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An Empirical Analysis of China's International Reserves Demand Function

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ABSTRACT:
The study aims to estimate an international reserves demand model for China using economic growth, propensity to import, real effective exchange rate and trade openness variables for quarterly period spanning from 1985Q1 to 2014Q4. The bounds testing technique to cointegration is used to test for a long run relationship, while the autoregressive distributed lag approach is used to estimate short run and long run coefficients. The bounds F-test critical values generated by Pesaran et al. (2001) are used for comparison. A long run cointegration relationship is found among the variables when international reserves demand is the dependent variable; and international reserves demand to be significant at conventional levels with respect to propensity to import and trade openness only in the long run. The error correction term is found negative and statistically significant in the short run.

Keywords: *China, ARDL approach, Bounds testing, International reserves*

INTRODUCTION

China is grouped as an upper middle-income country with Gross Domestic Product (GDP) of US$ 213.5 billion and GDP per capita as US$ 5,520 in the year 2014.The economy of China has achieved a growth rate of 4 per cent in 2014 as compared to 2.8 per cent in 2013, the first increase in previous eight years. The external position of China remained solid, with some of the weakness, like the ongoing down turn in the current account that revealed a deficit about 4 per cent of GDP for the first time since 15 years. The external financial situation also stayed firm, with international reserves evaluated at US$ 186 billion in 2014 that equates to 32 months of goods and services. The external debt is small equals to US$ 4 billion in 2014 i.e. 1.9 per cent of GDP (African economic outlook 2014).

International reserves have lucid involvements for exchange rate stability. They have implications for financial markets and in short for overall economic activities. A continuous debate can be seen in the literature about the need to keep international reserves [see Aizenman & Marion (2002, 2002a)]. Participants have diverse views about reserve holdings. Some economists argue that international reserves are ineffective and unutilized as Friedman (1953) defied that under fixed exchange rate system international reserves remain unutilized. On the contrary, some economists argue that international reserves are essential to settle down the payment imbalances in balance of payment [see Kemal (2002)]. By accumulating large stocks of international

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reserves, monetary authorities can purchase national currency in international capital markets, to stabilize its value. In brief, the rationale to hold international reserves is to finance external payment imbalances, intervening in international capital markets and secure a buffer to cushion the economy against external shocks.

Research on international reserves was started during 1960s particularly when Heller (1966) presented the estimations of the optimum level of international reserves by comparing marginal cost to marginal benefit. As strong justification to hold reserves have been provided it is important to analyze the determinants of international reserves. The issue of the determination of reserves has broadly been discussed in the literature (see Heller, 1966; Frenkel and Jovanovic, 1981; Lane and Burke, 2001; Flood and Marion, 2001; Irefin and Yabaa, 2012; Grubel, 1971; Kenen and Yudin, 1965); Kelly, 1970; Frenkel, 1974; Heller and Khan, 1978; Clark, 1970; Ben-Bassat and Gottlieb, 1992; Chin-Hong et al., 2011; Claassen, 1975; Courchene and Youssef, 1967; Edwards, 1983; Huang and Shen, 1999; Lizondo and Mathieson, 1987; Landell-Mills, 1989; Lane and Burke, 2001; Aizenman and Marion, 2002; Eichengreen and Mathieson, 2000; IMF, 2003; Romero, 2005; Malathy and Madhumati, 2007; Obstfeld et al., 2008, 2009; Prabheesh et al., 2007; Shegal and Chandan, 2007 and Gantt, 2010). They were able to get some explanatory variables as determinants of international reserves through empirical research. The determinants of reserves holding reported in the literature can be grouped into five categories: economic size of economic growth, current account vulnerability, capital account vulnerability, exchange rate flexibility, and opportunity cost. 'Buffer stock model' is largely used among all these models. The model suggests that monetary authorities hold international reserves as a buffer to control variations in external payment imbalances. This model has been remained as applicable in floating exchange regime as it was during the Bretton Woods regime.

Badinger (2002) stated that the conventional theory of reserves demand have some deficiencies. First, it assessed the demand in separation from the domestic money market, thus neglecting the importance of monetary approach to balance of payments. Second, it confronted the spurious regressions because nearly all studies estimated the demand for reserves employing Ordinary Least Squares or two stage least square methods. Third, the studies analyzed the cross-sectional data, thereby neglecting the institutional characters of individual economies. This paper is an endeavor to overcome most of these issues to determine international reserves demand function for China making use of the Autoregressive Distributed Lag (ARDL) approach.

The rest of the paper is organized as: After this introduction, section 2 presents relevant literature review, section 3 provides methodology. The estimation process and results obtained are presented in section 4 following the conclusion in Section 5.

