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Abstract

We use annual Japanese prefecture data on income, population, demand deposits and saving deposits from 1985 to 1997 to investigate the issue of whether there exists a stable money demand function under the low interest rate policy. The evidence appears to support the contention that there does exist a stable money demand function with long-run income elasticity less than one. Furthermore, Japan's money demand is sensitive to interest rate changes. However, there is no evidence of the presence of liquidity trap.

Key words: Money demand; Interest rate; Panel data; Prefecture data.

JEL classification: C23, C51, C52, E41, E47.

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1. Introduction

In response to the deterioration of Japanese economy in the 90's, expansionary fiscal and monetary policies have been implemented. However, according to *Highlights of the Budget for FY 2001 (April 2001)* published by the Ministry of Finance, Japan, the dependence ratio of the general account of the national budget (ippan kaikei) on the issuance of the bonds on an ongoing annual basis has dramatically increased and reached 38.5 percent in the fiscal year 2000 budget, up from 10.6 percent in 1990. On a stock basis, the government gross debt of GDP is approximately 135.3% in fiscal 2000, the worst level among industrialized countries (also see Fujiki, Okina and Shiratsuka (2001)). Has Japan's fiscal position deteriorated to an unsustainable level? Bohn (1995) suggests to check this issue in terms of (i) if the GDP ratio of the primary balance goes up as the GDP ratio of public debt goes up, and (ii) if the GDP ratio of public debt does not exceed some fixed level. According to his method, both conditions need to be satisfied. Doi (2000) has used this method for the Japanese general account from FY1956 to FY1998 and found that the conditions for the sustainability of debt were not met. Given the sustainability of fiscal debt is uncertain, it is natural that one might wonder if monetary policy could play a more important role for stimulating the Japanese economy. However, the effectiveness of monetary policy could be affected by many factors. Economists probably would agree that the stability of the following two relationships is critical. First, is there a stable money demand function? Second, to what extent money supply is responsive to operational target of central bank? This paper focuses on the first.

Nakashima and Saito (2000) use monthly aggregate time series data to analyze whether nominal prices move inertially when nominal interest rates are extremely low in Japan. They find that the real money balance was highly elastic with respect to nominal interest rate and real output had no impact on real money demand in the period between 1995 and 1999. The almost horizontal money demand function makes the nominal price level irresponsive to changes in money supply, hence makes the elementary argument that money issuance must ultimately raise the price level impotent.

In this paper we use data of 47 prefectures in Japan from 1985 to 1997 to study if there exists a stable money demand function under the policy of low interest rates. There are many advantages of using panel data as opposed to using time series or cross-sectional data. First, it allows more accurate estimates of parameters because it contains many more degrees of freedom and it reduces the problem of multicollinearity that is often present in time series data by appealing to interindividual differences. Second, it allows a more accurate modeling of dynamic adjustment behavior with a short time series. Third, it provides the possibility to control the impact of omitted variables. Fourth, it provides a possibility to control the impact of structural changes without relying on the conventional tests of structural breaks which are based on large sample theory with dubious finite sample properties. Fifth, it allows the possibility of controlling the problem of measurement errors (e.g. Hsiao (2001)).

We present our model in section 2. In section 3 we discuss statistical issues of estimating our models. Section 4 describes the data. Section 5 presents the empirical analysis and compare our results with other studies. Conclusions and policy implication are in section 6.

2. The Model

The basic model for our analysis is a combination of stock adjustment principle with a money demand equation by households and firms proposed by Fujiki and Mulligan (1996). Assuming that agent chooses the real money balance to minimize the rental cost subject to a CES - type production function for output and transaction service, Fujiki and Mulligan (1996) derive a log-linear (desired) money demand equation of the form

$$\begin{aligned} m_{it}^* = \alpha_i^* + b^* y_{it} + c^* r_t + \epsilon_{it} \\ i = 1, \ldots, N \\ t = 1, \ldots, T, \end{aligned} \tag{2.1}$$

where m_{it}^* denotes logarithm of the desired real money balance for agent i at time t, y denotes the logarithm of real income, r denotes the interest rate. The intercept α_i^* is an approximation of the effects of rental costs of inputs to the production function of output and transaction service, which may vary across i.

The actual logarithm of real money demand, m_{it}, is assumed to follow a stock adjustment principle,[1]

$$(m_{it} - m_{i,t-1}) = \gamma^*(m_{it}^* - m_{i,t-1}) + u_{it}, \tag{2.2}$$

where γ^* denotes the speed of adjustment, which is assumed to be between 0 and 1, and u_{it} is the error term that is assumed to be independently, identically distributed across i and over t with mean 0 and variance σ_u^2. Substituting (2.1) into (2.2) yields

$$\begin{aligned} m_{it} = (1-\gamma^*)m_{i,t-1} + by_{it} + cr_t + \alpha_i + v_{it}, \quad & i = 1, \ldots, N \\ & t = 1, \ldots, T, \end{aligned} \tag{2.3}$$

where $b = \gamma^* b^*, c = \gamma^* c^*, \alpha_i = \gamma^* \alpha_i^*$, and $v_{it} = \gamma^* \epsilon_{it} + u_{it}$.

3. Statistical Issues

Models of the form (2.3) is commonly referred to as a dynamic panel data model,

$$\begin{aligned} m_{it} = \gamma m_{i,t-1} + \underset{\sim}{\beta}' \underset{\sim}{x}_{it} + \quad & \alpha_i + v_{it} \\ & i = 1, \ldots, N \\ & t = 1, \ldots, T, \end{aligned} \tag{3.1}$$

where $\gamma = (1-\gamma^*), \underset{\sim}{x}_{it}' = (y_{it}, r_t), \underset{\sim}{\beta}' = (b, c)$. When the regional specific effects, α_i, is treated as fixed constants, it is commonly referred to as fixed effects model (FE). When α_i is treated as randomly distributed across i with mean μ and variance σ_α^2, it is commonly referred to as random effects model (RE).

The advantage of fixed effects specification is that it allows the presence of regional differences that can be fundamentally different across regions and these regional specific effects are allowed to be correlated with the included explanatory variables $(m_{i,t-1}, \underset{\sim}{x}_{it}')$.

[1]As pointed out by a referee, (2.2) is known as a "real adjustment mechanism" (Goldfeld (1966)). An alternative adjustment mechanism in time series literature is a "nominal adjustment mechanism". We have performed the analysis using the nominal form as well. The results are similar. Therefore, we only report the results in real term.

The disadvantage of fixed effects specification is that it introduces the classical incidental parameter problem if the time series dimension, T, is short (e.g. Neyman and Scott (1948)). The random effects specification assumes the regional differences as random draws from a common distribution. They are attributable to chance outcomes. The advantage of random effects specification is that there is no incidental parameters problem. The disadvantage is that it typically does not allow the correlation between the regional specific effects, α_i, and $\underset{\sim}{x}_{it}$. However, it does allow α_i to be correlated with $m_{i,t-1}$.

Applying the covariance transformation eliminates the regional specific effects, α_i, from the specification. However, in a dynamic model the usual covariance or within estimator is biased if T is finite (Anderson and Hsiao (1981, 82)). To obtain a consistent estimator of γ and $\underset{\sim}{\beta}$ when N is large, we can first take the difference of (3.1) to get rid of α_i for $t = 2, \ldots, T$,

$$\begin{aligned} \Delta m_{it} = \gamma \Delta m_{i,t-1} + \underset{\sim}{\beta}' \Delta \underset{\sim}{x}_{it} + \quad & \Delta v_{it}, \\ & t = 2, \ldots, T, \\ & i = 1, \ldots, N. \end{aligned} \tag{3.2}$$

where $\Delta = (1 - L), L$ denotes the lag operator that shifts the observation back by one period, $Lm_{it} = m_{i,t-1}$. Although the least squares estimator of (3.2) is inconsistent because $\Delta m_{i,t-1}$ is correlated with Δv_{it}, lagged $m_{i,t-j}, j = 2, \ldots, t-1$ are uncorrelated with Δv_{it}. Therefore, one may apply instrumental variable (IV) or generalized method of moments estimator (GMM) to (3.2) (e.g. Ahn and Schmidt (1995), Arellano and Bover (1995)).

The IV or GMM, although is consistent, Monte Carlo studies conducted by Hsiao, Pesaran and Tahmiscioglu (2001) show that they are subject to serious bias and size distortion in finite sample, in particular, if γ is close to 1. On the other hand, the likelihood approach performs remarkably well in finite sample. However, Δm_{i1} is a random variable and cannot be treated as a fixed constant when T is finite. To complete the system, we need to add a specification for the initial value,

$$\begin{aligned}\Delta m_{i1} &= E(\Delta m_{i1} \mid \Delta \underset{\sim}{x}_{i2}, \ldots, \Delta \underset{\sim}{x}_{iT}) + v_{i1} \\ &= g + \sum_{t=2}^{T} \underset{\sim}{\pi}_t' \Delta \underset{\sim}{x}_{it} + v_{i1}, i = 1, \ldots, N.\end{aligned} \tag{3.3}$$

We can apply minimum distance or maximum likelihood type estimator to the combined system of (3.2) and (3.3). The resulting estimator is consistent and asymptotically normally distributed as $N \to \infty$ and has very good finite sample properties (Hsiao, Pesaran and Tahmiscioglu (2001)).

