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Abstract: This paper studies the effect that financial innovation, which seems very prominent in recent years, has on money. Using Japanese regional data and the money demand specification, we first provide evidence of instability in the simple money-output relationship. However, when this relationship is extended to include a proxy for a comprehensive measure of financial innovation, the model is found to be stable. Furthermore, consistent with economic theory, evidence is obtained of financial innovation leading to decreased demand for liquid financial assets. In this respect, demand deposits seem to possess very similar characteristics to cash in Japan in recent years.

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I. Introduction

Using regional data, this paper analyzes the effects of financial innovation on money. The validity of the money demand function in Japan has been analyzed before (e.g., Corker, 1990; Miyao, 2000; Nagayasu, 2003); however, few efforts have been made to investigate the relationship between money and financial innovation despite the recent developments in economic theory (e.g., Alvarez and Lippi 2009) and the rapid progress in financial innovation.

Financial innovations in Japan may have been occurring all along, but they seem more prominent over the last decades. Although it is difficult to define financial innovation, we can identify some relevant historical incidents. For example, the Hashimoto government announced in November 1996 a comprehensive plan to liberalize and deregulate the financial system which was due to be completed by March 2001. This plan was expected to provide more business opportunities and make Japanese financial markets as competitive as their London and NY counterparts, and later this scheme would come to be referred to as the Japanese Big Bang, following the terminology used for British financial deregulation in October 1986 under the Thatcher government. One deregulation measure in this comprehensive package which is pertinent to this study is that banks are now allowed to engage in business related to a wide range of financial products such as bonds, mutual funds, insurance and pensions of their partner companies. Thus consumers can now purchase/sell a variety of financial products at the bank.

Furthermore, some notable innovations have come about in tandem with developments in information technology (IT). For example, Automatic Teller Machines (ATMs) were placed in convenience stores for the first time by Juroku Bank in Gifu prefecture in 1995, and then coutrywide by Sakura Bank in 1999. Furthermore, the present market leader, Seven Bank (formally Aiwai Bank) initiated countrywide ATM operations in 2001 in its affiliated convenience stores, Seven Eleven. The ATMs allow consumers to deposit/withdraw/transfer money with considerable ease. In addition, the Japan Net Bank initiated so-called internet banking in 2000 and allowed consumers to check their balance and transfer funds online, and finally while usage has been limited, electronic money (e.g., the Suica card) was introduced in 2004.

Our paper could be viewed as an extension of previous studies on the Japanese money demand function using regional data but it has several distinguishing features. First, we analyze the stability of the money-output relationship using the panel cointegration method. Thus a definition of stability is equivalent to the presence of cointegration in this paper, which is different from previous panel data studies (see next section) that often discuss stability without formal statistical analyses. Secondly, we consider financial innovation in this relationship, re-examine the appropriateness of its proxy used in previous studies, and also introduce new data to capture the effects of financial innovation which have not been used before in studies of Japan and which are indeed specific to Japan.

II. General Statistical Model

Our basic model for money is consistent with previous studies (e.g., Mulligan and Sala-i-Martin 1992; Fujiki and Mulligan, 1996; Fischer, 2007) that analyzed the regional money for advanced countries and can be summarized as follows:

$$Ln(M_{it}/P_{it}) = \alpha_i + \delta_t + \beta Ln(Y_{it}) + \gamma Ln(X_{it}) + u_{it} \tag{1}$$

where M is money stock, P is price, and Y is real output. Money and output are often expressed in terms of per capita. The Ln indicates that data are in logarithmic form, and u is the residual. Greek letters are the parameters to be estimated, and the subscripts, i and t, represent prefectures ($i = 1, \ldots, N$) and time ($t = 1, \ldots, T$). The α_i is fixed effects and δ_t time dummies. The latter is needed, when there is contemporaneous correlation among prefectures, in order to avoid a misspecification problem. The Baumol-Tobin inventory model of the transactions demand for money suggests $\beta = 0.5$, and more generally we expect $\beta > 0$: an increase in output (sometimes interpreted as income) results in a higher demand for money.

There are two distinguishing features in this equation. First, equation (1) has an additional scale variable (X_{it}) which is expected to capture the effects of other economic factors including financial innovation. With respect to financial innovation, Mulligan and Sala-i-Martin (1992) argued that there are differences in the speed of diffusion of financial technology across prefectures, and generally rich and highly-populated areas appreciate such diffusion at an early stage due to lower transaction costs. Alvarez and Lippi (2009) extended this analysis in their generalized Baumol-Tobin model which theoretically predicts a negative relationship between liquid money (cash) and financial developments when the nominal interest rate on deposits is almost zero as is the case in Japan over the last two decades.

In order to capture financial innovation, several proxies have been proposed. For example, Mulligan and Sala-i-Martin (1992) used population density, and Fujiki and Mulligan (1996) the ratio of primary industry to prefectural net product in addition to population density. More recently, Lippi and Secchi (2009) used information on the availability of ATM cards and bank branches (accounts) and showed the negative and often significant relationship between Italian cash holding and improvements in financial technology. The negative relationship was also reported by Lieberman (1977) and also Daniels and Murphy (1994) and Attanasio et al (2002) using ATM-related data as a proxy for financial innovation. Similarly, Fischer (2007) used the number of ATMs to capture financial innovation in Switzerland, but reports that this variable is not significant and is often negatively correlated with money (4 out of 6 cases). So far no attempt has been made to use this type of data as a proxy for financial innovation for Japan.