Literature Review

Talahite and Beji (2013) addressed the issue of international reserves in China and Tunisia and provided some possible alternative policy to the accumulation of international reserves.

Chin-Hong et al. (2011) examined the determinants of international reserves in Malaysia applying cointegration technique proposed by Johansen and Juselius (1990) over the period spanning from 1975 to 2007. They found that international reserves and the specified determinants have long run relationship. The economic size and opportunity cost had respectively positive and negative relationship to the reserves.

Irefin and Yabaa (2012) estimated Frenkel and Jovanovic's buffer stock model in case of Nigeria using Autoregressive Distributed Lag Approach (ARDL) proposed by Pesaran et al. (2001) over the period 1999Q1-2011Q2. They found that monetary policy rate, exchange rate, income and imports had a long run relationship to international reserves.

Khan et al. (2005) analyzed Pakistan's reserves demand function deploying cointegration technique and error correction model over the period 1982Q1 to 2003Q2. They set up a stable long-run reserves demand in Pakistan. The long run reserves policy of

Pakistan appeared to be determined by foreign trade, volatility of balance of payments and opportunity cost of holding reserves.

Dash and Narayanan (2010) examined the relationship among trade flows, exchange rate and demand conditions in terms of their impact on international reserves in India using multivariate cointegration technique developed by Johansen (1995) and vector error correction model on monthly data over the period 1994:Jan- 2008:Oct. Their study found that a long run and significant relationship existed among exports, world exports and real effective exchange rate. The study suggested that a minimum amount of reserves was desirable as a precautionary motive.

Shegal and Chandan, (2007) analyzed international reserves demand in a co-integration-error correction framework for India. Their study has utilized quarterly data from 1990Q2 to 2006Q1. They employed Gross domestic product, money supply, short run external debt, Portfolio investment and variability in the balance of payment as independent variable whereas international reserves as dependent one. They estimated most of the variables had significant influence on international reserves in India. The study suggested that India hold international reserves mainly for precautionary purpose.

Chakravarty (2009) assessed buffer stock model for foreign reserves demand in Indian context assuming high capital mobility and exchange rate flexibility. He employed Autoregressive Distributed Lag Approach (ARDL) and volatility of international transactions, opportunity cost, exchange rate flexibility and some scale variables as independent variables whereas international reserves minus gold as dependent one. He used a different volatility measure i.e. export receipts volatility. Their findings showed that the demand for international reserves was related positively to international transaction volatility and a scalar variable while opportunity cost exhibited negative relationship. However, he couldn't show flexibility of exchange rates a significant variable impacting reserves demand of Indian economy.

Aizenman and Marion (2002) compared the demand for foreign exchange reserves in the Far-East with the developing economies. They found that accumulation of international reserves is the result of many economic factors like volatility of international transactions, political considerations and exchange rate arrangements. After Asian financial-crisis in 1997, their model under predicted international reserve holdings. Their study proved that 'sovereign risk and costly tax collection to cover fiscal liabilities lead to a large precautionary demand in reserves'.

Peter and Machiel (2004) stated that the objective of managing international currency reserves has changed from retaining liquidity to expand total profit. They recognized long-term local government bonds, international government bonds and equities as those investment which give high return.

Frenkel (1978) stated that (MPI) i.e. marginal propensity to import determines openness to external shock of a country and hence it would exhibit positive relation with international reserves. Marginal propensity to import (MPI) was computed as the ratio of imports to GDP. He concluded that "optimal reserve holdings would increase as the volatility of reserves increased." He showed that reserves volatility was certainly a strong predictor of international reserve holdings.

Frenkel and Jovanovic (1981) found that almost all empirical studies consider real variables to determine the demand for foreign exchange reserves. These variables include: export, import, external debt- both short-term and long-term and trade shocks. According to Shcherbakov (2002), some factors determine the adequacy of international reserves for any country. These factors are- monetary adequacy, debt adequacy and import adequacy.

RESEARCH METHOD

Data Description and Variables

We used time series data of quarterly frequency for the period of 1985Q1-2014Q4. Our estimation process involves overall five variables namely total international reserves (IR), economic growth (Econ), vulnerability to external shocks (Imp), real effective exchange rate (Reer) and trade openness (Topen). Total international reserves is the dependent variable and rest are independents. According to IMF balance of payments manual, international

reserves are those external assets that are readily available to and controlled by monetary authorities for meeting balan
financing needs; interventio
markets to affect the currency e
other related purposes. We use
international reserves suggested
Financial Statistics. Interna
comprise of- (i) Gold (ii) f
deposits of the monetary autho
position in the IMF (iv) Special Drawing Rights. We exclude gold from international reserves for the purpose of our analysis for three reasons. First, gold accounts for only 3 per cent of world reserves holding when evaluated at 35 SDRs per ounce. Second, gold holdings of developing economies are negligible. Third, there is concern whether monetary authorities consider gold as liquid as international currency holdings. Generally central banks regard gold as 'the lender of last resort'.

