The Economic Journal of Nepal, Vol. 32, No. 2, April-June 2009 (Issue No. 126) © CEDECON-TU

Monetary Approach to Exchange Rate: Forecasting with VAR VECM

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Abstract

This paper explores to what extent the yen/dollar exchange rate follows the prediction made by the monetary exchange rate model. Post Bretton-Woods period (1973:1-2003:1) data are used for the purpose. We find some support for the monetary model. We estimate VAR, VECM, and AIRMA (0,1,4) models to forecast the yen/dollar exchange rate. The findings indicate that the VAR models are relatively better than other two alternative models for short-term yen/dollar exchange rate forecasting.

Introduction

The basic idea of the monetary approach to exchange rate (MAER) is that there exists a long run proportionality of the nominal exchange rate to relative money supplies between countries. This prediction is due to the fact that an exchange rate is the price of the two monies, and price of money increases at the relative rate of money supply in the long run. This monetary approach hypothesis is the open economy version of the quantity theory model.

This paper has dual objectives. The first objective is to test if the monetary model of the exchange rate holds between yen/dollar exchange rates. The second objective is to construct some form of vector autoregressive (VAR) system based on the monetary exchange rate model and test their forecast performances. Both VAR and vector error correction models (VECM) are constructed and used for the purpose. For comparison purpose, an ARIMA model is also constructed. Estimation results show that monetary model has mixed support for the theory. The 3-equation and 4-equation VAR models are good forecast models up to five quarters, but not beyond. ARIMA (0,1,4) gives comparable forecast results, but forecast errors are larger than the case of VAR models. However, VECM models are not good at all for predicting yen/dollar exchange rate.

The paper is organized as follows. After a brief literature review in section 2, the theoretical model and testing strategy is presented in section 3. Section 4 describes the data and the empirical results. The final section concludes.

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Literature Review

Frankel (1979) derives the theoretical monetary model of exchange rate determination, called the 'real-interest differential' (RID) model, and presents consistent empirical test for the theory.# Boothe and Glassman (1987) demonstrate that the RID models are inconsistent, and provide an alternative explanation for the empirical problems of the monetary models in general and RID model in particular. The main attraction of the RID model is that it synthesizes two competing models of exchange rate determination: the 'flexible-price' and 'sticky-price' models. The former is often called the 'Classical Approach' and the later is called the 'Keynesian Approach'.

Bilson (1978) finds strong support for the monetary approach in general and concludes, "... It appears that the marriage of theory and evidence, which appeared precarious in the early years of the float, has strengthened over time as theory had developed and evidence accumulated." DeJong and Husted (1993) neither find support nor can they reject the MAER using the exchange rate relative to the US dollar of the currencies of Canada, France, Germany, Japan, the Netherlands, and the UK for the period 1974:1-1988:12. Diamandis and Kouretas (1996) conclude that an unrestricted monetary model is a valid framework for analyzing the long-run equilibrium relationship of the exchange rate. They find support for the proportionality hypothesis of the exchange rate to the relative monies for the bilateral exchange rate between Greek drachma and US dollar, the Deutschemark, the French franc and the pound-sterling. Markydakis (1998) finds no support for the proportionality hypothesis between the Korean won-US dollar exchange rate and the relative money supplies using monthly data from 1980 to 1995 despite the fact that the unrestricted monetary model provided the valid explanation of the long-run nominal won-dollar exchange rate. Dutt and Ghosh (2000) find support for MAER under both fixed (1959-1972) and flexible (1973-1996) rate period using the yen-dollar nominal exchange rate.

Miyakoshi (2000) finds support for the MAER. Using the Korean won-German mark exchange rate, he finds support for the restrictions on the monetary models. Moersch and Nautz (2001) provide an alternative structural model to the commonly used reduced form approach to the MAER as it imposes implausible restrictions on the parameters of the exchange rate forecast equation. Using the DM/Dollar exchange rate, they find that the structural model outperforms alternative reduced form model. Karfakis (2003) finds support for the monetarist model using Lei/Dollar exchange rate and Romanian and US macroeconomic variables.

