11-1-2008

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Recommended Citation

Aizenman, J. and Riera-Crichton, D. 2008. "Real exchange rate and international reserves in an era of growing financial and trade integration." Review of Economics and Statistics. 90(4): 812-815. https://doi.org/10.1162/rest.90.4.812

REAL EXCHANGE RATE AND INTERNATIONAL RESERVES IN AN ERA OF GROWING FINANCIAL AND TRADE INTEGRATION

Joshua Aizenman and Daniel Riera-Crichton*

Abstract—This paper evaluates the impact of international reserves, terms-of-trade shocks, and capital flows on the real exchange rate (REER). We observe that international reserves cushion the impact of terms-of-trade shocks on REER, and that this effect is important for developing but not for industrial countries. This buffer effect is especially significant for Asian countries, and for countries exporting natural resources. Financial depth reduces the buffer role of international reserves in developing countries. Developing countries' REERs seem to be more sensitive to changes in reserve assets; whereas industrial countries display a significant relationship between hot money and REER.

I. Introduction

THIS paper evaluates how international reserves hoarding and economic structure affect the real exchange rate (REER) and its adjustment to inflows of capital, terms-of-trade (TOT) shocks, and other shocks. We compare the REER patterns between developing and the OECD countries.[1] The background of our study is the presumption that volatility induces first-order adverse effects on the economic performance of developing countries.[2] Recently, Aghion et al. (2006) found that REER volatility reduces growth for countries with relatively low levels of financial development; hence, factors mitigating REER volatility may be associated with superior economic performance. Other studies have unraveled the fact that TOT improvement leads to REER appreciation through the income effect.[3] For most developing countries, terms-of-trade shocks are the most important source of exogenous volatility. Developing countries are exposed to TOT volatility that is 3 times the volatility of industrial countries, resulting in income shocks that are 3.5 times as volatile as those affecting industrial countries (see IDB, 1995, and Hausmann, Panizza, & Rigobon, 2006). Dealing with TOT volatility is a challenge for natural resources exporters, exposed to TOT volatility that is 3 times the volatility of manufacturing countries. TOT shocks impose a daunting challenge for developing countries. Shallow domestic financial systems, relatively small size, and the lack of sectoral diversification in most developing countries limit the ability of these economies to mitigate TOT shocks by internal adjustment. Sovereign risk and the lack of proper financial instruments inhibit the ability to hedge against these shocks by relying on the global financial system (see Caballero, 2003). Developing countries are left with self-insurance as a last-resort option of dealing with TOT shocks.

Our study examines the degree to which international reserves mitigate the impact of TOT shocks on the REER. We find that this effect is important for developing countries, and especially important for Asian countries and for countries exporting natural resources, but not for industrial ones. We also confirm that financial depth is a key element in determining the degree of mitigation offered by international liquidity. The overall results are robust to adding controls such as capital flows, exchange rate management and monetary policy, and trade, and financial openness.

II. Effective TOT Shocks and REER Adjustment—The Shock-Absorbing Role of International Reserves

We start the analysis by testing the extent to which international reserves mitigate the impact of terms-of-trade shocks on the REER. The empirical analysis covers 1970 to 2004, sixty developing economies, and twenty industrialized economies.[4]

As a benchmark, we adopt a panel regression methodology:

$$\ln(REER_{it}) = a_{1,i} + \alpha_1(TO \times \ln(TOT))_{it} + \alpha_2(\{TO \times \ln(TOT)\} \times RES)_{it} + \varepsilon_{it}; \quad (1)$$

where the independent variable is the natural log of the real effective exchange rate (REER), defined such that higher REER indicates real appreciation (see appendix A for definitions), $TO \times \ln(TOT)$ is the *effective terms of trade,* defined by the trade openness, $TO = \ln\left[1 + \left(\frac{IM + EXP}{2GDP}\right)\right]$, times the natural log of the terms to trade, $\ln(TOT)$, and $RES = \ln\left[1 + \frac{\text{international reserves}}{\text{GDP}}\right]$, a proxy for the international reserves/GDP rate. Buffering effects of international reserves would be captured by $\alpha_2 < 0$. The mitigation of TOT shocks may stem from reducing the magnitude of the REER adjustment triggered by capital flows, thus minimizing the odds that such capital flight may end up with a full-blown financial crisis, potentially triggered by balance sheet effects of depreciation of nominal and real exchange rates (see Calvo, Izquierdo, & Mejia, 2004, and Mendoza, 2005, for further discussion of these balance sheet effects). Equation (1) is also consistent with the predicted patterns of financial intermediation and the real exchange rate in a collateral dependent open economy, extending the framework in Aizenman and Lee (2007) to a two-sector model (see appendix A).

