Measuring the Degree of Cross-Country Capital Mobility

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Abstract

Economic growth achieved by countries such as Japan, South Korea, and China through the pursuit of an export-led growth and an open-door capital market policy, has inspired many newly emerging economies, prompting them to revise their tax and other laws to create conducive environment for foreign direct investment into their countries. But any such attempt by a host country cannot unilaterally promote foreign direct investment into the country if capital is immobile internationally. There have been several studies to measure the degree of international capital mobility based on above four definitions. Studies, so far, on the measurement of the degree of international capital mobility basically fall into one of the following four categories: (a) measuring the degree of correlation between savings rate and investment rate, (b) testing the fulfillment of the covered interest parity condition, (c) checking to see if the uncovered interest parity condition is met, and (d) checking to see if current-account surplus and saving surplus parity condition is met. But our study takes a different approach, in it, we measure the degree of international capital mobility by measuring the degree of responsiveness of exchange rate between two currencies to the change in relative rate of return in domestic countries. We applied our model on the data on annual average exchange rate of Indian rupee with the U.S. dollar, and on annual average real interest rate in both the United States and India for the period, 1990 – 2015, obtained from the World Development Indicators, 2015. Our study found that both the dependent and the independent variables had a unit root and were integrated of order one. So, we applied the co integration test on the variables of our model to see if any long-run relationship existed between them. We found that the two variables were integrated. So, we estimated our model using OLS. Our estimate shows that our independent variable, the relative real interest rate in India, that is the variable $\mathbf{Z}_t$, dose have negative effect on the percentage change in rupee-dollar exchange rate, the variable $\boldsymbol{e}_t$. This implies that as the relative real interest rate in India rises, the exchange rate – defined as the number of Indian rupees needed to purchase one U.S. dollar – falls, which is logical. Because, as the relative real interest rate in India rises, it will cause capital outflows from the U.S. to India, increasing the demand for Indian rupee by U.S. investors causing the value of Indian rupee to appreciate, thereby, lowering the exchange rate. This in turn implies that capital is mobile internationally or at least between the U.S. and India.

JEL Classification: F3

Keywords: international capital mobility, real rate of interest, exchange rate, unit root, cointegration

1. Introduction

Inspired by economic growth achieved by countries such as Japan, South Korea, and China through the pursuit of an export-led growth and by open-door capital market policy, many newly emerging economies, following the suit, are increasingly revising their tax and other laws to create conducive environment for foreign direct investment into their countries. One of the examples is the recent enactment and implementation of GST (goods and services tax) Act and the enactment of Land Acquisition bill by the Modi government in India. But such an attempt can only bear fruits if the capital has perfect international capital mobility. Without so any such attempt by a host country cannot unilaterally promote foreign direct investment into the country. Moreover, the electoral defeat of pro-globalization leaders and the victory of populous ideas in developed countries that recently held election has created precursor for further restriction on capital outflows. In the midst of all such recent developments, it is interesting to see how smooth the flow of international capital is.

Frankel (1992) offers four definitions of perfect capital mobility: the (a) Feldstein-Horioka condition: this condition requires the saving rates to have no effect on investment rates, that is, saving rates and investment rate in any country should have no correlation; (b) Real interest rate parity:

Real interest rate should equalize across nations, that is, any real interest rate differential between any two countries should induce capital outflow from the low to the high real interest rate country; (c) Uncovered interest parity: capital flow should equalize expected rates of return on countries' bonds, regardless of exchange rate risks; and (d) Covered interest parity: capital flows should equalize interest rates across countries after exchange rate risks have been covered.

There have been several studies in an attempt to measure the degree of international capital mobility based on above four definitions. Feldstein and Horioka (1980) have developed a saving-investment model, in which they regressed investment to GDP ratio on saving to GDP ratio to measure the degree of international capital mobility. They reason that saving and investment should be perfectly correlated in a closed economy but unrelated in an open economy since saving could seek out the highest global returns. They conclude that capital is less mobile internationally in contrast to the conventional wisdom. Since then several studies have been conducted that have either supported or refuted the Feldstein-Horioka hypothesis. For example, a study by Sun (2004) measures time-varying capital mobility in East Asian countries using an inter-temporal current account model and concludes that capital is much more mobile over time in contrast to the previous studies, which show the lower degree of capital mobility either in developed or in developing countries. Kumhof (2001) analyzes daily covered interbank interest differentials for three emerging markets before and after the 1997/98 financial crises, and compare them with those of four developed economies and finds that mean differentials and their volatility were moderate before crises, but increased dramatically during crises. Also, the evidence for a cointegrating vector consistent with covered interest parity was strong, implying that, despite large short-term deviations, covered interest parity does hold as an equilibrium relationship, ultimately implying that capital is mobile internationally.