Another interesting study about the monetary models was done by Schroder and Dornau (2001). Instead of the observed values, they used expected values of the economic fundamentals as explanatory variables. They found strong significance of the expected foreign GDP growth that determines the exchange rate between DM/US dollar, DM/British pound, DM/Japanese yen, DM/French franc and DM/Italian lire. Rapach and Wohar (2002) observe that the problems with the monetary models on the empirical front appeared due to the shorter horizon data sets. Using almost a century long data set from 14

Frankel's empirical test suffers from time series data problems like non-stationary and cointegration.

different industrialized countries, they found considerable support for a simple form of the long-run monetary model of the US dollar exchange rate determination for France, Italy, Spain and the Netherlands, and moderate support for three other countries indicating that monetary model is not as elusive as it appeared in some studies.

Theory and the Testing Strategy

The basic monetary model assumes stable real money demand functions for the domestic and the foreign countries. In that case, the money market equilibrium in both of the economies is given by:

(1) $m_t - p_t = ay_t - bi_t$

(2) $m_t^* - p_t^* = ay_t^* - bi_t^*$

where m_t is domestic money supply, p_t is the domestic price level, y_t is domestic real output, and i_t is the domestic nominal interest rate. Asterisks denote the corresponding foreign variables. All of the variables are in log-level form except the interest rates. Here the explicit assumptions are that the income elasticities (á's) and the interest semi-elasticities (â's) are same across the countries.

Subtracting (2) from (1) yields the following:

(3) $p_t - p_t^* = (m_t - m_t^*) - \alpha(y_t - y_t^*) + \beta(i_t - i_t^*)$

If purchasing power parity (PPP) holds, then (3) can be written as

(4) $s_t = (m_t - m_t^*) - \alpha(y_t - y_t^*) + \beta(i_t - i_t^*)$

Equation (4) can be estimated econometrically in the following form:

(4a) $s_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3(i_t - i_t^*) + u_t$

where s_t is the log-level of the spot exchange rate between domestic and foreign moneys, u_t is the stochastic error term, and â's are the regression coefficients. If the uncovered interest parity holds, then

(5) $(i_t^* - i_t) = E(\Delta e_{t+1} \mid I_t)$

where *E(.)* is the expectation operator conditional upon the available information at period *t*. In the steady state (long-run) $\Delta e_{t+1} = 0$ if e_t is *I(0)* or *I(1)* process (Rapach and Wohar 2002), then we have

(6) $s_t = (m_t - m_t^*) - \alpha(y_t - y_t^*)$

It can be estimated econometrically using the following equation:

(6a) $s_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + u_t$

For empirical studies, Rapach and Wohar (2002) tested eq. (6a) type of model* while others used eq. (4a) type model to test the validity of the monetary approach. These equations impose the parameter restrictions by construction. Alternatively, the reduced form equation can be expressed without the parameter restriction, and test the hypothesis on those parameter restrictions. Such an unrestricted version of the monetary exchange rate model can be expressed as:

(7) $s_t = \beta_0 + \beta_1 m_t + \beta_2 m_t^* + \beta_3 y_t + \beta_4 y_t^* + \beta_5 i_t + \beta_6 i_t^* + u_t$

The main assumption of this model is that money demand functions are identical in both the domestic and the foreign countries. It is expected in the monetary model that exchange rate and the relative money supply should be proportional in the long run. The coefficients are expected to be: $\hat{a}_1 = 1$, $\hat{a}_2 = -1$, $\hat{a}_3 + \hat{a}_4 = 0$, and $\hat{a}_5 + \hat{a}_6 = 0$. The only difference between (4a) and (7) is that we have parameter restrictions in equation (4a), and we want to test those restrictions in the case of equation (7).

In order to implement the empirical tests, we first have to decide whether the relevant time series are stationary. We use the Augmented Dickey-Fuller unit root test to test the stationarity of the series. If all the relevant series are integrated of order one [*I(1)* processes] then, first differencing is the natural course of action to stabilize the series. However, time series data might have long run relationships (cointegrated) such that they might be moving together. Differencing throws such information away about the long run relationship. If relevant series are cointegrated, then we have to put back the long run relationship through error correction. The idea behind the cointegration test is that while a set of variables are *I(1)* processes individually, a linear combination of the variables might be a *I(0)* process so that those cointegrated variables can not drift far apart permanently. Both the unit root test and the cointegration test are implemented for the series under consideration.