A concern regarding regression (1) is the possibility of a unit root in the real effective exchange rate. The results of individual tests on REER series portraying these series as I(1) processes could be due to low power in those tests. We work around this problem using the panel unit root test developed by Levin, Lin, and Chu (2002).[5] Although we rejected the unit root hypothesis for the REER, we found high persistence: an autoregressive coefficient of about 0.84, but well below 1 [see table A7, appendix B].

The specification of regression (1) follows the observation that the *effective terms-of-trade shock, d* $\ln(TOT) \times TO$, is a first-order approximation of the income effect associated with the TOT improvement rate, $d\ln(TOT)$, where the income effect is defined as the GDP rate of change

Received for publication July 25, 2006. Revision accepted for publication July 5, 2007.

We would like to thank two anonymous references for their insightful comments. Any mistakes are ours.

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[1] See Edwards (1989), Edwards and Savastano (2000), Cheung, Chinn, and Fujii (2001), Chinn (2006), and Hau (2002) for analysis of the REER in developing countries, and the impact of productivity and other macro forces on the REER.

[2] See IDB (1995).

[3] See Mendoza (1995) and De Gregorio and Wolf (1994).

[4] See the appendix to Aizenman and Riera-Crichton (2007) for the exact list of countries included in each category, and for all the other references to the appendix in this note.

[5] The test assumes that each individual unit in the panel shares the same AR(1) coefficient, but allows for individual effects, time effects, and possibly a time trend. By introducing a series of lags, the test may be viewed as a pooled augmented Dickey-Fuller (ADF), with the null hypothesis of nonstationarity (I(1)) behavior. See Taylor and Sarno (1998) and Calderon (2002) for other references to the stationarity of pooled REER series.

The Review of Economics and Statistics, November 2008, 90(4): 812-815

TABLE 1.—REER VERSUS EFFECTIVE TERMS OF TRADE AND MITIGATION THROUGH RESERVE ACCUMULATION

Dependent Variable: Ln(REER)	All Countries	Developing Countries	Industrial Countries	Manufactures Exporters	Natural Resources Exporters	Latin America	Asia
ETOT	1.802***	1.836***	0.95	0.442	4.376***	1.642**	2.269**
	[0.244]	[0.255]	[0.594]	[2.077]	[0.779]	[0.802]	[1.104]
ETOT × RES	−3.873***	−3.937***	−1.603	12.269	−10.676	−0.537	−4.672**
	[0.746]	[0.766]	[4.607]	[23.668]	[7.013]	[9.164]	[2.280]
Observations	1,863	1,260	603	271	253	343	202
R-squared	0.4549	0.4367	0.5947	0.4066	0.6162	0.3903	0.2161
Years	1970–2004	1970–2004	1970–2004	1970–2004	1970–2004	1980–2004	1970–2004

REER is the real effective exchange rate, ETOT corresponds to effective terms of trade, and RES is the stock of international reserves.
Robust standard errors in brackets.
**Significant at 10%; **significant at 5%; ***significant at 1%.*
This regression includes fixed country effects not reported in the table.

induced by the shock.[6] By design, regression (1) implies that the elasticity of the REER with respect to effective terms-of-trade shocks is

$$\frac{d\ln(REER)}{TO \times d\ln(TOT)} = \alpha_1 + \alpha_2 \times RES. \quad (2)$$

Hence, regression (1) provides information about the degree to which hoarding international reserves may impact REER dynamics induced by terms-of-trade shocks. Table 1 reports the regression results for 1970–2004. Column 1 presents the baseline regression pooling all countries, subject to data availability. The elasticity of the REER with respect to the effective terms-of-trade shock is well above 1: a 1% improvement of the effective terms of trade induces an REER appreciation of about 1.8%.[7]

Column 1, table 1, implies that $d\ln(REER)/[TO \times d\ln(TOT)] \cong 1.8[1–2 \times RES]$; that is, international reserves hoarding lessens the elasticity of the REER with respect to the effective TOT by more than twice the international reserves/GDP. Hence, for a country with trade openness of 0.25, and IR/GDP ratio of 0.1, the elasticity of the REER with respect to the TOT is $0.25 \times 1.8\ (1 - 2 \times 0.1) = 0.36$. This is in line with De Gregorio and Wolf (1994), who found that the elasticity of the REER with respect to TOT, unconditional of the RES position, is about 0.4 for a sample of OECD countries. Table 2 summarizes the elasticity of the REER with respect to both the effective and the regular TOT. Developing countries, especially emerging Asia, and commodity exporters have been significantly more exposed to changes in the terms of trade. Increasing the stock of reserves in each of these countries could reduce this vulnerability to external shocks smoothing the reactions of their REERs to terms-of-trade changes.

