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Long-Run Demand for Money in Hong Kong: An Application of the ARDL Model

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Abstract

We examine the long-run demand for money of Hong Kong using the autoregressive distributed lag (ARDL) cointegration procedure on quarterly data over the period 1985Q1-1999Q4. Estimation results suggest that HK$M2 is cointegrated with its determinants. In addition, the CUSUM and CUSUMSQ tests confirm the stability of the money demand function.

Key words: money demand; Hong Kong; cointegration; error correction model; CUSUM test

JEL classification: C12; C22; E41

1. Introduction

There have been growing efforts among economists to re-examine an economy's money demand function, especially its long-run stability. This is in large part attributed to the rapid growth of cointegration techniques solving problems associated with non-stationary data and to revising the conventional closed-economy specification to take into account the impacts of foreign factors on the demand for domestic currency. External factors such as variations in foreign exchange rates or interest rates should, to some extent, affect the composition of optimal money holdings. For instance, expectation of exchange rate depreciation may increase the attractiveness of foreign assets, and induce individuals to substitute foreign assets for domestic assets including money balances. Failure to incorporate such foreign considerations in the money demand function could cause model misspecification and instability.

The 1997 Asian financial crisis has demonstrated the self-enforcing element of

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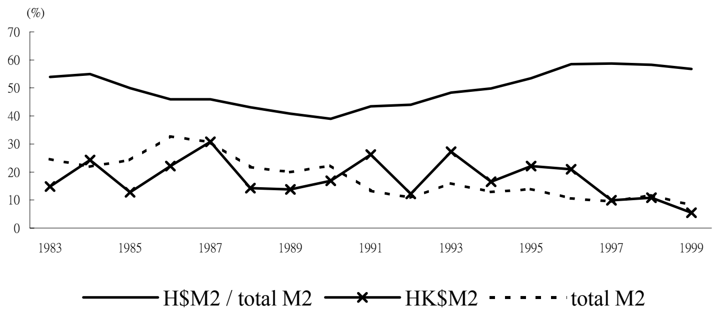
a crisis, prompting researchers or policy makers to re-examine its causes and the mechanism through which a financial crisis reinforces itself. Among other things, it could be seen as a process of accelerating currency substitution by domestic residents to hedge for foreign exchange risk. Exchange rate depreciation could cause the expectation of further currency depreciation and force individuals to shift their portfolio to hold more foreign money to avoid the associated capital loss. This could result in a vicious circle of exchange rate depreciation, continued currency substitution, and loss of confidence. This would in turn, if powerful and persistent enough, develop into a financial crisis. It has been widely argued that expectation of exchange rate depreciation generates a currency substitution effect on the demand for money [e.g., Arango and Nadiri (1981), Bahmani-Oskooee and Rhee (1994), and Bahmani-Oskooee and Techaratanachai (2001)]. This has important implications for Hong Kong, a small and extremely open economy and an international financial centre. Persistent currency substitution could pose challenge to Hong Kong's pegged exchange rate regime, forcing the authorities to abandon the pegged rate or the entire exchange rate peg.

Hong Kong has experienced rapid growth in its broad money aggregate (i.e., HK$M2) and a marked change in the ratio of HK$M2 to total M2 aggregate (including foreign currency M2). Growth rates of HK$M2, total M2, and HK$M2's share of total M2 in Hong Kong for the period 1983-99 are shown in Figure 1. HK$M2 grew rapidly by 17.7 percent per year over this period, though the growth rates showed a rather adverse pattern (relative to those of total M2). It reached as high as 30.76% in 1987 and 27.28% in 1993 before slowing to an average of 8.7% in 1997-99. In addition, the ratio of HK$M2 to total M2 dropped sharply from 53.9% in 1983 to 39.0% in 1990 but then climbed back to an average of 58.0% during 1996-1999. The volatile growth rates of HK$M2 (coupled with the adverse pattern of HK$M2/total M2) offer an interesting background.

Figure 1. Growth rates of HK$M2, total M2, and the ratios of HK$M2 to total M2, 1983-1999



The primary purpose of this paper is to estimate the demand for money function in Hong Kong and specifically to examine whether a long-run equilibrium relationship exists among Hong Kong's broad money aggregate and its determinants using cointegration analysis. In addition to establishing cointegration, we also test for stability of cointegrating vectors. We adopt an open-economy money demand function that, apart from a scale and a domestic interest rate variable, explicitly incorporates external factors including the foreign exchange rate and interest rate.