When α_i is treated as random variables, there is no incidental parameter problem. Therefore, there is no need to take the first difference of (3.1) to eliminate the individual effects, α_i. However, there is still an initial value problem because m_{i1} is a random variable and cannot be treated as fixed constants (e.g. Hsiao (1986)). To complete the system of (3.1), Bhargava and Sargan (1983) suggest the following specification,

$$\begin{aligned}m_{i1} &= E(m_{i1} \mid \underset{\sim}{x}_{i1}, \ldots, \underset{\sim}{x}_{iT}) + v_{i1}^* \\ &= g^* + \sum_{t=1}^{T} \underset{\sim}{\pi}_t^{*'} \underset{\sim}{x}_{it} + v_{i1}^*\end{aligned} \tag{3.4}$$

Applying the generalized least squares or maximum likelihood estimator to (3.1) and (3.4) is consistent and asymptotically efficient (Hsiao (1986)).

4. Data

This section explains the definition of prefecture income statistics, population, and prefecture money aggregates.

Prefecture Income Statistics

Prefecture income statistics compiled by the Economic and Social Research Institute (Former Economic Planning Agency of Japan) for each fiscal year provide a good counterpart to national GDP. We download the data from the homepage of Economic and Social Research Institute from 1987-1997, and supplement the data of 1986-1987 from Fujiki and Mulligan (1996).

The prefecture income data is deflated by the gross prefecture expenditure deflator during the period from fiscal year 1985 to fiscal year 1997.

Population

We use population to convert prefecture data to per capita data. The population of each prefecture is as of the beginning of October of each year.

Prefecture Money Aggregates

MF1

First, data on demand deposits[2]held by individuals and firms at domestically licensed bank by prefecture (end of month outstanding) are available from *Monthly Economic Statistics* of the Bank of Japan (Hereafter, MF1 data).[3] Due to the extension of the coverage banks included in this statistics in April 1989 and occasional consolidations of banks, MF1 data sometimes show an unusual increase, particularly in April 1989[4].

Since national M1 statistics is defined as the sum of cash currency in circulation and total demand deposits, net of the deposits held by the financial institutions, MF1 is prefecture counter part of national M1. However, the following caveats are in order. First, MF1 data do not include cash, because regional data on the amount of currency held by individuals are not available. Second, they do not have the breakdown by the individuals and firms. Third, they do not include the demand deposit at the community banks, the Norinchukin bank, and the Shokochukin bank, which are included in the computation of M1 statistics. Therefore, the aggregate MF1 is not M1. However, as shown in Figure 1 MF1 data always explains about 70 percent of M1 during the period from 1985 to 1988, and

[2]Substantial parts of demand deposits are either current deposits or ordinary deposits. Current deposits are deposits that the depositor may demand as freely as his needs require. Corporations use this account for the sake of settlement, but this account does not pay interest. The individuals and corporations with temporary excess funds mostly hold ordinary deposits.

[3]Domestically licensed banks include city banks, regional banks, regional II banks, trust banks and long-term credit banks. Note that the location of branches of each financial institution determines the prefecture the deposit belongs to.

[4]The data before 1989 March does not cover the deposit at the regional II banks.

about 80 percent from 1989 to 1991, and about 70 percent from 1992 to 1997. Therefore, if we are careful about the sample periods, MF1 predict almost constant proportion of M1.

MF2

The definition of MF2 is the sum of the deposit in domestically licensed banks, community banks and Shokochukin Bank. MF2 consists of both demand deposit and savings deposit. MF2 is our counterpart of national M2+CD minus cash, with the existence of the following statistical discrepancies[5]:

First, the prefecture breakdown of CDs outstanding does not exist, hence we ignore them. Second, we only eliminate the deposit held by the financial institutions for domestically licensed banks, since the breakdown of deposits held by financial institutions by prefecture are available for domestically licensed banks only. Third, we exclude the data for the Norinchukin bank from the regional deposit statistics to avoid possible double count of same deposits. Again, the aggregate MF2 is not M2. However, as shown in Figure 2, MF2 data always explains about 98 percent of M2+CD during the period from 1985 to 1992, and about 95 percent from 1993 to 1995, and about 90 percent from 1996 to 1997. Therefore, it we are careful about the sample periods, MF2 predict almost constant proportion of M2+CD.

PD (Personal Deposit)

Personal Deposit is the sum of deposits held by the individuals in domestically licensed banks, community banks, post offices, agricultural cooperatives, fishery cooperatives, credit cooperatives, and labor credit associations surveyed at the end of March. The data for the individual deposits are available from *The Prefecture Economic Statistics* and *Monthly Economic Statistics* published by the Bank of Japan.

Two important drawbacks of the personal deposit data are as follows. First, they

[5]National M2+CD adds saving deposits and Certificates of Deposit to M1. The financial institutions that are authorized to accept deposits are allowed to issue CDs since 1979. The interest rate for CDs are not regulated, and CDs may be sold to the third parties.

do not have the breakdown of the demand deposits and savings deposits. Second, they include the deposits of small businesses for the sake of business operation as long as the deposit is done in the name of individual.

All MF1, MF2, and PD figures are deflated by the gross prefecture expenditure deflator and divided by the population in each region to obtain the per-capita real money balance.

5. Empirical Results

In this section we report the results based on panel data analysis and discuss the differences between our findings and findings based on time series (Nakashima and Saito (2000)) or cross-sectional analysis (Fujiki (2001)).

We use prefecture data from 1985 to 1997. However, there are a number of data measurement issues being raised for the sample period. First, there was a change in the definition of the banks surveyed in the deposit statistics in 1989. Due to an extension of the coverage of regional II banks in the deposit statistics in that year the *Monthly Economic Statistics of the Bank of Japan* data show an unusual increase in 1989 and the sudden collapse of bubble in the early 1990 adds large savings to the data. Second, there is an argument that people live in the suburban area but work in the big metropolitan prefectures, Tokyo, Osaka or Kyoto, have their deposits in banks near where they work, instead of where they live. To avoid the possibility of obtaining biased results because of inconsistent data measurements in 1989 and 1990, one may just fit (2.3) for the year 1992 to 1997. To avoid the problem of people living in one prefecture but having banks in another prefectures, we can exclude the data of Tokyo, and its neighboring prefectures Chiba, Saitama, and Kanagawa from considerations and use the remaining 43 prefectures data to fit (2.3). We can also further exclude Osaka, Kyoto and the neighboring prefecture Hyogo from consideration and perform the analysis using the remaining 40 prefectures data.

First, we note that the change of definitions of the coverage of banks does create some instability in the estimates. Figure 3 plots the cross-sectional estimates of the coefficient of lagged dependent variable (log(MF1)) for model (2.3) from 1986 to 1997. There is a significant drop in the coefficient in 1989. However, after 1990, it shows remarkable stability over time. Therefore, to avoid possible contamination of regression results, we concentrate on estimating the money demand equation for the period 1992 - 1997, the period of low interest rate in the early 1990s adds large swings to the data.

Tables 1 and 2 present the generalized least squares estimates of the random effect and the MDE of the fixed effects model of MF1 for the 47 prefectures, 43 prefectures, and 40 prefectures, respectively (For detail, see Appendix A, B). Tables 3 and 4 present the random effects and fixed effects estimation of MF2, respectively. Tables 5 and 6 present the random and fixed effects estimation of PD. Practically all the model estimates have the expected signs and are statistically significant. In particular, the following points are worth noting:

First, the data of Tokyo, Osaka, Kyoto and their neighboring prefectures probably contain some systematic measurement errors. Table 7 presents the Hausman specification test of the presence of measurement errors by comparing the differences between the coefficients estimates based on 47 prefectures and 40 prefectures. They appear to confirm the presence of measurement errors in the seven prefectures we exclude from consideration. Both the coefficients of the lagged dependent variables and income variables for the 47 prefectures are somewhat different from the estimates for the 40 prefectures. However, the coefficients of interest rate are remarkably stable across estimates using data of different prefectures, indicating the substitution effects between money and other financial assets are not affected by the issue of whether people living in one prefecture could have bank accounts in a different prefectures.

Second, the income elasticity of money demand is positive and statistically significant. Based on the results of using 40 prefectures data, the short-run income elasticity for MF1 is about 0.36 for the RE model and is about 0.493 for the FE model. The long-run elasticity is 0.36/(1-0.728)=1.32 for the RE and 0.493/(1-0.719)=1.75 for the FE model. The short-run income elasticity for MF2 is about 0.151 for the RE model and 0.134 for the FE model. The long-run income elasticity for MF2 is about 0.29 for the RE model and about 0.28 for the FE model. The short-run income elasticity for PD is 0.08 for the RE model and 0.037 for the FE model. The long-run income elasticity is 0.196 for the RE model and 0.1 for the FE model.[6]

Third, the coefficients of the interest rate are negative and statistically significant. The short-run semi-interest rate elasticity for MF1 is about -0.05 for the random effects model and -0.036 for the fixed effects models. The long-run semi-interest rate elasticity for the RE model is about -0.18 and -0.14 for the FE model. The short-run semi-interest rate elasticity for MF2 is about -0.02 for the RE model and -0.019 for the FE model. The long-run semi-interest rate elasticity for MF2 is about -0.04 for the RE model and -0.04 for the FE model. The short-run semi-interest rate elasticity for PD is -0.026 for the RE and -0.028 for the FE. The long-run semi-interest rate elasticity is -0.06 for the RE and -0.07 for the FE model.

