Aggregate and Household Demand for Money: Evidence from the Public Opinion Survey on Household Financial Assets and Liabilities

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We use data from the Public Opinion Surveys on Household Financial Assets and Liabilities from 1991 to 2002 to investigate the issues of unobserved heterogeneity among cross-sectional units and stability of the Japanese aggregate money demand function. Conditions that permit individual data and aggregate data to be modeled under one consistent format are given. Alternative definitions of money are explored through year-by-year cross-sectional estimates of the Fujiki and Mulligan (1996b) household money demand model. We find that using M3 appears to be broadly consistent with time-series estimates using the aggregates constructed from the micro data. The results appear to support the existence of a stable money demand function for Japan. The estimated income elasticity for M3 is about 0.68, and five-year bond interest rate elasticity is about −0.124.

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The chief goal in empirical work is to find a way of organizing experience so that it yields "simple" yet highly dependable relationships. And one of the major devices that has proved successful in achieving this goal has been the use of carefully chosen, "right" levels of aggregation of different items.[1]

I. Introduction

Most microeconomic models try to be exhaustive representations of particular forms of economic activity. But in many cases, data for micro models are simply not available. One primary concern in economics is the recoverability of micro parameters from macro models or vice versa (e.g., Granger [1990], Lewbel [1992, 1994], Stoker [1993]) together with exploring conditions where simple micro models will also imply simple macro models. The conditions of perfect aggregation for linear models have been extensively explored by Granger (1987, 1990), Jorgenson, Lau, and Stoker (1980), Jorgenson and Slesnick (1984), Jorgenson, Slesnick, and Stoker (1988), Lau (1977, 1982), Powell and Stoker (1985), and so on. Because individual heterogeneity and dynamic structure in aggregate data are intertwined (e.g., Granger [1980], Hsiao, Shen and Fujiki [2005]) and the relations between aggregate and disaggregate models are often not linearly related like in the case of log-linear models, we will focus on conditions under which macro models can recover all or some of the key parameters of micro models and heterogeneous micro dynamic models and/or nonlinear models can lead to parsimonious aggregate models for prediction and policy evaluation.

In this study, we use the data from Public Opinion Surveys on Household Financial Assets and Liabilities from 1991 to 2002 to investigate the issues of aggregation and stability of money demand. The quantity theorists believe that there is a stable functional relation between the quantity of money demanded and the variables that determine it (e.g., Friedman [1969]). However, there is no hard-and-fast line between "money" and other assets. Many competing financial assets can fulfill the "transaction," "pre-cautionary," and "speculative" motives for holding money. This is particularly so with ever-changing technology and institutional arrangements. Moreover, it is possible to have stable micro-relations but unstable macro-relations because of the heterogeneity across micro units (e.g., Hsiao, Shen, and Fujiki [2005]). The Public Opinion Survey asks questions regarding the amount of household financial assets and liabilities, selection of financial products, perception of the financial environment, life in old age, and household characteristics (such as number of household members, age of the head of household, and employment conditions of family members and so forth) that allow us to investigate both the issues of appropriate definition of money and level of aggregation for Japan.

Although there exist many works on Japanese demand for money using time-series aggregate data (see Suzuki [2005a] for a literature review), only a few papers use micro data from Public Opinion Survey on Household Financial Assets and Liabilities data. Among those studies, Suzuki (2005a) estimated the demand for M1 (sum of average

1. Friedman and Schwartz (1971).

balance of cash and bank deposits) and M2 (sum of average balance of cash, bank current deposits, and bank time deposits). He first pooled the data from 1990 to 2003 to form the time-series aggregate income and money demand deflated by the consumer price index (CPI) and obtained income elasticities of M1 and M2 conditional on call rate, age, occupation, region and city size, and the number of household members. He also employed the Heckman (1979) method to control for the fact that some households did not have time deposits or current deposits. According to his analysis, income elasticity of M1 was 1.09 and interest rate elasticity was -0.84. Regarding M2, income elasticity was 1.06. However, the interest rate elasticity was not statistically significant. He also ran the cross-sectional year-by-year regressions. He got M1 income elasticities in the range of 0.5 to 1. M2 income elasticities were more stable. He added total financial assets to the explanatory variables and obtained income elasticity of M1 of about 0.4 and income elasticity of M2 of about 0.21. Based on these results, Suzuki (2005b) reported that the income elasticity of M1 demand was close to unity, and the interest elasticity of M1 demand measured by the call rate was about -0.2 using the pooled data from 1996 to 2003. On the other hand, Fujiki and Shioji (2006) used the micro data to analyze the demand for financial assets from 2001 to 2003. They proceeded in two stages. In the first stage, they used a multinomial logit model to analyze the determinants of the likelihood of holding a given combination of financial products. In the second stage, they analyzed the factors that shifted asset allocation along the intensive margin.

Our study differs from those prior studies in several aspects. First, we explore alternative definitions of money in terms of the stability of Fujiki and Mulligan (1996a) household demand for money model. Second, we explicitly match the household data with aggregate data by constructing the aggregate data from the household data. Third, we estimate both the household and aggregate demand for money based on the structural model of Fujiki and Mulligan (1996a). The consistent model format allows us to compare parameters estimated from two sources directly to check the conditions for perfect aggregation. Fourth, Fujiki and Mulligan (1996b) seek to infer parameters of household demand for money from estimates of a log-linear model using regional average data under the log-normal distribution assumption. The availability of household level data over time allows us to empirically investigate the legitimacy of the log-normal distribution assumption as well as if it is possible to model individual level data and aggregate data under one consistent format. Three versions of the Fujiki and Mulligan (1996b) household demand for money model are considered: the cross-sectional log-linear household demand for money; the time-series model of the average of household log-linear demand for money; and the time-series log-linear model using log of average data.

Section II presents the Fujiki and Mulligan (1996a, b) household demand for money model. Section III presents the aggregate Fujiki-Mulligan demand for money model under homogeneity and heterogeneity conditions. The data are presented in Section IV. Empirical estimates of cross-sectional household demand for money year by year and time-series estimates of the average of household log-linear model and log-linear model of the average data are presented and their implication discussed in Section V. Conclusions are in Section VI.

II. A Model of Household Demand for Money

Our empirical model of demand for money is based on the one developed by Fujiki and Mulligan (1996a, b). They assume a household production function of the form

$$
\begin{aligned}
y_{it} &= f(x_{1,it}, T_{it}, \lambda_f) \\
&= \left[(1-\lambda_f) x_{1,it}^{(\gamma-\beta)/\gamma} + \lambda_f \left(\frac{\gamma-\beta}{\gamma-1} \right) T_{it}^{(\gamma-1)/\gamma} \right]^{\gamma/(\gamma-\beta)}, \qquad (1)
\end{aligned}
$$

$$\lambda_f \in (0,1),\ \beta > 0,\ \gamma \in (0, \min(1,\beta)),$$

$$
\begin{aligned}
T_{it} &= \phi(m_{it}, x_{3,it}, A_{it}) \\
&= A_{it} \left[(1-\lambda_\phi) m_{it}^{(\psi_\phi - 1)/\psi_\phi} + \lambda_\phi x_{3,it}^{(\psi_f - 1)/\psi_f} \right]^{\psi_\phi/(\psi_\phi - 1)}. \qquad (2)
\end{aligned}
$$

Equation (1) shows i-th household creates output y using input x_1 and transaction service T. Equation (2) shows that transaction service T is created by real money balance m and goods x_3. A_{it} are the productivity parameters and Greek letters are constants. The constants λ_ϕ and λ_f lie between zero and one. In the case of a firm, y might be measured as firms' production or sales. In our case, y_{it} corresponds to "household production," which may not be observable, x_1 represents general goods used in household production, and x_3 represents goods only used in the production of transaction service. Our choice of empirical measures of x_1 and x_3 will be explained later in this section.

A household minimizes the cost of producing y subject to the constraints of equations (1) and (2). The cost to be minimized, r, consists of

$$r_{it} = q_{1,t} x_{1,it} + R_t m_{it} + q_{3,t} x_{3,it}. \qquad (3)$$

Here the price of good x_1 is q_1, the rental cost of m is interest rate R, and the price of good x_3 is q_3. Under the assumption that the rental cost r is equal to income I, Fujiki and Mulligan (1996a) derive the household money demand as follows:

$$
\begin{aligned}
\log m_{it} &= \log M(r_{it}, R_t, q_{it}, A_{it}) \\
&= \beta \log I_{it} - \gamma \log R_t + \pi_\phi(\psi_\phi - \gamma) \log \frac{q_{3,it}}{R_t} \\
&\quad + (\gamma - \beta) \log q_{1,it} - (1-\gamma) \log A_{it} + \text{constant} + u_{it}. \qquad (4)
\end{aligned}
$$

Based on the assumption that a household spends time to use financial services, say, in visiting banks or ATMs, we use log of wage rate to approximate q_3. Based on the assumption that a household needs general consumer goods for its household production, we use the regional price differential index to approximate q_1. To control for the difference in the technology of financial transactions, A_{it}, the set of variables, z_{it}, consists of the number of household members, occupation of the head of household, and dummy variable of home ownership. More specifically, (4) takes the form

$$\log m_{it} = a_0 + a_1 \log I_{it} + a_2 \log CPI_{it} + a_3 \log \text{wage}_{it} + a_4 \log R_t + \underset{\sim}{a}'_5 \underset{\sim}{z}_{it} + u_{it}. \quad (5)$$

III. Aggregate Demand for Money

In general, there are two approaches toward aggregation issues. One is to derive conditions under which macro models will reflect and provide interpretable information on the underlying behavior of micro units (e.g., see Stoker [1993]). The other is to derive conditional optimal forecasts of the aggregates based on a given disaggregate specification (e.g., van Garderen, Lee, and Pesaran [2000]). Since the purpose of this paper is to investigate if there is a stable demand for money equation by comparing the disaggregate and aggregate estimates, we will follow the first approach.

A central issue in deriving perfect aggregation conditions or an optimal aggregate forecasting model from a given micro model is whether "representative agent" assumptions hold. To allow for heterogeneity across micro units, we rewrite model (4) in the form

$$\log m_{it} = \underset{\sim}{a}'_i \log \underset{\sim}{x}_{it} + u_{it}, \quad i = 1, \ldots, N_t, \quad (5')$$

where the error u_{it} is assumed independent of explanatory variables $\underset{\sim}{x}_{it}$ and is independently, identically distributed with mean zero and variance σ^2. The coefficients of $\log \underset{\sim}{x}_{it}$ are allowed to vary across i.