Secondly, this specification does not contain any interest rate data because regional rates are not readily available in Japan and no significant discrepancy appears to exist between their estimated values.[1] However, equation (1) indirectly

[1] Kano and Tsutsui (2003) calculated the loan interest rate as the interest revenue of banks

captures interest rate effects through time dummies under the assumption that their effects on regional money are homogeneous among regions.

III. Empirical Studies

Basic Data

Our data are annual and cover a sample period from FY1990 to FY2005 (752 observations in total).[2] More specifically, we obtained price (the consumer price index, CPI), output (the gross domestic product, GDP), demand deposits, and population data, and our study analyzes data on real money and GDP per capita which are obtained using the CPI and population. These data are prefecture-specific and cover all 47 prefectures, and their details and sources are explained in Appendix 1.

Due to the absence of cash data at the prefectural level in Japan, we use demand deposits as a proxy for money. More specifically, demand deposits represent a narrower definition of money than M1 (see Appendix 2), and the institutional coverage of our data is also limited since only demand deposits held by banks are considered. Notably, post offices are excluded from our definition.

We regard demand deposits as equivalent to cash following the classification method discussed by Hicks (1967) since they possess very similar characteristics and functions to cash: demand deposits are very liquid and have a settlement function. The use of liquid assets in the analysis of money demands is in line with economic theory (e.g., Baumol 1952, Tobin 1956, Alvarez and Lippi 2009). Furthermore, Daniel and Murphy (1994) underscored importance of investigating demand deposits in addition to cash since their functions are similar.

The demand deposits are shown in Figure 1 and summarized in Table 1. Figure 1 shows an increasing trend in demand deposits which are aggregated across prefectures. This trend is particularly pronounced from 1995 when short-term

divided by the value of the outstanding loans and showed that there is no sigificant segmentation in Japanese bank loan markets using regional bank data for 1997.

[2] As of this writing, regional output data based on the 1993 System of National Accounts are only available from FY1990 to FY2005.

nominal interest rates reached their lower bound of zero percent. In these circumstances, demand deposits are often said to become a substitute for less liquid assets (i.e., time deposits) and actually became more attractive to depositors than time deposits since money can be withdrawn at any time.

Table 1 presents the proportion of demand deposits in M1 and M2, and shows that they accounted for nearly 70 percent of M1 on average. The demand deposit-M1 ratio is relatively stable until FY2003 but dropped to the level of 55 percent in FY2004/05. This drop may be due to the revised pay-off (deposit insurance) scheme implemented in 2005. This new scheme which excludes time deposits from coverage, was known to consumers well before 2005 since the introduction of this scheme was delayed for two years. Thus some consumers transferred their deposits to "safer" financial institutions like post offices which are not covered in our definition of demand deposits.[3]

In contrast, the ratio of demand deposits in M2 remained lower than that in M1 but had increased over the years and reached around 40 percent in 2005. The trend of these ratios indicates an increase in the relative importance of demand deposits in broader money, and this is consistent with the disproportionate expansion in M1 and M2 during this period. Reflecting extremely relaxed monetary policy, M1 has risen over time, but M2 has remained relatively stagnant. Furthermore, Suzuki (2005) pointed out that an upsurge in M1 is due to a rise in the elderly population and low-income households who traditionally have a high demand for liquid assets.

In addition, data on land values and the number of companies are gathered for each prefecture in order to capture effects of other financial assets and their economic structure. In this connection, we consider two measures. First, the ratio of company concentration (company) is calculated here. At times, this ratio

[3] According to the survey by Nikkei in 2002, respondents answered about 25 percent of their deposits should be transferred due to a change in the coverage of the pay-off scheme in April 2005.

was used as a proxy for market competition.[4] The higher this ratio, the more urban and competitive the prefecture is deemed to be.

$$\text{company}_{it} = Ln((\text{the number of company})_{it}/(\text{land area})_{it})$$

where i and t represent prefectures and time respectively. Finally, the data on land values are examined here to capture wealth effects. The real value of land is calculated as the land value per square kilometer, which is deflated by the CPI.[5]

$$\text{land}_{it} = Ln((\text{total land value})_{it}/(\text{land area} * \text{CPI})_{it})$$

Financial Innovation

Financial innovation may be relevant to our analysis because the data include the period of the Japanese Big Bang and the increasing prevalence of IT. But since it is difficult to define financial innovation, we consider several proxies.[6] The first is population density (popden1 and popden2) which has traditionally been used in Japanese studies. The population density (popden1) is calculated using the total land area in each prefecture, and popden2 is obtained using the habitable area in each prefecture, since about 70 percent of Japan is said to be inhabitable for topographical reasons, e.g., mountainous areas. These measures utilize the same definition of population, which is the sum of the number of

[4] See Boone, et al (2007) for a list of indicators which can be used to measure market competition at the country/industry level. While many proxies are available, our definition is largely determined by data availability.

[5] One could consider creating net wealth using consumption as a scale variable. However, this variable is not used since it is found to be stationary and has no relevance to a long-run (i.e., cointegration) analysis.

[6] We did not consider the agricultural share variable here because the agricultural sector has accounted for only a very small portion of Japanese economic activities in recent decades and its proportion has been relatively stable over time (1.9 percent in 1995 and 1.6 percent in 2004, OECD Factbook 2007).

residents (including non-Japanese) registered at the city council.

$$\text{popden1}_{it} = Ln((\text{population})_{it}/(\text{land area})_{it})$$
$$\text{popden2}_{it} = Ln((\text{population})_{it}/(\text{habitable area})_{it})$$

Furthermore, we propose three more measures of financial innovation. First, we use bank concentration data as a proxy for financial innovation. This indicator (bankcon) is calculated as the number of headquarters and branch offices of domestic banks divided by population.

$$\text{bankcon}_{it} = Ln((\text{the number of banks})_{it}/(\text{population})_{it})$$

This indicator can be regarded as analogous to the number of ATMs (ATM/population, ATM/area) considered by Fischer since banks are normally equipped with ATMs.[7] If we follow Fischer's motivation, the higher this indicator, the more financial innovation taking place and the more complex the financial market. This concentration ratio can also be interpreted as capturing transaction costs (waiting time) since a lower value of this ratio indicates more intensive use of banks (ATMs) and thus increased waiting time.

