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Money Growth Variability and the Term Structure of Interest Rates in Japan

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The hypothesis of this paper is that uncertain money growth leads to an increased yield spread between short term and long term interest rates. Since current inflation is obviously the same at any given time, the change in the term structure can be explained, in part, by the greater degree of uncertainty in the long term caused by monetary uncertainty. This hypothesis is tested by looking at the spread between short term and long term instruments in Japan and determining if increased monetary instability leads to a wider yield spread. We find that a rise in monetary uncertainty is associated with a wider spread between short term and long term instruments in Japan.

## Introduction

In the **Wall Street Journal** (August 30, 1994, p. A6) Bank of Mexico Governor Miguel Mancera Aguayo stated, "Interest rates are very high in Mexico because they contain a risk factor. And what is that risk factor? That inflation might rise again." This quote indicates that uncertainty about the future course of inflation is an important determinant of the overall level of interest rates. The future course of inflation is determined, in large part, by the current and past changes in the rate of growth of the money supply. If there is a fairly stable growth in the money supply over time, then there should be stable expectations about the future course of inflation. Conversely, if there is a past history of instability in the money supply, then the future course of inflation is much less certain in a country. Information about the inflationary expectations of the participants in the financial markets is contained in interest rates. Short run inflationary expectations influence short term rates and longer term expectations influence long term rates. The term structure of interest rates tells us that there is more uncertainty about the course of long term inflation. The upward sloping yield curve indicates that market participants view longer term financial instruments as being more risky because there is simply more uncertainty about the real purchasing power of future nominal payment when we look longer into the future.

If uncertainty causes the yield curve to be upward sloping, it follows that greater uncertainty would cause a more steeply sloped yield curve. While it is widely accepted that uncertainty about the future influences the spread between short and long term interest rates in a given economy, less attention has been paid to the influence of uncertainty across countries. Yet, the uncertainty about the real purchasing power of future nominal payments can vary across countries depending on the uncertainty about future inflation. Given that macroeconomic performance and stability vary so greatly across countries, it should not surprise us that the yield curve could have different slopes

in different countries. It should also not surprise us that an unstable monetary regime should increase the steepness of the slope of the yield curve.

The hypothesis of this paper is that increased instability in money growth leads to a higher yield spread between short term and long term interest rates at a given point in time. That is, the yield curve will be more steeply sloped when there is increased uncertainty about the future created by unstable monetary growth. This hypothesis is tested by looking at the spread between interest rates on short term and long term financial instruments in Japan and seeing if increased monetary instability can explain a wider yield spread. Although we started with a quote about uncertainty in Mexico, we use Japan as a test case because it is a country that has experienced stability in monetary growth in the past. Even given its past record of monetary stability our analysis of the Japanese data supports our hypothesis. We find that an increase in uncertainty about the future course of inflation causes a wider spread between short term and long term interest rates.

The term structure of interest rates has often been used as a test of the financial market participants' ability to forecast the future course of both interest rates and inflation. In that sense, the term structure in general, and this research in particular, wed macroeconomics and finance as it assesses what financial market participants know about the future course of the macroeconomy.

### Past Research

The term structure of interest rates as a precursor of the future course of the economy has been studied by numerous researchers. Fama (1990), Mishkin (1990), and Shiller (1983), among others, have obtained mixed results when testing for the ability of the term structure to accurately assess future inflation and interest rates. In cross country studies, the term structure is an accurate predictor in some countries but less so in others. There are a number of reasons for believing that an increase in monetary uncertainty will

make it more difficult for the term structure to adequately predict the future and thus will increase the yield spread between short and long term interest rates.

From a historical perspective, Baum and Thies (1989) investigated the movements of the interest rate spread during the Great Depression and concluded that the widened spread they observed was an indication of a high liquidity premium. Certainly if the participants in the economy put a premium on holding liquid assets, then the prices of those assets will rise and the yield on them will fall thus leading to a wider spread between short term and long term rates. The question is, why would monetary uncertainty put a premium on holding liquid assets? This idea has been explored by researchers who found that money growth variability influences velocity. Friedman has suggested that an increase in uncertainty about the future course of monetary growth leads individuals to hold more money thus reducing velocity. The effects of money growth variability on velocity have been studied in depth by a number of researchers; however, the results have been mixed.<sup>1</sup> Examining the US, Payne (1992a) found no evidence that money growth or interest rate variability impacted the demand for money. On the other hand, Hall and Noble (1987) and Fisher and Serletis (1989) found that monetary uncertainty caused a velocity decline in the United States and Lynch and Ewing (1995) found similar results for most of the G-7 countries. A velocity decline and a liquidity premium are essentially the same event and thus, these latter results are consistent with a link between instability in the money supply and a steeper yield curve.