Fourth, there are some differences between the random effects and fixed effects estimation, although not substantial. Which model provides more reliable inference? Unfortunately, the Hausman(1978) specification test of random versus fixed effects specification cannot be implemented because the estimated covariance matrix is negative. Therefore, to check the reliability of the random effects versus fixed effects inference, we rely on the prediction principle (Hsiao and Sun (2000)). We reestimate the random-effects and fixed effects models for the period 1992-1996 and use the estimated coefficients to predict the

[6] One might argue that since rich people buy large amount of financial assets such as large saving deposit, hence income elasticity of MF2 might be larger compared with MF1. However, our result shows that long-run income elasticity of MF1 is far larger than that of MF2. One interpretation about this evidence might be that substantial part of demand deposits are held by firms, while the saving deposit is presumably held by the individuals. Hence, if our dynamic panel approach is correct, relatively high-income elasticity of MF1 could be due to the demand for money by firms. The idea is consistent with the evidence that personal deposit, that excludes the deposit made by the firms, shows the smallest income elasticity of money demand. Information on the distribution of demand deposits held by firms might provide such evidence.

outcomes of 1997. Figure 4-9 plot the actual and predicted value of the 40 prefectures in 1997. It is quite remarkable how well both models predict the outcomes. Table 8 provides the root mean square prediction error of these four models. Again the difference is not significant, although it does appear to favor random effects specification slightly.

Using the information of panel data we find that there appears to have a stable relationship between Japan's demand for real balance and real income and nominal interest rate even during the period of low interest rate whether we use random or fixed effects specification. Table 9 summarizes the estimated income elasticities and semi-interest elasticities based on data of 40 prefectures. They are of similar magnitudes between the RE and FE specifications. On the other hand, Nakashima and Saito (2000) using monthly aggregate time series data find that there was a structural break in 1995 and there did not appear to have a stable relation between money demand and income for the period 1995 to 1999. Moreover, they find that money demand was extremely interest-elastic, implying the existence of liquidity trap. Unfortunately, our annual panel data contains too few time dimension information to directly test for structural break in 1995. However, if there was indeed a structural break in 1995, then one would expect that estimates based on 1992-1996 data probably would not predict the outcomes of 1997 well. But figures 4-9 show that the predictions for 1997 are remarkably well. This may be viewed as an indirect evidence in support of a stable disaggregate money demand function. Furthermore, although we find that money demand is responsive to interest rate changes, they are not in the magnitude of Nakashima and Saito (2000). Their estimated semi-interest elasticity for M1 is in the range of -0.415 to -0.592. Ours is much smaller, the long-run semi-interest elasticity for MF1 is in the magnitude of -0.13 based on the FE model and -0.18 based on the RE model.

Compared to the study that also uses panel data, Fujiki (2001) obtains employee income elasticities of MF1 about 1, while our estimated short-run income elasticity is significantly below one and the implied long-run income elasticity is above one. However, there is a significant difference in the two model specifications. First, cross-sectional estimates uses a static model while our model is a dynamic one. Secondly, cross-sectional estimates do not use call rate as an explanatory variable. We find that both the coefficients of the lagged dependent variable and call rate are highly significant.

A referee has suggested to use gross prefecture product to approximate regional economic activity because the prefecture income data represents income received by residents of each specific area, regardless of the location of the economic activity that generates the income. Tables 10, 11, 12, and 13 present the RE and FE estimates of regional MF1 and MF2 demand model using gross prefecture activity instead of gross prefecture income. The results are very similar, again appear to support a stable relationship between disaggregate money demand and economic activity.

6. Conclusions

In this paper we use Japanese prefecture data from 1992-1997 to estimate the money demand equations. Contrary to the findings relying on aggregate time series, we find that there is a stable money demand equation for Japan even during the period of low interest rate. Based on the results of random effects dynamic panel data model, the estimated short-run income elasticity is in the magnitude of 0.493 and long-run income elasticity is about 1.32 for MF1, 0.151 and 0.29, respectively, for MF2, and 0.08 and 0.196, respectively, for PD. The estimated short-run semi-interest rate elasticity is about -0.05 and the long-run semi-elasticity is about -0.18 for MF1, -0.02 and -0.04, respectively, for MF2 and -0.026 and -0.06, respectively, for PD.

The conflicting evidence between the analysis based on aggregate time series data and disaggregated panel data could be due to many reasons: First, our analysis is in fact an analysis of the demand for deposits of various types, because panel data on holdings of currency are not available. However, Japan is an economy where currency is widely used, especially by households. Second, there could be an issue of aggregation. Third, there could be an issue of simultaneity between the aggregate money and income. Fourth, the most troublesome issue on the analysis of aggregate time series data is the lack of sample variability. The minimum and maximum value of the logarithm of real GDP are 14.943 and 15.4925 of real M1 are 13.6094 and 17.7069 of real M2 are 14.738 and 15.7089 respectively for the quarterly data over the period 1980.IV - 2000.III . With sample observations clustered together, any regression results are possible depend on the period covered or variability of particular pair of observations. We plan to investigate the discrepancy between aggregate and disaggregate time series in future. However if there indeed exists a stable real money demand equation, then the elementary argument that "The monetary authorities can issue as much money as they like. Hence, if the price level were truly independent of money issuance, then the monetary authorities could use the money they create to acquire indefinite quantities of goods and assets. This is manifestly impossible in equilibrium. Therefore, money issuance must ultimately raise the price level, even if nominal interest rate, are bounded at zero." (Bernanke (2000)) presumably should hold. Then why did monetary authorities failed to stimulate aggregate demand and prices in the 90's? If the estimate is of any guide, it is not because of the ineffectiveness of the low interest rate policy, but perhaps because that money supply did not increase as much as desired by the monetary authority. Figure 10 plots the M2 from 1980.I - 2000.IV. It is obvious that the growth rate of M2 in the 90's fails to maintain the same rate as in the 80's. In the 80's, the average growth rate is about 9.34%, yet the inflation rate (GDP deflator) is only 1.98% (and real GDP growth rate of 4.13%). In the 90's, the average growth rate of M2 is only 2.69%, with an inflation rate of 0.14% (and real GDP growth rate of 1.38%). This significant drop in the growth rate of money supply is mainly due to the reluctance of commercial banks to make loans to small and medium-sized enterprises because of the erosion of their capital base due to the accumulation of nonperforming assets after the bubble burst in 1990. In fact, the growth rate of high powered money is about 5.67% in the 90's (relative to 8.08% in the 80's). It is the ineffectiveness of the transmission of the growth of high powered money to the growth of M2 that led to the slowdown of the growth of money supply. Moreover, buying long term bond is likely to push the interest rate further down and money demand is sensitive to interest rate changes. It appears that the challenge to the monetary authority to find a way to increase the supply of money cannot be resolved through monetary means alone. Complementary fiscal policies have to be implemented. If the U.S. experience could be applied to Japan, the policy option of raising tax to the high income families may deserve serious study. Raising tax of the high income families within bound may have negligible discouraging effects on consumption and investment. After all, Clinton administration imposed 10% surcharge to high income families and U.S. consumption and investment remained strong in the 90's. With the increased revenue from the income tax surcharge, government can retire the bad loans held by the financial institutions. Hopefully, with the improved balance sheets, commercial banks will be more willing to lend to small and medium sized enterprises, hence lead to increase in money supply and get Japan out of deflation. However, taxing wealthy people in Japan might mean taxing old people, and could discourage consumption more if the uncertainly regarding the social security system is an important factor. It appears that a case can be made to conduct serious empirical studies on the discouraging consumption and investment effects with tax surcharging on high income families.

Appendix A: Specification and Estimation in the GLS Estimation

We start with a model

$$y_{it} = \rho y_{i,t-1} + \underset{\sim}{\beta}' \underset{\sim}{x}_{it} + \underset{\sim}{\gamma}' \underset{\sim}{z}_i + v_{it}, i = 1, \ldots, N, t = 2, \ldots, T. \tag{A.1}$$

where $\underset{\sim}{x}_{it}$ is $k_1 \times 1$ vector of time variant explanatory variables, $\underset{\sim}{z}_i$ is $k_2 \times 1$ vector of time invariant explanatory variables including the constant term, $v_{it} = \alpha_i + u_{it}$. The error term u_{it} and the prefecture specific effects α_i satisfies

$$E\alpha_i = Eu_{it} = 0, \quad E\alpha_i \underset{\sim}{z}'_{it} = 0', E\alpha_i \underset{\sim}{x}'_{it} = \underset{\sim}{0}',$$

$$\begin{aligned} E\alpha_i u_{it} &= 0, \\ E\alpha_i \alpha_j &= \sigma_\alpha^2 \text{ if } i = j, \\ &= 0 \text{ if otherwise} \\ Eu_{it}u_{js} &= \sigma_u^2 \text{ if } i = j, t = s, \\ &= 0 \text{ if otherwise} \end{aligned}$$

and $\rho, \underset{\sim}{\beta}$, and $\underset{\sim}{\gamma}$ are parameters of interest. For the model in this paper, $\underset{\sim}{x}_{it}$ includes prefecture income, call rate, and z_i is a intercept term.