In order to analyze the monetary exchange rate model, we use the error correction model (ECM) as the relevant series are I(1) processes, their first differences are I(0) processes, and all the variables except the interest rate differential are cointegrated. For the VAR modeling, we adopt the restricted version of the monetary models given by equations (4a) and (6a) as the parameter restrictions help to limit the number of parameters to be estimated in the VAR system. This restricted version of the model is chosen for the analysis as we have less than 30 years of quarterly data (small sample). The parameter restrictions help to preserve the efficiency of the small sample case.

Let $ms_t = (m_t - m^*_t)$, $inc_t = (y_t - y^*_t)$, $int_t = (i_t - i^*_t)$, and also let $\grave{U}_t = \{ ms_{t, \ldots,} ms_{t-k+1,} inc_{t, \ldots,} inc_{t-k+1,} int_{t, \ldots,} int_{t-k+1,} s_t, \ldots, s_{t-k+1}\}'$, then the k[th] order

* They used the over a century data that can be considered as a long-run scenario

VAR model can be expressed as:

$$(8)\quad s_t = \phi\Omega_{t-1} + u_{1t}$$
$$ms_t = \psi\Omega_{t-1} + u_{2t}$$
$$inc_t = \Sigma\Omega_{t-1} + u_{3t}$$
$$int_t = \Pi\Omega_{t-1} + u_{4t}$$

where ϕ, ψ, Σ and Π are coefficients vectors of order 1*4k, and u_{it} are the error terms (white noise). The VAR system is used to forecast the out-of-sample nominal exchange rate for the Japanese yen/US dollar. For the estimation purpose we use 1973:1-2000:4 data, and the remaining nine observations (2001:1-2003:1) are kept aside for the out-of-sample forecast comparisons. Based on the results of unit root and cointegration tests, we also estimate the VECM to compare its results with VAR results in terms of forecast performance. The forecast performance is tested using Theil's U-statistics. In both the VAR model and VECM, quarterly dummies are used to account for the seasonality. Finally, results from VAR and VECM are compared with ARIMA models.

Data and Empirical Results

Data

The International Monetary Fund collects several economic data series for all member countries. The Fund's international financial statistics (IFS) provides those data online. As this study is mainly focused on the post Bretton Woods period, quarterly data from 1973:1-2003:1 are used for the analysis. We treated Japan as the home country and the US as the foreign country. The nominal exchange rate is expressed as yens per dollar. Both monetary aggregates are M1 measures. In IFS, the Japanese real GDP starts from 1980, so we use industrial production indices as the proxies for the real income of both countries.[+] Interest rates are short run end-of-the-period rates.

Dickey-Fuller Unit Root Test Results

In order to see if the time series data are stationary, we use the augmented Dickey-Fuller (ADF) unit root tests. The ADF test can be expressed in the following form:

$$(9)\ \Delta y_t = \alpha + \delta\, y_{t-1} + \Sigma\, \theta_i\, \Delta y_{t-i} + \varepsilon_t$$

where y_t is the variable of interest. The null of nonstationarity is $d = 0$. The number of lags in (9) depends on whether those lag-dependent terms are significant, and whether the error process is white noise with the given number of lag-dependent variables. The objective of the inclusion of the lagged dependent variables is to clean up the serial correlation in Δy_t. We employ the AIC and SC criteria to decide the optimal lag length. But, in our case,

[+] Most of the previous studies used the industrial production index as a proxy for the real income.

these criteria do not give very satisfactory results. The AIC suggests that more than 15 lags are optimal, and SC suggests just the opposite that just 1 lag is sufficient in most of the series. As we have less than 30 years of quarterly data, using more than 15 lags is inefficient as we will lose considerable degrees of freedom, and using just one lag based on SC may not account for the dynamics involved in the quarterly data.

One way to avoid such conflicting criteria is to use the lags up to the point where the error process becomes white noise, and those lags are significant. In our case, the error processes are white noise with 4 lags, and it is consistent with the nature of the data (quarterly). The ADF unit root test results are presented in the following table. The *t*-statistics for *d* is greater than the critical values in the case of log-level series, and it is less than the critical values in the case of the first differences.