Belongia and Koedijk (1988) tested the expectations model of the term structure for several countries, including Japan, over the 1981-1986 period. The expectations

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<sup>1</sup> For evidence that variability in money growth affects velocity see Hall and Noble (1987), and Fisher and Serletis (1989); those not finding support include Mehra (1989). Others have found that the relationship is sensitive to both the proxy for money growth variability and the lag structure, see Payne (1992b). Recently, others have decomposed money growth into its anticipated and unanticipated parts and found support for the monetarist proposition in all of the G7 countries except Italy, see Lynch and Ewing (1995).

model of the term structure suggests that in a riskless world, the one-period interest rate should be equivalent to the expected return to holding a longer term instrument for one period. They regress the spread between actual yields on one-period bills in consecutive periods on the difference between the forward and spot rates on one-period bills and a constant term. The expectations model implies that the coefficient on the future rate - spot rate spread should be one if the forward rate is an unbiased predictor of the future spot rate, and the intercept term should be zero. Of course, they recognize that it is not possible to discern a "true" rejection of this hypothesis from the effect that a non-zero term premium might have. They reject the simple expectations model for three out of five countries in their study, but not for Japan where explanatory power was actually found to be the highest. Belongi and Koedjik generally conclude that the expectations model of the term structure does not hold up. One would expect that it is more difficult for the expectations model to hold up empirically when there is increased uncertainty about the future caused by instability in the growth of the money supply.

The link between inflation uncertainty and the term structure has also been investigated by Backus and Zin (1993) who focus on the dynamics of interest rates. They incorporate risk, in the form of inflation expectations, into the theoretical structure of the yield curve. The central concern of their paper is an attempt to discern what is behind the behavior of long yields. They provide some evidence for an inflation component of nominal yields; however, exactly how inflation expectations affect nominal yields is left unanswered by their paper. Mascaro and Meltzer (1983) contend that money growth volatility contributed to the high nominal interest rates in the US post-1979 period. Thus, while a number of researchers have investigated monetary uncertainty and the term structure and related topics for the United States, the idea that money growth variability affects the term structure of interest rates has not been widely examined outside of the US.

It is a somewhat straightforward proposition that uncertainty and higher interest rates go hand in hand in such countries as Mexico which has a history of high inflation.

However, it is equally interesting to see if the relationship holds in a country with a relatively stable monetary regime such as Japan. Also, with increased importance placed on US-Japan relations, knowledge of the effects of monetary uncertainty in Japan is a timely topic.<sup>2</sup>

### Methodology and Results

We are testing for the existence of a relationship between the uncertainty associated with the variability of past values of money growth and the yield spread of interest rates. Recent advances in macroeconomic modeling have made it possible to discern short term relationships between time-series from long term equilibrium relationships. In order to test the hypothesis we need to determine whether the standard Granger-causality framework can be implemented or if we should take into account the possible cointegration between the series by augmenting the model with what is called an error-correction term. The choice of methodology depends, in part, on the properties of the time-series data themselves.

The data we use are obtained from the International Financial Statistics CD-ROM as quarterly observations over the 1966:4-1992:1 period. As a measure of monetary instability, we construct an eight quarter moving average of the standard deviation of actual money growth ( $\sigma_{mg}$ ).<sup>3</sup> We define the interest rate "spread" as the difference between the long term and short term interest rates. The short rate is the money market

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<sup>2</sup> Interestingly, Lynch and Ewing (1995) report that once one adjusts for different data reporting methods, as suggested by Milton Friedman (1983), Japan has the most stable money supply of the G7 countries, as determined by a normalized measure of the eight quarter standard deviation of actual money growth.