Secondly, for the same reason, we use a concentration ratio of post offices as a proxy for financial innovation or transaction costs. Japan Post which was privatized in October 2007 has traditionally been one of the largest financial institutions in Japan and also has ATMs in each branch.[8] While our demand deposits do not cover those held by post offices, the number of post offices is also considered since consumers could transfer their money to/from the partner institutions of post offices (known as *sogo-sokin*) although there were a limited

[7] We also consider the ratio of banks (post offices) to land mass, but the results are not reported in this paper since they are found to be statistically insignificant.

[8] As of March 2007, the amount of deposits in the post office belonging to private entities was 185 trillion yen, which accounts for about 25 percent of the total deposits in Japan.

number of partners.[9]

$$\text{postof}_{it} = Ln((\text{the number of post offices})_{it}/(\text{population})_{it})$$

Thirdly, we have created the most comprehensive measure, "fininov", which includes information on the number of ATMs other than those in branches of banks and post offices. The most notable example is Seven Bank which initiated installing the ATMs in convenience stores (i.e., Seven Eleven) in 2001. The choice of Seven Bank in this study is due to data availability as well as market prominence. Our data comprise the number of Seven Eleven stores and the headquarters as well as its largest shareholder (Ito Yokado) where ATMs are also in place.

$$\text{fininov}_{it} = Ln((\text{the number of banks+post offices+Seven Elevens})_{it}/(\text{population})_{it})$$

Please note that easier access to ATMs at Seven Eleven not only brings the function of demand deposits more in line with that of cash, since consumers can more easily deposit, withdraw, and transfer money from ATMs there, but these ATMs provide opportunities to purchase and sell a wide range of financial products since Seven Bank has partnerships with many financial institutions (e.g., 97 banks, 16 investment/insurance firms, *shinkin* banks, credit unions, agricultural cooperatives, fisheries cooperatives, *shoko-chukin* banks, etc). Another distinguishing feature of this proxy is that the order of placement of ATMs in convenience stores did not exactly follow the size of prefectures in terms of population. One example is the installation in the first year (2001) in Shizuoka (a medium-level income) prefecture which is frequently used by firms for the purpose of trying out new products as residents there seem to have neutral tastes. It follows therefore that a prefecture with high population density does not necessarily

[9] Since January 2009, Japan Post joined the standard banking network system in Japan, and thus has affliated with most domestic banks.

represent one with high financial innovation.

While fininov is a more comprehensive measure of financial innovation in Japan, we are aware that this does not include all effects of financial innovation. For example, neither electronic money nor internet banking is directly considered in this study. However, our data may be justified because electronic money has been accepted as a substitute for cash for small transactions only in the late 2000s which is not covered by our study. Similarly, internet banking still remains primitive and the deposits of Japan Net Bank in 2009 was 0.4 trillion yen which is very small compared with deposits of 122 trillion yen for Mitsubishi UFJ FG, the largest domestic private bank.

Table 2 is the correlation matrix. The first column (m) which shows the relationship of real money to other variables is of most interest to us. As expected, real money is positively correlated with real output and land value: an increase in output and wealth induces a higher demand for money. Furthermore, other financial innovation measures (postof, bankcon and fininov) are negatively correlated with real money. In contrast, although population density (popden1 and popden2) and economic structure (company) data are positively correlated with each other as anticipated, they are also positively correlated with real money. Thus, based on previous studies (e.g., Lippi and Secchi 2009), these indicators positively correlated with real money may suffer from a measurement error and may not represent financial innovation. In short, high population density, more companies and high money holdings seem to be a characteristic of industrial prefectures. These relationships can be observed in Figures 2 and 3.[10]

Panel Cointegration Analysis between Money and Output

Now we investigate the long-run relationship between money and output in the context of panel data. It should be noted that we regard the presence of cointegration as evidence of the stability between these variables, and for this

[10] These data are found to be nonstationary using the standard unit root test (e.g., the Augumented Dicky-Fuller tests).

purpose we use the panel cointegration method (Pedroni 1999) (see Appendix 3).[11] While Pedroni has proposed several statistics to evaluate the null hypothesis of no cointegration ($\rho_i = 1$ where ρ is an adjustment coefficient in the test specification), we employ parametric tests here: the so-called Panel ADF and Group ADF statistic tests. The null hypothesis is the same for these tests, but the alternative is slightly different where that of the Panel ADF test is $\rho < 1$, and that of the Group ADF test is $\rho_i < 1$ for all i. Thus, the Group ADF test can be viewed as a more general form with different adjustment coefficients for each prefecture and thus cross-sectional heterogeneity is taken care of.

Table 3 summarizes the results from Pedroni's tests which are conducted for the full sample. Although the Group ADF test can be considered as more general, Karaman-Orsal (2008) shows that the Panel ADF statistic has the best size and power properties among the tests developed by Pedroni. We therefore regard rejection of the null from both tests as evidence of the presence of cointegration. With this criterion, this table shows no evidence of cointegration in the simple money-output relationship: the statistics are positive, which is not evidence of cointegration.[12] Our result of no cointegration is consistent with most studies using aggregated (country-level) data (Corker, 1990; Miyao 2000; Nagayasu, 2003).