Table 1. Unit Root and Stationarity Tests

Variable	Log-level		First difference	
	t-statistics[1]	Nature of series	t-statistics[2]	Nature of series
s_t	-2.745	I(1)	-9.661***	I(0)
$m_{t-} m_t^*$	-0.797	I(1)	-11.341***	I(0)
$y_t - y_t^*$	-1.683	I(1)	-11.960***	I(0)
$i_t - i_t^*$	-2.714	I(1)	-7.314***	I(0)

1 Critical values: 1%= -4.039, 5%= -3.448, 10%= -3.149 (with time trend, and intercept)

2. Critical values: 1%= -3.486, 5%= -2.885, 10%= -2.579 (with intercept)

✧ **** Indicates that the null of non-stationarity is rejected at 1% level using ADF test.*

The results in table 1 show that all the log-level series are non-stationary i.e. they are integrated of order one (*I(1)* processes), and the first differences of all the series are stationary (*I(0)* processes). The autocorrelation functions (ACFs) of all series in terms of log-levels show that the ACFs die out very slowly indicating that the non-stationarities of the log-level series are highly persistent. On the other hand, the ACF's of the first differenced series die out quickly indicating that those differenced series are stable.[**]

Cointegration Tests

There are some competing alternative methods for testing the cointegration between time series variables. In this paper, we use the two-step Engle-Granger type cointegration tests.[##] In this test, we regress one variable (say s_t) on another variable (say m_t-m_t*), and extract the residuals. Then we run the regression of the first difference of the residuals on

** ACF graphs are not reported here to save space.

Alternatives to Engel-Granger bivariate cointegration test are Johansen's system approach, and Kremers et al.'s (1992) one-step procedure.

its lagged values. The null of no cointegration is tested against the alternative of cointegration. The test results between four different variables (s_t, $m_t - m_t^*$, $y_t - y_t^*$, and $i - i_t^*$) are presented in the following table.

Table 2. Cointegration Tests

Variable	$(m_t - m_t^*)$	$(y_t - y_t^*)$	$(i_t - i_t^*)$
s_t	-3.804***	-3.643**	-2.762
$(m_t - m_t^*)$		-3.307	-1.306
$(y_t - y_t^*)$			-1.784

- Ø *Critical values: 1%= -4.32, 5%= -3.78, 10%= -3.50 (with time trend)*
- Ø **** Indicates that the null of no cointegration is rejected at 5% level*
- Ø *** Indicates that the null of no cointegration is rejected at 10% level.*

Table-2 shows that s_t and $(m_t - m_t^*)$, and s_t and $(y_t - y_t^*)$ are cointegrated meaning that they are moving together in the long run. However, s_t and $(i_t - i_t^*)$ are not cointegrated. As three out of four variables under consideration are cointegrated, the first step to construct a VAR model is to use the variables in the log-levels, as differencing throws information away regarding long-run relationships between the variables. Before running the VAR or VECM models, it would be good to have a look in the simple monetary model's performance.

Results from Simple Monetary Model

As the time series log-level data are *I (1)* processes, and the first differences are *I(0)* processes, we can use the ECM to see if the results are consistent with what the monetary model predicts. The first step to estimate the ECM is to regress the s_t on all three fundamental variables (in log-levels) and get the residuals. Then we regress the difference of the s_t on the difference of the all independent variables including the lagged residuals from the first stage regression. The results from the ECM are reported in the following table.

Table 3. Single Equation Monetary ECM results

Variable	Coefficient	P-value
Constant	-0.0076	0.1842
$DLMS_t$	0.2246*	0.0901
$DLINC_t$	-0.1717	0.3942
$DINT_t$	0.0043	0.5933
U_{t-1}	0.0852	0.3725

- Ø *D in front the relevant variable refers to the first difference, and L indicates that the series is in log.*
- Ø **Significant at 10% level*

The results from the ECM show that the coefficients of $(m_t - m_t^*)$ and $(y_t - y_t^*)$ have the expected signs, and the coefficient is significant at 10% level in the case of relative money supply. The sign of the interest differential is opposite to what the theory predicts, but it is highly insignificant (p-value = 0.5933). These results indicate that monetary model may hold to some extent in the case of yen/dollar nominal exchange rate determination.