To complete the system, we let

$$y_{i0} = \underset{\sim}{\bar{\pi}}' \underset{\sim}{\bar{x}}_i + \underset{\sim}{\bar{\gamma}}' \underset{\sim}{z}_i + v_{i0}, \quad i = 1, \ldots, N, \tag{A.2}$$

where y_{i0} is the initial observation for i, $\underset{\sim}{\bar{x}}_i = \frac{1}{T} \sum_{t=1}^{T} \underset{\sim}{x}_{it}$. The GLS estimates for (A.1) and (A.2) is given by

$$\hat{\delta}_{GLS} = \left(\sum_{i=1}^{N} X_i' V^{-1} X_i \right)^{-1} \left(\sum_{i=1}^{N} X_i' V^{-1} y_i \right),$$

where $\delta = (\underset{\sim}{\bar{\pi}}'_i, \underset{\sim}{\bar{\gamma}}', \rho, \underset{\sim}{\beta}', \underset{\sim}{\gamma}')$,

$$X_i = \begin{bmatrix} \underset{\sim}{x}_i & \underset{\sim}{z}_i & 0 & 0 & 0 \\ 0 & 0 & y_{i0} & \underset{\sim}{x}'_{i1} & \underset{\sim}{z}'_i \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & y_{i,T-1} & \underset{\sim}{x}'_{iT} & \underset{\sim}{z}'_i \end{bmatrix},$$

$$V = \begin{bmatrix} \sigma^2_{v_0} & r_{01} & \dots & \dots r_{oT} & \\ r_{01} & \sigma^2_u + \delta^2_\alpha & \sigma^2_\alpha & & \sigma^2_\alpha \\ \vdots & \sigma^2_\alpha & \ddots & \ddots & \\ r_{ot} & \sigma^2_\alpha & & & \sigma^2_u + \sigma^2_\alpha \end{bmatrix},$$

since $V(v_{it}) = \sigma^2_u + \sigma^2_\alpha, E(v_{it}v_{is}) = \sigma^2_\alpha$ for $t = 1, 2, \dots, T$, and $\underset{\sim}{y}_i = (y_{i0}, y_{i1} \dots y_{iT})'$.

To obtain the initial values for the implementation of the GLS estimation we first take the first difference of (A.1), we obtain

$$y_{it} - y_{i,t-1} = \rho(y_{i,t-1} - y_{i,t-2}) + \underset{\sim}{\beta}'(\underset{\sim}{x}_{it} - \underset{\sim}{x}_{i,t-1}) + u_{it} - u_{i,t-1} \tag{A.3}$$

Since by assumption $y_{i,t-2}$ are not correlated with $u_{it} - u_{i,t-1}$ but are correlated with $y_{i,t-1} - y_{i,t-2}$, we use $y_{i,t-2}$ as an instrument for $y_{i,t-1} - y_{i,t-2}$ and estimate $\underset{\sim}{\beta}$ and ρ by the instrumental variable method.

Second we substitute estimated $\underset{\sim}{\beta}$ and ρ into

$$\bar{y}_i - \gamma \bar{y}_{i,-1} - \underset{\sim}{\beta}'\bar{\underset{\sim}{x}}_i = \underset{\sim}{\gamma}'\underset{\sim}{z}_i + \alpha_i + \bar{u}_i \tag{A.4}$$

to estimate $\underset{\sim}{\gamma}$ using OLS method, where $\bar{y}_i, \bar{\underset{\sim}{x}}_i$ and $\bar{u}_i$ are averages taking over T for prefecture i.

We then can estimate σ^2_u based on (A.3):

$$\sigma^2_u = \frac{\sum_{i=1}^N \sum_{t=2}^T \left[(y_{it} - y_{i,t-1}) - \hat{\rho}(y_{i,t-1} - y_{i,t-2}) - \hat{\underset{\sim}{\beta}}'(\underset{\sim}{x}_{it} - \underset{\sim}{x}_{i,t-1})\right]^2}{2N(T-1)}$$

and σ^2_α is estimated by

$$\sigma^2_\alpha = \frac{\sum_{i=1}^N (\bar{y}_i - \hat{\rho}\bar{y}_{i,-1} - \hat{\underset{\sim}{\beta}}'\bar{\underset{\sim}{x}}_i)^2}{N} - \frac{1}{T}\hat{\sigma}^2_u.$$

To obtain estimates of $\sigma^2_{v_0}$ and the covariance between v_{i0} and v_{it}, we can first use OLS procedure to estimate the equation in (A.2) cross-sectionally, then use the estimated error sum of squares to estimate the initial variance $\sigma^2_{v_0}$. To estimate the covariance between v_{i0} and v_{it}, we first plug in the estimated ρ, β, and γ into (A.1) to estimate v_{it}, then estimate the covariances by

$$r_{0t} = \text{cov }(v_{i0}, v_{it}) = \frac{\sum_{i=1}^N (v_{it} - \bar{v}_i)v_{i0}}{N}.$$

Appendix B: Minimum Distance Estimation (MDE)

We take first difference of (A.1) to eliminate α_i, we have

$$\Delta y_{it} = \gamma \Delta y_{i,t-1} + \underset{\sim}{\beta}' \Delta \underset{\sim}{x}_{it} + \Delta u_{it}, \quad \begin{matrix} t = 2, 3, \ldots, T \\ i = 1, 2, \ldots, N \end{matrix} \tag{B.1}$$

(B.1) is well defined for $t = 2, \ldots, T$ but not for $t = 1$ since $y_{i,-1}$ are not available. The marginal distribution of Δy_{i1} conditional on $\Delta \underset{\sim}{x}_i$, can be written as

$$\Delta y_{i1} = b^* + \underset{\sim}{\pi}' \Delta \underset{\sim}{x}_i + v_{i1} \tag{B.2}$$

where $\underset{\sim}{\pi}$ is a $(T-1) \times k_1 \times 1$ vector of unknown coefficients which in general varies independent of the variations of β and ρ, and $\Delta \underset{\sim}{x}_i = (\Delta \underset{\sim}{x}'_{i2}, \ldots, \Delta \underset{\sim}{x}'_{iT})'$. (Please refer to Hsiao, Pesaran and Tahmiscioglu (2001) for details of specification and discussion of strictly exogenous on weakly exogenous assumption of x_i). We consider $\underset{\sim}{x}_i$ to be strictly exogenous and the likelihood function is given by

$$(2\pi)^{-\frac{NT}{2}} \mid \Omega \mid^{-\frac{N}{2}} \ \exp \ \left\{ -\frac{1}{2} \sum_{i=1}^{N} \Delta \underset{\sim}{u}_i^{*\prime} \Omega^{-1} \Delta \underset{\sim}{u}_i^* \right\} \tag{B.3}$$

where

$$\Delta \underset{\sim}{u}_i^* = [\Delta y_{i1} - b^* - \underset{\sim}{\pi}' \Delta \underset{\sim}{x}_{i1}, \Delta y_{i2} - \gamma \Delta y_{i1} - \underset{\sim}{\beta}' \Delta \underset{\sim}{x}_{i2}, \ldots, \Delta y_{iT} - \gamma \Delta y_{iT-1} - \underset{\sim}{\beta}' \Delta \underset{\sim}{x}_{iT}]',$$

and

$$\Omega = \sigma_u^2 \begin{bmatrix} \omega & -1 & 0 & \ldots & 0 & \\ -1 & 2 & -1 & 0 & \ldots & \\ 0 & -1 & 2 & -1 & \ldots & \\ \vdots & & & & \ddots & -1 \\ 0 & & & -1 & 2 & \end{bmatrix} = \sigma_u^2 \Omega^*,$$

where $\omega = \frac{1}{\sigma_u^2}$ Var (Δy_{i1}).

The MLE estimator is highly nonlinear. A simple but less efficient estimator of (B.1) and (B.2) is to estimate $\underset{\sim}{\theta} = (\gamma, \underset{\sim}{\beta}')'$ by minimum distance estimator (MDE)

$$\hat{\underset{\sim}{\theta}} = \begin{pmatrix} \hat{\gamma} \\ \hat{\underset{\sim}{\beta}} \end{pmatrix} = \left[\sum_{i=1}^{N} \Delta Z_i' \Omega^{*-1} \Delta Z_i \right]^{-1} \left[\sum_{i=1}^{N} \Delta Z_i' \Omega^{*-1} \Delta \underset{\sim}{y}_i \right],$$

where

$$\Delta Z_i = \begin{bmatrix} 1 & \Delta \underset{\sim}{x}'_i & 0 & 0 & \\ 0 & 0 & \Delta y_{i1} & \Delta \underset{\sim}{x}'_{i2} & \\ & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \Delta y_{i,T-1} & \Delta \underset{\sim}{x}'_{iT} & \end{bmatrix}.$$

In our estimation, to avoid singularity problem, we use $\Delta \bar{\underset{\sim}{x}}'_i$ instead, where $\Delta \bar{\underset{\sim}{x}}'_i$ contains averages of each explanatory variables over time.

The variable covariance matrix for $\hat{\gamma}$ is estimated by $\text{cov}(\hat{\underset{\sim}{\theta}}) = \hat{\sigma}_u^2 \cdot \left[\sum_{i=1}^{N} \Delta Z'_i \Omega^{*-1} \Delta Z_i\right]^{-1}$.