The outline of this note is as follows. Section 2 specifies the money demand model to be estimated and briefly describes the methodology. Section 3 reports the empirical results, and Section 4 concludes. Definitions and sources of data are provided in the Appendix.

2. Model Specification and Estimation Techniques

We extend the conventional demand for money by incorporating foreign sector considerations. Assume an open economy in which domestic residents can choose to hold wealth in a portfolio of four assets: domestic money, foreign money, domestic bonds, and foreign bonds. Expected depreciation of domestic currency is then the measure of return on holding wealth in the form of foreign money, and the foreign interest rate (adjusted for expected depreciation rate) measures the rate of return on foreign bonds. The demand for real money balances is then determined by a scale variable proxied by real domestic income and other variables that measure the opportunity cost of holding domestic money—namely, the domestic interest rate, the foreign interest rate, and the foreign exchange rate. Therefore, the demand for money takes the following form:

$$ln\, M_t = a + b\, ln\, Y_t + cR_t + dFR_t + e\, ln\, EX_t + \varepsilon_t, \quad (1)$$

with M_t as the broad money balances in real terms, Y_t as the scale variable proxied by real income, and R_t and FR_t measuring the domestic and foreign interest rates respectively. Denote by EX_t the foreign exchange rate measured as the index of the nominal effective exchange rate and by ε_t the error term.

Variation in the foreign exchange rate may have two effects on the demand for domestic currency. On the one hand, as argued for instance by Arango and Nadiri (1981) and Bahmani-Oskooee and Rhee (1994), there is a wealth effect. Assume that wealth holders evaluate their asset portfolio in terms of their domestic currency. Exchange rate depreciation would increase the value of their foreign assets held and hence be wealth enhancing. To maintain a fixed share of their wealth invested in domestic assets, they will repatriate part of their foreign assets to domestic assets, including domestic currency. Hence, exchange rate depreciation would increase the demand for domestic currency. On the other hand, exchange rate movements may generate a currency substitution effect, in which investors' expectation plays a crucial role. If wealth holders develop an expectation that the exchange rate is likely to fall further following an initial depreciation, they will respond by raising the share of foreign assets in the portfolio. Currency depreciation in a sense means higher (opportunity) cost of holding domestic money, so currency substitution can be used to hedge against such risk. In this regard, exchange rate depreciation would decrease the demand for domestic money. The ultimate impact of exchange rate depreciation on the demand for money will be determined empirically.

An increase in the foreign interest rate raises the attractiveness of foreign bonds, and encourages domestic residents to substitute foreign bonds for domestic assets in their portfolio. This will reduce the demand for domestic money balances (i.e., the capital mobility effect). In contrast (and less traditionally), based on a theoretical model in which firms borrow and hold domestic and foreign money to provide a certain level of monetary services required to support their productive activities and decide the composition of money balances that minimises the borrowing cost, Marquez (1987) argues that an increase in the foreign interest rate will raise the demand for domestic money balances. Given that domestic and foreign money are substitutes for each other in the production of such monetary services, a rise in the foreign interest rate (i.e., the cost of borrowing foreign money) increases the demand for domestic money. Thus, while the estimate of b is expected to be positive and c negative, the signs for coefficients d and e are to be determined empirically and could be either positive or negative.

To examine the long-run relationship between Hong Kong's broad money aggregate and its determinants, we employ the autoregressive distributed lag (ARDL) cointegration procedure introduced by Pesaran et al. (1996). To begin with, we test for the null of no cointegration against the existence of a long-run relationship. Unlike other cointegration techniques (e.g., Johansen's procedure) which require certain pre-testing for unit roots and that the underlying variables to be integrated are of order one, the ARDL model provides an alternative test for examining a long-run relationship regardless of whether the underlying variables are I(0), I(1), or fractionally integrated. The error correction representation of the ARDL model for Equation (1) is given by:

$$\begin{aligned}\Delta \ln M2 = {} & a_0 + \sum_{j=1}^{k1} b_j \Delta \ln M2_{t-j} + \sum_{j=0}^{k2} c_j \Delta \ln Y_{t-j} + \sum_{j=0}^{k3} d_j \Delta R_{t-j} + \\ & \sum_{j=0}^{k4} e_j \Delta FR_{t-j} + \sum_{j=0}^{k5} f_j \Delta \ln EX_{t-j} + n_2 \ln Y_{t-1} + \\ & n_3 R_{t-1} + n_4 FR_{t-1} + n_5 EX_{t-1} + \varepsilon_t . \end{aligned} \tag{2}$$

Accordingly, the null hypothesis of no cointegration (as defined by H_0: $n_1 = n_2 = n_3 = n_4 = n_5 = 0$) is tested against the alternative by means of the F-test.