Let $\underset{\sim}{a}_i = \bar{\underset{\sim}{a}} + \underset{\sim}{\epsilon}_i$. We consider two situations:

A1: Homogeneous household behavior: $\underset{\sim}{\epsilon}_i = \underset{\sim}{\epsilon}_j = \underset{\sim}{0}$, or $\underset{\sim}{a}_i = \underset{\sim}{a}_j = \bar{\underset{\sim}{a}}$.

A2: Heterogeneous household behavior: $\underset{\sim}{\epsilon}_i \neq \underset{\sim}{\epsilon}_j$. We assume $\underset{\sim}{\epsilon}_i$ is randomly distributed with $E(\underset{\sim}{\epsilon}_i) = 0$, and

$$E\underset{\sim}{\epsilon}_i \underset{\sim}{\epsilon}'_j = \begin{cases} \Delta, & \text{if } i = j, \\ \underset{\sim}{0}, & \text{if } i \neq j. \end{cases}$$

We also assume the distribution of $\underset{\sim}{\epsilon}_i$ is independent of $\underset{\sim}{x}_{it}$.

Aggregating ($5'$) over i and dividing by N_t yields

$$\log m_t = \frac{1}{N}\sum_{i=1}^{N_t} \log m_{it}$$

$$= \frac{1}{N_t}\sum_{i=1}^{N_t} \underset{\sim}{a}_i' \log \underset{\sim}{x}_{it} + \frac{1}{N_t}\sum_{i=1}^{N_t} u_{it}$$

$$= \bar{\underset{\sim}{a}}' \log \underset{\sim}{x}_t + \frac{1}{N}\sum_{i=1}^{N} \underset{\sim}{\epsilon}_i' \log \underset{\sim}{x}_{it} + \bar{u}_t, \tag{6}$$

where $\log m_t = \frac{1}{N_t}\sum_{i=1}^{N_t} \log m_{it}$, $\log \underset{\sim}{x}_t = \frac{1}{N_t}\sum_{i=1}^{N_t} \log \underset{\sim}{x}_{it}$, $\bar{u}_t = \frac{1}{N_t}\sum_{i=1}^{N_t} u_{it}$.

Proposition 3.1: *Either A1 or A2 is sufficient to imply a log-linear relation among the aggregates,*

$$\log m_t = \bar{\underset{\sim}{a}}' \log \underset{\sim}{x}_t + v_t, \tag{7}$$

with $E(v_t \mid \log \underset{\sim}{x}_t) = 0$, *when the aggregates are defined as the averages of the logarithm of the corresponding variables.*

In many aggregate studies with log-linear specifications, the observations for micro units $(m_{it}, \underset{\sim}{x}_{it})$, $i = 1, \ldots, N_t$, are not available. Instead, $m_t^* = \frac{1}{N_t}\sum_{i=1}^{N_t} m_{it}$ and $\underset{\sim}{x}_t^* = \frac{1}{N_t}\sum_{i=1}^{N_t} \underset{\sim}{x}_{it}$ are provided. When $\log m_t^*$ is used in lieu of $\log m_t$, the form of the corresponding aggregate model depends critically on whether household behavior is homogeneous because ($5'$) implies

$$m_t^* = \frac{1}{N_t}\sum_{i=1}^{N_t} e^{\log m_{it}} = \frac{1}{N_t}\sum_{i=1}^{N_t} e^{\underset{\sim}{a}_i' \log \underset{\sim}{x}_{it} + u_{it}}. \tag{8}$$

We first consider the case of homogeneous households. Rewrite $\log \underset{\sim}{x}_{it} = \log \underset{\sim}{x}_t^* + \log \underset{\sim}{x}_{it} - \log \underset{\sim}{x}_t^*$. Under A1,

$$m_t^* = \exp\{\bar{\underset{\sim}{a}}' \log \underset{\sim}{x}_t^*\} \cdot \left\{ \frac{1}{N_t}\sum_{i=1}^{N} \exp\{\bar{\underset{\sim}{a}}'(\log \underset{\sim}{x}_{it} - \log \underset{\sim}{x}_t^*)\} + u_{it} \right\}. \tag{9}$$

Therefore,

$$\log m_t^* = \bar{\underset{\sim}{a}}' \log \underset{\sim}{x}_t^* + v_t, \tag{10}$$

where

$$v_t = \log \left\{ \frac{1}{N_t}\sum_{i=1}^{N} \exp[\bar{\underset{\sim}{a}}'(\log \underset{\sim}{x}_{it} - \log \underset{\sim}{x}_t^*) + u_{it}] \right\}.$$

Assuming

A3: The micro units, $\log \underset{\sim}{x}_{it}$, are independently normally distributed across i with mean $\log \underset{\sim}{x}_t$ and variance Σ^*.

A4: The aggregate measures, $\log \underset{\sim}{x}_t - \log \underset{\sim}{x}_t^*$, are independently normally distributed over time with mean $\underset{\sim}{w}$ and variance $\tilde{\Sigma}$ and are independent of the distribution of $\log \underset{\sim}{x}_{it}$.

Then

$$\log \underset{\sim}{x}_{it} - \log \underset{\sim}{x}_t^* = (\log \underset{\sim}{x}_{it} - \log \underset{\sim}{x}_t) + (\log \underset{\sim}{x}_t - \log \underset{\sim}{x}_t^*) \sim N(\underset{\sim}{w}, \Sigma),$$

where $\Sigma = \Sigma^* + \tilde{\Sigma}$. Further, assume

A5: u_{it} is independently normally distributed with mean zero and variance σ^2.

It follows from A3–A5,

$$E\left[e^{\bar{\underset{\sim}{a}}'(\log \underset{\sim}{x}_{it} - \log \underset{\sim}{x}_t^*) + u_{it}}\right] = e^{\bar{\underset{\sim}{a}}'\underset{\sim}{w} + \frac{1}{2}[\sigma^2 + \bar{\underset{\sim}{a}}'\Sigma\bar{\underset{\sim}{a}}]}. \tag{11}$$

Therefore, we may write (10) as

$$\log m_t^* = a_0^* + \bar{\underset{\sim}{a}}' \log \underset{\sim}{x}_t^* + v_t^*, \tag{12}$$

where

$$a_0^* = \bar{\underset{\sim}{a}}'\underset{\sim}{w} + \frac{1}{2}[\sigma^2 + \bar{\underset{\sim}{a}}'\Sigma\bar{\underset{\sim}{a}}]$$

and

$$v_t^* = v_t - a_0^*,$$

with $Ev_t^* = 0$.

Therefore,

Proposition 3.2: *Under A1, A3–A5, it is possible to identify the household demand for money parameters, $\bar{\underset{\sim}{a}}$, except for the constant term from regressing $\log m_t^*$ on $\log \underset{\sim}{x}_t^*$.*

When micro observations are available, it is possible to estimate the covariance matrix of $\log \underset{\sim}{x}_{it}$ from cross-sectional surveys. Hence we may relax A3 by

A3′: $\log \underset{\sim}{x}_{it} - \log \underset{\sim}{x}_t^*$ are independently normally distributed with constant mean $\underset{\sim}{w}$ and heteroskedastic covariance matrix Σ_t.

Corollary 3.1: *Under A1, A3′, and A5, the micro relation (4) implies an aggregate demand function of the form*

$$\log m_t^* = \bar{\underset{\sim}{a}}' \log \underset{\sim}{x}_t^* + \frac{1}{2}\bar{\underset{\sim}{a}}'\Sigma_t\bar{\underset{\sim}{a}} + \frac{1}{2}\sigma^2 + v_t^*, \tag{12′}$$

where $E(v_t^* \mid \log \underset{\sim}{x}_t^*) = 0$.

When household behaviors are heterogeneous, $\underset{\sim}{a}_i \neq \underset{\sim}{a}_j$. Under A2–A5,

$$E\left(e^{\underset{\sim}{a}_i' \log \underset{\sim}{x}_{it}} \mid \log \underset{\sim}{x}_t\right) = E\left[e^{\bar{\underset{\sim}{a}}' \log \underset{\sim}{x}_{it} + \underset{\sim}{\epsilon}_i' \log \underset{\sim}{x}_{it}} \mid \log \underset{\sim}{x}_t\right]$$

$$= E\left[e^{\bar{\underset{\sim}{a}}' \log \underset{\sim}{x}_{it} + \frac{1}{2} \log \underset{\sim}{x}_{it}' \Delta \log \underset{\sim}{x}_{it}} \mid \log \underset{\sim}{x}_t\right]$$

$$= e^{\frac{1}{2}\bar{\underset{\sim}{a}}' C \bar{\underset{\sim}{a}} + \bar{\underset{\sim}{a}}' C \Sigma^{*-1} \log \underset{\sim}{x}_t - \frac{1}{2} \log \underset{\sim}{x}_t' A \log \underset{\sim}{x}_t}, \tag{13}$$

where $C = \left(\Sigma^{*-1} - \Delta\right)^{-1}$, and $A = \Sigma^{*-1} - \Sigma^{*-1}\left(\Sigma^{*-1} - \Delta\right)^{-1}\Sigma^{*-1}$. Therefore,

$$\log m_t^* = \log E\left[\frac{1}{N_t}\sum_{i=1}^{N_t} e^{\underset{\sim}{a}_i' \log \underset{\sim}{x}_{it} + u_{it}} \;\middle|\; \log \underset{\sim}{x}_t\right] + v_t^*$$

$$= \tilde{a}_0 + \underset{\sim}{b}' \log \underset{\sim}{x}_t - \frac{1}{2} \log \underset{\sim}{x}_t' A \log \underset{\sim}{x}_t + v_t^*, \tag{14}$$

where

$$\tilde{a}_0 = \frac{1}{2}(\sigma^2 + \bar{\underset{\sim}{a}}' C \bar{\underset{\sim}{a}}),$$

$$\underset{\sim}{b} = \bar{\underset{\sim}{a}}' C \Sigma^{*-1}.$$

Since $E(v_t^* \mid \log \underset{\sim}{x}_t) = 0$, $\tilde{a}_0$, $\underset{\sim}{b}$ and A can be consistently estimated by the nonlinear least squares estimator to (14). However, there is no way one can retrieve $\bar{\underset{\sim}{a}}$ from the estimated $\underset{\sim}{b}$ unless Δ and Σ^* are known *a priori*.