Exchange Rate Forecasting

Vector Autoregressive (VAR) Method

The monetary exchange rate model seems to be valid (to some extent) in the case of the yen/dollar nominal exchange rate. The next step is to construct the VAR model for forecasting and compare the forecasted values with the *out-of-sample* values. We construct both equation (4) and equation (6) type log-level VAR models. We choose the log-level VAR models in the first place as the concerned series are *I(1)* processes, and they are cointegrated except the interest rate differential. As the interest rate differential $(i_t - i_t^*)$ is not cointegrated with any of the other variables (Table 2) we construct an equation (6) type VAR model as well to see if it is better than the equation (4) type VAR model. We might be running a spurious regression if we use log-level form for equation (4) as the interest differential is not cointegrated with any of the other variables. In order to avoid such spuriousness, we also construct a VECM that takes care of both the spuriousness between s_t and the interest rate differential and also preserves the long-run relationship between s_t and relative money supply and the relative real income between Japan and the US.

The VAR order has been selected based on the frequency of the data as the AIC and the SC criteria give conflicting results as discussed earlier (section 3.2). The forecasting performance results from both four-variable and three-variable log-level VAR models are presented in table 4.

We estimated the VAR models using 1973:1-2000:4 data, and kept nine observations (2001:1-2003:1) for *out-of-sample* comparison of the actual exchange rate with the forecasted values. Results from 3-variable and 4-variable VAR models are presented in Table 4.

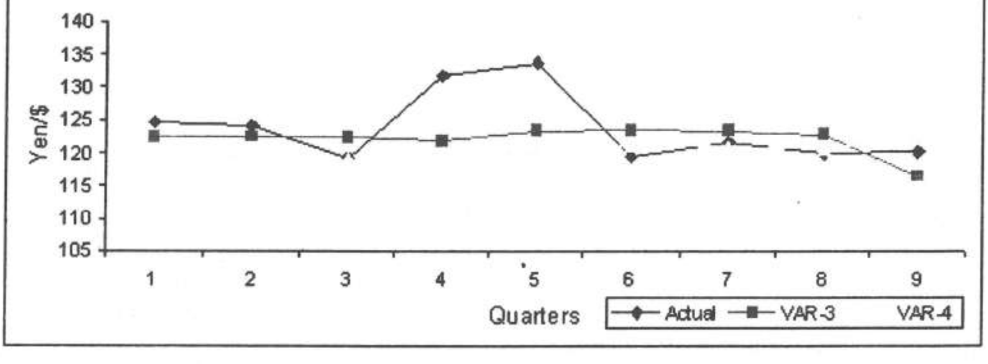
Table 4. Level-VAR Models Forecasting Performance (four lags)

Year: Quarter	Actual	VAR-3			VAR-4		
	Ex-rate	Forecast	Error (%)	Theil's U	Forecast	Error (%)	Theil's U
2001:01	124.60	122.39	-0.018	0.849	119.09	-0.044	0.869
2001:02	124.05	122.48	-0.013	0.285	119.34	-0.038	0.078
2001:03	119.30	122.32	0.025	0.843	119.25	-0.000	0.707
2001:04	131.80	121.78	-0.076	0.710	118.85	-0.098	0.898
2002:01	133.80	123.34	-0.074	0.200	120.66	-0.094	0.046
2002:02	119.45	123.47	0.034	3.978	121.00	0.013	2.542
2002:03	121.55	123.35	0.015	0.317	121.00	-0.004	0.207
2002:04	119.90	122.84	0.024	2.476	120.69	0.006	2.397
2003:01	120.15	116.46	-0.031	0.731	122.61	0.020	0.986

• *Exchange rates are nominal values, not in logs.*

The Theil's U forecast statistics for both VAR models show that both models are good to forecast exchange rate up to first five quarters only. It is because the U statistics are over 1 in some quarters after the fifth period indicating bad forecast performance of the model beyond 5th quarter. In order to compare the eq (4) type VAR model with the eq (6) type, we estimated 3-variable VAR model as well. The forecast performance of 3-variable VAR model is comparable to the 4-variable VAR model. One visible difference between the 3-variable VAR model and the 4-variable VAR model is that the former is over-predicting while the latter is under-predicting. It can be seen from the following Fig.1.