Note that the asymptotic distributions of the F-statistic are non-standard irrespective of whether the variables are I(0) or I(1). Pesaran et al. (1996) provide two sets of asymptotic critical values. One set assumes that all variables are I(0) and the other assumes they are all I(1). If the computed F-statistic falls above the upper bound critical value, then the null of no cointegration is rejected. If it falls below the lower bound, then the null cannot be rejected. Finally, if it falls inside the critical value band, the result would be inconclusive. Once cointegration is confirmed, we move to the second stage and estimate the long-run coefficients of the money demand function and the associated ARDL error correction models.

3. Estimation Results

Equation (1) is estimated for Hong Kong using quarterly data over the 1985-1999 period. In testing the null of no cointegration, we must decide about the order of lags on the first-differenced variables. Bahmani-Oskooee and Bohl (2000) have shown that the results of this first step are usually sensitive to the order of VAR. To confirm this, we impose 2, 4, 6, 8, and 10 on the first difference of each variable and compute the F-statistic for the joint significance of lagged levels of variables. The computed F-statistic for each order of lags is reported in Table 1 along with the critical values at the bottom of the table. As can be seen, the test outcome varies with the choice of lag order. For $j = 4$, the computed F-statistic is inconclusive, but it is significant at 90% for $j = 6$ and significant at 95% for $j = 8$ and $j = 10$. The results seem to provide evidence for the existence of a long-run money demand equation (particularly when a higher order of lag is selected for formulating the model). These results should be considered preliminary and indicate that in estimating Equation (1) we must retain the lagged level of variables.

Table 1. F-Statistics for Testing the Existence of a Long-Run Money Demand Equation

Order of Lag	F-statistics
2	1.399
4	2.779
6	3.624*
8	9.580**
10	18.502**

Note: The relevant critical value bounds are given in Table C1.iii (with an unrestricted intercept and no trend; number of regressors = 4), Shin and Smith (1999). They are 2.86 – 4.01 at the 95% significance level and 2.45 – 3.52 at the 90% significance level. * denotes that the F-statistic falls above the 90% upper bound and ** denotes above the 95% upper bound.

In the second stage, we retain the lagged level of variables and estimate Equation (2) using an appropriate lag selection criterion such as the adjusted R^2, AIC, and SBC (with maximum order set at 6). The long-run coefficient estimates are reported in Table 2. Note that the estimated coefficients obtained from all three model selection criteria are very similar and all regressors are highly significant. As expected, the coefficient of the real income variable is positive and that of the domestic interest rate is negative. The positive coefficient obtained for the foreign exchange rate lends support to the currency substitution argument. Exchange rate depreciation induces currency substitution in favour of foreign currency and reduces the demand for domestic money. The positive coefficient obtained for the foreign interest rate, however, seems to support the less conventional argument as provided by Marquez (1987) rather than the capital mobility effect.

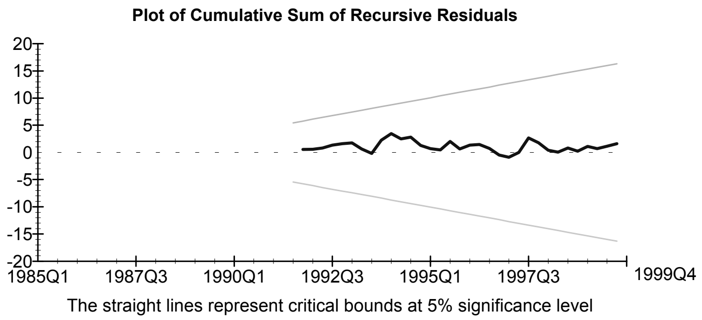
The estimates of the error correction representation selected by the adjusted R^2, AIC, and SBC are presented in Table 3. The long-run coefficients reported in Table 2 are used to generate the error correction terms. The adjusted R^2 are 0.68, 0.68, and 0.58 for the three models respectively, suggesting that such error correction models fit the data reasonably well. In addition, the computed F-statistics clearly reject the null hypothesis that all regressors have zero coefficients for all cases. Importantly, the error correction coefficients carry the expected negative sign and are highly significant in all three cases. This helps reinforce the finding of cointegration as provided by the F-test.