Proposition 3.3: *Under A3 and 5, heterogeneity of the form A2 will not allow the identification of household demand function slope parameters $\bar{\underset{\sim}{a}}$ from (14) unless Δ and Σ^* are known a priori.*

If $\log \underset{\sim}{x}_t$ are not available, but $\log \underset{\sim}{x}_t^*$ are available, then

$$\log m_t^* = \log E\left[\frac{1}{N_t}\sum_{i=1}^{N_t} e^{\underset{\sim}{a}_i' \log \underset{\sim}{x}_{it} + u_{it}} \;\middle|\; \log \underset{\sim}{x}_t^*\right] + \tilde{v}_t^*$$

$$= \tilde{a}_0^* + \underset{\sim}{b}^{*\prime} \log \underset{\sim}{x}_t^* - \frac{1}{2} \log \underset{\sim}{x}_t^{*\prime} \tilde{A} \log \underset{\sim}{x}_t^* + \tilde{v}_t^*, \tag{15}$$

where

$$\tilde{a}_0^* = \frac{1}{2}\{\sigma^2 + (\bar{\underset{\sim}{a}} + \Sigma^{-1}\underset{\sim}{w})'[\Sigma^{-1} - \Delta]^{-1}(\bar{\underset{\sim}{a}} + \Sigma^{-1}\underset{\sim}{w}) - \underset{\sim}{w}'\Sigma^{-1}\underset{\sim}{w}\},$$

$$\underset{\sim}{b}^* = \Sigma^{-1}[\Sigma^{-1} - \Delta]^{-1}[\bar{\underset{\sim}{a}} + \Sigma^{-1}\underset{\sim}{w}] - \Sigma^{-1}\underset{\sim}{w},$$

$$\tilde{A} = \Sigma^{-1} - \Sigma^{-1}[\Sigma^{-1} - \Delta]^{-1}\Sigma^{-1}.$$

In other words,

Proposition 3.4: *Under heterogeneity, there is no way to retrieve micro parameters* $\bar{\underset{\sim}{a}}$ *from the macro variables* $\log m_t^*$ *and* $\log \underset{\sim}{x}_t^*$. *However, if the loss of prediction error is symmetric, a quadratic function for* $\log \underset{\sim}{x}_t^*$ *(equation [15]) still yields the minimum loss predictor for* $\log m_t^*$ *provided A2 and A4–A6 hold.*

IV. Data

This section provides an explanation of the Data from the Public Opinion Survey on Household Financial Assets and Liabilities and other data for our empirical investigation.

A. Data from the Public Opinion Survey on Household Financial Assets and Liabilities[2]

The Public Opinion Survey on Household Financial Assets and Liabilities has been conducted from late June through early July each year since 1953 on households nationwide with at least two members. Since 1963, the Public Opinion Survey has used a stratified two-stage random sampling method to first select 400 survey areas and then randomly select 15 households from each area for a total of 6,000 samples. Out of the 6,000 households surveyed in those years, there were responses from about 4,000 households in each year.

The survey asks questions regarding the amount of household financial assets and liabilities, the selection of financial products, income and expenditures, and perception of the financial environment, and so on. Some of the questions change from year to year. In particular, the survey asks the amount of net tax income from 1991 to 2003, while in other years the survey asks the range of income level to which the household belongs. Since we need the amount of net tax income to estimate income elasticity of demand for money, and from 2003 onward, the government has changed its policy to only insure all time deposits in the failed banks up to ¥10 million in total, we restrict our attention to the period from 1991 to 2002.

We explain the details of the variables used in our analysis in turn, dividing them into continuous variables and household characteristics variables.

1. Continuous variables

First, the Public Opinion Survey data provide information on the household financial assets outstanding by type of financial product. In detail, the survey asks, “Does your household currently have any savings?” Households that answer “Yes” are asked to provide the outstanding amounts (to the nearest ¥10,000) of their deposits in banks and post offices (both current deposits and time deposits) for years from 1991 to 2003.[3]

2. This section heavily depends on Fujiki and Shioji (2006).

3. The data we actually received were rounded off to the three highest digits.

Second, the survey provides information on the average amount of cash outstanding for years from 1991 to 2003, except for years 1995 and 1997. Specifically, the survey asks, "In your household, what is the average balance of cash on hand?" The survey asks the average balance to the nearest ¥10,000 for years from 1998 to 2003, to the nearest of ¥1,000 for years 1993 and 1994, to the nearest of ¥100 for years 1991 and 1992.

Third, the survey provides information on annual income (after tax) and consumption for each household. We define net income as aftertax household annual income.

To explore which definition of money could yield the most stable household demand function involving a small number of variables, we focus on financial assets that possess the following characteristics: (1) the asset has a "face" value stated in nominal monetary units, and this "face" value is close to the nominal amount for which the asset can be acquired and is also close to the nominal amount that can be realized for the asset; (2) the asset is available on demand; and (3) using the asset to finance purchases does not automatically involving incurring a matching liability (Friedman and Schwartz [1971]). Therefore, we will consider M1 $=$ average amount of cash outstanding $+$ bank current deposits, and M2 $=$ M1 $+$ bank time deposits. Furthermore, in Japan post offices are everywhere, but not bank branches, and many Japanese households have savings in the form of postal savings but not necessarily in bank deposits, so we will also consider M3 $=$ M2 $+$ deposits in postal savings. However, the Public Opinion Survey does not provide information on the average amount of cash outstanding for years 1995 and 1997; therefore, neither M1 nor M2 or M3 is not accurately measured in years 1995 and 1997.

2. Household characteristic variables

The Public Opinion Survey records information about the number of household members, age of the head of household, job category of the head of household, state of employment of household members, and location of the household.

First, for the number of household members, the respondents were asked, "How many people are there in your household, including yourself?" and instructed to specify a number between two and six persons, or to answer "Seven or more." We use the response of this question to construct a variable DM, a dummy that takes one for the household with two or three members and zero elsewhere.

Second, for the state of employment of household members, the options were "No one in the household, including the head, is working," "Only the head of the household is working," "The head of the household and his/her spouse are working," and "Other." We construct dummy variables for the first three options and name them as "shugyo0," "shugyo1," and "shugyo2," and take the sum of the last three variables and define it as DE. That is, DE is a dummy variable for the household with at least one member working.

Third, the survey asks if the household has its own home or not. If the households live in houses or condominiums that they purchased or live in houses that they inherited or were donated, they are classified as homeowners. We construct a dummy variable DH for home ownership.

The survey also asks the age of the head of household. The respondents were given a choice of 20s, 30s, 40s, 50s, 60–64, 65–69, or 70 or older. The survey asks the job category of the head of household, which includes “Agriculture, forestry, and fisheries,” “Business proprietor (commerce, industry, or services),” “White-collar worker,” “Blue-collar worker,” “Manager,” “Professional worker,” and “Other.” These responses are used to construct the wage variable in the next subsection.

B. Data for Conditioning Variables

1. Price index for household

We assume that household service is produced from consumer goods. Based on this assumption, we use the Regional Difference Index of Consumer Prices (general, excluding imputed rent, Japan = 100) for the Hokkaido, Tohoku, Kanto, Hokuriku, Tokai, Kinki, Chugoku, Shikoku, and Kyushu regions for 1991 to 2003 for the proxy of variable q_1. To make a time-series comparison, we multiplied the Index of Consumer Prices for Japan (general, excluding imputed rent) for each year. Those data are available from the website http://www.stat.go.jp/data/cpi/index.htm.

2. Wage

We assume that households create financial service by spending time and visiting banks, hence use wages for the proxy of variable q_3. We obtain hourly wage data from two sources. First, we obtain average wage data, hours worked, and number of workers by the category of occupation, industry, age, and region reported in the Basic Survey on Wage Structure from the website http://www.jil.go.jp/kokunai/statistics/. The Basic Survey on Wage Structure provides information on the wage structure for regular employees in major industries, in terms of industry, region, size of enterprises, sex, type of worker, educational level, occupational category, type of occupation, type of work, age, length of service, and experience.

We did our best to match the job, age, sex, and regional category for the data series in the Public Opinion Survey on Household Financial Assets and Liabilities and the categories for the data series in the Basic Survey on Wage Structure. In particular, we use the following seven wage data series depending on the job category of the head of household.

First, regarding the job category of the business proprietors (commerce, industry, or services), we use wage data for males, all industry average wage data from each prefecture by age from the Basic Survey on Wage Structure for the proxy of their opportunity cost of time. We use weighted-average wage data by the number of workers in each prefecture to get regional data consistent with the classifications of age and regional categories in the Public Opinion Survey on Household Financial Assets and Liabilities. See the Appendix for the combination of prefectures for regions, and category of wages.

Second, for the job category of white-collar workers, we use wages for employed male engineers and general clerical male workers in mining, construction, and manufacturing industry by age from the Basic Survey on Wage Structure. We use weighted-average wage data by the number of workers in each age group and industry group to be consistent with the age groups in the Public Opinion Survey on Household Financial Assets and Liabilities. There is no regional breakdown for these data series.

Third, for the job category of blue-collar workers, we use wages for employed male work-site workers in mining, construction, and manufacturing industry by age from the Basic Survey on Wage Structure. We use weighted-average wage data by the number of workers in each age group and industry group to be consistent with the age group in the Public Opinion Survey on Household Financial Assets and Liabilities. There is no regional breakdown for these data series.

Fourth, for the job category of managers, we use wages for employed male directors and male section chiefs for all industry average by age from the Basic Survey on Wage Structure. We use weighted-average wage data by the number of workers in each age group to be consistent with the age group in the Public Opinion Survey on Household Financial Assets and Liabilities. There is no regional and industry breakdown for these data series.

Fifth, for the job category of professional workers, we use wages for employed male medical doctors by prefecture and age from the Basic Survey on Wage Structure. We use weighted-average regional wage data by the number of employed male medical doctors in each prefecture to be consistent with the regional breakdown in the Public Opinion Survey on Household Financial Assets and Liabilities. There is no breakdown by age of these data series.