A similar study by Kim et al (2005) using a panel data on savings and investment rates on 11 Asian countries finds the savings and investment rates to be nonstationary and cointegrated, thereby concluding that capital mobility increased in Asian countries in the 1980s and 1990s. Payne and Kubazawa (2006) examine the savings-investment relationship on data from 47 developing countries. Their study indicates higher capital mobility with a savings coefficient of 0.36. Obstfeld (1993) studies data on international interest-rate differences, international consumption correlations, international portfolio diversification, and the relations between saving and investment rates. He concludes that while international capital mobility has increased markedly in the last two decades, international capital movements remain less free than intra-national movements, even among the industrial countries. Gundlach and Sinn (2006) reason that if the ratio of the current account balance to GDP is found to be integrated of the order of one, the country is likely to be part of the world capital market. Their results for the whole period of 1950-1988 indicate that the current account balance of at least Germany, Japan and the United States contains a unit root and, therefore, conclude that international capital mobility increased after the breakdown of the Bretton Woods System. Jansen (1996) argues that saving-investment correlations are important indicators of capital mobility, but they are best estimated by an Error Correction Model (ECM), because an ECM is consistent with intertemporal general equilibrium models and is more powerful in detecting cointegration than the two-step Engle-Granger procedure. His study finds the evidence of a large country effect and an increase in capital mobility within the OECD area. Similarly, Adedeji and Thornton (2006) use panel co-integration techniques on data from six African countries over the period 1970-2000 to test the Feldstein-Horioka approach to measuring capital mobility and finds the estimated savings-retention ratio to be less than one and declining over time, indicating that capital mobility in African countries has increased over time.

Using data from 1971-1999 on ten Asia Pacific nations and investigating the saving-investment nexus through the unit root test, cointegration procedure, unrestricted VAR causality, and dynamic OLS, Chan et al (2003) finds that capital mobility was more apparent for four newly industrialized economies while capital flows in ASEAN countries seemed to be more restricted as their long run saving retention coefficients were in the moderate range (0.56 and 0.45). Adhikari (2006) develops a different model called 'current-account surplus saving surplus parity condition' to measure the degree of capital mobility and applies the model on U.S. time series data. His study finds that U.S. capital is mobile internationally. Thus, studies, so far, on the measurement of the degree of international capital mobility basically fall into one of the following four categories: (a) correlation between savings rate and investment rate, (b) covered interest parity condition, (c) uncovered interest parity condition, and (d) current-account surplus saving surplus parity condition, using varying econometric tools, such as, unit root test, cointegration procedure, unrestricted VAR causality, and dynamic OLS.

Therefore, our study will be a net addition to the body of current literature on measuring international capital mobility, in it, we measure the degree of international capital mobility by measuring the responsiveness of exchange rate between two currencies to the change in relative rate of return in domestic country. Our study has been organized as following: section 2 develops the model; section 3 lays out the methodology; section 4 specifies the data source; section 5 reports the empirical findings; and section 6 summarizes the study.

2. The Model

Suppose, $\boldsymbol{A}$ is the amount of domestic currency invested in foreign assets, $\boldsymbol{i_h}$ is the real rate of interest on domestic assets, $\boldsymbol{i_f}$ is the real rate of interest on foreign assets, $\boldsymbol{r}$ is the rate of return on foreign assets, and $\boldsymbol{R}$ is the spot exchange rate defined as the number of domestic currency units received for each unit of a foreign currency, then

$$Amount\ of\ domestic\ currency\ invested\ in\ foreign\ assets = A$$

$$Amount\ of\ foreign\ currency\ invested\ in\ foreign\ assets = \frac{A}{R}$$

$$Amount\ of\ foreign\ currency\ received\ upon\ the\ maturity\ of\ foreign\ assests = \frac{A}{R}(1+i_f)(1+e)$$

