a general conclusion drawn from this later literature is that the economies of scale in cash management are essentially negligible.

Recently, Mulligan (1997) re-estimates firm's money demand based on the value of time approach developed by Karni (1973) and Bomberger (1993), by constructing a pseudo panel data set from COMPUSTAT, which is clearly superior to the conventionally used cross-sectional data. In particular, Mulligan uses the wage rate to measure the cash manager's value of time and finds that an increase in the value of time results in higher money demand. His estimates of sales elasticities around 0.83 suggest moderate economies of scale of money in facilitating firm transactions.

Our paper contributes to the literature in two important aspects. First, we construct an intertemporal model of money demand by firms, in contrast to the conventional inventory or value of time approach.[2] The central feature of the theory developed here is the consideration of differential cash constraints in which firms' entire wage bills require cash in advance whereas a nontrivial fraction of investment purchases can be financed by credits. This framework is not only simplistic to permit analytic solution for the money demand function, but also realistic to capture different cash requirements for different types of firms' purchases. An infinitely lived firm owner optimizes over labor, capital investment, asset holdings and real cash balances. In steady-state equilibrium, a firm's demand for money depends crucially on its wage bills and investment purchases, as well as on the nominal interest rate and an array of profitability and financial variables that may influence labor employment and the endogenous differential cash constraint factor.

Second, we perform empirical analyses based on a new data set that contains 345 Taiwanese companies of various sizes and industrial categories over the period of 1990-97. Although the data at the firm level are much smaller in sample size than the COMPUSTAT data, we are able to construct a complete panel from the original source particularly suitable for the purpose of our

[2] For a survey of dynamic models of money from an integrated household-firm unit, the reader is referred to Dornbusch and Frenkel (1973) and Wang and Yip (1992).

study. Our empirical work based on the generalized differential cash constraint theory can be thought of as a complement to the conventional inventory and the value of time models. While a firm's demand for money is increasing in wage bills and investment purchases, the coefficient estimates for wage bills far exceed those for investment purchases, justifying our differential cash constraint hypothesis. Moreover, the results lend support to the presence of economies of scale for firms' transactions use of money and indicate that lower financial leverage or higher firm profitability tends to induce greater money demand. The overall scale elasticity is in the range of 0.58 to 0.68, implying significant scale economies in firms' cash management. The interest rate elasticity is higher than the conventional estimates, falling between 0.70 and 0.98 (in absolute value). While the financial leverage is a consistently powerful explanatory variable for both the fixed-effects model and the instrumental variable method, turnover rates and term and risk premia have statistically significant effects in some specifications. These findings are robust to an alternative two-step estimation and to deletion of extreme sales values.

The remainder of the paper is organized as follows. Section 2 develops an intertemporal model of a representative firm owner facing a differential cash constraint. In Section 3, we solve and characterize the property of money demand in steady-state equilibrium. Section 4 presents the data, the empirical methodology and the panel data estimation using the fixed-effects model as well as the instrumental variable method. Finally, we conclude the paper and acknowledge the limitations of our study in Section 5.

II. The Model

Time is continuous. Consider a representative firm with an owner, utilizing labor (L) and physical capital (K) to produce a good Y. The production function of the firm is assumed strictly increasing and strictly concave in each of the inputs, K and L, satisfying the constant-returns-to-scale property and the Inada conditions. It can thus be specified as: $Y = Y(K, L) = Ly(k)$, where the output per unit labor functions, y, is strictly increasing and strictly concave in the capital-labor ratio, k. Moreover, the firm owner is a residual claimer who consumes an amount of that good Q to receive utility of V(Q) at a particular point in time.[3] The instantaneous utility of the firm owner is strictly increasing and strictly concave in Q, satisfying the Inada conditions. Time index t is omitted whenever it does not cause any confusion.

There are three investment alternatives: the interest-bearing asset (A), the capital good (PK) and non-interest-bearing real money balances (M), where P is the relative price of the capital goods in unit of the output product. Thus, the three evolution equations are:

$$\dot{A} = \left[Y(K, L) - WL - PI\right] + RA - Q - Z \tag{1}$$

$$\dot{K} = I - \delta K \tag{2}$$

$$\dot{M} = Z - \pi M \tag{3}$$

where I and Z are, respectively, the flow investment in machine/equipment and real money balances, Q is the consumption by the owner of firm, W and R are, respectively, the real wage rate and real interest rate, δ is the rate of depreciation of physical capital, π is the inflation rate. While (2) and (3) are obvious, (1) implies that the asset incremental is governed by the flow profit (in squared bracket) plus interest earnings net of firm owner consumption and incremental money holdings.

We follow in the spirit of the household demand for money model developed by Wang and Yip (1992), generalizing the Stockman (1981) cash-in-advance constraint to:

$$WL + \phi\, PI \leq M \tag{4}$$

where $\phi \in [0, 1]$. Importantly, when $\phi = 0$, only wage bills require cash payments; when $\phi = 1$, all investment good purchases require cash in advance.[4] The cash-in-advance setup highlights the transactions use of money by firms. In general, one may anticipate that only a fraction of

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[3] The residual claimer setup follows Diamond and Yellen (1990). Under a constant-returns-to-scale production technology, the structure yields comparative-static results consistent with those under the profit maximization framework.

[4] In the household demand for money literature, Stockman (1981) assumes both consumption and investment purchases requires cash in advance ($\phi = 1$) whereas Wang and Yip (1992) allows a fraction of investment spending to be financed by credits ($0 < \phi < 1$). As pointed out by Wang and Yip (1992) and Laing, Li and Wang (2000), the cash-in-advance setup, under plausible conditions, yields comparative-static predictions generally consistent with the money-in-the-production-function, the money-in-the-utility-function, the transactions-cost and the search-theoretic approaches.

investment good purchases is subject to the cash-in-advance constraint, as observed in reality. Thus, 1- ϕ measures the fraction of credit goods, which is positively related to the leverage ratio (debt/equity) facing the firm. That is, the higher the financial leverage ratio is, the more accessible a firm will be able to undertake external financing and the more effective a firm will be able to manage cash flows, thus leading to less cash demand for facilitating transactions. Because money has no intrinsic value and the firm owner utility function obeys nonsatiation, optimization implies this above cash-in-advance constraint must hold at equality in equilibrium.

The problem of this representative firm owner is specified as:

$$\max_{Q,I,Z,L} \quad \Omega = \int_0^\infty V(Q)\, e^{-\int_0^t \gamma(\tau)d\tau}\, dt$$

s.t. (1)-(4); $i \geq 0$ ($i = Q, I, Z, L$); $A(0) = A_0 > 0, K(0) = K_0 > 0$ and $M(0) = M_0 > 0$

where $\gamma \in (0, \infty)$ is the subjective rate of discount of the firm. The current-value Hamiltonian for this problem can be written as:

$$H = V(Q) + \lambda\big[Y(K,L) - WL - PI + RA - Q - Z\big] + \alpha\big[I - \delta K\big] + \beta\big[Z - \pi M\big] + \eta\big[M - WL - \phi PI\big]$$

where λ, α and β are the co-state variables associated with the state variables A, K and M, respectively, and η is the Lagrangian multiplier associated with the cash-in-advance constraint.

Since our primary concern is with asset portfolio and money demand, we will regard the relative price and real wage rate as exogenously given. The only price variables to be determined in the model are therefore the inflation rate and the real interest rate. To close the model, we need to specify the money supply process, money market equilibrium and the asset portfolio possibility frontier pinned down by the loanable funds market. Money supply injected in the firm sector is assumed to grow at a constant rate $\mu > 0$ and thus money market equilibrium implies:

$$\frac{\dot{M}}{M} = \mu - \pi \tag{5}$$

The asset portfolio possibility frontier is simply given by a linear transformation schedule:

$$A = \Psi PK \tag{6}$$

where $\Psi > 0$ measures the ability to accumulate interest-bearing financial assets, depending positively on the profitability of the operation of the firm.