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Table 1 Random Effects
Estimation of MF1
1992 – 1997

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
M1F(-1)	0.7135467	0.023	0.7058972	0.024	0.7274535	0.021
Income	0.278585	0.101	0.352682	0.109	0.36039	0.093
Call rate	-0.056227	0.004	-0.053894	0.004	-0.049996	0.004
Constant	-0.292315	4.139	-0.532102	3.963	-0.601234	4.146

Table 2 Fixed Effects
Estimation of MF1
1992 – 1997

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
M1F(-1)	0.74237	0.022	0.7312153	0.021	0.719448	0.017
Income	0.7421883	0.082	0.6907008	0.078	0.4928584	0.073
Call rate	-0.024654	0.004	-0.025385	0.003	-0.03623	0.003

Table 3 Random Effects
Estimation of MF2
1992 – 1997

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
M2F(-1)	0.5341371	0.028	0.4759139	0.036	0.4816737	0.040
Income	0.104616	0.051	0.1682348	0.060	0.1509663	0.064
Call rate	-0.018824	0.002	-0.020053	0.002	-0.020409	0.003
Constant	1.2678714	1.299	1.2436977	1.235	1.2655871	1.156

Table 4 Fixed Effects Estimation
of MF2, **1992 - 1997**

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
M2F(-1)	0.5728791	0.035	0.5821186	0.037	0.5260964	0.034
Income	0.2267694	0.046	0.1989373	0.044	0.13421	0.048
Call rate	-0.015508	0.002	-0.016457	0.002	-0.018925	0.002

Table 5 Random Effects Estimation
of PD, **1992 - 1997**

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
PD(-1)	0.5701339	0.023	0.5705362	0.023	0.5776041	0.023
Income	0.0680518	0.041	0.0826052	0.042	0.0828102	0.042
Call rate	-0.02766	0.002	-0.026781	0.002	-0.025963	0.002
Constant	1.4446436	0.616	1.3940537	0.619	1.3611469	0.652

Table 6 Fixed Effects Estimation
of Personal Deposit, 1992 - 1997

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
PD(-1)	0.6572339	0.021	0.6737774	0.022	0.6117796	0.022
Income	0.0710172	0.032	0.0987517	0.030	0.0374674	0.036
Call rate	-0.024685	0.002	-0.023485	0.001	-0.02802	0.002

Table 7 Hausman Test of the
Presence of Measurement Error

Variables	RE Models	FE Models
MF1	--	1163.21
MF2	11.49*	28.23^
PD	21.77*	26.027

--: Hausman Test statistics is negative.
^: Deleting Call rate to avoid singularity problem.
*: Test statis tics based on instrumental variable (IV) results.

Table 8 Root Mean Square Prediction Error Comparison

	Variables	Random Effects	Fixed Effects
47 Prefectures	MF1	0.2464175	0.3991713
	MF2	0.1298313	0.0947786
	PD	0.0577891	0.0699875
43 Prefectures	MF1	0.1984528	0.3217305
	MF2	0.098601	0.0802794
	PD	0.0571144	0.0750199
40 Prefectures	MF1	0.2563202	0.2396092
	MF2	0.0928625	0.1235308
	PD	0.0569416	0.0875089

Table 9 Estimated Income Elasticity and Semi-Interest Rate Elasticity

Elasticities of Interest		MF1		MF2		PD	
		Short Run	Long Run	Short Run	Long Run	Short Run	Long Run
Income Elasticity	Random Effects	0.36	1.32	0.15	0.29	0.08	0.196
	Fixed Effects	0.49	1.75	0.13	0.28	0.037	0.1
Semi-interest Elasticity	Random Effects	-0.05	-0.18	-0.02	-0.04	-0.026	-0.06
	Fixed Effects	-0.04	-0.14	-0.019	-0.04	-0.028	-0.07

Table 10 Random Effects Estimation of MF1
Using Gross Prefecture Product Per Capita (GPPP)
1992 – 1997

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coeffic ients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
M1F(-1)	0.693043	0.024	0.6818123	0.025	0.7038531	0.023
GPPP	0.3101102	0.119	0.3850224	0.126	0.3511967	0.116
Call rate	-0.058755	0.003	-0.057112	0.004	-0.054193	0.003
Constant	-1.861866	12.591	-2.464089	12.145	-2.232297	11.772

Table 11 Fixed Effects Estimation of MF1
Using GPPP
1992 – 1997

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
M1F(-1)	0.6935864	0.025	0.6998196	0.025	0.6816032	0.019
GPPP	0.6500913	0.116	0.6277681	0.113	0.4633072	0.097
Call rate	-0.030653	0.004	-0.02988	0.003	-0.042808	0.003

Table 12 Random Effects Estimation of MF2
Using GPPP
1992 – 1997

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
M2F(-1)	0.5707841	0.026	0.4715272	0.040	0.4767578	0.045
GPPP	-0.005415	0.053	0.117768	0.072	0.0914852	0.082
Call rate	-0.0202	0.002	-0.022064	0.002	-0.022619	0.002
Constant	1.5367653	3.513	0.8552777	3.210	1.0357334	2.774

Table 13 Fixed Effects Estimation of MF2
Using GPPP
1992 – 1997

	47 Prefectures		43 Prefectures		40 Prefectures	
Variables	Coefficients	Standard Error	coefficients	Standard Error	coefficients	Standard Error
M2F(-1)	0.552082	0.038	0.5494894	0.040	0.4879865	0.038
GPPP	0.2027199	0.061	0.2532376	0.060	0.1801645	0.064
Call rate	-0.016098	0.002	-0.016448	0.002	-0.019677	0.002

Figure 1 Natural Logarithm of Real M1 With and Without Currency

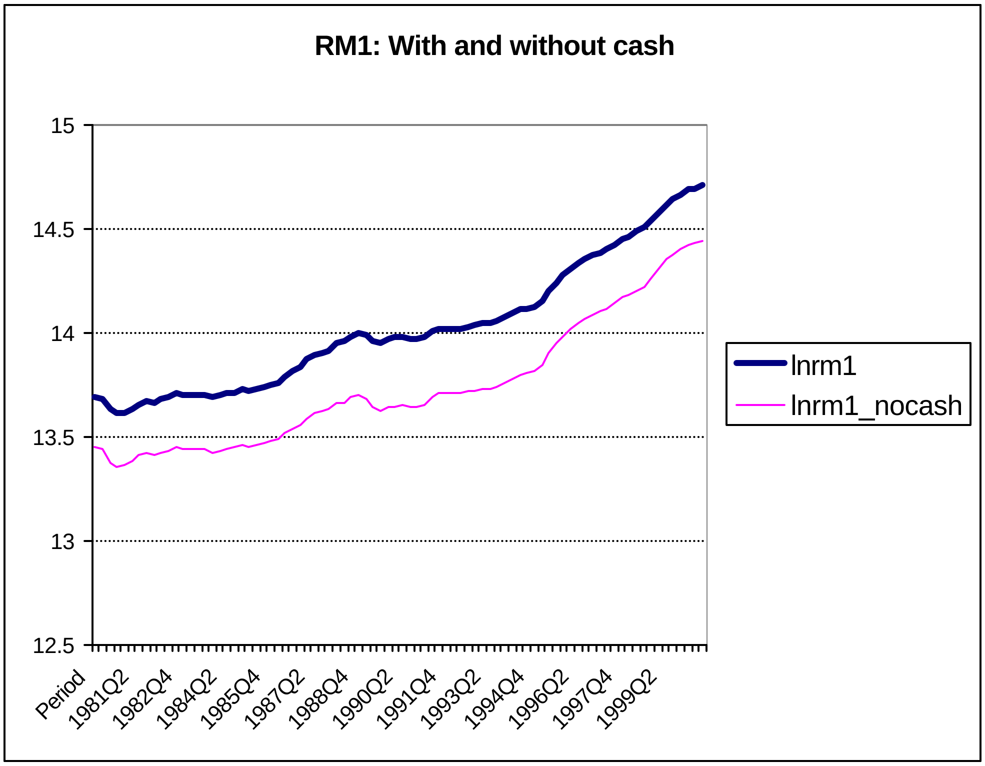


Figure 2 Natural Logarithm of Real M2 With and Without Currency

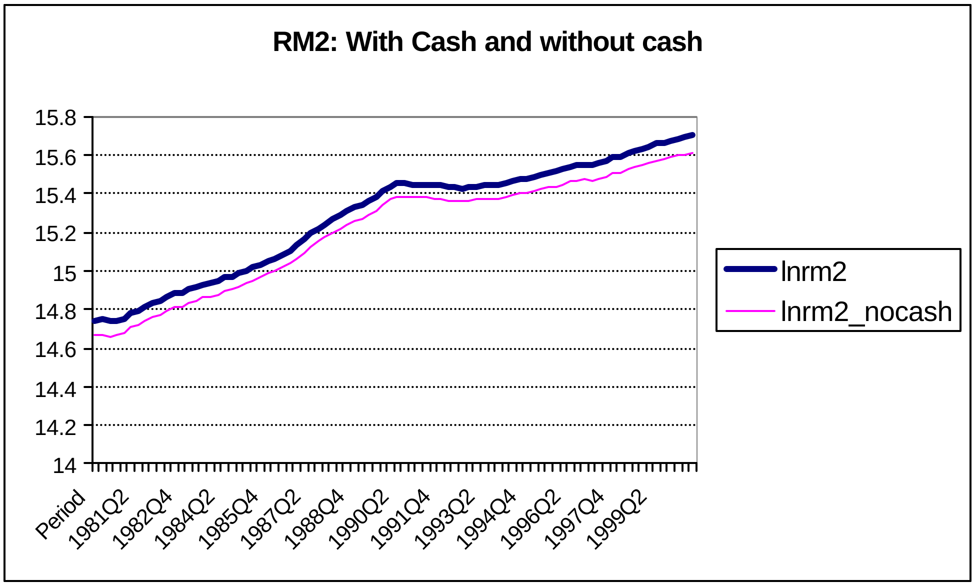


Figure 3. Cross-Sectional Estimates of the Coefficient of Lagged Dependent Variables from 1986 – 1997