<sup>3</sup> We use seasonally adjusted, quarterly data for narrowly defined money. The eight quarter standard deviation of money growth has been used by others as a proxy for money growth variability in the US (Fisher and Serletis (1989), Mehra (1989), Payne (1993)), and other countries (Arize (1993) and Payne (1992b)).

rate and the long rate is the government bond yield. The money market rate from November 1990 on is the lending rate for collateral and overnight loans in the Tokyo Call Money Market. Prior to November 1990 it is the lending rate for collateral and unconditional loans. The long rate is the arithmetic average yield to maturity of all government bonds with seven years to maturity. (Source: IFS) Figure 1 presents a graph of the two series -- spread and  $\sigma_{mg}$  -- over the sample period. A casual inspection of the graph indicates simultaneous movement in the two variables and suggests a more rigorous investigation is warranted.

Before actually choosing an econometric approach with which to analyze the data, it is necessary to determine whether or not the data are stationary. The importance of recognizing nonstationary behavior in macroeconomic time-series when choosing an econometric approach is pointed out in numerous articles (Engle and Granger (1987) and Johansen (1988), to name a few). A time series is said to be integrated of order  $d$  if it achieves stationarity after being differenced  $d$  times. A time series containing a unit root requires first-differencing in order to obtain stationarity and is said to be first-order integrated,  $I(1)$ . A variable that is stationary in level form, that is without first differencing, is  $I(0)$ . If two time series are nonstationary in levels, but some linear combination of them is stationary, then the variables are said to be cointegrated. In the case where cointegration is present, the standard Granger-causality model includes the lagged residuals from the cointegration regression, known as an error-correction term. However, if the two variables are integrated of different orders then no cointegrating vector exists and the standard Granger-causality test may be implemented.

Cointegration analysis tests for a possible long-run relationship between time series that are both  $I(i)$  where  $i = 1, 2, \dots, n$ . The presence of cointegration is often interpreted as a long-run equilibrium relationship between the variables and, therefore, they can not move “too far” away from each other. (Dickey, et. al. 1991) The most common cointegration procedures are those developed by Engle and Granger (1987) and Johansen (1991). In order to determine if cointegration exists we test for the presence of unit roots and stationarity of the time-series using the Augmented Dickey-Fuller (ADF) test. The ADF test is conducted from estimating the following ordinary least squares equation.

$$(1) \quad X_t = \rho_0 + \rho_1 X_{t-1} + \sum_{i=1}^m \phi_i \Delta X_{t-i} + \varepsilon_t$$

$\Delta$  is the first-difference operator,  $\varepsilon_t$  is a white noise error term, and  $m$  is chosen such that the residuals are serially uncorrelated.<sup>4</sup> The null hypothesis of nonstationarity is rejected if  $\rho_1 < 0$  and statistically significant. MacKinnon (1991) developed finite sample critical values for the ADF test and we use these to determine statistical significance. Results of the unit root and stationarity tests are reported in Table 1 for both levels and first differences. Our findings suggest that spread is  $I(0)$  and  $\sigma mg$  is  $I(1)$ .<sup>5</sup> Thus, spread is level stationary and  $\sigma mg$  is first-difference stationary.<sup>6</sup> Since it is found that the respective

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<sup>4</sup> Setting  $m$  equal to eight was sufficient to ensure  $\varepsilon$  was white-noise.

<sup>5</sup> Our finding that the eight-quarter standard deviation of money growth is  $I(1)$  corroborates that of others. See, for instance, Mehra (1989), Serletis (1990) and Arize (1993). In particular, Chowdhury (1988) and Thornton (1995) found money growth variability in Japan to contain a unit-root.

<sup>6</sup> It is interesting that money growth variability has a stochastic trend, i.e., a unit root. The presence of a unit root implies that shocks are permanently incorporated into the variability of money growth. Therefore, policy aimed at decreasing the uncertainty associated with monetary volatility may have some merit. On the other hand, this finding suggests that shocks that adversely affect money growth variability may also be permanently felt.

time-series are integrated of different orders, no cointegrating vector exists, and we do not proceed to cointegration analysis. Hence, it is appropriate to implement the standard Granger-causality test.<sup>7</sup> Equation (2) gives the specification of the model we estimate.<sup>8</sup>

$$(2) \quad \text{spread}_t = \beta_0 + \sum_{i=1}^p \beta_i \text{spread}_{t-i} + \sum_{j=1}^q \gamma_j \Delta \sigma \text{mg}_{t-j} + v_t$$