III. Theoretical Results

The associated necessary conditions for the optimization problem facing the representative firm owner are given by:

$$V_Q - \lambda = 0 \tag{7a}$$

$$-P + \alpha - \eta\phi P = 0 \tag{7b}$$

$$-\lambda + \beta = 0 \tag{7c}$$

$$\lambda(Y_L - W) - \eta W = 0 \tag{7d}$$

$$\dot{\lambda} = \lambda(\gamma - R) \tag{7e}$$

$$\dot{\alpha} = (\gamma + \delta)\alpha - \lambda Y_K \tag{7f}$$

$$\dot{\beta} = (\gamma + \pi)\beta - \eta \tag{7g}$$

$$\lim_{t\to\infty} e^{-\gamma t}\lambda(t)A(t) = 0, \quad \lim_{t\to\infty} e^{-\gamma t}\alpha(t)K(t) = 0, \quad \lim_{t\to\infty} e^{-\gamma t}\beta(t)M(t) = 0 \tag{7h}$$

where (7a)-(7d) are the efficiency conditions associated with the controls, Q, I, Z and L, respectively, (7e)-(7g) are the Euler equations governing the states, A, K and M, respectively, and (7h) presents the transversality conditions.

From (7a) and (7c), we obtain:

$$\lambda = \beta = V_Q \tag{8}$$

Thus, the shadow costs of interest-bearing assets and money (i.e., λ and β, respectively) are equal to firm's marginal valuation of output (V_Q).

Using (7a) and (7d), one gets:

$$\eta = \left(\frac{Y_L}{W} - 1\right)V_Q \tag{9}$$

Combining (7a), (7b) and (7d) gives:

$$\alpha = p\left[1 + \phi\left(\frac{Y_L}{W} - 1\right)V_Q\right] \tag{10}$$

Thus, all the co-state variables and Lagrange multipliers (λ, β, η and α) are now written as functions of control and state variables in a recursive manner, which greatly simplifies the analysis. Obviously, one must impose a restriction on the real wage rate such that $W<Y_L$ to ensure sensible results. The ratio Y_L/W may be regarded as the "relative labor productivity" which depends negatively on the severity of the diminishing returns of the labor input.

Next, substitution of (8)-(10) into (7f) and (7g) yields:

$$\frac{\dot{\alpha}}{\alpha}=(\gamma+\delta)-\frac{V_Q}{p\left[1+\phi(Y_L/W-1)V_Q\right]} \tag{11}$$

$$\frac{\dot{\beta}}{\beta}=(\gamma+\phi)-(\frac{Y_L}{W}-1) \tag{12}$$

Therefore, the rates of change of both the shadow cost of capital (α) and the shadow cost of money (β) are increasing in the severity of cash requirement (ϕ). This provides a channel through which money complements capital, which is a consequence of the cash-in-advance setup. While the rate of change of the shadow cost of money is decreasing in the relative labor productivity, the rate of change of the shadow cost of capital is increasing in the relative labor productivity and decreasing in the firm's marginal valuation of output.

In the steady state, all variables are constant. Thus, equations (7e) and (5) imply:

$$R=\gamma \tag{13}$$

$$\pi=\mu \tag{14}$$

That is, the real interest rate and the inflation rate are pinned down, respectively, by the subjective time discount rate and the money supply growth rate. Utilizing (10), (12) and (14), we derive:

$$Y_L=(1+R+\mu)W \tag{15}$$

This relationship equates the marginal value of labor with its marginal cost. Since wage payments require cash in advance, the real wage rate is augmented by the intertemporal cost of money holdings (i.e., the nominal interest rate, R + μ) to measure the marginal cost of labor.

From (10), (11) and (15), we have:

$$\left[1-\phi\,P(R+\delta)(R+\mu)\right]V_Q=P(R+\delta) \tag{16}$$

which determines the firm owner consumption demand: $Q^d=Q^d(R,P,\mu)$ where $\partial Q^d/\partial i<0$ for i

= R, P, μ.[5] While the negative effects of the real interest rate and the relative price of capital on the firm owner's residual claim is straightforward, the downward force of money growth deserves further elaboration. An increase in the rate of money growth raises the intertemporal cost of money holdings. Due to cash requirements, both augmented wage and investment costs become higher. As a result, the firm's profitability is lower, thereby reducing its owner's consumption demand.

By the constant-returns property, the marginal product of labor (Y_L) depends on the capital-labor ratio (k) alone. This, together with (15), implies the equilibrium capital-labor ratio, k^*, is a monotone increasing function of $(1+R+\mu)W$. Applying (2) in the steady state, we have:

$$I = \delta L k^*\left[(1+R+\mu)W\right] \tag{17}$$

That is, an increase in the money growth rate creates a positive "asset substitution" effect in that the representative firm lowers money holdings and increases capital investment. However, there is also a negative productivity effect: the increased marginal cost of labor (as a result of the cash requirement for wage payments) reduces employment, thus leading to lower investment (as the two production factors are Pareto complements, i.e., $Y_{LK} > 0$).

Finally, by tedious but straightforward manipulations of the steady-state version of (1), (2) and (3), and (4) (with equality), (6), (14) and (17), one obtains:

$$Y(\frac{I}{\delta}, L) - (1+\mu)WL = \frac{1}{\delta}\left[(1+\phi\mu)\delta + \Psi R)PI + Q\right] \tag{18}$$

Define $\Gamma(R,P,\mu,k,W,\Psi) = \{y(k[\cdot]) - (1+\mu)W - [(1+\phi\mu)\delta + \Psi R]Pk[\cdot]\}$ where $\Gamma > 0$, $\partial\Gamma/\partial k > 0$ [using the envelope property of the production function with the steady-state version of (1)] and $\partial\Gamma/\partial i < 0$ for i = R, P, μ, Ψ. Then, (16)-(18) together with the production function lead to:

$$\Gamma(R,P,\mu,k,W,\Psi)L = Q^d(R,P,\mu) \tag{19}$$

An important implication of (19) is that the effect of a higher Ψ is to increase steady-state labor employment (L^*). As for the effects of R and μ, there are three channels: (i) a negative direct effect via Q^d , (ii) a negative capital accumulation effect via k, and (iii) a positive factor

[5] It is useful to note that $|\partial Q^d/\partial \mu| = [V_Q^2/(-V_{QQ})]\phi < [V_Q^2/(-V_{QQ})]\{\phi + 1/[P(R+\delta)^2]\} = |\partial Q^d/\partial R|$.

substitution effect via Γ. Throughout the remainder of the paper, we assume that the elasticity of factor substitution is not too high so that a higher rate of real interest or money growth results in a lower level of employment.[6] This may be referred to as an "intertemporal employment normality" condition (or, shortly, Condition N), which is consistent with findings in conventional optimal monetary growth models summarized by Wang and Yip (1992).

We are now ready to use (4) (with equality) to pin down the money demand function:

$$M^d(W,k,\phi,\Psi,R,\mu) = (W + \phi P\delta k)L^*(\cdot,k,\Psi,R,\mu) \tag{20}$$

Under the intertemporal employment normality condition, straightforward differentiation of (20) yields: $\partial M^d/\partial W > 0$; $\partial M^d/\partial k > 0$; $\partial M^d/\partial \phi > 0$; $\partial M^d/\partial \Psi > 0$; $\partial M^d/\partial R < 0$; and, $\partial M^d/\partial \mu < 0$. Intuitively, an increase in the wage rate, via the cash-in-advance constraint, increases firm demand for money. An increase in investment enlarges the capital-labor ratio and, via the fractional cash-in-advance constraint and labor employment, raises money demand. An increase in the severity of the cash requirement for investment good purchases (higher ϕ) enhances the role of money in facilitating firm transactions and thus induces higher money demand. Increased profitability that raises firm ability to hold interest-bearing financial assets (higher Ψ) induces a greater demand for money. Finally, an increase in either the real interest rate or the money growth rate creates an adverse effect on steady-state employment, thereby reducing firm's money demand.

Equation (20) provides a theoretical foundation for the econometric model of money demand by firms to be constructed in the next section. In practice, the capital stock data are not available, and hence, we must proxy the capital-labor ratio by the firm's capital investment.[7] Such a transformation can be obtained by manipulating (18)-(20), throughout replacing k with $I/(\delta L^*)$.[8]

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[6] Precisely, by noting that $|\partial Q^d/\partial\mu| < |\partial Q^d/\partial R|$, it is sufficient to assume the following inequality holds in the steady state: $|\partial Q^d/\partial\mu| + WL\{y_k - P[(1+\phi\mu)\delta + \Psi R]\}/(-ky_{kk}) > L\ \max\{W + \phi\delta Pk,\ \Psi Pk\}$.