Columns 2 and 3 in table 1 show that aggregation matters—the mitigation effects associated with international reserves apply to developing, but not to industrial, countries. This is consistent with the notion that limited development of the capital market in developing countries hampers their ability to mitigate the volatility associated with shocks. Economic structure matters greatly—exports of natural resources magnify the impact of the effective terms-of-trade shocks and the mitigation associated with international reserves by a factor exceeding 2. Interestingly, this mitigation effect is insignificant for that group, yet we will show later that it is significant for the lagged effective TOT shock. In contrast, these interactions are insignificant for manufacturing-intense countries. The last two columns focus specifically on Latin America and Asia; effective TOT shocks induce large effects in both blocks. International reserves provide a powerful mitigation of effective TOT shocks in Asian countries, but not in Latin America.

Table B8 in the appendix supports the robustness of prior results, evaluating the adjustment to the one-year lagged effective terms-of-trade shock on the contemporaneous REER:

$$\ln(REER_{it}) = a_{1,i} + \alpha_1(TO \times \ln(TOT))_{it-1} + \alpha_2(TO \times \ln(TOT) \times RES)_{it-1} + \varepsilon_{it}. \quad (1')$$

The signs are identical to table 1, the main difference being that shocks are apparently absorbed faster in Latin America and Asia, where most of the coefficients on the lagged shocks are insignificant for these blocks. Tables C2 and C3 in appendix C report country-specific results. The above suggests that the volatility of the real effective exchange rate would be mitigated by higher levels of international reserves. We validate this conjecture in our data (see appendix F). For further reference to previous studies looking at this relationship see Hviding, Nowak, and Ricci (2004).

To verify robustness, Table C1 in appendix C reports distinct specifications of regressions (1) and (1′) for subsets of countries. The regularities uncovered in these regressions include the following:

- Reserves play a role in the mitigation of TOT shocks only in developing countries. This mitigation role is not displayed by industrial countries under any specification.
- REERs in countries that specialize in exports of manufactures are inelastic to changes in their terms of trade. Reserves do not play a role as shock absorber for this subgroup.
- Commodity exporters display a very elastic REER against changes in the terms of trade. This role is consistently more significant for lagged values of TOT.
- REERs in Latin American emerging economies are remarkably independent from changes in the TOT, and reserves do not seem to function as shock absorbers for those economies. Exceptions are Argentina, Chile, or Ecuador (see table C2 in the appendix).
- For Asian emerging markets, TOT changes clearly have an impact on their REER, and reserves play a central role moderating the effects of changes in the TOT.

[6] That is, for small terms-of-trade shocks, $\Delta GDP/GDP \cong TO \times \Delta \ln(TOT)$.

[7] See appendix F, table F1, for regressions of the REER on the effective TOT and international reserves in the absence of interaction terms. For developing countries, the elasticity of the REER with respect to the effective TOT is well above 1, whereas the elasticity of the REER with respect to the stock of IR/GDP is well below −1—higher stock of IR/GDP is associated, on average, with depreciated REER.

TABLE 2.—MEANS OF THE INTERACTION TERMS AND REER ELASTICITY WITH RESPECT TO ETOT AND TOT

	All Countries	Developing Countries	Industrial Countries	Manufacturers Exporters	Natural Resources Exporters	Latin America	Asia
Means							
Reserves over GDP	0.09	0.108	0.055	0.163	0.078	0.075	0.056
Trade openness	0.23	0.24	0.2	0.32	0.16	0.19	0.22
REER Elasticity to							
Effective TOT	1.45	1.42	1.24	1.51	1.60	3.58	1.13
Terms of trade	0.33	0.34	0.25	0.48	0.26	0.68	0.25
Sample period	1970–2004	1970–2004	1970–2004	1970–2004	1970–2004	1980–2004	1970–2004

These elasticities are calculated based on the average holding of international reserves and average trade openness for each subgroup.

Appendix C submits our initial findings to a series of controls. We show that the transmission of effective terms-of-trade shocks into the REER and the buffer role of foreign liquid assets are augmented by greater flexibility of exchange rate regimes. REER seems to be more sensitive and reserves play a more prominent role after negative effective TOT shocks. Although we do not find a significant change in the slope of the interaction between effective TOT and reserves for all developing countries after the 1997 Asian crisis, we find that after 1997, reserves in Latin American economies and commodity-exporting countries play a bigger role.

Faced by changes in their terms of trade, we expect countries with deep financial markets will be able to internally self-adjust more effectively than those with shallow markets. To verify this, we introduce the interaction of our reserve mitigation term [$TO \times \ln(TOT) \times RES$] with a measure of financial depth represented by the M2 money aggregate deflated by GDP (see appendix D). Financial depth significantly decreases the role of reserves as shock absorber for our global sample of developing economies. This effect seems to be insignificant for Latin American emerging markets, industrialized economies, commodity exporters, and manufacture exporters. Interestingly, Asian economies seem to be extremely sensitive to both the mitigation effect of reserves and the role of financial development in the domestic market. The same regression holds for lagged values of terms of trade, reserves, and liquid liabilities. Although the role of financial development seems to die faster than that of reserves for all emerging markets, the results are quite robust, especially for Asian economies, where both effects (that is, reserves as shock absorber and the corresponding mitigation of this role through financial depth) remain highly significant.