The Effects of Financial Innovation

We will investigate reasons for the lack of cointegration in the simple money-output relationship in a panel cointegration framework by introducing extra variables which are expected to capture wealth, financial innovation, or other

[11] There is an arugment that the presence of cointegration may not necessarily imply model stability. For example, Johansen (1991) proposed a statistical method for the multivariate cointegration test, and then Hansen and Johansen (1999) suggested the parameter constancy test on top of the Johansen test. However, I believe that a firm conclusion cannot be drawn as to whether cointegration does not imply model stability, and furthemore a solid method is not yet established for testing parameter constancy in cointegrated panel data. Therefore, the concept of cointegration is treated as equivalent to model stability in this paper.

[12] One needs be careful about interpreting our results since our sample period is limited. However, given that there is a bias in favor of non-cointegration when the period is short (Gutierrez 2003), our result from rejecting the null hypothesis may be valid. Furthermore, we note that our result for fininov is statistically sigificant at the one percent level, and using the Kao (1999) method, we were able to confirm the presence of cointegration in all cases where Pedroni tests raised evidence of cointegration.

prefecture-specific effects previously discussed as reasons for failure of the money demand. Obviously, our data do not cover all causes of breakdown of the simple model previously discussed, but we believe that they form a good starting point.

At the same time, we check the robustness of our findings using different groupings of the 47 prefectures. Two groups are considered in this study: the large industrial areas (7 prefectures) and the remaining 40 prefectures. The industrial areas consist of Tokyo and Osaka areas (Tokyo, Kanagawa, Saitama, Chiba, Osaka, Hyogo and Kyoto). Previous research (e.g. Fujiki et al 2002, Fischer 2007) used this method to analyze whether income elasticity is sensitive to geographical area.

Table 4 shows the p-values of the simple Student-t test results in order to examine if any significant difference (D) exists between their average values: the null hypothesis of no significant difference is rejected in favor of the alternative that their average value is less for the 40 non-metropolitan prefectures. Thus, money and output levels between the two groups are clearly different and are higher in the industrial areas. Furthermore, a similar observation can be made with respect to the volatility of these data. Both money and output are more volatile (measured in the standard deviation) in the industrial areas.

The results of our extended analysis to include extra explanatory variables are summarized in Table 3. Again a large negative statistic is evidence of cointegration. This table shows that even if extra variables are included in the standard model, there are few improvements in their relationship. Only when the most comprehensive measure of financial developments (fininov) is included in our specification, do we obtain a valid long-run relationship. A traditional proxy for financial innovation and market competitiveness (population density and company concentration respectively) seems irrelevant in our long-run analysis. Since bankon and postof alone do not have a long-run effect on money, our results imply that the effect of financial innovation related to ATMs at convenience stores (since 2001) is sizable. The irrelevance of bankcon and postof, which were found to be negatively correlated with money (Table 2), in the cointegration analysis, also highlights the difficulty of identifying an appropriate proxy for financial innovation. While other economic and financial factors may be potentially influential, our study shows that at least financial innovation together with output can explain dynamics of demand deposits.

Further Investigation

So what then is the relationship between money and these scale variables? In order to answer this question, we estimate the money equation using several panel estimation methods (the Fully-Modified OLS (FMOLS) and Dynamic OLS (DOLS)) since the standard OLS estimates are biased and inefficient. Kao and Chiang (2000) developed them in the context of estimating the cointegrated panel regression, and FMOLS and DOLS make adjustments to endogeneity and autocorrelation biases using semi-parametric and parametric methods respectively. Based upon their Monte Carlo simulations, they also show that the DOLS (equation 2) outperforms other estimation methods such as the OLS and FMOLS.

$$Ln(M_{it}/P_{it}) = \alpha_i + \beta x_{it} + \sum_{j=-q}^{q} c_{ij} \Delta x_{it+j} + u_{it} \tag{2}$$

where x_{it} comprises output and fininov which are found to be necessary in the cointegrated equation, and parameter β is superconsistent in the cointegrated model. Due to the limited span of our data, we use just one lag and lead ($q = 1$) to calculate the parameters, and following the conventional approach, contemporaneous movements across prefectures are removed from the data prior to estimation.

Table 5 reports the results including those of some non-cointegrated equations as well as those from the non-industrial areas and all 47 prefectures for comparison. The estimates for the cointegrated system are equations [2] and [4] and thus are statistically more reliable. Our results show first that financial innovation (fininov) is negatively and significantly correlated with real money, which is consistent with our expectation. Financial innovation induces a lower demand for money. Our second finding is related with income elasticity. Model [2] shows an income elasticity of around 1.2 from the FMOLS and DOLS with a financial innovation indicator which is close to the estimates by Fujiki et al (2002) and the high-end estimated by Fujiki and Watanabe (2004) using the sample period (FY1990-2000). Thus our extension of the sample to FY2005 did not seem to affect significantly the scale of income elasticity. However, this elasticity drops substantially to 0.4 when the 7 industrial prefectures are removed from our analysis [Model 4]. This is in sharp contrast to the results for financial innovation, and highlights that although income elasticity is always positive and statistically significant, it is very sensitive to the group composition under consideration.

However, the relatively low income elasticity in the non-industrial prefectures is consistent with domestic and international country-level data. We calculate the proportion of income elasticity below one using the information provided by Sriram (2001)[13] and find that this proportion is about 63 percent in developing countries compared to 42 percent in developed countries. In terms of the average value, income elasticity for developed countries in his study is 1.27 while that for developing countries is 1.02. These suggest that elasticity is higher in developed (i.e., high income) countries.