[7] In practice, firms use different methods assessing the values of machines, equipment and depreciation, thus making the capital stock data less compatible in cross-sections. Moreover, the increment of capital stock ties better with current needs for cash.

[8] From (18) and (19), $I = \delta k L^*(\cdot, k, \Psi, R, \mu)$ can be shown as a monotone increasing function in k under Condition N. It can thus be inverted to derive the monotone relationship $k=I/(\delta L^*)$.

Indeed, as we will see below, the econometric models are based on a log-linear approximation of the transformed money demand equation (20), with added empirical explanatory variables and/or industry dummies.

IV. Empirical Evidence

A. The Data

The firm-level data in this study are drawn from the *Taiwan Economic Journal Data Bank* which is collected by the Taiwan Economic Journal Company. The original data set consists of 376 companies. Selected items from corporate end-of-year balance sheets and income statements are reported for the manufacturing and nonmanufacturing sectors. The firms in our study are in 14 industries as classified by Standard Industrial Classification (SIC). These sectors include food processing, textile, plastic products, rubber products, electrical machinery and electronic products, cement, industrial chemicals and chemical products, pulp and paper products, non-metallic products, primary metal industry, motor vehicles, transportation equipment, construction, and service sector. Thus, these firms represent well the entire Taiwanese economy with regards to their scopes of production. Because all the firms are listed on the Taiwan Stock Exchange since 1990, it is expected that they are larger and likely better-performing than smaller enterprises, implying perhaps more effective cash management. That is, an average Taiwanese firm may be anticipated to have smaller scale economies in the transactions use of money than those of our sample firms.

To understand the determinants of firms' money demand behavior, we construct from the original data a balanced panel data set containing 345 Taiwanese firms from 1990-97.[9] A balanced panel ignores data on firms which are listed only a subset of the years 1990-97 and thus raises the issue of sample selection.[10] Table 1 reports basic statistics for the variables used in the

[9] We have deleted 31 sample firms from our empirical analyses due to incomplete data on cash and sales.
[10] The sample includes 28 firms in food processing, 49 firms in textile, 17 firms in plastic products, 8 firms in rubber products, 90 firms in electrical machinery and electronic products, 8 firms in cement, 18 firms in industrial chemicals and chemical products, 8 firms in pulp and paper products, 7 firms in non-metallic products, 23 firms in primary metal, 5 firm in motor vehicles, 14 firms in transportation equipment, 28 firms in construction, and 42 firms in service sector.

regression analysis. The variables are summarized into three groups: (i) firm-level variables, (ii) industry-level variables, and (iii) macro-level variables.

The real cash balances variable (M) is measured by "cash and cash equivalent" on each firm's balance sheet. It is defined as cash and any instruments normally accepted by banks for deposit and immediate credit to a customer's account, including bank drafts, banker's acceptances, checks, demand certificates of deposit, demand deposits, letters of credit, and money orders. There is an array of other firm-level variables used for econometric estimation. The conventional scale variable (S) is measured by "gross sales", the wage variable (W) by "wage bills", the capital investment variable (INV) by "investment bills" (including both new and replacement investments) and the profit variable by "pre-tax gross profits" all from each firm's income statement. We measure firm's profitability (denoted Π_F) by the ratio of profit to sales. Three firm-level financial variables available in the data set are the turnover days for funds-payable (F_P) and for funds-receivable (F_R), as well as the leverage ratio variable (θ), which is measured by the ratio of short-term borrowing to total current assets in percentage.

At the industry level, the value of time variable (VT) is measured by "annual wage and salary income per employee," which is obtained from the *Monthly Bulletin of Earnings and Productivity Statistics in Taiwan*. Another industry-level variable is exportability, measured by the "export to production share" for each industry classification. This is computed from the data on export values and production values by two-digit industry in the *Monthly Statistics of Exports and Imports in Taiwan* and the *Monthly Statistics of Industrial Production in Taiwan*, respectively.

At the macro level, the nominal interest rate (RN) is measured by the 3-month time deposit rate. While the risk premium (R_{RP}) by the difference between the annual average of unsecured loans rates and 91-day Treasury Bills rates in primary markets, the term premium (R_{TP}) by the difference between the 3-year time deposit rate and the 3-month time deposit rate. All the interest rates are posted by the Bank of Taiwan.

To correct for inflation, all monetary measures are expressed in 1990 New Taiwan dollars (NT$).[11] Notably, for comparison purposes, our measures of gross sales, the value of time, and the nominal interest rate are consistent with those used by Mulligan (1997).

B. Econometric Methodology

We estimate two models. The first is the value of time approach developed by Mulligan (1997). The second is based on our generalized differential cash constraint theory constructed in Sections 2 and 3 above. While the latter is our main focus, the former is included for comparison purposes.

1. The Value of Time Model. Denote the firm index by i, the industry index by j and the time index by t. The money demand regression setup based on the value of time approach is given by:

$$\ell n\, M_{it} = a_0 + a_1 \ell n\, S_{it} + a_2 RN_t + a_3 \ell n\, VT_{jt} + a_4 EX_{jt} + \varepsilon_{it} \tag{21}$$

where M_{it} = real cash balances (of firm i); S_{it} = gross sales (of firm i); RN_t = the nominal interest rate; VT_{jt} = annual wages per employee (of industry j), and EX_{jt} = the exports to output share (of industry j). Following the conventional wisdom, the sales and the value of time variables are transformed logarithmically, and thus the associated coefficients can be interpreted as elasticities. Any ratios or percentage measures are in levels.

In addition to the scale variable (S), the explanatory variables, RN and ℓn VT, enter equation (21) because they affect the opportunity cost of holding money relative to other inputs in the firm's production function. As in the Alais-Baumol-Tobin inventory model, a higher nominal interest rate increases the opportunity cost of money hoarding and is thus expected to lower the demand for money. Following the arguments in the value of time framework adopted by Mulligan (1997), a higher value of time (of the cash manager) suggests increased time costs for transactions, therefore increasing money holdings. The export share variable is included because it is emphasized by Tsiang (1977) that in a highly trade-dependent, small open economy such as

[11] The Wholesale Price Index is used to convert all current dollars to 1990 values. The exchange rate in 1990 was US$1= NT$27.11.

Taiwan, greater exportability requires more money demand. In summary, we expect: $a_1 > 0, a_2 < 0, a_3 > 0$, and $a_4 > 0$.

2. The Differential Cash Constraint Model. Based on our generalized differential cash constraint theory, the log-linear approximation of the transformed money demand equation (20) gives rise to the second econometric model:

$$\ell n\, M_{it} = b_0 + b_1\ \ell n\, W_{it} + b_2\ \ell n\, INV_{it} + b_3\, \Pi_{Fit} + b_4\, RN_t + b_5\, \theta_{it} + b_6\, X_{mt} + \upsilon_{it} \qquad (22)$$

where W_{it} = wage bills (of firm i); INV_{it} = investment bills (of firm i); RN_t = the nominal interest rate; Π_{Fit} = the profit to sales ratio (of firm i); θ_{it} = the leverage or debt-to-equity ratio (of firm i); and, X_{mt} = other added explanatory variables (of firm i or industry j with m = i or j).