Sixth, for the job category of others, we need the reservation wages for people without regular occupations. We use wages for part-time workers, all industry average from each prefecture from the Basic Survey on Wage Structure. We take the weighted average of the number of workers in each prefecture to get regional data consistent with the regional breakdown in the Public Opinion Survey on Household Financial Assets and Liabilities.

Finally, for the job category of agriculture, forestry, and fisheries, we use the male agricultural wage index (average, all Japan) for the years from 1991 to 2003. The wage index reports daily cash payment, and thus we divide the data by eight to get the hourly wage assuming that the working hour is eight hours a day. We obtain the wage index from the website http://www.tdb.maff.go.jp/toukei/toukei.

C. Data Preview

Table 1 shows the summary statistics for logM1, logM2, logM3, logI, logCPI, and logWage, DE, DH, and DM. We can generate CPI variables for all households; however, for the households that do not report the job category of household head, we cannot compute the logWage variable. Some households do not report the net income. Shapiro-Francia W′ test statistics applied to the variables logI, logCPI, and logWage, although not reported here, take large values in each year and support the assumption of log-normal distributions for these variables. Table 2 shows the correlation matrix for those variables in each year from 1991 to 2002. Correlations between logI and logM1, logM2, and logM3 are weakly positive. Correlations between three major explanatory variables, logI, logCPI, and logWage, are at most 0.4. Regarding the correlations between logM1, logM2, and logM3, we find that the correlations between logM3 and logM2 are about 0.8, which seems high and stable. However, the correlations between logM3 and logM1 are about in the range between 0.4 and 0.5, and the correlations between logM2 and logM1 are in the range between 0.5 and 0.6, except for the year 2002 and two years, 1995 and 1997, where the data on cash are not available. Based on those results, we conjecture that the regression results based on logM3 and logM2 would be reasonably close, while the results based on logM1 would not be close to those based on logM3.

Table 1 Summary Statistics

1991	Observation	Mean	S.D.
logM1	3097	3.637	1.739
logM2	3117	4.774	1.871
logM3	3120	5.244	1.792
logI	3058	6.140	0.575
logCPI	3979	4.567	0.028
logWage	3939	7.449	0.435
DE	3979	0.911	0.285
DH	3979	0.654	0.476
DM	3979	0.374	0.484

1992	Observation	Mean	S.D.
logM1	3216	3.477	1.730
logM2	3254	4.895	1.877
logM3	3265	5.410	1.747
logI	3142	6.166	0.577
logCPI	4138	4.582	0.030
logWage	4095	7.465	0.457
DE	4138	0.910	0.286
DH	4138	0.677	0.468
DM	4138	0.410	0.492

1993	Observation	Mean	S.D.
logM1	3193	3.519	1.685
logM2	3212	4.725	1.920
logM3	3221	5.262	1.840
logI	2830	6.202	0.623
logCPI	4107	4.593	0.027
logWage	4042	7.524	0.457
DE	4107	0.904	0.295
DH	4107	0.692	0.462
DM	4107	0.418	0.493

1994	Observation	Mean	S.D.
logM1	3396	3.582	1.708
logM2	3426	4.789	1.900
logM3	3437	5.340	1.825
logI	2978	6.187	0.619
logCPI	4225	4.599	0.028
logWage	4175	7.534	0.443
DE	4225	0.909	0.287
DH	4225	0.679	0.467
DM	4225	0.422	0.494

Table 1 (continued)

1995	Observation	Mean	S.D.
logM1	2087	4.595	1.257
logM2	2795	5.492	1.333
logM3	3092	5.866	1.283
logI	3047	6.221	0.606
logCPI	4217	4.596	0.027
logWage	4164	7.523	0.441
DE	4217	0.894	0.308
DH	4217	0.692	0.462
DM	4217	0.438	0.496

1996	Observation	Mean	S.D.
logM1	3666	3.571	1.431
logM2	3678	4.954	1.736
logM3	3685	5.523	1.654
logI	3278	6.247	0.527
logCPI	4317	4.595	0.027
logWage	4288	7.543	0.442
DE	4317	0.901	0.299
DH	4317	0.703	0.457
DM	4317	0.445	0.497

1997	Observation	Mean	S.D.
logM1	2083	4.769	1.336
logM2	2817	5.563	1.377
logM3	3155	5.957	1.287
logI	3266	6.262	0.532
logCPI	4286	4.611	0.027
logWage	4250	7.551	0.428
DE	4286	0.899	0.302
DH	4286	0.700	0.458
DM	4286	0.461	0.499

1998	Observation	Mean	S.D.
logM1	3510	3.797	1.560
logM2	3523	5.021	1.770
logM3	3530	5.594	1.701
logI	3121	6.226	0.517
logCPI	4287	4.620	0.026
logWage	4265	7.559	0.436
DE	4287	0.895	0.306
DH	4287	0.736	0.441
DM	4287	0.469	0.499

Table 1 (continued)

1999	Observation	Mean	S.D.
logM1	3398	3.838	1.636
logM2	3398	5.041	1.835
logM3	3398	5.601	1.745
logI	3072	6.193	0.563
logCPI	4278	4.616	0.026
logWage	4249	7.517	0.442
DE	4278	0.876	0.329
DH	4278	0.747	0.435
DM	4278	0.482	0.500

2000	Observation	Mean	S.D.
logM1	3376	3.878	1.688
logM2	3376	5.033	1.847
logM3	3376	5.658	1.730
logI	3068	6.171	0.562
logCPI	4235	4.610	0.020
logWage	4199	7.514	0.446
DE	4235	0.884	0.320
DH	4235	0.769	0.421
DM	4235	0.483	0.500

2001	Observation	Mean	S.D.
logM1	3121	3.981	1.689
logM2	3121	5.076	1.832
logM3	3121	5.658	1.750
logI	3087	6.138	0.588
logCPI	4234	4.601	0.020
logWage	4197	7.479	0.461
DE	4234	0.869	0.338
DH	4234	0.747	0.435
DM	4234	0.505	0.500

2002	Observation	Mean	S.D.
logM1	3112	4.119	1.762
logM2	3112	5.059	1.931
logM3	3112	5.636	1.846
logI	3075	6.070	0.611
logCPI	4149	4.591	0.021
logWage	4101	7.460	0.470
DE	4149	0.853	0.354
DH	4149	0.737	0.441
DM	4149	0.521	0.500

Table 2 Correlation Matrix

1991	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.585	1.000							
logM3	0.478	0.848	1.000						
logI	0.195	0.285	0.246	1.000					
logCPI	0.127	0.074	0.073	0.071	1.000				
logWage	0.044	0.036	0.009	0.265	0.053	1.000			
DE	0.008	−0.016	−0.060	0.177	0.011	0.236	1.000		
DH	0.113	0.202	0.200	0.206	−0.018	0.030	−0.078	1.000	
DM	0.006	−0.009	0.023	−0.224	0.033	−0.184	−0.207	−0.017	1.000

1992	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.516	1.000							
logM3	0.398	0.828	1.000						
logI	0.192	0.241	0.217	1.000					
logCPI	0.039	0.048	0.030	0.075	1.000				
logWage	0.057	0.028	−0.024	0.290	0.096	1.000			
DE	0.025	−0.044	−0.094	0.152	0.013	0.263	1.000		
DH	0.117	0.218	0.234	0.167	−0.056	−0.008	−0.083	1.000	
DM	0.038	0.003	0.052	−0.225	0.065	−0.194	−0.207	−0.018	1.000

1993	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.586	1.000							
logM3	0.451	0.809	1.000						
logI	0.204	0.235	0.232	1.000					
logCPI	0.090	0.030	0.024	0.102	1.000				
logWage	0.043	0.001	−0.025	0.226	0.133	1.000			
DE	−0.010	−0.039	−0.080	0.152	0.011	0.264	1.000		
DH	0.144	0.167	0.177	0.152	−0.042	0.008	−0.116	1.000	
DM	−0.007	0.014	0.056	−0.198	0.032	−0.169	−0.174	−0.019	1.000

1994	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.580	1.000							
logM3	0.472	0.829	1.000						
logI	0.182	0.196	0.182	1.000					
logCPI	0.062	0.043	0.032	0.045	1.000				
logWage	0.069	−0.003	−0.042	0.272	0.140	1.000			
DE	−0.017	−0.051	−0.077	0.155	0.001	0.256	1.000		
DH	0.161	0.196	0.202	0.157	−0.090	0.027	−0.098	1.000	
DM	0.016	0.064	0.100	−0.209	0.057	−0.164	−0.208	−0.019	1.000

Table 2 (continued)

1995	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.710	1.000							
logM3	0.610	0.877	1.000						
logI	0.232	0.272	0.298	1.000					
logCPI	0.031	0.039	0.045	0.134	1.000				
logWage	0.015	0.006	0.008	0.332	0.142	1.000			
DE	−0.105	−0.118	−0.138	0.155	0.077	0.251	1.000		
DH	0.208	0.248	0.257	0.187	−0.074	−0.001	−0.142	1.000	
DM	0.013	0.055	0.062	−0.207	0.015	−0.211	−0.207	−0.026	1.000

1996	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.511	1.000							
logM3	0.419	0.816	1.000						
logI	0.184	0.252	0.226	1.000					
logCPI	0.053	0.016	0.019	0.151	1.000				
logWage	0.043	−0.018	−0.053	0.296	0.146	1.000			
DE	−0.031	−0.061	−0.082	0.191	0.043	0.268	1.000		
DH	0.101	0.185	0.176	0.161	−0.062	0.005	−0.112	1.000	
DM	−0.039	0.000	0.030	−0.266	0.043	−0.170	−0.196	0.007	1.000

1997	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.736	1.000							
logM3	0.605	0.851	1.000						
logI	0.250	0.314	0.303	1.000					
logCPI	−0.015	0.011	0.049	0.178	1.000				
logWage	0.000	0.013	−0.013	0.357	0.171	1.000			
DE	−0.056	−0.088	−0.115	0.162	0.029	0.247	1.000		
DH	0.196	0.272	0.245	0.149	−0.059	0.044	−0.080	1.000	
DM	0.063	0.058	0.087	−0.245	0.015	−0.225	−0.161	−0.053	1.000