Further Discussion

There may be several explanations for income elasticity's sensitivity to the composition of prefectures. Among many other factors, one possible explanation lies in the mismatch between the location of residence and the bank account, i.e., a location missmatch (Hsiao et al 2005). Someone may work in Tokyo where output per capita is highest, but has his bank account near his residence in a suburb (e.g., Saitama). Then a rise in his output captured in Tokyo would be

[13]When there are several income elasticity estimates for one country in a single study, we view that such a study suggests estimates be less than one if there are a majority of findings to support that. Furthermore, when there are an equal number of findings, we do not regard this study suggesting any conclusive result in terms of the level of income elasticity.

expected to reflect the increase in deposits in Saitama in our data set. In this connection, this location mismatch effect is less pronounced in rural areas. To the extent that labor mobility is low across prefectures in Japan (Nagayasu and Inakura 2009), the practice of commuting to a different prefecture is a distinctive feature of Japanese industrial areas.

Furthermore, our result may be attributable to demographic factors. The demographic index (*Rounenka shisu*) compiled by the Ministry of Internal Affairs and Communications suggests that the proportion of elderly people is higher in non-industrial areas: all 7 prefectures are included at the high end of this index.[14] The elderly, especially retirees, tend not to make financial decisions based on their current income but instead on their level of savings and other economic factors. Since the aging of Japanese society is advancing sharply and statistics suggest that elderly people are actually "dissaving" (Horioka 2010), their financial decisions likely induce even a negative relationship between their deposits and output. Thus, at the prefectural level, a high dependency ratio may explain less income elasticity in non-industrial areas.

IV. Summary

This paper analyzed the money demand function for (very narrow) money using Japanese regional data and investigated whether financial innovation has any effect on liquid asset holding. Using advanced statistical methods, we uncover evidence that financial innovation tends to reduce demand deposits like evidence from other countries using cash data, and this result is robust to the composition of prefectures. While there are many studies reporting a negative relationship between financial innovation and cash, this is perhaps the first study using high liquid deposit data to report it. In this respect, our data suggest that demand deposits possess very similar characteristics to cash in Japan.

Finally, there are some issues which could usefully be considered in future studies. Data coverage could be improved. For example, our definition of fi-

[14] This data is not available for our entire sample period.

nancial innovation is still limited by data availability. As discussed, ignoring electronic money and internet banking can be justified taking account of their size and development and our sample period. However, there are other elements such as credit cards which could also be usefully included in future. Similarly, the institutional coverage of money can be extended to include other financial institutions if data are available. Finally, we used demand deposits as a proxy for cash because cash data are not available at the prefectural level, but we still reported a negative relationship between this definition of money and financial innovation. In this connection, one can extend this study to investigate the relationship between financial innovation and less liquid assets (e.g., time deposits) in order to see how financial developments affect more comprehensive financial portfolios.

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Appendix

Appendix 1. Data Description

Variable	Unit	Source
CPI	Index 2005=100	Statistics Bureau, Ministry of Internal Affairs and Communications
Demand deposits	100 mil. yen	Financial and Economic Statistics Monthly, Bank of Japan
GDP	Mil. yen	Kenmin keizai keisan nenpo, Economic and Social Research Institute, Cabinet Office
Population	Registered citizens+ foreigners	Jumin kihon zaichou jinko yoran, Japan Geographic Data Center +Shutkoku Kanri Tokei Nenpo, Ministry of Justice
Land area	Km^2	Zenkoku todofuken, shikuchoson betsu menseki cho, Geographical Survey Institute
Habitable area	Km^2	Kokusei chosa, Ministry of Internal Affairs and Communications
Land value	100 mil. yen	Koteishisan no kakakunado gaiyochosho, Ministry of Internal Affairs and Communications
No. of banks	unit	Nitkin shiryo nenkan, Nihon Kinyu Tsushin Sha
No. of post offices	unit	Nitkin shiryo nenkan, Nihon Kinyu Tsushin Sha
No. of companies	unit	Zeimu tokei nenpo, National Tax Agency
No. of ATMs in Seven Eleven, Ito Yokado & Headquares	unit	Biannual Report of Seven Bank
Birth rates	%	Jinko Nodo Tokei, Ministry of Health, Labor and Wealth

Appendix 2. Definition of Money Stock

Indices	Definition and coverage
M1	Cash currency in circulation+ deposit money Deposit money: demand deposits (current deposits, ordinary deposits, saving deposits, deposits at notice, special deposits, and deposits for tax payments) less checks and notes held by financial institutions
M2	Cash currency in circulation+ deposits

Source: Bank of Japan, http://www.boj.or.jp/en/type/exp/stat/exms.htm

Appendix 3. Panel Cointegration Tests

This appendix summarizes panel cointegration tests developed by Pedroni (1999) and Westerlund (2006). The former test assumes no structural break but the latter takes account of it under both the null and alternative hypotheses.

The Pedroni test is based on the following specification.

$$Ln(M_{it}/P_{it}) = \alpha_i + \delta_t + \beta_i Ln(Y_{it}) + \gamma_i Ln(X_{it}) + e_{it}$$

The null of no cointegration can be examined by analyzing the residual.

$$e_{it} = \rho_i e_{it-1} + \sum_{j=1}^{p} \Psi_j \Delta e_{it-j} + \mu_{it}$$

The null hypothesis can be studied by evaluating $\rho_i = 1$, and two statistics are used in this study.