A time-series ( $\sigma \text{mg}$ ) is said to Granger-cause another time-series ( $\text{spread}$ ) if the prediction error of current spread declines by using past values of  $\sigma \text{mg}$  in addition to past values of  $\text{spread}$ . We thus test the null hypothesis that all of the coefficients of the lagged values of  $\sigma \text{mg}$  are jointly insignificant. If the null hypothesis is rejected, then the conclusion is that the lagged values of  $\sigma \text{mg}$  cause spread in a Granger sense. Our hypothesis is further supported if the sum of these coefficients is greater than zero, thus indicating that not only does the variability in money Granger-cause the interest rate spread, but it leads to a wider spread.

A Granger test is sensitive to the number of lags employed in the test with too few lags resulting in biased estimates, and lag lengths that are too long leading to unbiased but inefficient results. The Final Prediction Error method is used to determine variable lag lengths on  $\text{spread}$  ( $p$ ) and  $\sigma \text{mg}$  ( $q$ ). We searched sequentially over a number of different lag structures choosing the one that provided the minimum FPE value. The optimal  $[p, q]$  is found to be  $[3, 5]$ .<sup>9</sup> The Granger-causality test is conducted by constructing a standard F-statistic and an asymptotic Chi-square statistic that test the null hypothesis of the joint

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<sup>7</sup> The Granger-causality test requires that the time-series be stationary.

<sup>8</sup> We include a constant term in the equation as the Granger methodology requires that the series be mean-corrected.

<sup>9</sup> Because lagged values of  $\text{spread}$  are included in the model we tested for autoregression using Durbin's  $m$  test. No evidence of autoregression was found for  $\text{AR}(p)$ ,  $p=1,2,3,4$ . These results are available from the authors.

insignificance of the  $\gamma_j$ . The results are presented in Table 2. The F-statistic of 2.74 (p-value = .0236) and the Chi-square of 13.70 (p-value = .0176) allow us to reject the null and conclude that money growth variability causes the interest rate spread in Japan in a Granger sense. Additionally, the sum of the  $\gamma_j$  is positive, suggesting that greater money growth variability led to a wider yield spread in Japan. Mascaro and Meltzer found that monetary uncertainty led to a rise in interest rates in the United States in the early 1980s. Our results lead us to conclude that Japan's experience is similar to that of the United States.

#### Evaluation of the Model

The model performs well in terms of diagnostic tests and dynamic forecasting. Our first check of the model was to test for the presence of autocorrelation in the residuals which, if present, suggests that the error process contains information that could improve the forecasts of the term structure. A lack of autocorrelation is indicative of an adequate representation of the term structure. We find no evidence of autocorrelation, or serially correlated disturbances, based on the results of Box-Pierce and Breusch-Godfrey tests. The corresponding test statistics and associated p-values were, respectively:  $Q = 9.01$ , p-value = 0.91 and  $\chi^2 = 1.93$ , p-value = 0.38.

In ordinary least squares estimation a desirable property of an empirical model is to have homoskedastic disturbances. In some macroeconomic time series the size of the current residuals may be related to the size of recent residuals and thus the ability to predict varies from period to period. The appropriate test for heteroskedasticity in this context is the ARCH (auto-regressive conditional heteroskedasticity) LM test. The results of this test indicated that ARCH is not present in our case.

In order to check the stability of the parameters over time we conducted Chow's Breakpoint Test. We chose 1973:1 as a potential breakpoint since this period corresponded to the beginning of the flexible exchange rate period. The resulting F =

.4229 with p-value = .9191 suggests that the implementation of the flexible exchange rate system did not cause a structural break in the model.

As a further check of the model we performed dynamic forecasting. The dynamic forecast actually uses previously forecasted values of the yield spread for its predictions. Following the literature on this subject we forecasted the last six quarters of our sample period: 1990:4-1992:1. The Root Mean Square Error (RMSE) measure for this period is 1.3125 and the graph of the forecast (not presented here) is entirely within (+) or (-) two standard errors.<sup>10</sup> We interpret the diagnostic and forecasting results as supportive of the model specification chosen to test our hypothesis.