Economic growth plays a crucial role in the determination of total international reserves. Economic growth is captured by real gross domestic product (GDP) for estimation purpose. Vulnerability to external shocks (Imp) is captured by total import of goods and services divided by real GDP. real effective exchange rate are taken in their real term and trade openness is proxied by sum of total export and total import of goods and services divided by real GDPAll figures used in this study (chapter) are in current US dollar. Data for all variables are obtained from the International Monetary Fund's *international financial statistics,* World Development Indicators of the World Bank and the database of OECD countries.

Model Specification

We develop following model relating total international reserves to some macroeconomic variables for China:

$$IR = f(\text{Econ, Imp, Reer, Topen}) \quad (1)$$

The explicit form of this model is represented as under:

$$IR_t = \beta_0 + \beta_1 Econ_t + \beta_2 Imp_t + \beta_3 Reer_t + \beta_4 Topen_t + \varepsilon_t \quad (2)$$

All the variables were transformed into their logarithmic forms. Transformation is to avoid the situation in which the residuals may reflect

minus gold, Econ is economic growth proxied by real gdp, Imp is propensity to import proxied by total import of goods and services divided by real gdp, Reer is real effective exchange rate in real terms and Topen is trade openness captured by sum of total export and total import of goods and services divided by real gdp. All terms are taken in current US dollar.

Estimation Process and Empirical Results

In experimental research on the data that is time series in nature, generally the problem of unit root or non-stationarity arises. We employed Augmented Dickey Fuller (ADF) and Phillips Perron (PP) test to check stationarity of all the variables under study. Non-stationarity causes the conventional tools of econometrics such as ordinary least square (OLS) and two stage least square (2SLS) inappropriate. To avoid this problem, the co-integration technique has been proposed by Engle and Granger (1987); Johansen and Juselius (1990, 1992). The restriction for co-integration analysis is that all variables should be non-stationary at level and become stationary of the same order. The unit root tests available in the literature may be employed to determine order of integration. The results obtained from the available tests may differ based on power of the tests. This may produce a bias in selecting the unit root test which gives the same order of integration for each variable in the system. Another problem may arise also i. e., the variables under consideration may be integrated of different orders, which leaves the co-integration techniques useless. To avoid this problem, Pesaran and Shin (1999); Pesaran, Shin & Smith (2001) proposed a bounds testing autoregressive distributed lag (ARDL) approach which does not consider the order of integration. The ARDL approach can be applied to test any long run relationship despite of whether the variables become stationary at the same or different order.

If any long-run relationship is found among the variables, we can assess long-run coefficients and corresponding lagged error correction term to understand the long-run effect of the variables and the speed of adjustment.

To capture the speed of adjustment, we can write equation (3) in an error correction format as:

$$\Delta \text{LnIR}_t = \beta_0 + \sum_{i=1}^{m} \beta_1 \Delta \text{LnIR}_{t-i} + \sum_{i=0}^{m} \beta_2 \Delta \text{LnEcon}_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta \text{LnImp}_{t-i} + \sum_{i=0}^{m} \beta_4 \Delta \text{LnReer}_{t-i} + \sum_{i=0}^{m} \beta_5 \Delta \text{LnTopen}_{t-i} + \beta_6 \varepsilon_{t-1} + \mu_t \quad (4)$$

Pesaran, Shin & Smith (1999) develop a two-step process to estimate equation (3). First, the null hypothesis (H_0) of non-existence of long-run relationship among IR_t, $Econ_t$,Imp_t, $Reer_t$ & $Topen_t$ is defined by $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$. The approximate critical values for the F-statistics are obtained from Pesaran et. al (2001). Rejection of null hypothesis implies that a long-run relationship among IR_t, $Econ_t$, Imp_t, $Reer_t$ & $Topen_t$ exists. The relevant t-statistics to test the null hypothesis are the well-known F-statistics with critical values calculated by Pesaran et al. (2001). To apply the ARDL process, we model equation (3) as follows:

$$\Delta \text{LnIR}_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta \text{LnIR}_{t-i} + \sum_{j=0}^{p} \gamma_j \Delta \text{LnEcon}_{t-j} + \sum_{k=0}^{p} \gamma_k \Delta \text{LnImp}_{t-k} + \sum_{l=0}^{p} \theta_l \Delta \text{LnReer}_{t-l} + \sum_{m=0}^{p} \psi_m \Delta \text{LnTopen}_{t-m} +$$

$$\lambda_1 \text{LnIR}_{t-1} + \lambda_2 \text{LnEcon}_{t-1} + \lambda_3 \text{LnImp}_{t-1} + \lambda_4 \text{LnReer}_{t-1} + \lambda_5 \text{LnTopen}_{t-1} + \varepsilon_t \quad (5)$$