Importantly, an increase in financial leverage θ is expected to lead to a higher fraction of credit purchases (i.e., lower ϕ in the theoretical model), whereas greater profitability (higher Π_F) corresponds to a positive autonomous change in ψ. Therefore, the comparative statistics derived from the equation system (18)-(20) imply: $b_1 > 0, b_2 > 0, b_3 > 0, b_4 < 0$, and $b_5 < 0$. Despite that the ratio of the coefficients b_2 / b_1 does not provide a direct empirical measure for the factor of differential cash constraints, ϕ, a small value of this ratio would suggests the likelihood for investment purchases to require proportionally less cash-in-advance than wage payments (i.e., $\phi <$ 1). Notice that our benchmark specification of the interest rate uses the semi-log form, yet we report the estimates in complete log-form in the Appendix to check the robustness of our findings. In addition to the interest rate variable, we take term premium (R_{TP}) and risk premium (R_{RP}) as alternatives to RN in our analysis. While a higher term premium suggests greater time preferences and opportunity costs of cash hoarding, an increase in the risk premium favors money holdings as cash is certainly a safer portfolio outlet. Hence, R_{TP} has a negative impact on money demand, but the effect of R_{RP} is positive. Moreover, we also include the turnover days for funds-payable (F_P) and for funds-receivable (F_R) as two additional indicators for firm's financial status. Obviously, an increase in F_P loosens the cash flow whereas an increase in F_R tightens it. While the effect of a higher F_R is expected to reduce firm’s demand for money, that of a greater F_P need not be associated with an increased demand for money because it may be a *consequence* of poor cash management which results in longer funds-payable turnovers and lower real money holdings.

As an alternative to the log-linearized regression specification (22), one may adopt a two-step procedure. In the first step, one may obtain a direct estimate of a firm's expenditures that require cash payments:

$$E_{it} = W_{it} + \phi_i \, INV_{it} \tag{23}$$

Since ϕ_i is unobservable, we would need to estimate by utilizing the data on financial leverage (θ_i). More precisely, we order all firms by θ_i, assign that with lowest value of θ with $\phi = .8$ and that with lowest value of θ with $\phi = .2$ (the plausible upper and lower bounds for ϕ), and interpolate all other values of ϕ_i linearly according to θ_i. In the second step, we estimate the following econometric model:

$$\ell n\, M_{it} = d_0 + d_1 \, \ell n\, E_{it} + d_2 \, \Pi_{Fit} + d_3 \, RN_t + d_4 \, X_{mt} + \upsilon_{it} \tag{24}$$

where the comparative statistics derived from the equation system (18)-(20) imply: $d_1 > 0$, $d_2 > 0$ and $d_3 < 0$.

Both random-effects and fixed-effects models are estimated in our analyses. The former assumes that firm-specific factors are uncorrelated with the regressors. In contrast, the latter allows for such a correlation. Under the specification test suggested by Hausman (1987), one cannot reject the hypothesis of no correlation.[12] Thus, both fixed and random-effects estimators are consistent (and the random-effects estimator is efficient). Following the conventional wisdom, we report the fixed-effects model as the benchmark while relegating the random-effects model to the Appendix. This is because that inter-firm variation in cash holdings is expected to depend on the nature of its industrial environment (e.g., the market structure, the manufacturing process, the nature of rivalry, the inventory policy, and the degree of riskiness). The estimation

[12] The Hausman test is based on the observation that, if the individual effects are uncorrelated with the independent variables, random-effects estimators are consistent. The Hausman test statistics uses a specific metric to measure the difference between fixed and random-effects estimates. If fixed and random-effects estimates are different, this suggests that the random-effects estimator is inconsistent. The Hausman test rejects the random-effects model if the test statistics is greater than a critical value taken from the Chi-squared distribution (Green, 1997).

using fixed-effects models accounts for such a possibility, capturing diverse industrial influences on firm behavior.

C. Empirical Evidence

1. The Value of Time Model. Columns 1 to 3 in Table 2 present the results of estimation based on the quantity theory, the conventional inventory approach, and Mulligan's value of time model as specified in (21), respectively. Extensions of the inventory and the value of time frameworks with an added exportability variable are reported in columns 4 and 5, respectively.

Column 1 shows that the elasticity of the demand for money with respect to sales is about 0.63, which is reduced in magnitude (to 0.56) when the interest rate is included in the second column. Consistent with models of money demand, the sign of interest rate is negative. Based on the semi-elasticity estimates, we can compute the interest rate elasticity as 0.92, which is much higher than that implied by the Alais-Baumol-Tobin square-root formula (0.5). In column 3, we use an index of wages and salaries per worker as a proxy for transactions-time costs associated with cash management. If labor is a substitute for money as suggested by the value of time approach, one may expect that the value of time measure (VT) should increase the demand for money. Our finding is consistent with this prediction, displacing an estimated wage elasticity of 1.16.[13] Moreover, the sales elasticity is about 0.53 (column 3), much lower than the comparable figure reported by Mulligan (1997), which is about 0.83. Thus, we have identified stronger scale economies of cash management.

To understand the role of export orientation in determining firm's money demand behavior, we add the export share variable in our analysis. The coefficient of export share is positive but statistically insignificant in both columns 4 and 5.

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[13] Based on the money-in-the-production empirical framework developed by Nadiri (1969), Dennis and Smith (1978) find that real cash balances is a substitute for labor and capital inputs in 11 U.S. manufacturing industries. However, using India's manufacturing industry data, Laumas and Williams (1983) conclude that cash balances and labor are predominantly substitutes, yet cash balances and capital are by and large complementary.

2. The Differential Cash Constraint Model. The results obtained from estimating regression (22) are presented in Table 3, whereas those from estimating (24) are summarized in Table 4.[14] In all cases, the coefficients on wage bills, investment purchases and profit rates are positive and statistically significant at the 1 percent (for most cases) or at least the 5 percent level. These findings are consistent with the predictions of our theoretical model.

Based on the model specified as in (22), a measure of the overall scale elasticity ($\xi = \xi_W + \xi_{INV}$, which corresponds to the estimates of $b_1 + b_2$) is in the range of 0.60-0.68, based on regressions in columns 6-8, and 0.58 based on regressions in columns 9 and 10. The result implies significant scale economies associated with the use of money by firms. Moreover, the coefficient estimates for wage bills (ranging from 0.54 to 0.56 in the benchmark regressions in columns 6 and 9) far exceed those for investment purchases (ranging from 0.03 to 0.04). Although the coefficient estimates for investment bills may be downward biased due to the nature of its lumpy adjustments, such significantly low values (with a ratio of approximately 1:16 compared to the wage bill coefficient estimates) together with extremely tight standard error bands (with 95 percent confident interval lower and upper bands given by 0.015 and 0.055) lead us to conclude that the differential cash constraint hypothesis earns fairly strong empirical support.

The interest rate elasticity is 0.70 (computed from the semi-elasticity figure in column 6), lower than the estimates in Table 2. We also take term and risk premia as alternatives to interest rate. The influence of term premium on the cash holdings is, as anticipated, significantly negative (column 7). Conversely, the coefficient estimate of risk premium is significantly positive (column 8), indicating that an increase in the degree of riskiness concerning a firm's portfolio choice raises the demand for the safe asset, money. The positive effect of exportability on money holdings by firms is statistically insignificant, contrasting with the evidence found in a macroeconomic study

[14] The sample is reduced to 126 firms after deleting the missing information on key variables.

by Tsiang (1977).[15] With respect to measures of firms' financial status, we find that the leverage ratio has strong negative impact on firms' money demand, regardless of econometric model specifications. The negative and generally significant coefficient estimates of turnover days for funds-payable (F_P) indicate that longer funds-payable turnovers are likely associated with poor cash management and lower cash holdings. The coefficient of turnover days for funds-receivable (F_R) is, as expected, positive but statistically insignificant.

We next turn to the model specified as in (24) where in the first step we estimate cash required expenditures according to firm-specific financial leverage measures. A robust finding is the scale economies in cash management (based on the coefficient estimates on ℓn E. Compared with the same specification in Table 3, the interest rate and the turnover days for funds-payable continue to have significantly negative effects on money demand, whereas the positive profitability and exportability effects become more significant.