1998	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.589	1.000							
logM3	0.475	0.819	1.000						
logI	0.210	0.279	0.243	1.000					
logCPI	0.072	0.054	0.035	0.152	1.000				
logWage	0.043	0.004	−0.028	0.324	0.099	1.000			
DE	−0.009	−0.058	−0.131	0.211	0.063	0.320	1.000		
DH	0.114	0.209	0.220	0.169	−0.067	0.016	−0.140	1.000	
DM	0.030	0.046	0.089	−0.238	0.012	−0.193	−0.227	−0.023	1.000

Table 2 **(continued)**

1999	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.590	1.000							
logM3	0.481	0.830	1.000						
logI	0.217	0.197	0.169	1.000					
logCPI	0.037	−0.002	0.004	0.060	1.000				
logWage	0.026	−0.020	−0.039	0.346	0.017	1.000			
DE	0.001	−0.038	−0.075	0.236	−0.004	0.303	1.000		
DH	0.099	0.185	0.211	0.101	−0.015	0.000	−0.117	1.000	
DM	0.004	0.083	0.099	−0.231	0.034	−0.225	−0.268	−0.009	1.000

2000	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.622	1.000							
logM3	0.490	0.807	1.000						
logI	0.190	0.204	0.184	1.000					
logCPI	0.026	0.026	0.006	0.085	1.000				
logWage	0.013	0.009	−0.006	0.289	0.088	1.000			
DE	−0.008	−0.059	−0.096	0.191	0.043	0.297	1.000		
DH	0.106	0.181	0.194	0.120	−0.035	0.020	−0.124	1.000	
DM	0.063	0.097	0.118	−0.211	−0.031	−0.197	−0.239	0.006	1.000

2001	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.639	1.000							
logM3	0.524	0.825	1.000						
logI	0.246	0.226	0.178	1.000					
logCPI	−0.022	−0.035	−0.018	0.001	1.000				
logWage	0.020	−0.003	−0.053	0.300	0.006	1.000			
DE	−0.013	−0.050	−0.106	0.225	−0.017	0.357	1.000		
DH	0.075	0.140	0.163	0.119	0.029	−0.014	−0.111	1.000	
DM	0.044	0.055	0.092	−0.262	0.023	−0.249	−0.271	−0.022	1.000

2002	logM1	logM2	logM3	logI	logCPI	logWage	DE	DH	DM
logM1	1.000								
logM2	0.727	1.000							
logM3	0.614	0.850	1.000						
logI	0.261	0.261	0.230	1.000					
logCPI	0.085	0.055	0.072	0.084	1.000				
logWage	0.065	−0.024	−0.042	0.288	0.060	1.000			
DE	−0.014	−0.093	−0.118	0.232	0.013	0.342	1.000		
DH	0.140	0.178	0.188	0.118	−0.070	−0.001	−0.105	1.000	
DM	0.025	0.049	0.061	−0.268	−0.004	−0.239	−0.293	−0.005	1.000

V. Empirical Results

For the existence of a stable aggregate money demand function for Japan, three conditions must hold. First, the appropriate definition of money is used. Second, year-by-year cross-sectional estimates are stable over time given the standard assumption for regression analysis, which is that conditional on certain variables the dependent variable is randomly distributed with constant mean $E(\log m_{it} \mid \log \underset{\sim}{x}) = \bar{\underset{\sim}{a}}' \log \underset{\sim}{x}$. In other words, conditional on $\log \underset{\sim}{x}$, there is no more unobserved heterogeneity. Third, the cross-sectional estimates must be compatible with the aggregate time-series estimates, because under homogeneity aggregation condition holds.

We estimate household money demand equation (5) by regressing $\log m_{it}$ on $\log \underset{\sim}{x}_{it}$ year by year using cross-sectional survey data from 1991 to 2002. However, since all households face the same interest at a given time, the impact of $a_4 \log R_t$ is merged with the intercept a_0 for cross-sectional regressions yielding a time-varying intercept because $\log R_t$ varies over time. The least-squares method will yield consistent estimates of $\bar{\underset{\sim}{a}}$ under either the homogeneity assumption A1 or heterogeneity assumption A2.

For the estimation of aggregate time-series models, we will assume homogeneity and

$$\log I_{it} \sim N[\mu_{i,t}(h), \sigma^2_{It}(h)],$$

$$\log q_{j,it} \sim N[\mu_{j,t}(h), \sigma^2_{jt}(h)], \quad j = 1, 3.$$

$$\log A_{it} \sim N[\mu_{A,t}(h), \sigma^2_{At}(h)]. \tag{16}$$

Under these assumptions, if the average household income and household demand for money are $I_t(h)$ and $m_t(h)$, respectively, as shown in (12) or (12′), equation (4) has an aggregate counterpart in equation (17),

$$\begin{aligned} \log m_t(h) = {} & \beta \log I_t(h) - \gamma \log R_t + \pi_\phi(\psi_\phi - \gamma) \log \frac{q_{3,t}(h)}{R_t} \\ & + (\gamma - \beta) \log q_{1,t}(h) - (1 - \gamma) \log A_t(h) \\ & + \frac{1}{2}\beta(\beta - 1)\sigma^2_{It}(h) + \frac{1}{2}\pi_\phi(\psi_\phi - \gamma)[\pi_\phi(\psi_0 - \gamma) - 1]\sigma^2_{3t}(h) \\ & + \frac{1}{2}(1 - \gamma)(2 - \gamma)\sigma^2_{At}(h) + \frac{1}{2}(\gamma - \beta)(\gamma - \beta - 1)\sigma^2_{1t}(h) \\ & + \text{covariances} + \text{constant} + e_t. \end{aligned} \tag{17}$$

We estimate equation (17) using time-series aggregate data constructed from the 1991 survey to the 2002 survey. We also take into account the set of nonlinear parameter restrictions in equation (17) and estimate equation (18) by nonlinear least square and obtain parameter estimates for $b0$, $b1$, $b2$, and $b3$. Under homogeneity, the income elasticity, a_1, in equation (4) should be identical to the income elasticity, $b1$, in (18).

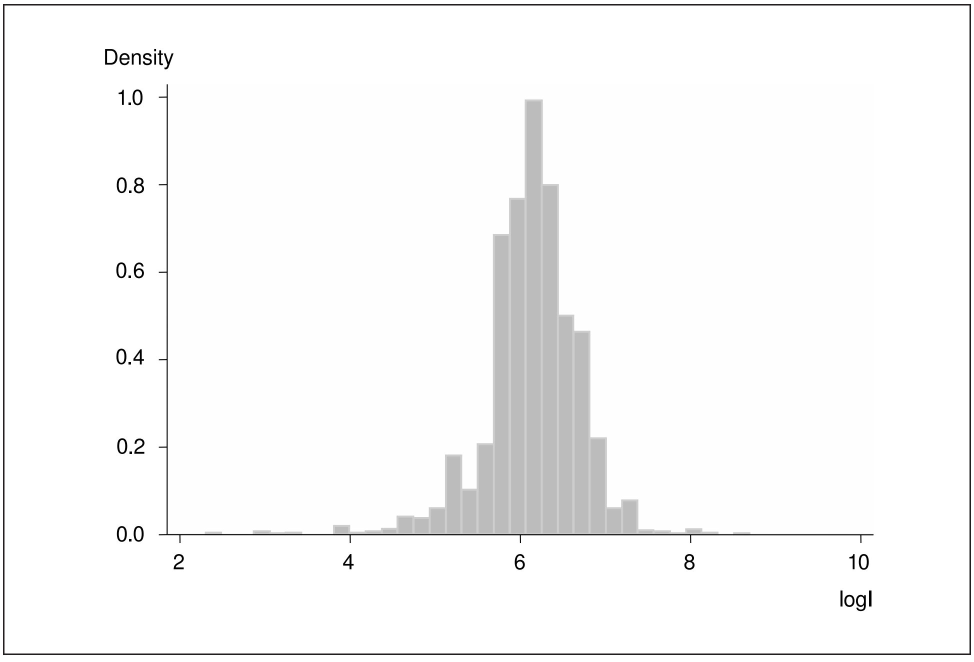
$$
\begin{aligned}
\log m_t = {} & b0 + b1 \log I_t - b2 \log R_t + b3 \log \frac{\text{Wage}_t}{R_t} \\
& + (b2 - b1) \log CPI + \frac{1}{2} b1(b1 - 1)^* \operatorname{var} \sigma_{It} \\
& + \frac{1}{2} b3(b3 - 1)^* \operatorname{var} \sigma_{\text{wage}\,t} + \frac{1}{2}(1 - b2)(2 - b2)^* \operatorname{var} \sigma_{At} \\
& + \frac{1}{2}(b2 - b1)(b2 - b1 - 1)^* \operatorname{var} \sigma_{CP1\,t} + e_t,
\end{aligned} \tag{18}
$$

where $t = 1991, \ldots, 2002$.

Nonlinear least-squares regression of (18) would yield consistent income and interest rate elasticity provided the homogeneity and log-normal distribution assumption (16) hold. The spread of the micro data appears to support (16). For instance, Figure 1 plots the 1991 logI, which is roughly symmetrical and bell shaped.

If the homogeneity assumption does not hold, estimation of (17) and (18) will yield biased income and interest rate elasticities due to the omitted variable effects as shown in (14) and (15). However, due to the limited degrees of freedom, we cannot consider the heterogeneity counterpart of (14) or (15).

Figure 1 logI Data in 1991



Tables 3, 4, and 5 provide the cross-sectional estimates for, logM1, logM2, and logM3 year by year from 1991 to 2002. We will focus our discussion on alternative definition of money and income, partly because it is generally agreed that a scale variable, income, is the most important single variable affecting the quantity of money demanded and partly because other variables do not exhibit much variation, which makes it hard to obtain relatively precise estimates.