### Concluding Remarks

The introductory quote from the head of the central bank in Mexico, Miguel Mancera Aguayo, opened the discussion that countries that have a past history of a high degree of monetary and inflation uncertainty will have high long term rates. These results show that the impact of money growth variability on the term structure of interest rates in Japan is significant. It is interesting that in a country like Japan, which has a recent past history of a stable monetary regime, increased instability in the money supply also sets off interest rate jitters in financial markets. Diagnostic tests and dynamic forecasting experiments indicate the estimated model is stable and performs reasonably well. Therefore, we conclude that more monetary uncertainty leads to a wider spread between short and long interest rates for Japan.

Generalizing this result, it has been found that countries with higher inflation have lower long term real growth rates than countries with lower inflation. It is also known that the higher the inflation rate, the greater the instability in inflation. This research

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<sup>10</sup> As a further test we compared dynamic forecasts over 1990:4-1992:1 of the Autoregressive model (with 3 lags) and the full model. The RMSE for the full model was lower.

provides a potential link between these two observations by tying an uncertain money supply to higher long term real interest rates which reduce investment. A further investigation of these results can have important implications for the implementation of appropriate monetary policy.

Table 1  
Augmented Dickey-Fuller Tests for Presence of Unit Root

Variable	Statistic for Levels	Statistic for First-Differences
spread	-3.900*	----
σmg	-1.417	-3.29**

\* (\*\*) significant at the 1% (5%) level. MacKinnon critical values are used to determine significance.

Table 2  
Granger-Causality Test of Effect of Monetary Variability on Interest Rate Spread

Variable	Estimated Coefficient (t-statistic)
constant	0.0587 (0.8293)
spread <sub>t-1</sub>	1.1361 (10.732)
spread <sub>t-2</sub>	-0.2786 (1.7702)
spread <sub>t-3</sub>	-0.0693 (0.6513)
$\Delta\sigma m_{t-1}$	15.5982 (1.8502)
$\Delta\sigma m_{t-2}$	4.6623 (0.7284)
$\Delta\sigma m_{t-3}$	-9.3687 (1.5319)
$\Delta\sigma m_{t-4}$	10.0434 (1.16031)
$\Delta\sigma m_{t-5}$	-17.3884 (2.0972)

Adjusted R-squared = 0.7896

Granger-Causality: F = 2.74

Chi-square = 13.70

p-value = 0.0239

p-value = 0.0176

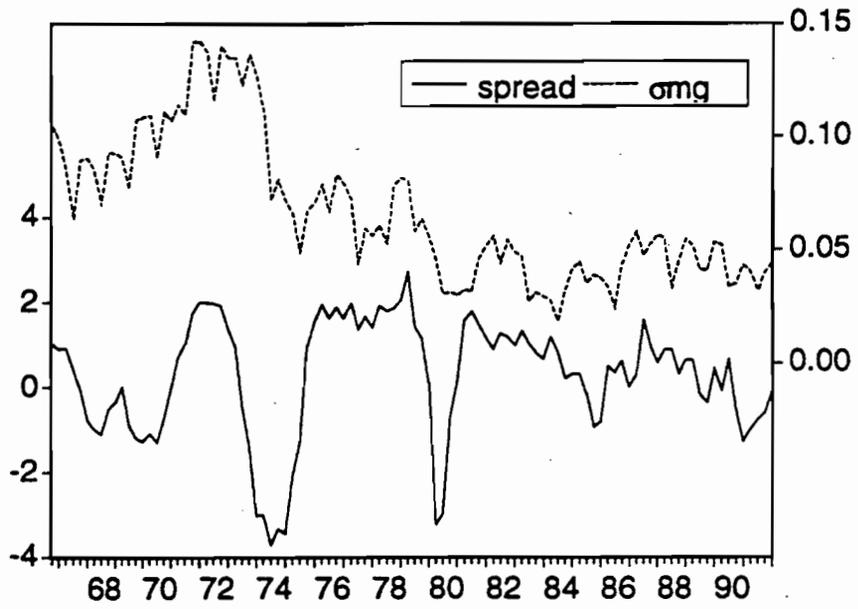


Figure 1: The interest rate spread and variability of money growth

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