The panel-ADF statistic is calculated as:

$$Panel\_ADF(\zeta_{panel}) = \left(\widetilde{s}_{NT}^2 \sum_{i=1}^{N} \sum_{t=2}^{T} \omega_{11i}^{-2} e_{it-1}^2 \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=2}^{T} \omega_{11i}^{-2} e_{it-1} \Delta e_{it}$$

where $\widetilde{s}_{NT}^2 = N^{-1} \sum_{i=1}^{N} s_{i=1}^2$,where s_i^2 is the variance of μ_{it} (i.e., $s_i^2 = \frac{1}{T} \sum_{t=1}^{T} \mu_{it}$. The ω_{11i}^2 is the long-run variance of the residual of the relationship between differenced y and m. This term makes an adjustment for autocorrelation and allows for endogeneity of explanatory variables. If ξ is the residual from the differenced y and m, $\Omega_i = \lim_{T \to \infty} E[T^{-1}(\sum_{t=1}^{T} \xi_{it})(\sum_{t=1}^{T} \xi_{it}') = \Omega_i^0 + \Gamma_i + \Gamma_i'$, where Ω_i^0 and Γ_i are contemporaneous and dynamic variances. Alternatively,

$$\Omega_i = \begin{pmatrix} \Omega_{11i} & \Omega_{21i} \\ \Omega_{21i} & \Omega_{22i} \end{pmatrix}.$$

Then long-run variance can be defined as $w_{11i}^2 = \Omega_{11i} - \Omega_{21i}' \Omega_{22i}^{-1} \Omega_{21i}$, and its consistent estimator is obtained by the Newey-West approach. The $\Omega_{22i} > 0$

ensures that there is no cointegration among regressors.

The group-ADF statistics is obtained as:

$$Group\_ADF(\zeta_{group}) = N^{-1/2} \sum_{i=1}^{N} \left(\sum_{t=2}^{T} s_i^2 e_{it-1}^2 \right)^{-1/2} \sum_{t=2}^{T} e_{it-1} \Delta e_{it}$$

He shows that with some adjustments in these statistics, they follow the standard normal distribution.

$$\frac{\zeta - w\sqrt{N}}{\sqrt{v}} \sim N(0,1)$$

The adjustment terms, w and v, are obtained by the Monte Carlo experiments.

Table 1. The Ratio of Demand Deposits to M1 and M2 (%)

Year	DD/M1	DD/M2
1990	80.632	20.798
1990	80.632	20.798
1991	82.092	20.576
1992	76.649	19.596
1993	72.307	19.480
1994	71.098	19.653
1995	69.177	19.256
1996	68.072	21.693
1997	67.456	22.163
1998	66.292	22.328
1999	65.938	22.987
2000	65.775	25.043
2001	66.862	26.494
2002	67.463	33.664
2003	68.393	35.477
2004	55.832	37.041
2005	55.991	38.055

Notes: M1 and M2 are the average observations measured in March each year, and are obtained from the IMF's IFS. Data on demand deposits are from the Bank of Japan.

Table 2. Correlation Matrix

	m	y	land	pop-den1	pop-den2	post-of	bank-con	fin-inov	comp-any
m	1								
y	0.500	1							
land	0.565	0.533	1						
popden1	0.532	0.469	0.720	1					
popden2	0.527	0.439	0.691	0.932	1				
postof	-0.374	-0.338	-0.726	-0.853	-0.750	1			
bankcon	-0.197	-0.068	-0.542	-0.330	-0.311	0.533	1		
fininov	-0.208	-0.243	-0.698	-0.730	-0.650	0.924	0.673	1	
company	0.615	0.581	0.777	0.978	0.922	-0.818	-0.335	-0.691	1

Notes: Data are in log form.

Table 3. Panel Cointegration Tests

	47 prefectures				40 prefectures			
	Panel-ADF		Group-ADF		Panel-ADF		Group-ADF	
m, y	3.281		5.219		1.835		3.442	
m, y, land	-0.337		0.090		-0.404		0.154	
m, y, popden1	1.079		2.769		0.498		2.444	
m, y, popden2	1.141		2.081		-0.015		0.466	
m, y, postof	1.408		3.604		1.421		2.850	
m, y, bankcon	0.657		2.559		0.734		-0.169	
m, y, postof+bankcon	0.525		-0.187		0.689		0.045	
m, y, fininov	-2.662	**	-2.875	**	-3.107	**	-3.238	**
m, y, company	3.292		3.552		0.146		1.355	

Notes: Full sample. The common effect is removed from the original data before conducting the tests. The five percent critical value is -1.65. The constant term is included in the test specification. The maximum lag is set at two. All tests examine the null hypothesis of non-cointengration, but the alternative hypothesis is different according to test type. The alternative of the Panel-ADF is common AR coefficients, that of the Group –ADF is individual ADF. ** and * indicate that a statistic is significant at the one and five percent significance level respectively.

Table 4. A Comparison of the Basic Data

H_0: DM=0	H_1: DM<0	H_1:DM≠0	H_1:DM>0
m	0.000	0.000	1.000
y	0.000	0.000	1.000
H_0: DV=1	H_1: DV<1	H_1:DV≠1	H_1:DV>1
m	0.000	0.000	1.000
y	0.000	0.000	1.000

Notes: *p*-values are reported. DM =average (40 prefectures) – average (7 prefectures). DV= var(40)/var(7).