Because these larger firms included in our sample are more likely to have longer-term investment plan, it is reasonable to regard investment purchases as exogenous to cash management. However, wage bills may be endogenous to the money demand decision. Thus, instrumental variable (IV) procedures are used to account for possible endogeneity of W_{it}. Lacking of other sensible alternatives (such as firm-level years of schooling and employment tenure data), we simply utilize one and two-year lagged wage bills, $W_{i,t-1}$ and $W_{i,t-2}$, as instruments in the estimation.[16] The results are reported in Table 5-1, which are largely consistent with our previous findings presented in Tables 3 and 4. In particular, there still exist significant scale economies in cash management (with the overall scale elasticities now ranging from 0.67 to 0.73 based on estimates in columns 6-10) and strong financial leverage effects (all significantly negative). The positive effects of investment bills and the profitability measure generally remain

[15] Using the macro data over the period from 1953 to 1972, Tsiang introduces the ratio of the volume of trade relative to the national income into the money demand regression and finds that it has a significant effect on the demand for money in Taiwan.
[16] For a discussion of instrumental variable estimation in the panel data, see Hsiao (1986). In particular, our procedure follows closely to that in Bregman, Fuss and Regev (1995).

statistically significant. For other financial variables, the term and risk premia and the turnover days become statistically insignificant. We also instrument using one and two-year lagged employment data ($L_{i,t-1}$ and $L_{i,t-2}$) and one and two-year lagged computed wage payment data (by the multiple of firm employment $L_{i,t-p}$ and industrial wage rates YW_{t-p}). The estimates, reported in Tables 5-2 and 5-3, suggest that our main findings are robust. Of course, by the nature of annual data, using one or two-year lagged variables as instruments may lose important current information. Therefore, the IV method is adopted only to complement rather than replace the fixed-effects OLS estimation.

To further test the robustness of our empirical findings, we first account for possible sample selection problems by eliminating extreme large and extreme small firms (those ranked within the top 5 and bottom 5 percent in sales). The results are presented in Appendix Table A3-1. While previous conclusions remain qualitatively unchanged, the degree of scale economies in cash management increases slightly by a few percentage points. Second, since some previous studies (including Mulligan) use complete log-linear specification applying to all variables (including interest rates), we report estimates from this alternative specification in Appendix Tables A3-2, A4, A5-1 and A5-2. Third, we report results under the random-effects specifications in the Appendix (Table A3-3). As the estimation efficiency is improved, some financial variables previously insignificant under the fixed-effects specification now become significant. Overall, the degree of scale economies in cash management also increases slightly over the benchmark case.[17]

In summary, our empirical results are consistent with the theoretical predictions obtained from our generalized differential cash constraint model. They lend strong support to our theory that firms' demand for money is increasing in wage bills and investment purchases. As the coefficient estimates for wage bills far exceed those for investment purchases, the differential cash constraint hypothesis is justified empirically. Moreover, while there are apparent economies

[17] The corresponding robustness results for the value of time model are provided in Appendix Tables A2-1 and A2-2.

of scale concerning the role of money in facilitating firm transactions, several profitability and financial variables are found to influence firms' money demand significantly. In particular, a lower financial leverage ratio or a higher firm profitability ratio tends to increase firms' money demand significantly. The results also indicate that the industry effects are rather weak, implying the absence of unobservable heterogeneity across industries.

Notably, even without including gross sales (which is known to be a powerful explanatory variable), the regressions based on our differential cash constraint theory (i.e., Columns 6-10 in Tables 3 and 5) still perform very well. Indeed, they are as good as any using the conventional inventory (Column 2 in Table 2) or the value of time framework (Column 3 in Table 2). Our econometric model can therefore be thought of as a good alternative to previous approaches.

In macroeconomic studies using Taiwanese data, the income and interest rate elasticities of money demand in Taiwan can be found in Tsiang (1980) and Shea (1983). While the income elasticity is in the range of 1.08-1.49, the interest rate elasticity falls in 0.13-0.42. Interestingly, the firm-level estimates in Tables 3-5 show much larger scale economies in cash management and more sensitive responses of money demand to the nominal interest rate. Moreover, by comparing our results with the existing literature on the demand for money by firms, our measure of scale economies is by far the largest.

What are the implications for monetary policy? The presence of large scale economies in Taiwanese firms' cash management implies that there is less need for money supply accommodation to these Taiwan Stock Exchange-listed businesses. Since the interest rate elasticity of money demand is significantly higher than conventional estimates, previous welfare cost measures of inflation are likely to suffer severe downward bias. Such distortions are likely to affect larger firms disproportionately more severely, and the resultant reduction in social welfare may provide a rationale for conducting conservative central bank policy (in the sense of assigning greater weights to the social welfare loss from inflation). Furthermore, since firms' financial status is crucial for their money demand decision, an effective monetary policy requires careful account for and assessment of the underlying financial environment.

V. Concluding Remarks

We have revisited the issue of firm's demand for money by developing a generalized differential cash constraint model and undertaking empirical tests with a complete panel of Taiwanese firms over the period of 1990-97. We support the hypothesis of differential cash constraints and the property of economies of scale in the transaction role of money for firms where the overall scale elasticity is in the range of 0.56 to 0.78. The nominal interest rate has a conventional negative effect on money demand with the elasticity measures falling between 0.70 and 0.98. Several firm profitability and financial variables also play significant roles in influencing the money demand behavior, including the profit/sales ratio, the leverage (debt/equity) ratio and the term and risk premia.

In the end, we would like to acknowledge the limitations of this study. On the one hand, the data is at annual frequency, which is not suitable for studying within-the-year adjustments in cash. On the other, since our sample includes only firms listed on the Taiwan Stock Exchange, the resultant selection bias problem exists. Thus, our conclusions, especially those regarding scale economies in the transactions use of money, may not be entirely applicable to small enterprises in which cash management is arguably less effective. Nonetheless, our empirical evidence provides an interesting contrast with that in previous work, and our generalized differential cash constraint theory can be applied to performing econometric analysis using available data from other countries.

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Table 1: Definition of Variables and Summary Statistics

Variables	Definition	Mean	Standard Deviation	Minimum	Maximum	N
A. Firm-Level Variables						
ℓn M	Log (Cash and cash equivalent) (NT$)	11.954	1.508	4.697	16.671	2760 (345 × 8)
ℓn S	Log (Gross sales) (NT$)	14.779	1.123	3.867	18.198	2760 (345 × 8)
ℓn W	Log (Wage bill) (NT$)	12.502	0.967	6.886	15.530	1008 (126 × 8)
ℓn INV	Log (Investment bill) (NT$)	11.529	3.914	0.000	17.210	1008 (126 × 8)
Π_F	Profit / Sales (%)	6.415	8.517	-59.165	41.196	1008 (126 × 8)
θ	Short-term borrowing / Total current assets (%)	27.589	49.372	0.000	703.687	1008 (126 × 8)
F_P	Turnover days for funds-payable (days)	35.997	24.249	0.000	305.000	992 (124 × 8)
F_R	Turnover days for funds-receivable (days)	63.057	34.529	2.000	282.000	992 (124 × 8)
B. Industry-Level Variables						
ℓn VT	Log (Annual wage and salary income per employee by industry) (NT$)	12.801	0.182	12.357	13.144	112 (14 × 8)
EX	Export share by industry (%)	35.848	31.167	0.000	93.300	112 (14 × 8)
C. Macro-Level Variables						
RN	Three-month time deposits rate (%)	6.359	0.741	5.250	7.750	8
R_{TP}	Three-year time deposits rate-three month deposits rate (%)	1.272	0.371	0.825	2.000	8
R_{RP}	Annual average of unsecured loan rates-91 day treasury bills in primary market (%)	17.871	0.651	16.770	18.780	8

Notes: N is the number of observations. While 115 observations have zero short-term borrowing, 6 show zero funds-payable turnover days. Industry-level wages do not include bonus or overtime payments. The Wholesale Price Index is used to convert all current dollars to 1990 values. The exchange rate in 1990 was US$1= NT$27.11.

Table 2: Value of Time Model (Dependent Variable: ℓn M)

Independent Variables	(1)	(2)	(3)	(4)	(5)
ℓn S	0.627 (5.96)***	0.558 (5.45)***	0.526 (5.28)***	0.559 (5.46)***	0.526 (5.29)***
RN		-0.126 (-4.26)***	0.021 (0.47)	-0.121 (-3.66)***	0.023 (0.48)
ℓn VT			1.157 (3.20)***		1.155 (3.20)***
EX				0.001 (0.26)	0.0003 (0.11)
Adj.-R^2	0.64	0.65	0.65	0.65	0.65

Notes: All regressions contain a balanced panel of 345 firms and are estimated using a fixed-effects model. The asymptotic covariance matrix is calculated by using White correction. Intercept denotes the constant term; ℓn S, RN, ℓn VT and EX measure gross sales, national nominal interest rates, industrial wages and industrial export shares, respectively. Student t-statistics are in parentheses where ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. See also Table 1 for detailed data description.