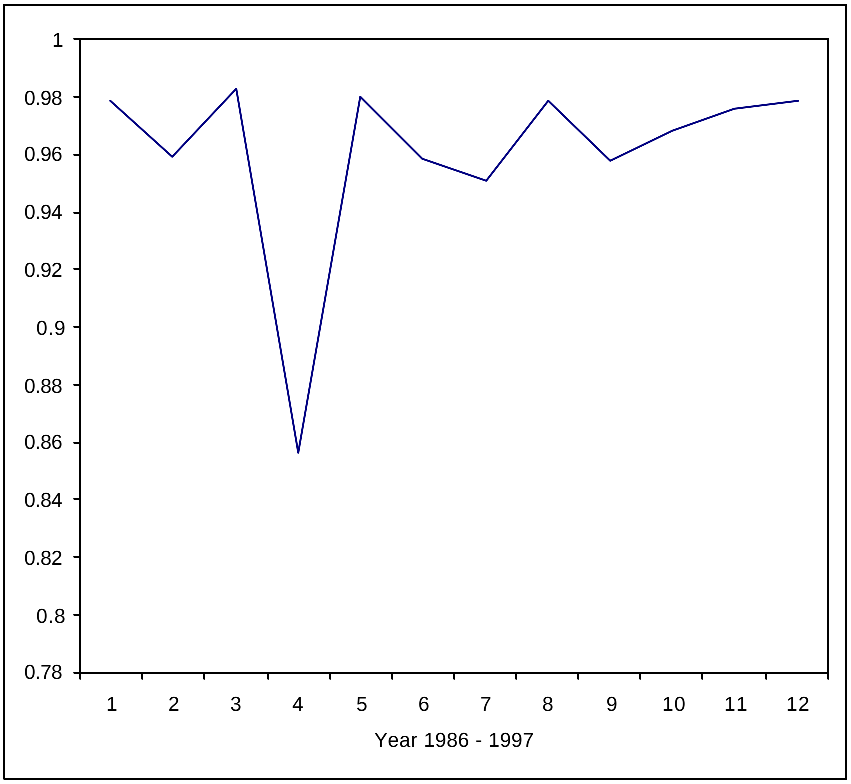


Figure 4 Post – Sample Actual and Random Effects Predicted Values
of 1997 MF1 for the 40 Prefectures

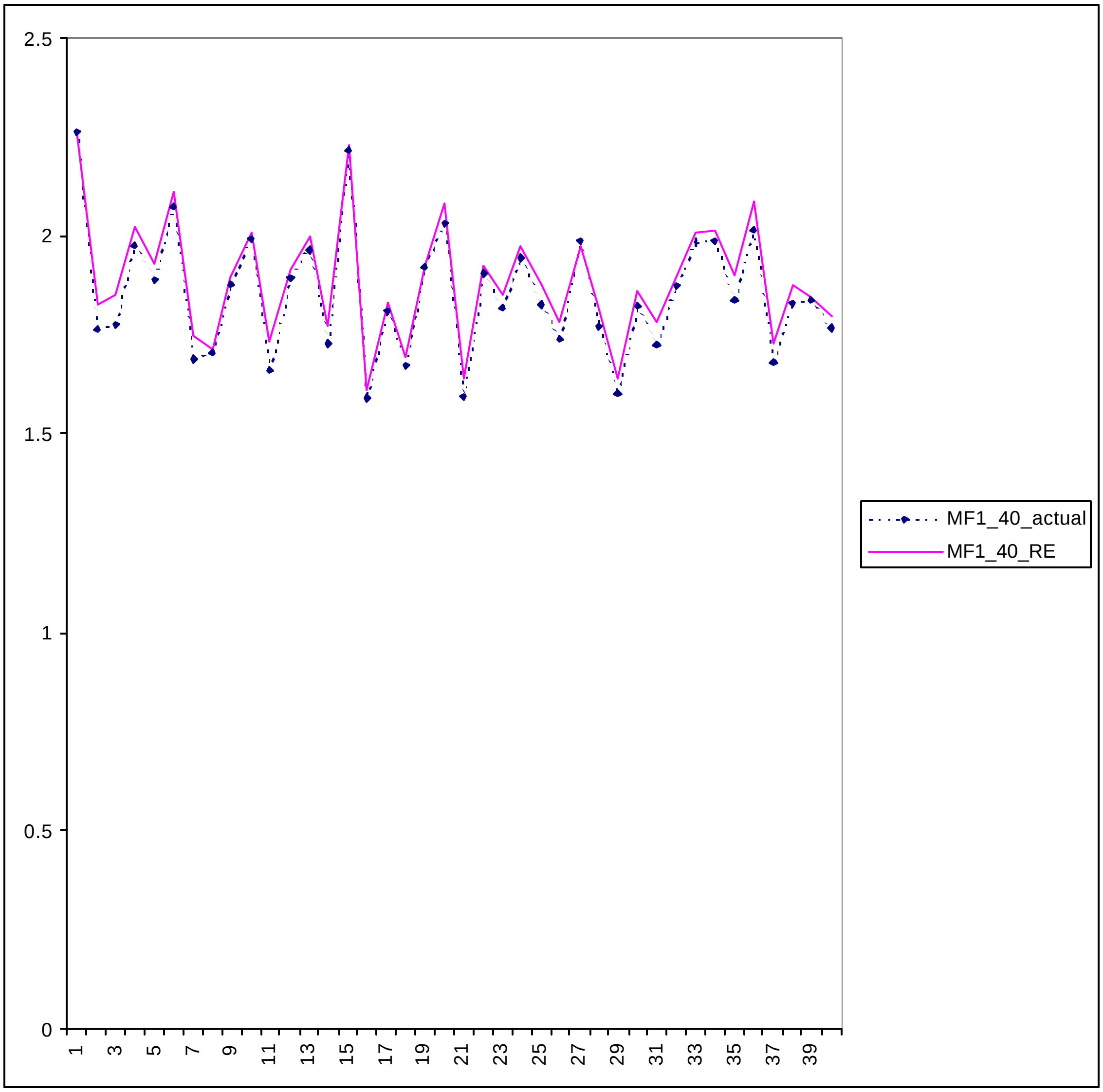


Figure 5 Post – Sample Actual and Fixed Effects Predicted Values
of 1997 MF1 for the 40 Prefectures

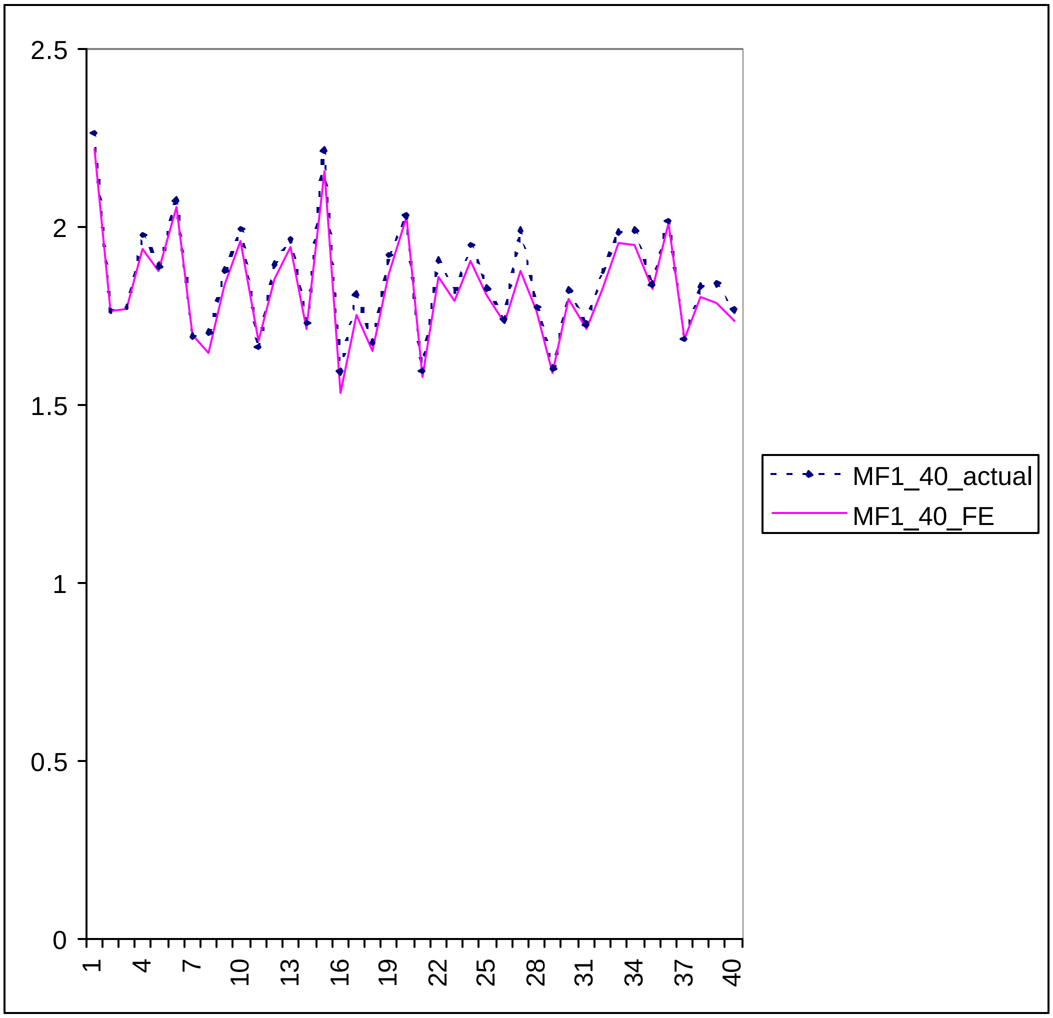


Figure 6 Post – Sample Actual and Random Effects Predicted Values
of 1997 MF2 for the 40 Prefectures