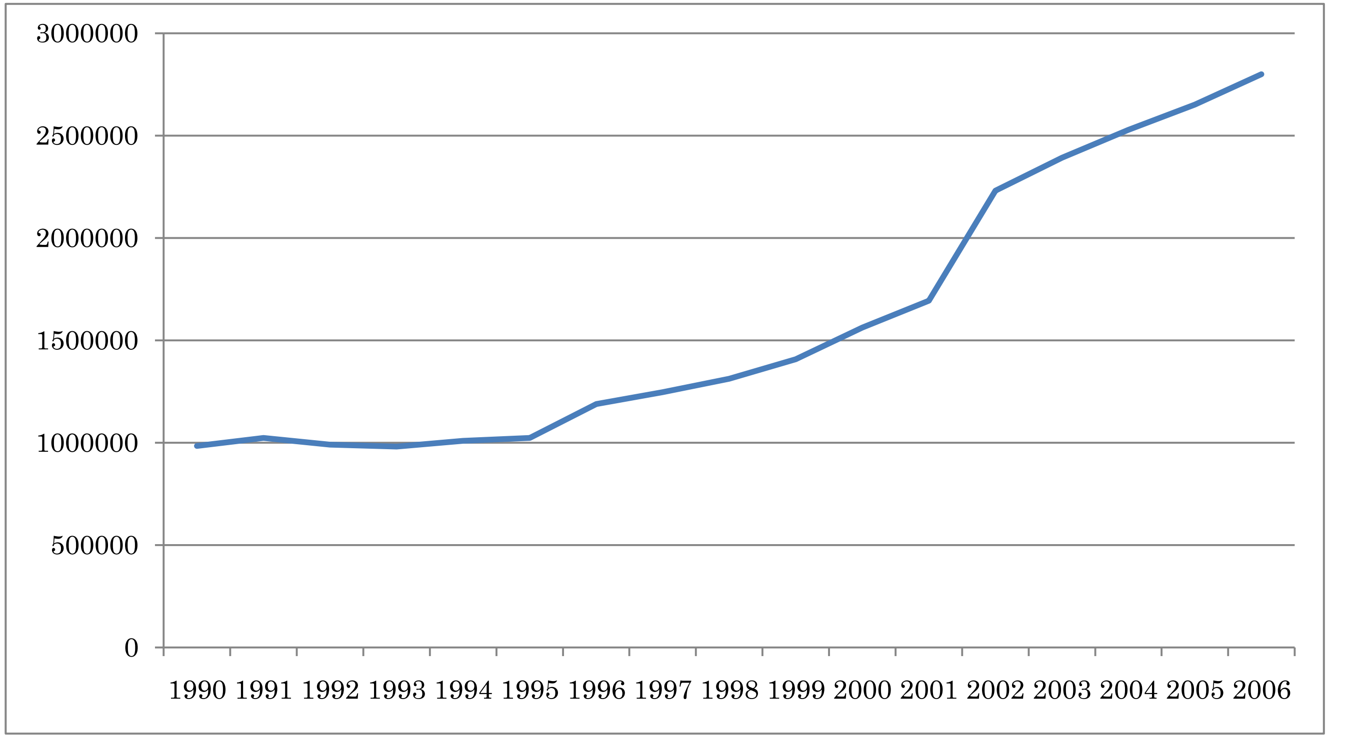
Table 5. DOLS Estimates of the Money Demand Function

47 prefectures	FMOLS	DOLS
[1] y	1.325 (8.991)	1.325 (7.642)
[2] y	1.232 (8.427)	1.227 (7.273)
fininov	-0.286 (-5.537)	-0.279 (-4.691)
40 prefectures		
[3] y	0.623 (4.195)	0.521 (3.035)
[4] y	0.461 (3.116)	0.426 (2.494)
fininov	-0.288 (-5.406)	-0.202 (-3.297)

Notes: The dependent variable is real money (m), and figures in ( ) are t statistics.