Table 3: Differential Cash Constraint Model (Dependent Variable: ℓn M)

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ℓn W	0.753 (6.71)***	0.644 (5.27)***	0.645 (5.28)***	0.588 (4.76)***	0.611 (5.22)***	0.561 (4.73)***	0.586 (4.90)***	0.639 (5.69)***	0.540 (4.20)***	0.548 (4.10)***
ℓn INV	0.046 (3.82)***	0.034 (2.64)***	0.034 (2.64)***	0.033 (2.62)***	0.033 (2.54)***	0.033 (2.52)***	0.035 (2.71)***	0.038 (3.01)***	0.031 (2.36)**	0.031 (2.35)**
Π_F				0.014 (2.11)**		0.013 (2.03)**	0.011 (1.84)*	0.011 (1.75)*	0.013 (2.07)**	0.013 (1.93)*
RN		-0.126 (-2.72)***	-0.123 (-2.49)***	-0.153 (-3.05)***	-0.107 (-2.25)**	-0.135 (-2.80)***			-0.154 (-3.11)***	-0.157 (-2.96)***
R_{TP}							-0.216 (-2.21)**			
R_{RP}								0.094 (2.17)**		
EX			0.001 (0.14)	0.0004 (0.10)	0.001 (0.28)	0.001 (0.23)	0.002 (0.37)	0.003 (0.71)	0.0001 (0.02)	-0.0003 (-0.06)
θ					-0.003 (-3.36)***	-0.003 (-3.35)***	-0.003 (-3.41)***	-0.003 (-3.31)***	-0.003 (-3.05)***	-0.003 (-3.05)***
F_P									-0.005 (-2.76)***	
F_R										0.00001 (0.003)
Adj.-R^2	0.66	0.66	0.66	0.67	0.67	0.67	0.67	0.67	0.68	0.67
N	1008	1008	1008	1008	1008	1008	1008	1008	992	992

Notes: All regressions are estimated using a fixed-effects model. The asymptotic covariance matrix is calculated by using White correction. ℓn W and ℓn INV measure, respectively, wage and investment bills; R_{TP} and R_{RP} measure, respectively, term and risk premium; Π_F measures profit to sales ratio and θ measures the financial leverage ratio (debt/equity); and, F_P and F_R measure, respectively, the turnover days for funds-payable and funds-receivable. N is the number of observations. See also notes to Table 2.

Table 4: Differential Cash Constraint Model (Dependent Variable: ℓn M)

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ℓn E	0.639 (9.04)***	0.469 (4.93)***	0.465 (4.88)***	0.408 (4.18)***	0.456 (4.84)***	0.499 (5.98)***	0.406 (4.01)***	0.383 (3.81)***
Π_F				0.018 (2.73)***	0.016 (2.55)***	0.016 (2.52)***	0.018 (2.73)***	0.018 (2.69)***
RN		-0.153 (-3.11)***	-0.103 (-1.85)*	-0.142 (-2.50)***			-0.137 (-2.32)**	-0.155 (-2.52)***
R_{TP}					-0.192 (-1.76)*			
R_{RP}						0.072 (1.54)		
EX			0.008 (1.73)*	0.008 (1.64)*	0.009 (1.95)**	0.011 (1.54)	0.008 (1.73)*	0.007 (1.53)
F_P							-0.006 (-3.82)***	
F_R								0.0001 (0.05)
Adj.-R^2	0.65	0.65	0.65	0.66	0.66	0.66	0.66	0.66
N	1008	1008	1008	1008	1008	1008	1008	1008

Notes: All regressions are estimated using a fixed-effects model. The asymptotic covariance matrix is calculated by using White correction. E = W + ϕ*INV measures cash spending. See also notes to Table 2 and Table 3.

Table 5-1: Differential Cash Constraint with Instrumental Variable Method (Dependent Variable: ℓn M) – using (ℓn W_{t-1}, ℓn W_{t-2}) as instruments

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ℓn W	0.802 (4.49)***	0.695 (3.81)***	0.670 (3.68)***	0.655 (3.86)***	0.650 (3.67)***	0.640 (3.80)***	0.692 (3.81)***	0.680 (3.88)***	0.638 (3.79)***	0.626 (3.76)***
ℓn INV	0.047 (2.82)***	0.033 (1.95)**	0.031 (1.87)*	0.032 (1.98)**	0.031 (1.88)*	0.032 (1.96)**	0.040 (2.45)***	0.039 (2.43)***	0.032 (1.91)*	0.035 (2.11)**
Π_F				0.025 (4.46)***		0.021 (3.70)***	0.019 (3.43)***	0.019 (3.40)***	0.021 (3.70)***	0.019 (3.26)***
RN		-0.185 (-2.93)***	-0.112 (-1.58)	-0.194 (-2.72)***	-0.076 (-1.08)	-0.151 (-2.10)**			-0.154 (-2.13)**	-0.191 (-2.62)***
R_{TP}							0.001 (0.003)			
R_{RP}								0.023 (0.40)		
EX			0.010 (1.75)*	0.007 (1.17)	0.011 (1.89)*	0.008 (1.36)	0.014 (2.22)**	0.013 (2.29)**	0.008 (1.36)	0.007 (1.21)
θ					-0.005 (-2.61)***	-0.004 (-2.58)***	-0.004 (-2.66)***	-0.004 (-2.64)***	-0.004 (-2.60)***	-0.004 (-2.58)***
F_P									-0.001 (-0.39)	
F_R										-0.004 (-1.67)*
Adj.-R^2	0.67	0.67	0.67	0.68	0.68	0.69	0.69	0.69	0.69	0.69
N	756	756	756	756	756	756	756	756	756	756

Notes: All regressions are estimated using the instrumental variable method where one and two-year lagged values of ℓn W (ℓn W_{t-1}, ℓn W_{t-2}) are used as instruments for ℓn W. The asymptotic covariance matrix is calculated by using White correction. See also notes to Tables 2 and 3.

Table 5-2: Differential Cash Constraint with Instrumental Variable Method (Dependent Variable: ℓn M) – using (ℓn L_{t-1}, ℓn L_{t-2}) as instruments

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ℓn W	0.591 (4.41)***	0.615 (4.67)***	0.593 (4.56)***	0.597 (4.62)***	0.537 (4.46)***	0.541 (4.48)***	0.540 (4.45)***	0.540 (4.46)***	0.534 (4.59)***	0.428 (3.41)***
ℓn INV	0.070 (3.12)***	0.045 (1.79)*	0.042 (1.61)	0.049 (1.93)**	0.047 (1.80)*	0.050 (1.92)**	0.051 (1.88)*	0.051 (1.97)**	0.047 (1.74)*	0.055 (2.27)**
Π_F				0.019 (2.22)**		0.008 (0.97)	0.006 (0.81)	0.006 (0.76)	0.010 (1.29)	0.002 (0.22)
RN		-0.245 (-2.48)***	-0.185 (-1.72)*	-0.217 (-2.06)**	-0.074 (-0.71)	-0.092 (-0.88)			-0.120 (-1.20)	-0.179 (-1.76)*
R_{TP}							-0.138 (-0.64)			
R_{RP}								0.067 (0.87)		
EX			0.008 (1.03)	0.006 (0.80)	0.012 (1.64)*	0.011 (1.51)	0.011 (1.54)	0.011 (1.68)*	0.011 (1.66)*	0.008 (1.19)
θ					-0.017 (-6.31)***	-0.016 (-5.82)***	-0.016 (-6.11)***	-0.016 (-6.20)***	-0.017 (-5.97)***	-0.017 (-6.37)***
F_P									-0.009 (-2.36)**	
F_R										-0.010 (-3.77)***
Adj.-R^2	0.53	0.54	0.54	0.55	0.58	0.58	0.58	0.58	0.58	0.60
N	756	756	756	756	756	756	756	756	756	756

Notes: All regressions are estimated using the instrumental variable method where one and two-year lagged values of ℓn L (ℓn L_{t-1}, ℓn L_{t-2}) are used as instruments for ℓn W. The asymptotic covariance matrix is calculated by using White correction. See also notes to Tables 2 and 3.