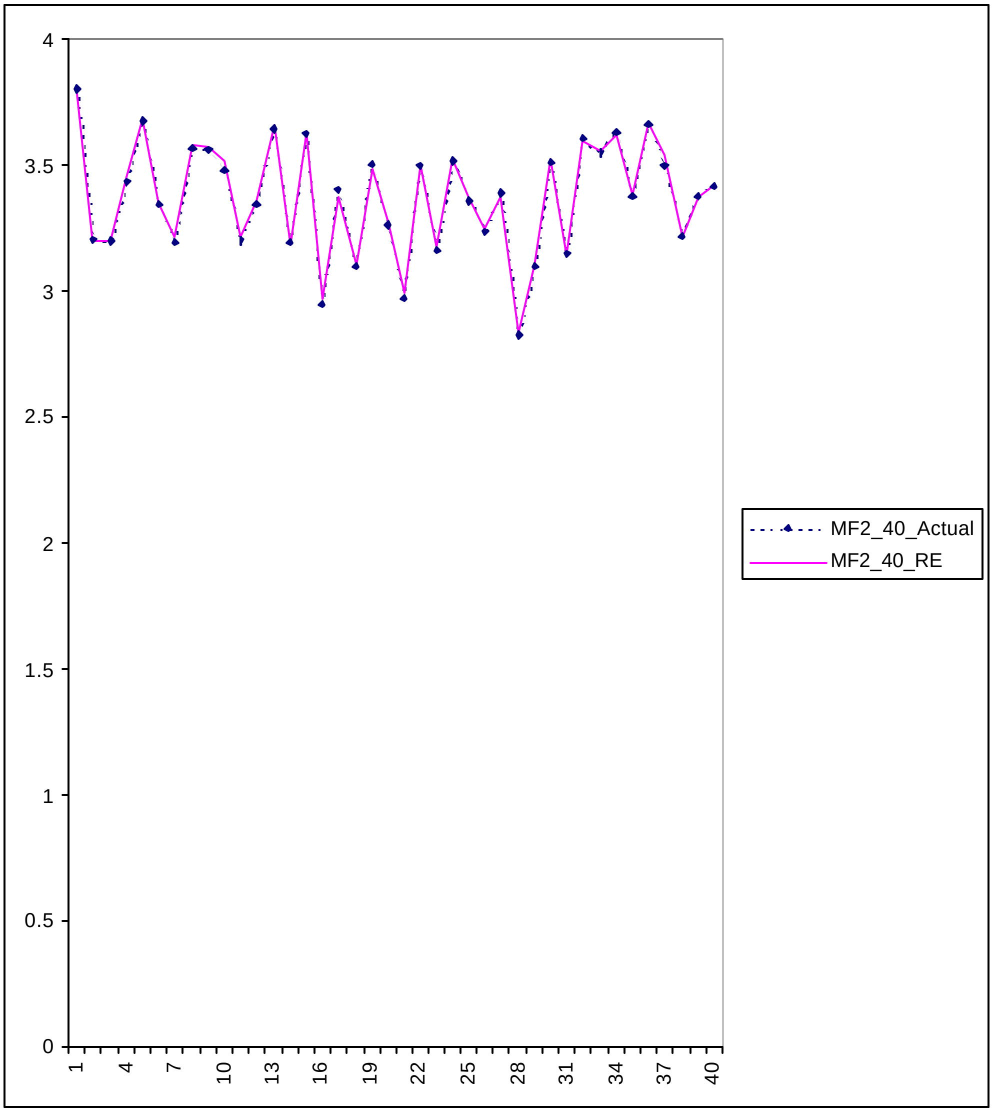


Figure 7 Post – Sample Actual and Fixed Effects Predicted Values of 1997 MF2 for the 40 Prefectures

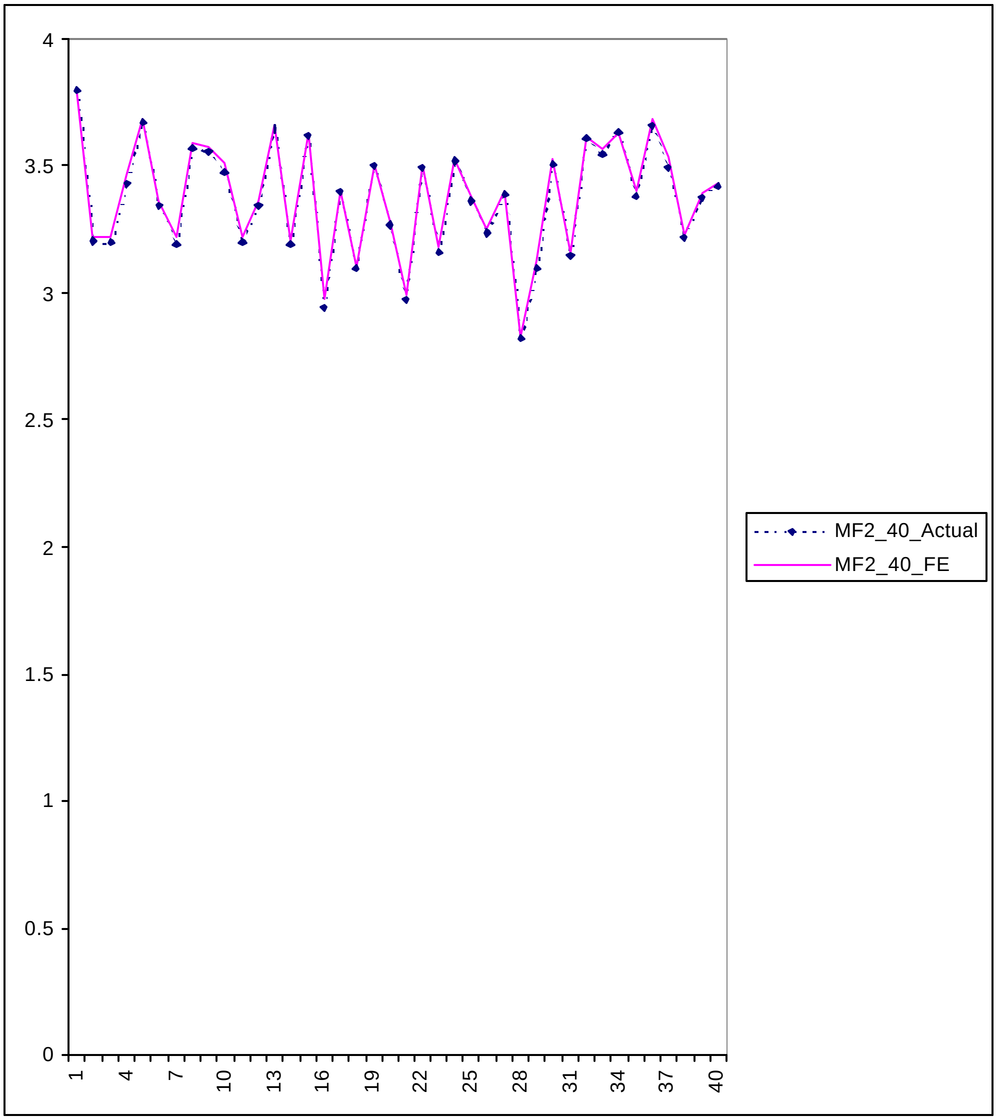


Figure 8 Post – Sample Actual and Random Effects Predicted Values of 1997 PD for the 40 Prefectures