Where, $\boldsymbol{e}$ is the percentage change in the exchange rate between the time money invested on foreign assets and the time return on foreign assets received.

$$Amount\ of\ domestic\ currency\ received\ upon\ the\ maturity\ of\ foreign\ assests = \frac{A}{R}(1+i_f)(1+e).R = A(1+i_f)(1+e)$$

$$Rate\ of\ return\ on\ foreign\ assets: r = \frac{A(1+i_f)(1+e)-A}{A} = (1+i_f)(1+e)-1$$

According to the Fisher equation, an exchange rate equalizes interest rates (rates of return) across nations, which implies, $i_h = r,\quad or$

$$i_h = (1+i_f)(1+e)-1$$

$$\rightarrow 1+i_h = (1+i_f)(1+e)$$

$$\rightarrow 1+e = \frac{1+i_h}{1+i_f} \text{ or}$$

$$\rightarrow e = \frac{1+i_h}{1+i_f} - 1 = \frac{1+i_h-1-i_f}{1+i_f} = \frac{i_h-i_f}{1+i_f} \quad (1)$$

If $i_h > i_f, then\ \ e < 0$. That is, if the real rate of interest on domestic assets is greater than that on foreign assets, then the exchange rate falls or equivalently the domestic currency appreciates. It seems logical, because, a higher real interest rate on domestic assets causes capital inflows, raising the supply of foreign currency at home, thereby, causing the appreciation of domestic currency and fall in the exchange rate. On the contrary, if $i_h < i_f, then\ \ e > 0$. That is, if the real rate of return on domestic assets is less than that on foreign assets, then the exchange rate rises or equivalently the foreign currency appreciates. Equation (1) is called the Fisher equation for exchange rate that shows how exchange rates change to equalize the real interest rates or the real rate of return on assets across nations. But equation (1) only holds if capital is perfectly mobile across nations. So, testing the validity of equation (1) is equivalent to testing the mobility of capital across nations.

3. *Methodology*

In its stochastic form, equation (1) can be specified as following:

$$e_t = \delta_0 + \delta_1\left(\frac{i_h-i_f}{1+i_f}\right) + u_t \quad (2)$$

Or

$$e_t = \delta_0 + \delta_1 Z_t + u_t \quad (3)$$

Where $\boldsymbol{Z_t} = \left(\frac{\boldsymbol{i_h-i_f}}{\boldsymbol{1+i_f}}\right)$. If the null hypothesis of $\boldsymbol{\delta_1 = 0}$ cannot be rejected, then we can conclude that capital is immobile across nations, otherwise, it is mobile internationally. We test this model with respect to the United States and India.

4. Data

We obtained the data on annual average exchange rate of Indian rupee with the U.S. dollar, and on annual average real interest rate in both the United States and India for 1990 to 2015 from the World Development Indicators, 2015. We then compute the variable, $\boldsymbol{Z_t}$, as

$$\boldsymbol{Z_t} = \left(\frac{\boldsymbol{i_h - i_f}}{\boldsymbol{1 + i_f}}\right)$$

Also, we compute the percentage change in the exchange rate for each year as following:

$$Percentage\ change\ in\ the\ exchange\ rate\ for\ current\ year = \frac{\text{Exchange rate in current year} - \text{Exchange rate in previous year}}{\text{Exchange rate in previous year}}$$

5. Empirical Findings

Most macroeconomic time series have long-run trend and, therefore, are nonstationary. The problem with nonstationary time series is that the standard OLS regression can produce very high values of R^2 and high t-values for the independent variables while the dependent variable and the independent variables may not have any interrelationship, leading to a so-called spurious regression. However, even if the variables involved are nonstationary, their OLS residuals can be a white noise if they have long-run relationships. In such cases nonstationarity does not pose a problem and the OLS output can be used to draw a conclusion. However, for any long-run relationship to exist among the variables of a model, those variables must be integrated of the same order.