To verify robustness, we estimate the REER adjustment in four ways: panel with country effects, country effects on de-trended real effective exchange rate, time and country effects on log of real effective exchange rate, and country effects and quadratic time trend on log of real effective exchange rate, controlling for various types of capital flows, exchange rate regime, trade and financial openness, and relative income (see appendix E). Overall, the relationship between TOT, REER, and the mitigation effect from reserve accumulation described above is robust to the inclusion of these controls. Breaking capital inflows in several categories allows us to expose systematic distinctions in the effect of those flows on the REER for different subgroups of countries (see table 3).

- Inflows associated with short-term capital and decreases in foreign reserve assets tend to appreciate the REER. Developing countries' REERs seem to be very sensitive to changes in reserve assets, fairly inelastic to movements of short-term capital, and highly inelastic to changes in long-term foreign capitals. Industrial countries display a very consistent positive correlation between FDI inflows and REER appreciations across the board. Inflows of hot money are also associated with real appreciations in these industrialized economies. When we interact reserves with trade openness, we observe that the effects of a decrease in reserves on the REER are diminished as we move toward greater trade openness (see appendix E).
- Manufactures exporters display a highly significant relationship between inflows of hot money and appreciation of the REER, while natural resource countries' REERs are not related to changes in capital inflows, once we adjust for trade openness. REERs in Asian emerging economies consistently react to inflows of hot money, especially in those specifications that take trade openness into consideration. Changes in reserve assets and FDI inflows seem to play a minimal role in the determination of the REER for these Asian economies. Latin American emerging

TABLE 3.—SUMMARY OF CORRELATIONS BETWEEN CAPITAL INFLOWS AND REER APPRECIATIONS

	Specifications without Interactions			Specifications with Interactions		
Type of Inflow Sign of the Significant Coefficient	FDI +/−	Hot Money +/−	Decrease in Official Reserves +/−	FDI +/−	Hot Money +/−	Decrease in Official Reserves +/−
Developing countries	0/0	2/0	8/0	0/0	2/0	8/0
Industrial countries	6/0	8/0	5/0	8/0	8/0	2/0
Manufactures exporters	6/2	8/0	0/0	0/3	8/0	2/0
Commodity exporters	0/0	8/0	2/0	0/0	0/1	0/0
Latin America	2/0	2/0	8/0	0/7	5/4(*)	0/0
Asia	0/0	2/5	0/0	2/0	8/0	2/0

Each number represents the number of significant (at 10%) coefficients of each type of capital inflows to REER across our eight different specifications (see appendix D). "0/0" would correspond to eight insignificant coefficients for that country subgroup.

A positive-signed coefficient uncovers a positive relationship between inflow and appreciation. In the case of reserves, positive-signed coefficients reveal a positive relationship between reductions of official reserves and appreciations.

(*) For Latin America, there is a distinction between the effects of "other investment" inflows and "portfolio" inflows.

markets' REERs seem to be considerably sensitive to changes in reserve assets, although this relationship is broken when we use the interactions with trade openness.

For Latin America, "other investment" inflows seem to be associated with appreciations of the REER, while "portfolio" inflows are associated with real depreciations.

- REER depreciation associated with FDI, found by Athukorala and Rajapatirana (2003), is only consistently present in manufactures exporters and Latin American economies once we account for trade openness. FDI inflows tend to appreciate REER in industrial countries, though at a slower rate than other types of capital.
- The results support the hypothesis that international trade helps mitigate pressures for real appreciation (see Hau, 2002).
- Nominal exchange rate depreciation has the expected negative effect on REER across the board. Natural resource exporters and Latin American economies seem to be especially sensitive to these changes in nominal exchange rates.
- Higher international reserves/GDP ratio is associated with depreciated REER. However, this effect is mitigated by trade openness. These results are much weaker for the OECD.

III. Concluding Remarks

Our paper suggests that hoarding and managing international reserves has the effect of mitigating the impact of TOT shocks on the REER. Consequently, countries exposed to TOT volatility may benefit from active management of international reserves in ways that go well beyond the conventional prerogative of a central bank (see Davis et al., 2001, for a review of the experience of Chile and Norway). Greater integration of financial markets may have increased the responsiveness of financial flows to TOT shocks. Hence, TOT improvement associated with higher domestic returns would induce capital inflows, leading to further REER appreciation. Similarly, TOT deterioration may lead to disorderly outflows, where the rush to exit is motivated by the wish to minimize capital losses. Better understanding of these issues is left for future investigation.

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