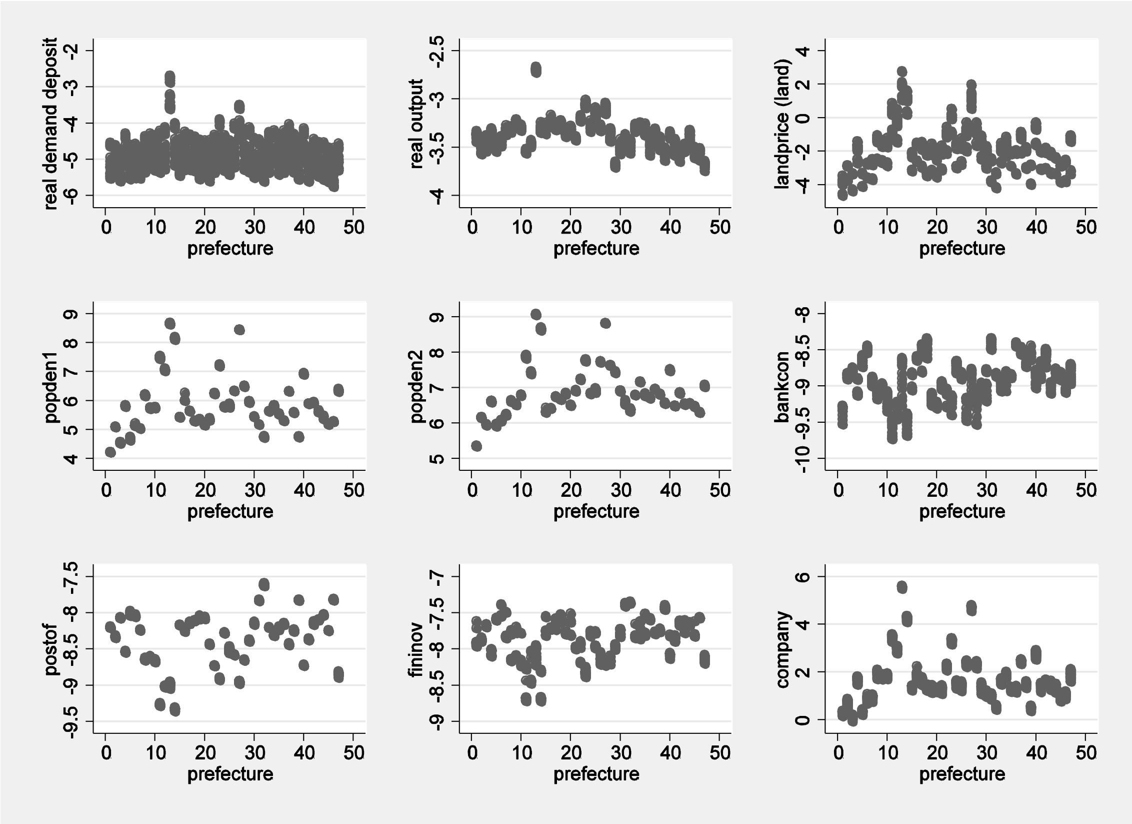
Figure

Figure 1. Aggregate Demand Deposits



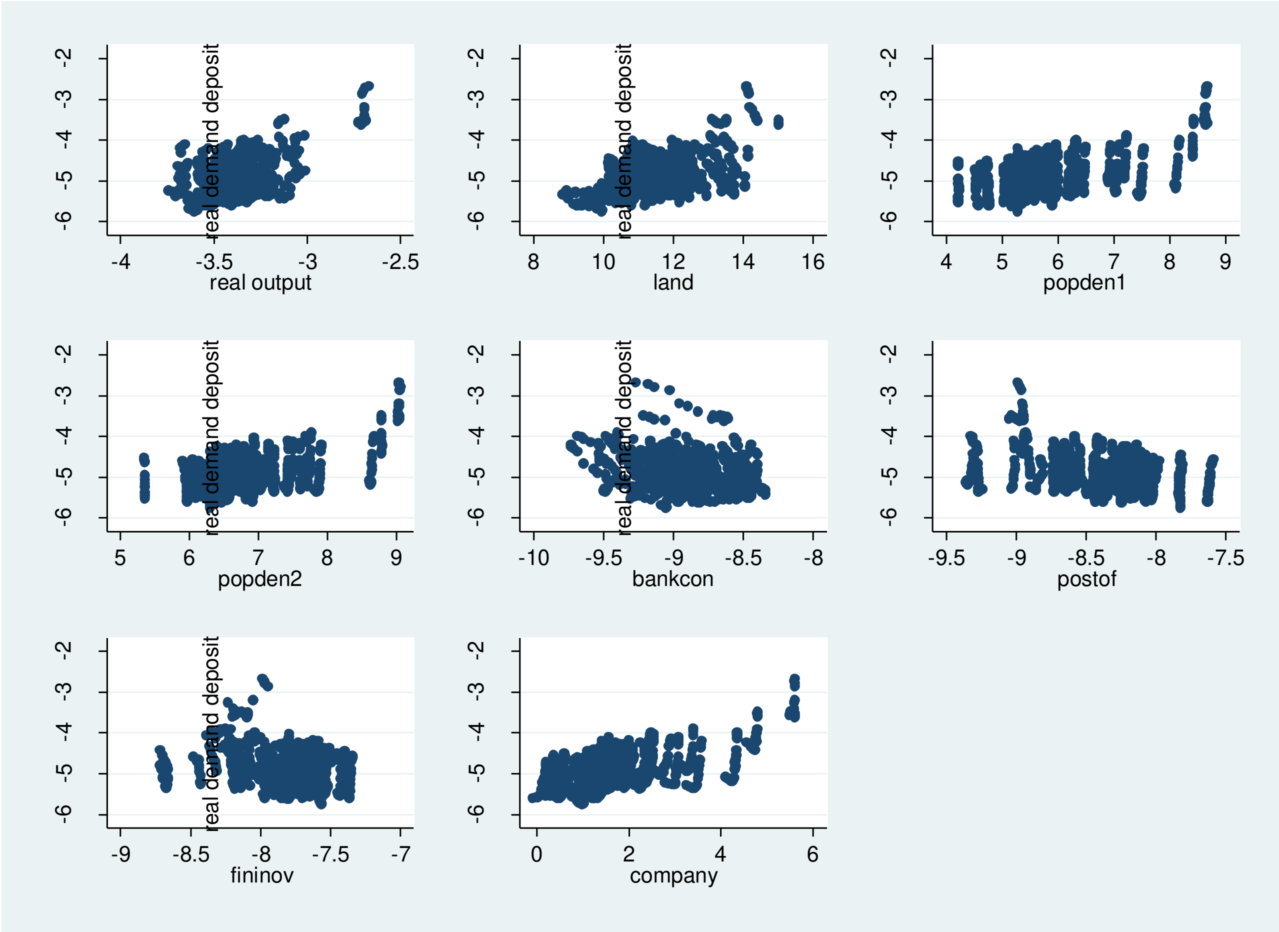
Note: Data are the total value of demand deposits in Japan and cover the period from 1990-2005. Units are 100 million yen.

Figure 2. Scatted Data by Prefecture



Note: Note: The x axis (1 to 47) presents prefectures (Hokkaido, Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima, Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Niigata, Toyama, Ishikawa, Fukui, Yamanashi, Nagano, Gifu, Shizuoka, Aichi, Mie, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama, Tottori, Shimane, Okayama, Hiroshima, Yamaguchi, Tokushima, Kagawa, Ehime, Kochi, Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagashima and Okinawa).

Figure 3. Real Demand Deposit via-vis Other Data



Note: The statistics are based on all 47 prefectures from FY1990 to FY2005.