The range of income elasticity for M1 between 1991 and 2002 is $(0.450, 0.836)$ with an average of 0.623 and standard deviation of 0.127. The range of income elasticity for M2 is $(0.585, 0.996)$ with an average of 0.786 and standard deviation of 0.125. The range of income elasticity for M3 is $(0.532, 0.847)$ with an average of 0.683 and standard deviation of 0.1. These results indicate that using M3 as a definition of money appears to yield the most stable household demand for the money function. The coefficients on logI are statistically significant and quite stable over time. The average income elasticity from 1991 to 2002 is 0.683. The coefficients of logWage also have the expected negative signs and are statistically significant for all the years except for 2000. However, the coefficients of logCPI are considerably less stable and are only statistically significant for 1991, 1994, 1995, 1997, and 2002, perhaps due to insufficient variation across regions. Coefficients for household attributes are all statistically significant. The coefficients for DE (at least one household member has a job) are consistently negative, DH (home ownership) are consistently positive, and DM (household members fewer than four) are consistently positive.

Tables 6, 7, and 8 present the aggregate time-series estimates using the cross-sectional average for $\log m_{it}$ and $\log \underset{\sim}{x}_{it}$ (model [7]) with dummy variables for 1995 and 1997. The top part of these tables presents the regression results without household characteristic variables. The bottom part reports the regression results with household characteristic variables as additional regressors. Since the addition of household characteristic variables leaves us with only three degrees of freedom and the regression of the model in the top part remains consistent if our sample does not involve distributional changes over time, we only discuss the results of the top part. Again, the results based on logM3 appear more broadly consistent with year-by-year cross-sectional estimates than the results based on logM1 or logM2. The income elasticities, although in the same ballpark as the cross-sectional estimates, are not statistically significant, but the interest rate elasticities are statistically significant. The income elasticity for M3 is 0.708 when the overnight call rate is used, and 0.746 when the five-year bond rate is used. The interest rate elasticity is -0.033 for the call rate and -0.117 for the five-year bond rate. However, the results based on logM1 yield negative and statistically insignificant income elasticities. The results based on logM2 are more close to the results based on logM3.

Tables 9, 10, and 11 present the aggregate time-series estimates using the logarithm of the average m_{it} and $\underset{\sim}{x}_{it}$ together with the estimated covariances of logI, logWage, and logCPI as implied by homogeneity assumption (model [12′]). They yield similar results for M3 compared with those using the average of $\log m_{it}$ and $\log x_{it}$. The estimated income elasticity is 0.686 when the call rate is used as the interest rate and 0.658 when the five-year bond rate is used. The interest rate elasticity is -0.035 for the

Table 3 Results of Cross-Sectional Regression for logM1

logM1	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
logI	0.555	0.549	0.522	0.450	0.524	0.492	0.771	0.653	0.713	0.635	0.836	0.776
(s.e.)	0.063	0.065	0.058	0.056	0.055	0.055	0.064	0.062	0.062	0.061	0.061	0.059
logCPI	7.123	1.753	4.527	3.622	1.057	1.767	−2.346	2.649	1.448	1.439	−2.194	5.644
(s.e.)	1.178	1.100	1.193	1.150	1.049	0.974	1.111	1.072	1.173	1.591	1.579	1.549
logWage	−0.001	0.012	−0.001	0.100	−0.093	0.001	−0.198	−0.037	−0.149	−0.108	−0.099	0.073
(s.e.)	0.080	0.078	0.078	0.079	0.071	0.062	0.077	0.072	0.076	0.077	0.078	0.077
DE	−0.200	0.034	−0.131	−0.150	−0.470	−0.289	−0.261	−0.127	−0.111	−0.031	−0.170	−0.229
(s.e.)	0.131	0.126	0.126	0.119	0.106	0.092	0.109	0.099	0.100	0.106	0.102	0.102
DH	0.273	0.338	0.425	0.510	0.413	0.213	0.446	0.274	0.283	0.336	0.162	0.447
(s.e.)	0.071	0.073	0.073	0.071	0.064	0.058	0.066	0.066	0.074	0.080	0.079	0.080
DM	0.090	0.007	0.090	0.165	0.092	−0.015	0.320	0.227	0.141	0.337	0.346	0.307
(s.e.)	0.070	0.070	0.069	0.067	0.059	0.054	0.061	0.059	0.065	0.067	0.068	0.070
constant	−32.254	−8.237	−20.604	−16.764	−2.778	−7.429	11.966	−12.348	−6.227	−6.170	9.606	−27.248
(s.e.)	5.365	4.998	5.412	5.231	4.759	4.402	5.024	4.902	5.417	7.299	7.280	7.083
obs	2625	2667	2449	2636	1784	2957	1821	2795	2681	2705	2548	2532
Rbar	0.057	0.043	0.060	0.057	0.095	0.042	0.113	0.058	0.057	0.052	0.076	0.094

Note: Estimation methods are OLS. The row labeled “obs” shows the number of total observations, and the row labeled “Rbar” shows the adjusted R square. Data on logM1 for 1995 and 1997 do not include cash.

Table 4 Results of Cross-Sectional Regression for logM2

logM2	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
logI	0.850	0.752	0.675	0.585	0.622	0.885	0.883	0.996	0.755	0.716	0.797	0.920
(s.e.)	0.062	0.064	0.061	0.057	0.049	0.062	0.054	0.064	0.064	0.062	0.062	0.061
logCPI	3.440	2.419	1.080	3.073	1.816	−0.458	0.541	1.638	−1.099	1.750	−3.580	3.741
(s.e.)	1.170	1.086	1.268	1.177	0.958	1.089	0.961	1.118	1.215	1.623	1.619	1.610
logWage	−0.105	−0.090	−0.155	−0.184	−0.184	−0.267	−0.274	−0.235	−0.264	−0.087	−0.129	−0.224
(s.e.)	0.079	0.077	0.083	0.080	0.064	0.070	0.065	0.074	0.079	0.079	0.080	0.080
DE	−0.268	−0.335	−0.255	−0.236	−0.506	−0.384	−0.513	−0.323	−0.122	−0.260	−0.292	−0.536
(s.e.)	0.131	0.124	0.134	0.122	0.093	0.102	0.091	0.103	0.104	0.109	0.105	0.106
DH	0.530	0.682	0.515	0.645	0.579	0.480	0.617	0.579	0.652	0.643	0.442	0.588
(s.e.)	0.070	0.072	0.078	0.073	0.058	0.065	0.057	0.069	0.077	0.081	0.081	0.083
DM	0.137	0.142	0.172	0.333	0.228	0.157	0.373	0.312	0.405	0.450	0.354	0.317
(s.e.)	0.070	0.069	0.073	0.069	0.054	0.061	0.053	0.061	0.067	0.068	0.070	0.073
constant	−15.365	−10.207	−3.188	−11.678	−5.425	3.640	−0.581	−7.098	7.045	−7.126	17.528	−16.016
(s.e.)	5.329	4.937	5.755	5.353	4.350	4.925	4.360	5.112	5.611	7.445	7.461	7.366
obs	2644	2702	2467	2658	2356	2967	2446	2803	2681	2705	2548	2532
Rbar	0.107	0.097	0.074	0.082	0.134	0.098	0.171	0.124	0.087	0.087	0.082	0.119

Note: Estimation methods are OLS. The row labeled “obs” shows the number of total observations, and the row labeled “Rbar” shows the adjusted R square. Data on logM2 for 1995 and 1997 do not include cash.

Table 5 Results of Cross-Sectional Regression for logM3

logM3	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
logI	0.700	0.651	0.629	0.532	0.637	0.769	0.842	0.847	0.608	0.595	0.632	0.755
(s.e.)	0.057	0.056	0.053	0.051	0.044	0.056	0.047	0.057	0.057	0.054	0.056	0.056
logCPI	3.198	1.269	0.514	2.315	1.656	0.037	2.482	0.738	−0.528	0.223	−1.988	5.007
(s.e.)	1.072	0.948	1.110	1.047	0.865	0.987	0.839	0.995	1.082	1.415	1.463	1.467
logWage	−0.132	−0.193	−0.187	−0.274	−0.173	−0.334	−0.281	−0.211	−0.244	−0.072	−0.199	−0.224
(s.e.)	0.073	0.067	0.073	0.072	0.058	0.063	0.057	0.066	0.071	0.068	0.072	0.073
DE	−0.447	−0.482	−0.409	−0.267	−0.507	−0.387	−0.564	−0.588	−0.232	−0.373	−0.412	−0.562
(s.e.)	0.120	0.109	0.117	0.108	0.082	0.093	0.079	0.092	0.093	0.095	0.095	0.096
DH	0.489	0.636	0.468	0.591	0.570	0.410	0.514	0.530	0.675	0.597	0.485	0.587
(s.e.)	0.064	0.063	0.068	0.065	0.053	0.059	0.049	0.061	0.068	0.071	0.073	0.076
DM	0.181	0.242	0.273	0.394	0.200	0.204	0.361	0.359	0.371	0.428	0.363	0.280
(s.e.)	0.064	0.060	0.064	0.061	0.048	0.055	0.046	0.055	0.060	0.059	0.063	0.066
constant	−12.444	−2.859	0.663	−6.565	−4.451	3.239	−8.673	−1.311	5.864	1.375	12.428	−20.171
(s.e.)	4.881	4.307	5.038	4.763	3.930	4.462	3.801	4.548	4.999	6.493	6.742	6.709
obs	2645	2712	2472	2666	2580	2972	2718	2809	2681	2705	2548	2532
Rbar	0.096	0.106	0.088	0.091	0.149	0.094	0.182	0.132	0.092	0.092	0.084	0.116

Note: Estimation methods are OLS. The row labeled “obs” shows the number of total observations, and the row labeled “Rbar” shows the adjusted R square. Data on logM3 for 1995 and 1997 do not include cash.