Therefore, as a first step we checked the stationarity of the variables in our model, namely, $\boldsymbol{e}$ (percentage change in exchange rate) and $\boldsymbol{Z}$ (relative rate of return). The Augmented Dicky-Fuller tests of stationarity are reported in Appendix-A & B. As shown in the appendices, an Augmented Dickey-Fuller (ADF) test on the dependent variable $\boldsymbol{e}$ and the independent variable $\boldsymbol{Z}$ indicates that the null hypothesis of unit root cannot be rejected as the t-values of the test for the both variables are less than the 1%, 5%, and 10% critical value. In order to determine if both variables are integrated of order one, we next applied the ADF test on the first difference values of each of the two variables. The output of the test is shown in Appendix-C & D. The t-value this time is greater than 5% critical value for variable $\boldsymbol{e}$ and greater than 1% critical value for variable Z, indicating the absence of a unit root on the differenced value of both variables. Thus, while the levels of these variables were found to be nonstationary, their first differences were stationary, indicating that both variables are integrated of order one.

Further, in order to check if any cointegrating vector exists between these two variables, we conducted the Johansen cointegration test, the output of which is shown in Appendix-E. The trace statistics for the hypotheses of no cointegration and at most one cointegration are greater than their 5% critical value indicating that the variables of our model are cointegrated and have a long-run relationship. Therefore, we applied OLS to estimate our model, equation (3). The output of the regression is shown below.

$$\mathrm{e_t} = 0.092015 - 0.0144202\mathrm{Z_t} \qquad (4)$$
$$\mathrm{t} = \quad (1.868) \qquad (-2.597)$$

R^2 = 0.219403; F-statistic = 6.745689; Prob(F-statistic) = 0.016; D-W stat (d) = 1.6

Although the R^2 value is very low, but the probability associated with the F-statistic is 1.6% indicating that the model is still significant. The lower limit (d_L) and the upper limit (d_U) of Durbin-Watson statistic at 5% significance level and with 26 observations and one independent variable are 1.072 and 1.222 respectively while the D-W statistic (d) from our estimate is 1.6. Thus, both d and ($4 – d$) are greater than d_U indicating that there is no statistical evidence that the error terms of our regression (equation (4)) are negatively or positively autocorrelated. So, we can safely interpret the output of our regression.

First of all, the probability of the t-statistic associated with our independent variable ($\boldsymbol{Z_t}$) is 0.0158 indicating that the hypothesis of $\boldsymbol{\delta_1 = 0}$ has been rejected and that the relative real interest rate in India does affect the exchange rate between Indian rupee and U.S. dollar. This implies that capital is mobile between India and the U.S. Also, the sign of the coefficient of the independent variable ($\boldsymbol{Z_t}$) is negative. This implies that as the relative real interest rate in India rises, the exchange rate – defined as the number of Indian rupees needed to purchase one U.S. dollar – falls, which is logical.

Because, as the relative real interest rate in India rises, it will induce capital outflows from the U.S. to India, increasing the demand for Indian rupee by U.S. investors causing thereby the value of Indian rupee to appreciate and the exchange rate between U.S. dollar and Indian rupee to fall.

6. Conclusion

Economic growth achieved by countries such as Japan, South Korea, and China through the pursuit of an export-led growth and an open-door capital market policy, has inspired many newly emerging economies, prompting them to revise their tax and other laws to create conducive environment for foreign direct investment into their countries. But any such attempt by a host country cannot unilaterally promote foreign direct investment into the country if capital is immobile internationally. Moreover, recent electoral defeat of prominent pro-globalization leaders and victory of populous ideas in developed countries has created a precursor for further restriction on capital outflows. In the midst of all such recent developments, it is interesting to see how mobile international capital is.

So far, four definitions of perfect capital mobility have been offered: the (a) Feldstein-Horioka condition, which requires the saving rates and investment rate in any country to have no correlation; (b) real interest rate parity condition, which requires the real interest rate to equalize across nations; (c) uncovered interest parity condition, which requires the expected rates of return on bonds to equalize across nations, regardless of exchange rate risks; and (d) covered interest parity condition, which requires interest rates to equalize across countries after exchange rate risks have been covered.

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APPENDICES

Appendix-A

Null Hypothesis: e has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.593102	0.1031
Test critical values:	1% level	-2.660720	
	5% level	-1.955020	
	10% level	-1.609070	

*MacKinnon (1996) one-sided p-values.

Appendix-B

Null Hypothesis: Z has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.566282	0.1084
Test critical values:	1% level	-2.660720	
	5% level	-1.955020	
	10% level	-1.609070	

*MacKinnon (1996) one-sided p-values.