Where, all variables are defined as before. Pesaran and Shin (1999); Pesaran et al. (2001) tabulated two sets of critical values. One set assumes all variables are I(1) and another assumes all variables are I(0). This provides a band covering all possible classifications of the variables into I (1) and I (0) or fractionally integrated. If the calculated F-statistic lies above the upper level of the band, the null is rejected indicating co-integration. If the calculated F statistic falls below the lower level of the band, the null cannot be rejected supporting lack of co-integration. If, however it falls within the band, the result is inconclusive.

Unit Root Tests

In table 1 we have presented Augmented Dickey Fuller (ADF) and Phillips Perron (PP) test statistics for each variable. From the table we can see directly that LnReer is stationary at level while other four variables that are LnIR, LnEcon, LnImp, LnTopen are nonstationary at the same level showing the integration order of I(0) and I(1) respectively. These results prevent us to use the standard co-integration techniques proposed by Engle and Granger (1987). In this case the autoregressive distributed lag (ARDL) bounds testing method of Pesaran et al. (2001) seems reasonable to test the long-run relationship among the variables.

Table 1: Unit root test results

Variables	Augmented Dickey Fuller (ADF)		Phillips-Perron (PP)	
	Level	1st difference	Level	1st difference
LnIR	-0.21	-6.79*	-0.03	-6.75*
LnEcon	-0.05	-3.22**	1.83	-4.09**
LnImp	-1.69	-3.53**	-1.62	-5.19*
LnReer	-3.29**	-9.20*	-3.31**	-9.29*
LnTopen	-1.73	-3.98**	-1.95	-5.56*

* and ** denotes significant at 1% and 5% level.

Co-integration

The bounds testing for co-integration is li...

When international reserves is the dependent variable for China, the computed F-statistic F_{IR} (IR/Econ, Imp, Reer, Topen) = 3.60 is higher than the upper bound critical value of 3.52 at 10 per cent level of significance. However, when we use rest of the variables as a dependent one, the calculated F-statistic found lower than the lower bound critical value (2.45). This suggests that the null hypothesis of no co-integration cannot be accepted for China and that there exists a unique co-integration relationship between international reserves and its determinants. Conversely, we set up that international reserves, economic growth, propensity to import, real effective exchange rate and trade openness are co-integrated only when international reserves is the dependent variable.

Long Run and Short Run Elasticities

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the explanatory variables have a statistically significant impact on total international reserves. Interestingly, total international reserves seem to be mainly determined by trade openness. For instance, our results reveal that a 1% increase in trade openness induces an increase of near about 4 per cent in international reserves. Meanwhile, we find that a 1 per cent increase in propensity to import leads to a 2.6 per cent decrease in international reserves. Our results suggest that trade openness and propensity to import determine China's demand for international reserves in the long run. This confirms that developing countries accumulate large stockpiles of reserves for both precautionary and mercantilist purposes in recent time.

Table 2: F-statistics for cointegration

k	90% level		95% level		99% level	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
4	2.45	3.52	2.86	4.01	3.74	5.06

Calculated F-statistics:

F_{IR} (IR/Econ, Imp, Reer, Topen)	= 3.60
F_{Econ} (Econ/IR, Imp, Reer, Topen)	= 2.05
F_{Imp} (Imp/Econ, IR, Reer, Topen)	= 0.18
F_{Reer} (Reer/Econ, IR, Imp, Topen)	= 3.17
F_{Topen} (Topen/Econ, IR, Reer,Imp)	= 0.49

Note: Critical values are extracted from Pesaran , Shin & Smith (1999); k is number of regressors.

Table 3: Long run estimates: (Dependent variable $lnIR_t$)

Regressors	Coefficient	t-statistics
Constant	-14.61	-23.98*
$lnEcon_t$	1.36	46.32*
$lnImp_t$	-2.55	-8.22*
$lnReer_t$	0.81	5.37*
$lnTopen_t$	3.66	10.36*

* denotes significant at 1 per cent level.