Table 6 Results of Aggregate Model for logM1: Log-Log Model (7)

$$\log m_t = a \log x_t + v_t, \text{ where } \log m_t = \left(\frac{1}{N_t}\right)\sum_{i=1}^{N_t} \log m_{it} \text{ and } \log x_t = \left(\frac{1}{N_t}\right)\sum_{i=1}^{N_t} \log x_{it}.$$

logI $b1$ (s.e.)	logR $b2$ (s.e.)	logCPI $b3$ (s.e.)	logWage $b4$ (s.e.)	DE $b5$ (s.e.)	DH $b6$ (s.e.)	DM $b7$ (s.e.)	D9597 (s.e.)	Constant $b0$ (s.e.)	Interest rate	Rbar
–2.626	–0.047	0.616	0.874				1.071	18.767	Call rate	0.948
(1.438)	(0.017)	(2.941)	(2.042)				(0.108)	(17.846)		
–2.560	–0.173	1.251	–0.009				1.024	14.139	5-year rate	0.960
(1.246)	(0.050)	(2.305)	(1.674)				(0.098)	(14.653)		
–2.868	–0.292	–2.502	1.136				1.052	35.405	10-year rate	0.971
(1.038)	(0.067)	(2.570)	(1.504)				(0.080)	(14.893)		
–2.297	–0.032	–0.628	0.686	0.253	–0.484	1.801	1.039	21.438	Call rate	0.905
(2.201)	(0.069)	(5.742)	(3.250)	(10.984)	(4.287)	(5.212)	(0.230)	(33.152)		
–2.709	–0.259	2.974	–0.525	1.055	–0.040	–1.256	1.005	6.007	5-year rate	0.924
(1.868)	(0.256)	(6.577)	(3.223)	(9.395)	(2.884)	(5.465)	(0.195)	(34.364)		
–2.880	–0.298	–2.590	1.096	0.489	0.054	0.110	1.048	35.292	10-year rate	0.942
(1.633)	(0.197)	(4.253)	(2.446)	(7.935)	(2.439)	(4.172)	(0.154)	(22.521)		

Note: Estimations are done by OLS. For dummy variables DE (at least one member has a job), DH (a household with its own house), and DM (household members fewer than four), we use the sample average rather than the log, since we cannot take zero of the log. The row labeled “obs” shows the number of total observations, and the row labeled “Rbar” shows the adjusted R square. Numbers in parentheses are standard errors. Sample periods are 1991 to 2002, and we have 12 observations. D9597 is dummy variables that take one in 1995 and 1997 and zero for other years, because M1 in those years excludes cash.

Table 7 Results of Aggregate Model for logM2: Log-Log Model (7)

$$\log m_t = a \log x_t + v_t, \text{ where } \log m_t = \left(\frac{1}{N_t}\right)\sum_{i=1}^{N_t} \log m_{it} \text{ and } \log x_t = \left(\frac{1}{N_t}\right)\sum_{i=1}^{N_t} \log x_{it}.$$

logI $b1$ (s.e.)	logR $b2$ (s.e.)	logCPI $b3$ (s.e.)	logWage $b4$ (s.e.)	DE $b5$ (s.e.)	DH $b6$ (s.e.)	DM $b7$ (s.e.)	D9597 (s.e.)	Constant $b0$ (s.e.)	Interest rate	Rbar
0.611	–0.024	2.418	–1.584				0.390	–12.458	Call rate	0.977
(0.601)	(0.007)	(1.253)	(0.859)				(0.041)	(7.518)		
0.660	–0.087	2.714	–2.027				0.364	–14.773	5-year rate	0.986
(0.477)	(0.019)	(0.897)	(0.640)				(0.035)	(5.611)		
0.418	–0.125	1.536	–1.643				0.387	–7.149	10-year rate	0.977
(0.582)	(0.038)	(1.459)	(0.846)				(0.041)	(8.404)		
0.954	–0.008	1.231	–1.718	–0.312	–0.656	1.706	0.363	–9.367	Call rate	0.991
(0.563)	(0.017)	(1.529)	(0.844)	(3.187)	(1.013)	(1.463)	(0.041)	(8.205)		
0.896	–0.014	1.287	–1.748	–0.648	–0.418	1.549	0.364	–9.090	5-year rate	0.991
(0.570)	(0.076)	(1.979)	(0.971)	(3.214)	(0.863)	(1.717)	(0.045)	(10.140)		
0.886	–0.016	0.983	–1.662	–0.661	–0.415	1.631	0.366	–7.510	10-year rate	0.991
(0.571)	(0.068)	(1.541)	(0.857)	(3.134)	(0.843)	(1.529)	(0.041)	(7.868)		

Note: Estimations are done by OLS. For dummy variables DE (at least one member has a job), DH (a household with its own house), and DM (household members fewer than four), we use the sample average rather than the log, since we cannot take zero of the log. The row labeled "obs" shows the number of total observations, and the row labeled "Rbar" shows the adjusted R square. Numbers in parentheses are standard errors. Sample periods are 1991 to 2002, and we have 12 observations. D9597 is dummy variables that take one in 1995 and 1997 and zero for other years, because M2 in those years excludes cash.

Table 8 Results of Aggregate Model for logM3: Log-Log Model (7)

$$\log m_t = a \log x_t + v_t, \text{ where } \log m_t = \left(\frac{1}{N_t}\right)\sum_{i=1}^{N_t} \log m_{it} \text{ and } \log x_t = \left(\frac{1}{N_t}\right)\sum_{i=1}^{N_t} \log x_{it}.$$

logI $b1$ (s.e.)	logR $b2$ (s.e.)	logCPI $b3$ (s.e.)	logWage $b4$ (s.e.)	DE $b5$ (s.e.)	DH $b6$ (s.e.)	DM $b7$ (s.e.)	D9597 (s.e.)	Constant $b0$ (s.e.)	Interest rate	Rbar
0.708	−0.033	3.448	−1.041				0.177	−16.305	Call rate	0.914
(0.717)	(0.009)	(1.480)	(1.025)				(0.043)	(8.960)		
0.746	−0.117	4.013	−1.706				0.140	−20.121	5-year rate	0.938
(0.605)	(0.024)	(1.127)	(0.812)				(0.038)	(7.115)		
0.431	−0.170	2.368	−1.176				0.167	−9.631	10-year rate	0.903
(0.740)	(0.048)	(1.838)	(1.075)				(0.046)	(10.655)		
1.014	−0.006	0.607	−1.283	3.370	0.965	3.049	0.154	−10.646	Call rate	0.947
(0.634)	(0.019)	(1.640)	(0.952)	(3.629)	(1.179)	(1.684)	(0.043)	(9.232)		
0.953	−0.020	0.815	−1.335	3.124	1.129	2.759	0.154	−11.050	5-year rate	0.946
(0.617)	(0.076)	(2.019)	(1.025)	(3.402)	(0.935)	(1.875)	(0.044)	(10.385)		
0.938	−0.027	0.374	−1.219	3.153	1.122	2.869	0.156	−8.796	10-year rate	0.947
(0.612)	(0.070)	(1.613)	(0.925)	(3.323)	(0.909)	(1.681)	(0.041)	(8.399)		

Note: Estimations are done by OLS. For dummy variables DE (at least one member has a job), DH (a household with its own house), and DM (household members fewer than four), we use the sample average rather than the log, since we cannot take zero of the log. The row labeled "obs" shows the number of total observations, and the row labeled "Rbar" shows the adjusted R square. Numbers in parentheses are standard errors. Sample periods are 1991 to 2002, and we have 12 observations. D9597 is dummy variables that take one in 1995 and 1997 and zero for other years, because M3 in those years excludes cash.

Table 9 Results of Aggregate Model for logM1: Anti-Log Model (12′)

$$\log m_t^* = a \log x_t^* + \frac{1}{2} a \Sigma a + \frac{1}{2}\sigma_t + v_t^*, \text{ where } \log m_t^* = \log \sum_{i=1}^{N_t} \left(\frac{m_{it}}{N_t}\right) \text{ and } \log x_t^* = \log \sum_{i=1}^{N_t} \left(\frac{x_{it}}{N_t}\right).$$

logI	logR	logCPI	logWage	DE	DH	DM	Constant	Interest rate	Rbar
$b1$	$b2$	$b3$	$b4$	$b5$	$b6$	$b7$	$b0$		
(s.e.)	(s.e.)	(s.e.)	(s.e.)	(s.e.)	(s.e.)	(s.e.)	(s.e.)		
1.609	–0.051	–0.063	–0.255				–5.744	Call rate	0.315
(1.387)	(0.048)	(9.907)	(5.456)				(57.107)		
1.604	–0.248	–1.585	–0.448				1.215	5-year rate	0.088
(1.252)	(0.151)	(8.198)	(3.792)				(45.996)		
1.908	–0.367	–4.429	–0.244				12.696	10-year rate	0.054
(1.089)	(0.252)	(10.290)	(4.335)				(54.657)		
0.678	–0.157	–4.166	–2.227	29.437	–7.060	13.827	–12.025	Call rate	0.315
(2.017)	(0.119)	(14.802)	(4.194)	(17.088)	(7.613)	(8.409)	(74.665)		
0.641	–0.314	–7.720	–2.219	26.497	11.719	3.463	–1.649	5-year rate	0.261
(2.212)	(0.519)	(17.254)	(5.262)	(16.650)	(13.718)	(90.683)	(9.708)		
1.711	–0.636	–10.451	–2.445	24.008	–2.521	10.735	13.240	10-year rate	0.150
(1.662)	(0.808)	(15.926)	(5.031)	(18.234)	(7.332)	(12.377)	(79.931)		

Note: Estimations are done by OLS. The row labeled "obs" shows the number of total observations, and the row labeled "Rbar" shows the adjusted R square. Numbers in parentheses are standard errors. Sample periods are 1991 to 2002, and we have 12 observations. For the estimation of the Σ matrix, we use three variables; logI, logWage, and logCPI only, because the other dummy variables do not have cross-sectional variation. In particular, we compute the Σ^* matrix from cross-sectional data for each year, and compute $\tilde{\Sigma}$ using the variance based on data from 1991 to 2002 data, which takes the same value for all years.