Table 2. Long-Run Coefficient Estimates of M2 Money Demand

	Model Selection Criterion		
Regressors	Adjusted R^2	AIC	SBC
	(5,5,5,0,5)	(5,0,2,0,5)	(3,0,0,0,3)
$\ln Y$	1.730 (29.43)	1.685 (23.88)	1.641 (16.63)
R	- 0.038 (2.68)	- 0.044 (2.32)	- 0.045 (2.26)
FR	0.070 (4.57)	0.066 (3.37)	0.055 (2.63)
$\ln EX$	2.264 (12.35)	2.150 (11.39)	2.105 (8.77)
Constant	-18.217 (17.03)	-17.053 (18.08)	- 16.243 (13.12)

Note: Numbers inside the parenthesis are the absolute value of t-ratios.

Figure 2. Plots of CUSUM and CUSUMSQ Statistics for Coefficient Stability



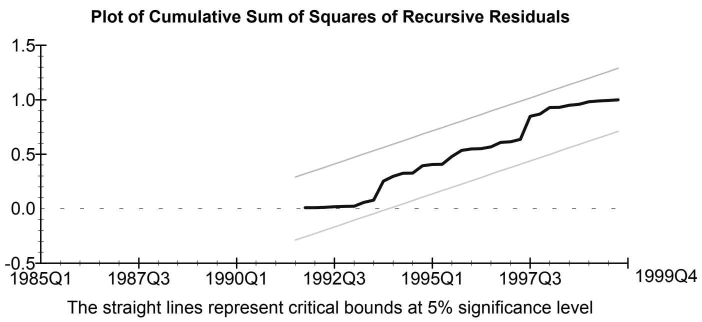


Table 3. Error Correction Representation of ARDL Model
(Dependent Variable is $\Delta \ln M_t$)

	Model Selection Criterion		
Regressors	Adjusted R^2	AIC	SBC
$\Delta \ln M_{t-1}$	-0.156 (1.12)	-0.108 (0.97)	-0.174 (1.67)
$\Delta \ln M_{t-2}$	-0.510 (3.49)	-0.381 (3.27)	-0.197 (2.01)
$\Delta \ln M_{t-3}$	-0.727 (5.28)	-0.520 (4.71)	-0.412 (4.45)
$\Delta \ln M_{t-4}$	-0.358 (2.24)	-0.121 (1.12)	
$\Delta \ln M_{t-5}$	-0.535 (3.48)	-0.350 (3.40)	
$\Delta \ln Y_t$	0.669 (3.04)	0.557 (5.25)	0.368 (4.10)
$\Delta \ln Y_{t-1}$	-0.361 (1.55)		
$\Delta \ln Y_{t-2}$	0.014 (0.07)		
$\Delta \ln Y_{t-3}$	0.296 (1.54)		
$\Delta \ln Y_{t-4}$	0.167 (0.92)		
$\Delta \ln Y_{t-5}$	0.512 (2.70)		
ΔR_t	-0.012 (3.50)	-0.011 (3.04)	-0.010 (3.01)
ΔR_{t-1}	-1.3E-4 (0.00)	0.002 (0.60)	
ΔR_{t-2}	-0.010 (3.10)	-0.007 (2.55)	
ΔR_{t-3}	-0.008 (2.14)		
ΔR_{t-4}	-0.004 (1.31)		
ΔR_{t-5}	-0.006 (1.92)		
ΔFR_t	0.013 (1.80)	0.012 (1.70)	0.012 (3.01)
$\Delta \ln EX_t$	-0.205 (1.24)	-0.375 (2.69)	-0.368 (2.64)
$\Delta \ln EX_{t-1}$	-0.665 (2.85)	-0.331 (1.87)	-0.184 (1.11)
$\Delta \ln EX_{t-2}$	-0.707 (3.08)	-0.431 (2.93)	-0.260 (1.82)
$\Delta \ln EX_{t-3}$	-0.883 (4.33)	-0.616 (4.19)	-0.479 (3.24)
$\Delta \ln EX_{t-4}$	-0.309 (1.72)	-0.105 (0.74)	
$\Delta \ln EX_{t-5}$	-0.421 (2.28)	-0.283 (2.01)	
Constant	-8.307 (5.20)	-5.639 (5.64)	-3.64 (4.49)
EC_{t-1}	-0.456 (4.59)	-0.331 (5.10)	-0.224 (4.06)
$\bar{R}^2$	0.68	0.68	0.58
F-statistics	6.20	8.39	8.61
DW-statistics	2.06	2.01	2.03

Note: Numbers inside the parenthesis are the absolute value of t-ratios.