We follow Akaike Information Criteria (AIC) for selecting lag length which is determined as lag two. The short run elasticities

stability. We found no evidence of autocorrelation in the disturbance of the error term. The RESET test indicates that the model is

level. The coefficient being 0.23 suggests that convergence to equilibrium to international reserves is 23 percent each quarter i.e. 92 percent disequilibrium eliminated every year in China.

Diagnostic Tests

Table 5 provides a number of diagnostic tests which the short run model was tested for, including, tests of autocorrelation, normality and heteroskedasticity in the error stability term, and

estimations asymptotically as per Central Limit Theorem (Theil, 1978). The CUSUM test of squares based on the recursive residuals (see figure 1) demonstrate no proof of any statistically significant break. Finally, the R^2 of 0.36 indicates that 36 per cent of the variation in international reserves is explained by the variables in the model. Hence, based on these statistical properties, it is reasonable to say that the model is fit.

Table 4: Short run estimates: (Dependent variable $\Delta lnIR_t$)

Regressors	Coefficient	t-statistics
Constant	0.03	0.02**
$\Delta lnECON_{t-1}$	0.57	1.04
$\Delta lnECON_{t-2}$	-0.90	-1.71*
$\Delta lnIMP_{t-1}$	-0.53	-0.76
$\Delta lnIMP_{t-2}$	0.65	0.97
$\Delta lnREER_{t-1}$	0.20	1.12
$\Delta lnREER_{t-2}$	0.05	0.31
$\Delta lnTOPEN_{t-1}$	0.53	0.83
$\Delta lnTOPEN_{t-2}$	-0.40	-0.60
ECT_{t-1}	-0.232	-3.97***
R^2	**0.36**	
Durbin-Watson statistic	**2.01**	
F-statistic	**5.43**	

*, ** and *** denotes significant at 10%, 5% and 1% level.

Table 5: Diagnostic checks

Test	Statistics	p-value	Conclusion
Breusch-Godfrey Serial Correlation LM Test	1.41	0.49	No serial correlation
BPG Heteroskedasticity Test	9.83	0.55	No heteroskedsticity
Ramsey RESET Test	3.32	0.02	No misspecification
Jarque-Bera Normality test	5118.08	0.00	Normal

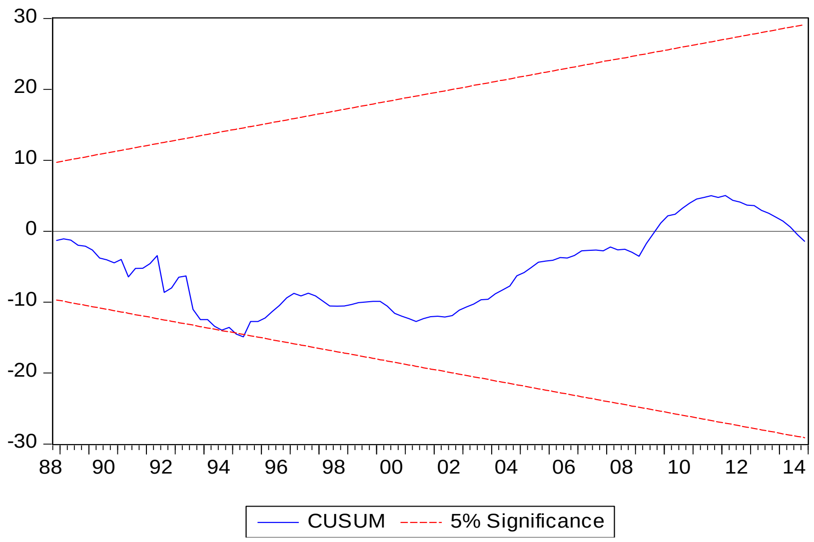

Figure 1: Plot of CUSUM of recursive residuals

CONCLUSION

The study employed the cointegration technique known as bounds testing method to test for a long run relationship among international reserves, propensity to imports, real effective exchange rate and trade openness for China. We find evidence of a cointegration relationship among the variables in international reserves demand function only when international reserves is the dependent variable at 10 per cent level of significance. This not only allows us to investigate the long run elasticities but also the short run elasticities of China's demand for international reserves.

We find that international reserves seem to be mainly determined by trade openness and propensity to import in our model. These results are consistent with theory and significant. Our results suggest that trade openness and propensity to import determine China's demand for international reserves in the long run.

Our study reveals that existing patterns of growing trade openness and greater exposure to financial shocks by China go a long way towards accounting for observed accumulation of international reserves. This confirms that large holding of international reserves is the outcome of foreign trade and developing countries accumulate large stockpiles of reserves for both export competitiveness and precautionary purposes.

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