Table 10 Results of Aggregate Model for logM2: Anti-Log Model (12′)

$$\log m_t^* = a \log x_t^* + \frac{1}{2} a \Sigma a + \frac{1}{2}\sigma_t + v_t^*,\text{ where } \log m_t^* = \log \sum_{i=1}^{N_t} \left(\frac{m_{it}}{N_t}\right) \text{ and } \log x_t^* = \log \sum_{i=1}^{N_t} \left(\frac{x_{it}}{N_t}\right).$$

logI $b1$ (s.e.)	logR $b2$ (s.e.)	logCPI $b3$ (s.e.)	logWage $b4$ (s.e.)	DE $b5$ (s.e.)	DH $b6$ (s.e.)	DM $b7$ (s.e.)	Constant $b0$ (s.e.)	Interest rate	Rbar
0.983	–0.028	0.971	–0.834				–6.067	Call rate	0.604
(0.442)	(0.012)	(2.356)	(1.226)				(13.765)		
0.958	–0.111	1.071	–1.289				–7.057	5-year rate	0.734
(0.360)	(0.033)	(1.731)	(0.722)				(9.937)		
1.159	–0.156	–0.033	–1.301				–3.282	10-year rate	0.634
(0.372)	(0.063)	(2.520)	(0.866)				(13.258)		
0.774	–0.034	–0.766	–1.280	7.654	–1.480	4.743	–5.464	Call rate	0.666
(0.513)	(0.032)	(3.486)	(1.213)	(5.754)	(1.909)	(2.621)	(17.827)		
0.838	–0.169	1.878	–2.238	5.756	–0.833	2.029	–17.252	5-year rate	0.711
(0.454)	(0.134)	(4.723)	(1.326)	(5.092)	(1.493)	(3.548)	(22.906)		
0.823	–0.071	–1.972	–1.311	6.117	–0.490	4.564	0.550	10-year rate	0.590
(0.702)	(0.183)	(3.712)	(1.565)	(6.141)	(1.815)	(3.381)	(19.316)		

Note: Estimations are done by OLS. The row labeled "obs" shows the number of total observations, and the row labeled "Rbar" shows the adjusted R square. Numbers in parentheses are standard errors. Sample periods are 1991 to 2002, and we have 12 observations. For the estimation of the Σ matrix, we use three variables; logI, logWage, and logCPI only, because the other dummy variables do not have cross-sectional variation. In particular, we compute the Σ^* matrix from cross-sectional data for each year, and compute $\tilde{\Sigma}$ using the variance based on data from 1991 to 2002 data, which takes the same value for all years.

Table 11 Results of Aggregate Model for logM3: Anti-Log Model (12′)

$$\log m_t^* = a \log x_t^* + \frac{1}{2} a \Sigma a + \frac{1}{2}\sigma_t + v_t^*, \text{ where } \log m_t^* = \log \sum_{i=1}^{N_t} \left(\frac{m_{it}}{N_t}\right) \text{ and } \log x_t^* = \log \sum_{i=1}^{N_t} \left(\frac{x_{it}}{N_t}\right).$$

logI $b1$ (s.e.)	logR $b2$ (s.e.)	logCPI $b3$ (s.e.)	logWage $b4$ (s.e.)	DE $b5$ (s.e.)	DH $b6$ (s.e.)	DM $b7$ (s.e.)	Constant $b0$ (s.e.)	Interest rate	Rbar
0.686	–0.035	1.710	–0.758				–7.009	Call rate	0.850
(0.408)	(0.008)	(1.659)	(0.945)				(10.097)		
0.658	–0.124	2.309	–1.527				–10.839	5-year rate	0.937
(0.257)	(0.019)	(0.977)	(0.415)				(5.772)		
0.976	–0.184	0.846	–1.543				–6.154	10-year rate	0.733
(0.284)	(0.043)	(1.692)	(0.566)				(8.884)		
0.358	–0.015	–1.365	–0.719	5.747	–0.032	4.473	2.175	Call rate	0.960
(0.304)	(0.013)	(1.274)	(0.593)	(2.399)	(0.734)	(1.063)	(7.144)		
0.388	–0.064	–0.575	–1.139	5.122	0.391	3.532	–1.649	5-year rate	0.961
(0.300)	(0.057)	(1.790)	(0.733)	(2.247)	(0.584)	(1.409)	(9.708)		
0.358	–0.024	–1.889	–0.700	4.898	0.466	4.369	5.105	10-year rate	0.948
(0.403)	(0.066)	(1.367)	(0.747)	(2.600)	(0.665)	(1.303)	(7.623)		

Note: Estimations are done by OLS. The row labeled "obs" shows the number of total observations, and the row labeled "Rbar" shows the adjusted R square. Numbers in parentheses are standard errors. Sample periods are 1991 to 2002, and we have 12 observations. For the estimation of the Σ matrix, we use three variables; logI, logWage, and logCPI only, because the other dummy variables do not have cross-sectional variation. In particular, we compute the Σ^* matrix from cross-sectional data for each year, and compute $\tilde{\Sigma}$ using the variance based on data from 1991 to 2002 data, which takes the same value for all years.

overnight call rate and −0.124 for the five-year bond rate. Results based on logM1 improved because they yield positive income elasticities, however; the estimates are still not statistically significant. Results based on logM2 yield positive and statistically significant income elasticities, but the estimates are larger than the largest cross-sectional estimates.

Table 12 presents the nonlinear least-squares estimates of the Fujiki and Mulligan (1996b) model by imposing the prior restrictions on the coefficients of the covariance matrix. The income elasticity is 0.866 when the overnight call rate is used as the interest rate and 0.668 when the five-year bond rate is used. The interest rate elasticity is −0.576 for the call rate and −1.390 for the five-year bond rate. Although we do not report the details here, the nonlinear least-square estimates using logM1 yield income elasticities around 2 and the same estimates using logM2 yield a range from 1 to 1.5. Those estimates take far larger values than the cross-sectional estimates do.

Since income is the most important scale variable for money demand and income elasticity estimates for M3 are statistically significant for both year-by-year cross-sectional regression and time-series regression using aggregate data, we may tentatively

Table 12 Results of Aggregate Model for logM3: Fujiki-Mulligan Model (18)

$$\begin{aligned}\log m_t = {} & b0 + b1\log I_t - b2\log R_t + b3\log\frac{\text{Wage}_t}{R_t} \\ & + (b2-b1)\log CPI_t + \frac{1}{2}b1(b1-1)^*\,\text{var}\,\sigma_{It} \\ & + \frac{1}{2}b3(b3-1)^*\,\text{var}\,\sigma_{\text{wage}\,t} \\ & + \frac{1}{2}(b2-b1)(b2-b1-1)^*\,\text{var}\,\sigma_{CPI\,t} + e_t,\end{aligned}$$

$$t = 1991, \ldots, 2002.$$

logI $b1$ (s.e.)	logR $b2$ (s.e.)	logWage/R $b3$ (s.e.)	Constant $b0$ (s.e.)	Interest rate	Rbar
0.866	−0.576	−0.536	1.451	Call rate	0.845
(0.516)	(0.832)	(0.836)	(5.831)		
0.668	−1.390	−1.251	−3.100	5-year rate	0.921
(0.401)	(0.444)	(0.450)	(3.417)		
1.346	−1.895	−1.710	−7.556	10-year rate	0.892
(0.289)	(0.347)	(0.359)	(2.473)		

Note: Estimations are done by NLS. The row labeled “obs” shows the number of total observations, and the row labeled “Rbar” shows the adjusted R square. Numbers in the parentheses are standard errors. Sample periods are 1991 to 2002, and we have 12 observations. Compared with the model (12′), we add restrictions for parameters and use the Σ^* matrix only for the Σ matrix in order to follow Fujiki and Mulligan (1996b). They do not assume assumption 4, and thus do not assume the properties of $\tilde{\Sigma}$.

conclude that, overall, the aggregate time-series estimates of income elasticity for M3 are compatible with those obtained from cross-sectional estimates. The interest rate elasticity also appears to be compatible with other studies using time-series data. Although it is hard to infer much from the aggregate model with so few degrees of freedom, combining the aggregate time-series results with those of cross-sectional estimates appears to indicate that a stable money demand function does exist for Japan.

VI. Conclusions

In this paper, we have explored the appropriate definition of money for Japan and heterogeneity issues from the perspective of stability and compatiblity of cross-sectional and aggregate time-series estimates. The basic framework is that under appropriate definition of money and homogeneity conditional on certain observable factors, the year-by-year cross-sectional estimates should be stable and the cross-sectional estimates and time-series estimates should be compatible. In this paper, we provided conditions that permit individual data and aggregate data to be modeled under one consistent format. We used Public Opinion Surveys on Household Financial Assets and Liabilities from 1991 to 2002 to investigate the issues of aggregation and stability of money demand. Our analysis of both year-by-year cross-sectional and aggregate time series of M1, M2, and M3 showed that using M3 as a definition of money for Japan yielded the most stable and compatible relations between households and aggregate money demand funciton.

The temporal cross-sectional data also allowed us to construct time-series aggregate data from the individual dataset to investigate the conditions for perfect aggregation. Although we had only limited degrees of freedom (12 time-series observations), the time-series analysis appeared to support the contention that when aggregation conditions hold, both household and aggregate demand for money share the same key parameters: income elasticity and interest rate elasticity for money. The estimated income elasticity for M3 was about 0.65 and five-year bond interest rate elasticity was about -0.124.

Finally, it should be noted that with only 12 time-series observations, one should not put too much emphasis on the results of aggregate analysis. However, as time goes on, the information collected by the Public Opinion Survey data should accumulate and the methodology developed in this paper could allow us to investigate further the “homogeneity” versus “heterogeneity” issues between the individual and aggregate data, because unless aggregation conditions hold it is not possible to retrieve micro parameters from the aggregate model. However, even with heterogeneous micro behavior, our analysis demonstrated that it may still be possible to use the micro model as a guide to generate the best predictable model for aggregate data.

APPENDIX

The appendix explains the relationship between prefectures and regions and age groups used to compile the wage dataset for our analysis.

Regarding the regional data, we use weighted-average data of Aomori, Iwate, Miyagi, Akita, Yamagata, and Fukushima prefectures obtained from the Basic Survey on Wage Structure to get the data for the Tohoku region. We use weighted-average data of Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, and Kanagawa prefectures for the Kanto region. We use weighted-average data of Niigata, Toyama, Ishikawa, and Fukui prefectures for the Horuriku region. We use weighted-average data of Yamanashi, Nagano, Gifu, Shizuoka, Aichi, and Mie prefectures for the Chubu region. We use weighted-average data of Shiga, Kyoto, Osaka, Hyogo, Nara, and Wakayama prefectures for the Kinki region. We use weighted-average data of Tottori, Shimane, Okayama, Hiroshima, and Yamaguchi prefectures for the Chugoku region. We use weighted-average data of Tokushima, Kagawa, Ehime, and Kochi prefectures for the Shikoku region. We use weighted-average data of the age group older than 65 in the Basic Survey on Wage Structure for the age of the head of household of 65–69 and older than 70.

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