Table 5-3: Differential Cash Constraint with Instrumental Variable Method (Dependent Variable: ℓn M) – using (ℓn (L_{t-1}*YW_{t-1}), ℓn (L_{t-2}*YW_{t-2})) as instruments

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ℓn W	0.604 (4.54)***	0.612 (4.68)***	0.590 (4.55)***	0.590 (4.59)***	0.534 (4.43)***	0.536 (4.44)***	0.530 (4.40)***	0.531 (4.41)***	0.528 (4.53)***	0.428 (3.42)***
ℓn INV	0.062 (2.73)***	0.042 (1.64)*	0.039 (1.50)	0.046 (1.82)*	0.045 (1.71)*	0.047 (1.82)*	0.051 (1.91)*	0.050 (1.94)**	0.045 (1.65)*	0.052 (2.18)**
Π_F				0.018 (2.14)**		0.007 (0.89)	0.006 (0.80)	0.006 (0.77)	0.009 (1.21)	0.001 (0.15)
RN		-0.210 (-2.14)**	-0.156 (1.45)	-0.187 (1.78)*	-0.048 (-0.46)	-0.064 (-0.62)			-0.092 (-0.93)	-0.158 (-1.56)
R_{TP}							-0.025 (-0.12)			
R_{RP}								0.025 (0.32)		
EX			0.007 (0.92)	0.006 (0.71)	0.011 (1.52)	0.010 (1.41)	0.011 (1.58)	0.011 (1.64)*	0.010 (1.55)	0.008 (1.10)
θ					-0.017 (-6.28)***	-0.016 (-5.81)***	-0.016 (-6.12)***	-0.016 (-6.17)***	-0.017 (-5.96)***	-0.017 (-6.36)***
F_P									-0.009 (-2.35)**	
F_R										-0.010 (-3.81)***
Adj.-R^2	0.54	0.54	0.54	0.55	0.58	0.58	0.58	0.58	0.58	0.60
N	756	756	756	756	756	756	756	756	756	756

Notes: All regressions are estimated using the instrumental variable method where one and two-year lagged values of ℓn (L*YW) (ℓn (L_{t-1}*YW_{t-1}), ℓn (L_{t-2}*YW_{t-2})) are used as instruments for ℓn W. The asymptotic covariance matrix is calculated by using White correction. See also notes to Tables 2 and 3.

Appendix

In this Appendix, we present additional regression results (i) accounting sample selection problem by deleting extreme sales values, (ii) employing complete log linear specification including the interest rate, and (iii) using random-effects models. We label the tables corresponding to those in the main text.

Table A2-1: Value of Time Model (Dependent Variable: ℓn M) – deletes extreme sales values (upper or lower 5%)

Independent Variables	(1)	(2)	(3)	(4)	(5)
ℓn S	0.582 (5.43)***	0.496 (4.99)***	0.464 (4.90)***	0.496 (5.00)***	0.465 (4.91)***
RN		-0.148 (-4.82)***	-0.003 (-0.07)	-0.137 (-3.94)***	0.004 (0.08)
ℓn VT			1.1352 (3.16)***		1.128 (3.14)***
EX				0.002 (0.59)	0.001 (0.44)
Adj.-R^2	0.60	0.61	0.61	0.61	0.61

Notes: All regressions contain a balanced panel of 311 firms and are estimated using a fixed-effects model. The asymptotic covariance matrix is calculated by using White correction. Intercept denotes the constant term; ℓn S, RN, ℓn VT and EX measure gross sales, national nominal interest rates, industrial wages and industrial export shares, respectively. Student t-statistics are in parentheses where ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively. See also Table 1 for detailed data description.

Table A2-2: Value of Time Model (Dependent Variable: ℓn M) --- ln RN

Independent Variables	(1)	(2)	(3)	(4)	(5)
ℓn S	0.627 (5.96)***	0.561 (5.49)***	0.526 (5.27)***	0.561 (5.49)***	0.526 (5.28)***
ℓn RN		-0.798 (-4.31)***	0.033 (0.13)	-0.771 (-3.72)***	0.034 (0.12)
ℓn VT			1.062 (3.15)***		1.062 (3.15)***
EX				0.001 (0.24)	0.00003 (0.01)
Adj.-R^2	0.64	0.65	0.65	0.65	0.65

Table A3-1 Differential Cash Constraint Model (Dependent Variable: ℓn M) – deletes extreme sales values (upper or lower 5%)

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ℓn W	0.744 (6.04)***	0.619 (4.71)***	0.628 (4.79)***	0.556 (4.16)***	0.597 (4.74)***	0.530 (4.10)***	0.563 (4.32)***	0.579 (4.73)***	0.519 (3.70)***	0.521 (3.57)***
ℓn INV	0.049 (3.54)***	0.036 (2.46)***	0.032 (2.23)**	0.032 (2.29)**	0.030 (2.08)**	0.031 (2.12)**	0.033 (2.29)**	0.033 (2.32)**	0.027 (1.90)*	0.029 (1.97)**
Π_F				0.017 (2.07)**		0.016 (2.11)**	0.015 (2.01)**	0.015 (1.99)**	0.016 (2.16)**	0.017 (2.11)**
RN		-0.146 (-2.96)***	-0.078 (-1.41)	-0.110 (-1.93)**	-0.056 (-1.05)	-0.087 (-1.59)			-0.095 (-1.69)*	-0.102 (-1.71)*
R_{TP}							-0.080 (-0.72)			
R_{RP}								0.044 (0.94)		
EX			0.011 (2.21)**	0.011 (2.17)**	0.012 (2.45)***	0.012 (2.40)**	0.014 (2.83)***	0.015 (3.09)***	0.013 (2.49)***	0.012 (2.27)**
θ					-0.003 (-3.34)***	-0.003 (-3.35)***	-0.003 (-3.40)***	-0.003 (-3.35)***	-0.003 (-3.05)***	-0.003 (-3.06)***
F_P									-0.005 (-2.78)***	
F_R										0.001 (0.43)
Adj.-R^2	0.64	0.64	0.64	0.65	0.65	0.65	0.65	0.65	0.66	0.65
N	912	912	912	912	912	912	912	912	897	897

Table A3-2 : Differential Cash Constraint Model (Dependent Variable: ℓn M) – ln RN

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ℓn W	0.753 (6.71)***	0.642 (5.31)***	0.645 (5.35)***	0.587 (4.80)***	0.610 (5.27)***	0.559 (4.76)***	0.561 (4.73)***	0.586 (4.90)***	0.542 (4.26)***	0.553 (4.17)***
ℓn INV	0.046 (3.82)***	0.033 (2.57)***	0.031 (2.44)***	0.030 (2.41)**	0.030 (2.33)**	0.030 (2.31)***	0.033 (2.52)***	0.035 (2.71)***	0.028 (2.13)**	0.028 (2.13)***
Π_F				0.015 (2.14)**		0.013 (2.05)**	0.013 (2.03)**	0.011 (1.84)*	0.013 (2.09)**	0.013 (1.96)**
ℓn RN		-0.836 (-2.89)***	-0.548 (-1.69)*	-0.754 (-2.28)**	-0.425 (-1.36)	-0.614 (-1.92)*	-0.135 (-2.80)***		-0.699 (-2.15)**	-0.724 (-2.09)**
R_{TP}								-0.216 (-2.21)**		
R_{RP}										
EX			0.008 (1.65)*	0.008 (1.57)	0.008 (1.88)*	0.008 (1.80)*	0.001 (0.23)	0.002 (0.37)	0.008 (1.79)*	0.008 (1.63)*
θ					-0.003 (-3.41)***	-0.003 (-3.40)***	-0.003 (-3.35)***	-0.003 (-3.41)***	-0.003 (-3.10)***	-0.003 (-3.11)***
F_P									-0.005 (-2.88)***	
F_R										0.0001 (0.09)
Adj.-R^2	0.66	0.66	0.66	0.67	0.67	0.67	0.67	0.67	0.68	0.68
N	1008	1008	1008	1008	1008	1008	1008	1008	992	992

Table A3-3: Differential Cash Constraint Model with Random Effects (Dependent Variable: ℓn M)