Appendix-C

Null Hypothesis: D(e) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.163083	0.0320
Test critical values:	1% level	-2.664853	
	5% level	-1.955681	
	10% level	-1.608793	

*MacKinnon (1996) one-sided p-values.

Appendix-D

Null Hypothesis: D(Z) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.160255	0.0000
Test critical values:	1% level	-2.664853	
	5% level	-1.955681	
	10% level	-1.608793	

*MacKinnon (1996) one-sided p-values.

Appendix-E

Date: 06/17/17 Time: 17:40
Sample (adjusted): 3 26
Included observations: 24 after adjustments
Trend assumption: Linear deterministic trend
Series: e Z
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.375103	17.13906	15.49471	0.0280
At most 1 *	0.216481	5.855030	3.841466	0.0155

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.375103	11.28403	14.26460	0.1406
At most 1 *	0.216481	5.855030	3.841466	0.0155

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

e	Z

12.00235	2.380228
15.22894	-0.093488

Unrestricted Adjustment Coefficients (alpha):

D(e)	-0.115825	-0.024775
D(Z)	-0.100862	0.305178

1 Cointegrating Equation(s):	Log likelihood	-14.01532

Normalized cointegrating coefficients (standard error in parentheses)

e	Z
1.000000	0.198314
	(0.04634)

Adjustment coefficients (standard error in parentheses)

D(e)	-1.390175
	(0.42591)
D(Z)	-1.210585
	(1.79467)

Appendix-F

Dependent Variable: e
Method: Least Squares
Date: 06/17/17 Time: 17:25
Sample (adjusted): 1 26
Included observations: 26 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.092015	0.049250	1.868301	0.0740
Z	-0.144202	0.055521	-2.597246	0.0158

R-squared	0.219403	Mean dependent var	0.015962
Adjusted R-squared	0.186878	S.D. dependent var	0.223926
S.E. of regression	0.201921	Akaike info criterion	-0.288073
Sum squared resid	0.978535	Schwarz criterion	-0.191296
Log likelihood	5.744943	Hannan-Quinn criter.	-0.260204
F-statistic	6.745689	Durbin-Watson stat	1.611408
Prob(F-statistic)	0.015802		

Appendix-G

Measuring the Degree of Cross-Country Capital Mobility					
Year	**Rupee-Dollar Exchange Rate**	**Real Interest Rate in India**	**Real Interest Rate in US**	**PCE**	**RR**
1990	17.49	5.27	6.09	0.298456261	-0.115656
1991	22.71	3.63	4.97	0.239982387	-0.224456
1992	28.16	9.13	3.88	0.111150568	1.07582
1993	31.29	5.82	3.54	0.003195909	0.502203
1994	31.39	4.34	4.91	0.032812998	-0.096447
1995	32.42	5.86	6.61	0.095311536	-0.098555
1996	35.51	7.79	6.33	0.02421853	0.199181
1997	36.37	6.91	6.62	0.13720099	0.038058
1998	41.36	5.12	7.19	0.040860735	-0.252747
1999	43.05	9.19	6.37	0.043902439	0.382632
2000	44.94	8.34	6.80	0.049399199	0.197436
2001	47.16	8.59	4.54	0.030746395	0.731047
2002	48.61	7.91	3.09	-0.041760955	1.178484
2003	46.58	7.31	2.09	-0.03112924	1.68932
2004	45.13	4.91	1.55	-0.026589852	1.317647
2005	43.93	6.25	2.88	0.029820168	0.868557
2006	45.24	4.48	4.74	-0.082891247	-0.045296
2007	41.49	9.02	5.25	0.055194023	0.6032
2008	43.78	4.28	3.07	0.104842394	0.297297
2009	48.37	5.77	2.47	-0.056026463	0.951009
2010	45.66	-0.60	2.00	0.017520806	-0.866667
2011	46.46	1.50	1.61	0.149806285	-0.042146
2012	53.42	2.47	1.38	0.095282666	0.457983
2013	58.51	4.02	1.61	0.042727739	0.923372
2014	61.01	6.79	1.43	0.05097525	2.205761
2015	64.12	7.96	2.16	-1	1.835443

Source: (1) World Bank, "World Development Indicators 2015," http://data.worldbank.org/data-catalog/world-development-indicators
(2) OFX, "Historical Exchange Rates," https://www.ofx.com/en-us/forex-news/historical-exchange-rates/