Finally, we examine the stability of the long-run coefficients together with the short-run dynamics. In doing so we follow Pesaran and Pesaran (1997) and apply the CUSUM and CUSUMSQ [proposed by Brown, Durbin, and Evans (1975)]. The tests are applied to the residuals of all three models in Table 3. Specifically, the CUSUM test makes use of the cumulative sum of recursive residuals based on the first set of *n* observations and is updated recursively and plotted against break points. If the plot of CUSUM statistics stays within the critical bounds of 5% significance level [represented by a pair of straight lines drawn at the 5% level of significance whose equations are given in Brown, Durbin, and Evans (1975)], the null hypothesis that all coefficients in the error correction model are stable cannot be rejected. If either of the lines is crossed, the null hypothesis of coefficient constancy can be rejected at the 5% level of significance. A similar procedure is used to carry out the CUSUMSQ test, which is based on the squared recursive residuals.

Figure 2 shows a graphical representation of the CUSUM and CUSUMSQ plots applied to the error correction model selected by the adjusted R^2 criterion. Neither CUSUM nor CUSUMSQ plots cross the critical bounds, indicating no evidence of any significant structural instability. Similar results followed when the tests were applied to the other two models.

4. Concluding Remarks

We examined the long-run demand for money in Hong Kong using quarterly data over the period 1985Q1-1999Q4. By applying a relatively new cointegration technique, we were able to identify a long-run relationship between real broad money aggregate, real income, nominal interest rates, foreign interest rates, and foreign exchange rates. Both the CUSUM and CUSUMSQ tests also confirm the stability of long-run coefficients of the money demand function. In addition to the expected signs obtained for the conventional scale and domestic interest rate variables, the estimation results suggest that foreign sector considerations do matter in explaining the variations in the broad money aggregate for a highly open economy like Hong Kong.

In particular, this study has confirmed that currency depreciation would reduce the demand for domestic currency. This is of particular relevance to the formulation of monetary and exchange rate policy in Hong Kong. It has, among other things, added an extra dimension (or difficulty) to the operation of Hong Kong's pegged exchange rate regime in which the primary (or sole) objective of the authorities would be to maintain the stability of the HK$ foreign exchange rate. Particularly, exchange rate depreciation, say triggered off by rapid capital outflows, could induce currency substitution, which would in turn exacerbate further currency depreciation and decline in the demand for domestic currency. Under a fractional reserve system in which the HK$M2 is not fully supported by foreign currency reserves, the expectation of currency depreciation, if strong enough, could cause persistent currency substitution and exchange rate volatility. This could pose a major challenge to the pegged exchange rate regime especially at the time of a financial crisis. Importantly, apart from the need to practice prudent fiscal and monetary policies (to avoid fiscal and external deficits) and to promote high market flexibility, the authorities should also take steps to thoroughly examine the mechanism and velocity of such currency substitution.

Appendix: Variable Specifications and Data Source

M = real HK$ money supply, definition two, seasonally adjusted. Nominal HK$M2 is adjusted by GDP deflator (1990=100) to obtain the real values.
Y = Gross Domestic Product (GDP) at constant 1990 prices, seasonally adjusted.
R = 3-month HK$ Inter-Bank Offered Rate (HIBOR).
FR = US 3-month CD interest rate.
EX = nominal effective exchange rate index, trade-weighted. (An increase in the index indicates currency appreciation.)

All quarterly data used in this study (except the US 3-month CD interest rate) were obtained from Hong Kong Census and Statistics Department, *Hong Kong Monthly Digest of Statistics*. The US interest rate was obtained from the Federal Reserve Statistical Release: Selected Interest Rates, www.whitehouse.gov/frsr/money.html, Federal Reserve Board. Seasonal adjustment of data series was obtained by applying the moving average method as provided by the TSP Version 4.4.

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