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	2.819 (3.47)***	4.682 (4.81)***	5.198 (5.32)***	5.125 (5.32)***	5.569 (5.77)***	4.811 (5.42)***	2.054 (2.13)***	6.369 (6.13)***	6.396 (5.92)***
ℓn W	0.689 (10.42)***	0.617 (8.94)***	0.577 (8.35)***	0.588 (8.64)***	0.554 (8.12)***	0.567 (8.32)***	0.606 (9.24)***	0.510 (6.85)***	0.509 (6.71)***
ℓn INV	0.046 (4.13)***	0.033 (2.88)***	0.034 (2.99)***	0.032 (2.84)***	0.033 (2.95)***	0.036 (3.15)***	0.039 (3.54)***	0.033 (2.38)**	0.033 (2.36)**
Π_F			0.015 (3.70)***		0.013 (3.36)***	0.012 (3.14)***	0.011 (2.86)***	0.009 (2.22)***	0.008 (1.73)*
RN		-0.133 (-3.43)***	-0.156 (-4.00)***	-0.119 (-3.11)***	-0.140 (-3.65)***			-0.133 (-3.26)***	-0.147 (-3.52)***
R_{TP}						-0.237 (-3.14)***			
R_{RP}							0.109 (2.79)***		
θ				-0.003 (-5.63)***	-0.003 (-5.43)***	-0.003 (-5.55)***	-0.003 (-5.46)***	-0.009 (-7.21)***	-0.008 (-6.83)***
F_P								-0.007 (-4.02)***	
F_R									-0.002 (-1.39)
Food	-0.451 (-1.09)	-0.421 (-1.01)	-0.368 (-0.89)	-0.456 (-1.11)	-0.406 (-0.99)	-0.417 (-1.01)	-0.429 (-1.04)	-0.294 (-0.71)	-0.315 (-0.75)
Textile	-0.081 (-0.14)	-0.056 (-0.10)	-0.050 (-0.09)	-0.148 (-0.26)	-0.138 (-0.24)	-0.145 (-0.25)	-0.152 (-0.27)	0.033 (0.06)	-0.070 (-0.13)
Plastic	-0.065 (-0.17)	-0.038 (-0.10)	0.014 (0.04)	-0.126 (-0.34)	-0.076 (-0.20)	-0.087 (-0.23)	-0.101 (-0.27)	-0.060 (-0.15)	-0.125 (-0.31)
Rubber	-0.737 (-1.27)	-0.676 (-1.16)	-0.628 (-1.08)	-0.708 (-1.23)	-0.664 (-1.15)	-0.677 (-1.17)	-0.710 (-1.23)	-0.513 (-0.91)	-0.512 (-0.90)
Electronics	0.230 (0.70)	0.285 (0.87)	0.302 (0.92)	0.200 (0.62)	0.219 (0.67)	0.207 (0.64)	0.183 (0.57)	0.504 (1.43)	0.409 (1.16)
Cement	1.218 (1.58)	1.331 (1.72)*	1.126 (1.46)	1.225 (1.60)	1.046 (1.36)	1.045 (1.36)	1.012 (1.32)	1.073 (1.45)	1.169 (1.58)
Chemical	-0.018 (-0.04)	0.003 (0.01)	0.039 (0.08)	-0.081 (-0.17)	-0.046 (-0.10)	-0.055 (-0.12)	-0.062 (-0.13)	0.064 (0.14)	0.038 (0.08)
Non-metallic mineral	-0.371 (-0.57)	-0.322 (-0.49)	-0.358 (-0.55)	-0.416 (-0.65)	-0.445 (-0.69)	-0.450 (-0.70)	-0.469 (-0.73)	-0.204 (-0.28)	-0.220 (-0.30)
Pulp and paper	-1.001 (-1.30)	-0.941 (-1.22)	-0.865 (-1.12)	-0.896 (-1.17)	-0.830 (-1.09)	-0.846 (-1.11)	-0.875 (-1.15)	-0.540 (-0.74)	-0.535 (-0.72)
Primary metal	-0.086 (-0.21)	-0.096 (-0.23)	-0.109 (-0.27)	-0.092 (-0.23)	-0.104 (-0.26)	-0.102 (-0.25)	-0.095 (-0.24)	0.027 (0.07)	0.079 (0.19)
Motor	-0.063 (-0.06)	0.084 (0.08)	0.206 (0.20)	0.024 (0.02)	0.136 (0.13)	0.101 (0.10)	0.032 (0.03)	0.268 (0.27)	0.164 (0.16)
Transportation	0.260 (0.62)	0.320 (0.77)	0.270 (0.65)	0.203 (0.49)	0.164 (0.40)	0.157 (0.38)	0.135 (0.33)	0.331 (0.78)	0.328 (0.76)
Construction	-1.179 (-1.53)	-1.121 (-1.45)	-1.092 (-1.42)	-1.174 (-1.54)	-1.147 (-1.50)	-1.159 (0.38)	-1.186 (-1.55)	-0.515 (-0.69)	-1.045 (-1.41)
Adj.-R^2	0.28	0.29	0.30	0.31	0.31	0.31	0.31	0.36	0.35
N	1008	1008	1008	1008	1008	1008	1008	880	880

Note: See notes to Tables 2 and 3.

Table A4: Differential Cash Constraint Model (Dependent Variable: ℓn M) – ln RN

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ℓn E	0.639 (9.04)***	0.466 (4.91)***	0.463 (4.87)***	0.403 (1.13)***	0.456 (4.84)***	0.499 (5.98)***	0.399 (3.94)***	0.377 (3.75)***
Π_F				0.018 (2.77)***	0.016 (2.55)***	0.016 (2.52)***	0.018 (2.77)***	0.018 (2.72)***
ℓn RN		-0.999 (-3.19)***	-0.683 (-1.93)**	-0.950 (-2.63)***			-0.924 (-2.47)***	-1.036 (-2.65)***
R_{TP}					-0.192 (-1.76)*			
R_{RP}						0.072 (1.54)		
EX			0.008 (1.68)*	0.007 (1.56)	0.009 (1.95)**	0.011 (2.49)***	0.008 (1.65)*	0.007 (1.45)
F_P							-0.006 (-3.83)***	
F_R								0.0001 (0.01)
Adj.-R^2	0.65	0.65	0.65	0.66	0.66	0.66	0.66	0.66
N	1008	1008	1008	1008	1008	1008	1008	1008

Table A5-1: Differential Cash Constraint with Instrumental Variable Method (Dependent Variable: ℓn M) – ln RN

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ℓn W	0.802 (4.49)***	0.697 (3.81)***	0.671 (3.69)***	0.656 (3.87)***	0.649 (3.67)***	0.640 (3.81)***	0.692 (3.81)***	0.680 (3.88)***	0.638 (3.79)***	0.627 (3.77)***
ℓn INV	0.047 (2.82)***	0.033 (1.95)**	0.031 (1.87)*	0.032 (1.98)**	0.031 (1.88)*	0.032 (1.96)**	0.040 (2.45)***	0.039 (2.43)***	0.031 (1.91)*	0.035 (2.10)**
Π_F				0.025 (4.47)***		0.021 (3.71)***	0.019 (3.43)***	0.019 (3.40)***	0.021 (3.71)***	0.019 (3.27)***
ℓn RN		-1.082 (-2.96)***	-0.666 (-1.63)*	-1.1418 (-2.78)***	-0.459 (-1.13)	-0.898 (2.15)**			-0.911 (-2.19)**	-1.123 (-2.67)***
R_{TP}							0.001 (0.003)			
R_{RP}								0.023 (0.40)		
EX			0.010 (1.6)*	0.007 (1.18)	0.011 (1.89)*	0.008 (1.36)	0.014 (2.22)**	0.013 (2.29)**	0.008 (1.37)	0.007 (1.23)
θ					-0.005 (-2.61)***	-0.004 (-2.58)***	-0.004 (-2.66)***	-0.004 (-2.64)***	-0.004 (-2.60)***	-0.004 (-2.58)***
F_P									-0.001 (-0.39)	
F_R										-0.004 (-1.67)*
Adj.-R^2	0.67	0.67	0.67	0.68	0.68	0.69	0.69	0.69	0.69	0.69
N	756	756	756	756	756	756	756	756	756	756