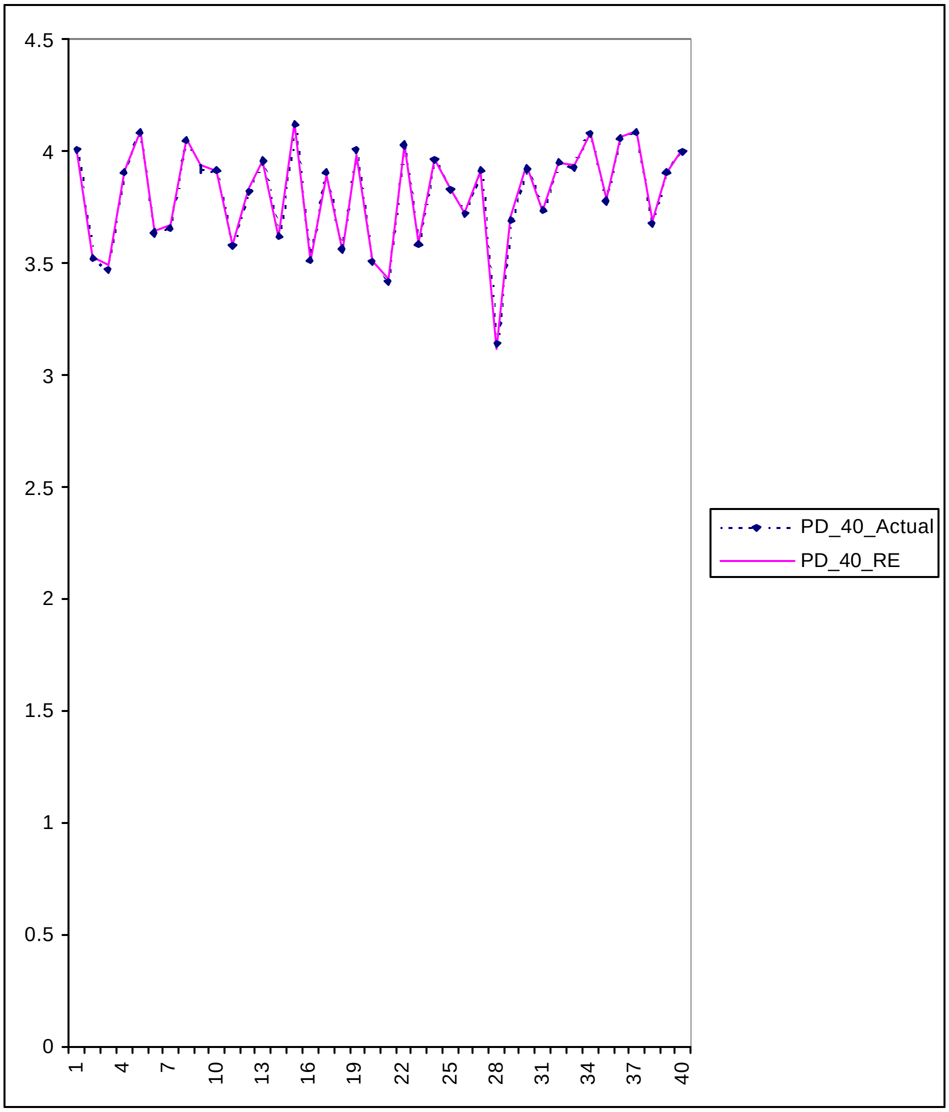


Figure 9 Post – Sample Actual and Fixed Effects Predicted Values of 1997 PD for the 40 Prefectures

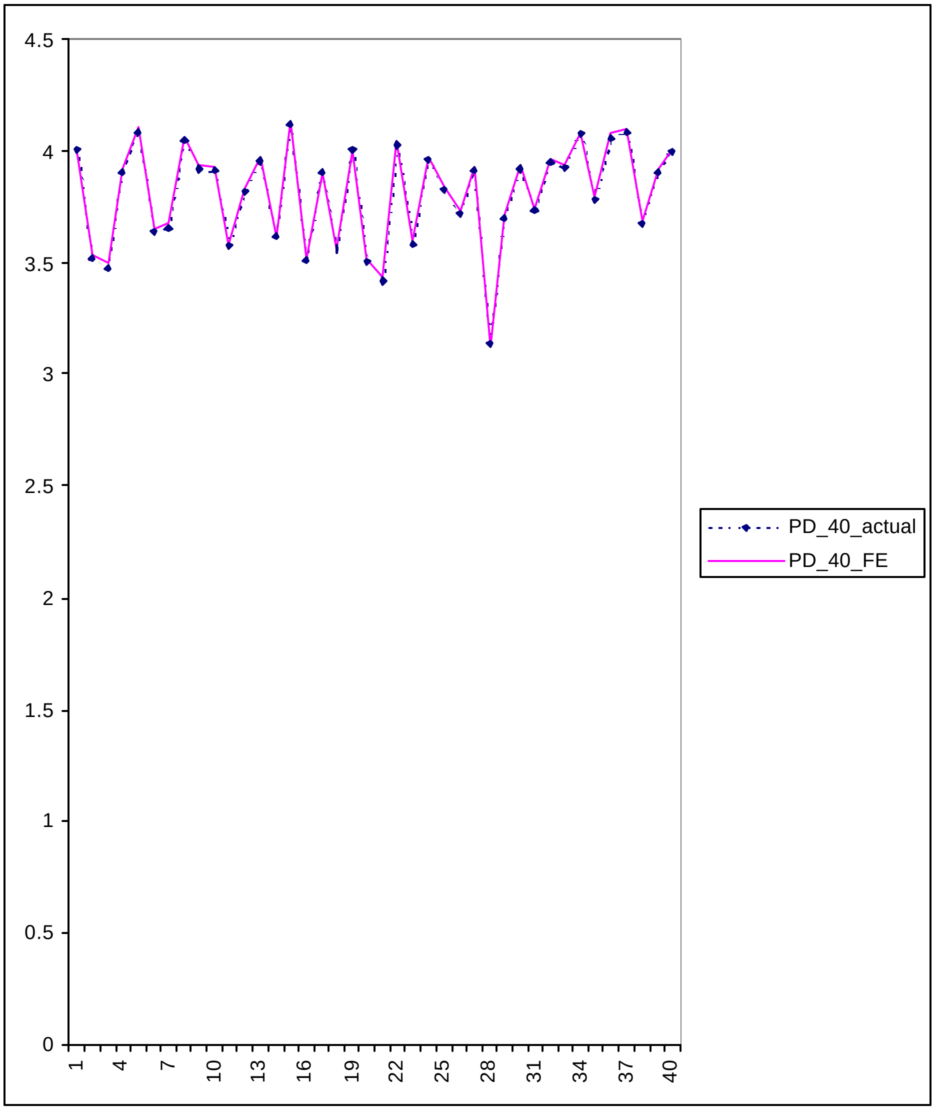
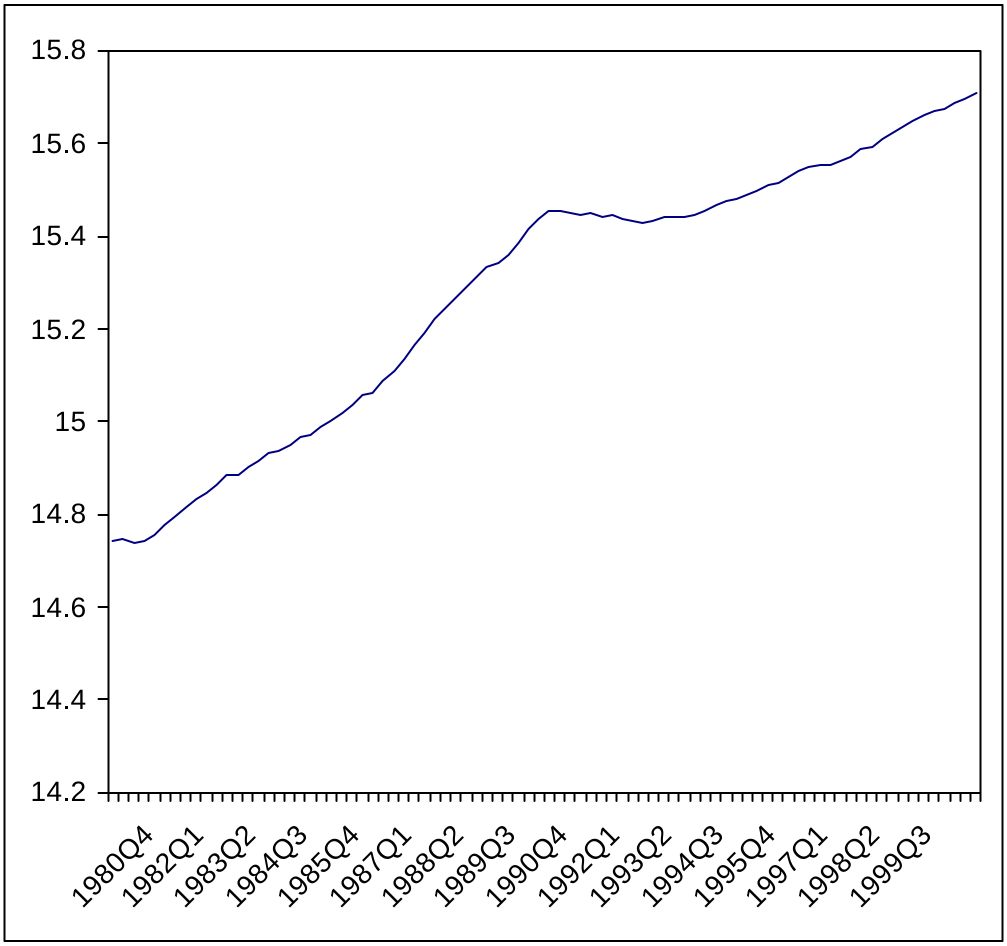


Figure 10. Quarterly M2 Data from 1980.I to 2000.IV*



* The M2 is Seasonally Adjusted. Measured in 100 Million Yen.