Fig.1: Forecast comparision between VAR-3 and VAR-4



Both of the forecast lines look very stable despite the ups and downs in the actual exchange rate. To account for such ups and down in the actual exchange rate, we need to know if there were any policy changes in any of the countries during the study period. In this paper we have not used such exogenous information for modeling purpose.

Vector Error Correction Method (VECM)

As discussed earlier, we are also interested to see if VECM is a good forecast model for the yen/dollar exchange rate. Forecast statistics from the 3-variable and 4-variable VECMs are presented in table 5. When we compare 3-variable VECM forecast statistics with that of the 4-vriable case, we see from Table 5 that the 3-variable VECM over-predicts the exchange rate in most of the periods, where as the 4-variable VECM grossly under-predicts the exchange rate for the entire out-of-sample nine quarters. The forecast errors are well within 5 % in the case of 3-variable VECM. This relatively low forecast error might lead one to make inference that 3-variable VECM is a good forecast model. But, it turns out that it is not a good forecast model for the yen/dollar exchange rate as the U-statistics are well over 1 in most of the cases. In the case of 4-vriable VECM, the forecast errors are up to 17 percent.

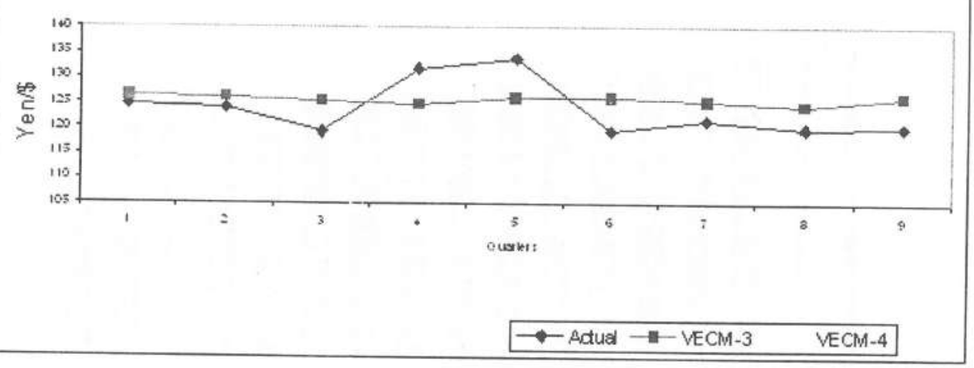
Table 5: VECM Models Forecasting Performance (four lags)

Year: Quarter	Actual	VECM-3			VECM-4		
	Ex-rate	Forecast	Error (%)	Theil's U	Forecast	Error (%)	Theil's U
2001:01	124.6	126.37	0.014	1.116	111.484	-0.105	1.093
2001:02	124.05	126.09	0.016	0.926	111.050	-0.105	0.901
2001:03	119.3	125.39	0.051	1.134	110.175	-0.076	1.096
2001:04	131.8	124.65	-0.054	0.877	109.257	-0.171	0.866
2002:01	133.8	125.99	-0.055	0.887	110.449	-0.171	0.664
2002:02	119.45	125.99	0.055	2.741	109.931	-0.080	2.150
2002:03	121.55	125.24	0.030	1.370	108.978	-0.103	1.398
2002:04	119.9	124.46	0.038	1.787	107.985	-0.099	1.660
2003:01	120.15	126.08	0.049	0.766	109.082	-0.092	0.572

Exchange rates are nominal values, not in logs.

Following figure shows that 4-variable VECM (VECM-4) under predicts the out-of-sample exchange rate, where as 3-variable VECM (VECM-3) over predicts most of the time except two quarters in the middle.

Fig.2: Forecast comparision between VECM-3 and VECM-4



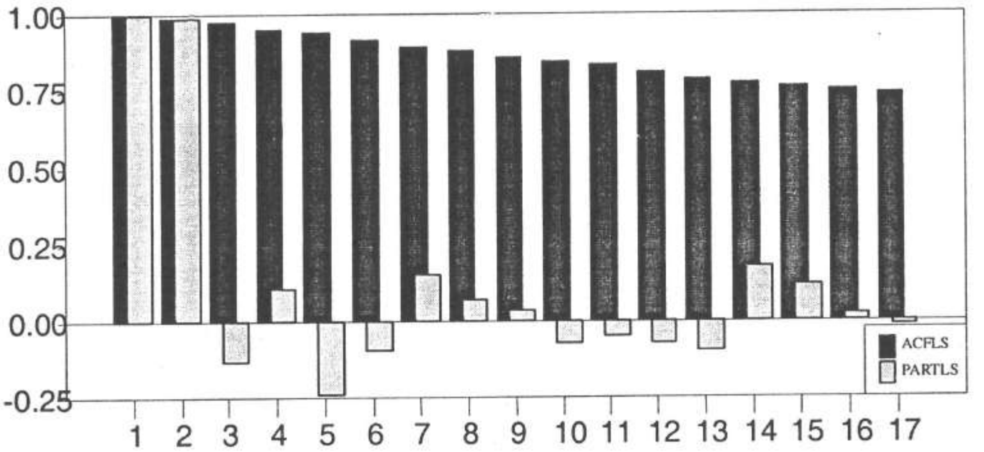
ARIMA Method

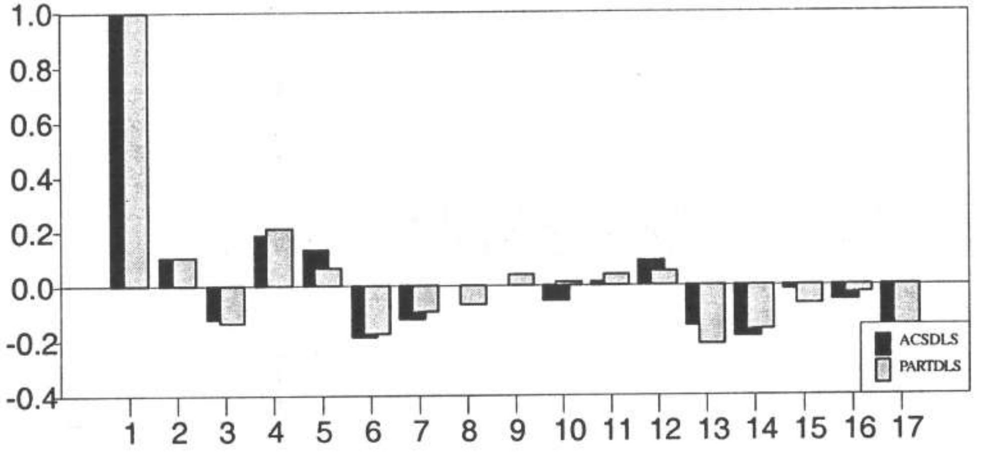
For the comparison purpose, we also examine univatiate ARIMA method for forecasting the yen/$ exchange rate. In fig 5, the upper' panel exhibits the ACF (autocorrelation function) and PACF (partial autocorrelation function) of log (yen/$) series. The ACF function is highly persistent meaning that the series is non-stationary. After taking the first difference of log (yen/$) series, it becomes stable as indicated by ACF and PACF (lover panel of fig. 5). After the differencing, the series appears like an MA (q) process. We use AIC and Q-statistics for appropriate lag length selection for the MA(q) process.

Table 6: Diagnostics for RW and ARIMA (p,r,q) Process

Process	AIC	Q_{16}	P-value
ARIMA (0,1,1)	-615.99	27.80	0.033
ARIMA (0,1,2)	-614.61	25.96	0.054
ARIMA (0,1,3)	-613.17	24.87	0.072
ARIMA (0,1,4)	-614.62	16.01	0.452

Fig 5: ACF and PACF of log (yen/$) and difference of log (yen/$) series



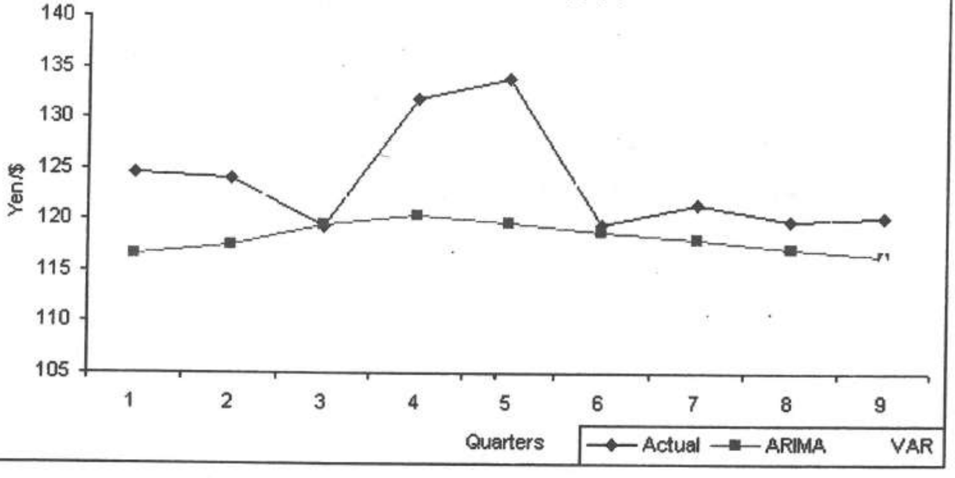


Clearly, AIC is minimum for the ARIMA(0,1,1) process. But, the error process is not white noise as indicated by the p-value of Q-statistics. Here the only model that has clean error process is ARIMA(0,1,4) (p-value = 0.452 for Q-statistics). So, we use ARIMA(0,1,4) for making forecasting comparison with VAR models. Table 7 presents the forecast results for ARIMA (0,1,4) and also from VAR-3 models for comparison. ARIMA(0,1,4) forecasts are comparable to VAR-3 forecasts in terms of Theil's U statistics. The difference is that ARIMA(0,1,4) has larger forecast errors. Fig. 3 exhibits the forecast performance of ARIMA(0,1,4) and VAR-3 models.

Table 7: Comparison of ARIMA (0,1,4) and VAR-3 Forecast Performance

Year: Quarter	Actual	ARIMA (0,1,4)			VAR-3		
	Ex-rate	Forecast	Error (%)	Theil's U	Forecast	Error (%)	Theil's U
2001:01	124.6	116.6	-0.064	0.819	122.39	-0.018	0.849
2001:02	124.05	117.48	-0.053	0.534	122.48	-0.013	0.285
2001:03	119.3	119.56	0.002	0.663	122.32	0.025	0.843
2001:04	131.8	120.4	-0.086	0.408	121.78	-0.076	0.710
2002:01	133.8	119.6	-0.102	0.241	123.34	-0.074	0.200
2002:02	119.45	118.81	-0.005	2.031	123.47	0.034	3.978
2002:03	121.55	118.02	-0.029	0.83	123.35	0.015	0.317
2002:04	119.9	117.23	-0.022	1.544	122.84	0.024	2.476
2003:01	120.15	116.46	-0.031	0.731	116.46	-0.031	0.731

Fig. 3: Forecast comparision between ARIMA(0,1,4) and VAR-3 models



We can see from fig. 3 that ARIMA (0,1,4) under predicts the exchange rate. Over all, VAR-3 model performance is better than all other alternatives considered in this paper.

Concluding Remarks

We test the monetary exchange rate model using the yen/dollar exchange rate for the period 1973:1-2003:1. We find some support for the monetary model as we find a positive and significant relationship between the yen/dollar exchange rate and the relative money supply between two countries. Unit root and the cointegration tests also support the hypothesis that there exists a long run relationship between the exchange rate and the monetary fundamentals between the two countries.

In our case study, we find that the VAR models are good enough to forecast exchange rate movements for the short period, but those models will give bad forecast if used to forecast exchange rate over five quarters. Also, ARIMA (0,1,4) provides comparable forecasts to VAR, but forecast errors are larger in the case of ARIMA (0,1,4). Despite the fact that the yen/dollar exchange rate is cointegrated with relative money supplies and the relative incomes between Japan and the US, the VECM appeared to be an inappropriate forecast model. This lack of predictability of the VECM could be due to the absence of the relevant information about the policy changes in either country during the study periods. So the natural extension of the model would be to use this extra information while constructing VAR models or VECMs. Another way of looking at the problem is to use the multivariate cointegration analysis to verify whether cointegration is present in all the data series.

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