Essays in International Finance

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Abstract

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This dissertation consists of three chapters. The first chapter, “What Makes a Commodity Currency?”, looks at real exchange rate behavior of developing countries that depend heavily on commodity exports. A primary purpose of this chapter is to understand various responses of real exchange rates to world commodity price shocks in these countries. Our panel data analysis using 63 countries for 1980-2010 finds that, in accordance with theory, the long-run cointegrating relationship between the real exchange rate and commodity export prices depends on the nation’s export market structure, its monetary policy choices and its degree of trade and financial openness. We also show that the commodity price-exchange rate connection is much weaker in the short-run and for a group of oil-exporting countries. Given concerns for the Dutch disease or resource curse, our findings are of particular relevance for monetary policy-making and for globalization strategy in commodity-exporting developing economies.

The second chapter of my dissertation, “Benefits of Reserve Pooling Arrangements”, examines the expected benefits of reserve-pooling arrangements between emerging economies in order to see if this bilateral coordination can help lower the degree of externality associated with the excessive reserve hoarding. I develop a two-period, two-states-of-nature precautionary savings model where agents have imperfect access to international financial markets, and

countries engage in competitive hoarding of reserves. To maximize utility, countries face a choice between hoarding larger *relative* reserves which lower the probability of a speculative attack in the second period, at the expense of foregone returns from the domestic capital accumulation. I compare resource allocations based on Nash- versus cooperative-equilibrium to investigate the possible gains from a multi-country collective management of reserves. Preliminary simulation results show that the level of reserve holdings and the probability of speculative attack decline noticeably under the cooperative equilibrium, while a level of domestic capital investment declines with the lower reserves. This result suggests that reserve co-management can effectively reduce the externality generated by the "keeping-up-with-the-Joneses" effect in reserve accumulation, and help relax the external credit constraint faced by emerging economies in a crisis.

Lastly, the third chapter, "Financial Openness, Exchange Rate Risk and Portfolio Rebalancing", studies a rebalancing motive of fund managers who invest in both developed and emerging economies. While the recent portfolio-data based literature generally finds a risk rebalancing as a dominant portfolio strategy by fund managers, we observe a large variation in the degree of rebalancing across different investment destination countries. This chapter seeks to explain this variation using country-specific economic determinants. Our fund-level panel data analysis based on 44 countries over the period 1999m01-2010m12 finds that, consistent with our portfolio balance model prediction, financial openness with a lower capital flow barrier and higher nominal exchange rate flexibility tend to reinforce the risk rebalancing motive. In addition, this rebalancing motive appears larger for a country with the larger volatility of its total equity market return, where the exchange rate return volatility plays a dominant role.

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DEDICATION

To my beloved wife, Hoonkyoung Seo, who has willingly sacrificed herself to provide a constant source of support and encouragement for my success

Chapter 1: What Makes a Commodity Currency? (with Yu-chin Chen)

1 Introduction

About a third of the countries in the world rely on primary commodities such as mineral, agricultural, and energy products as a significant source of export earnings. The wild fluctuations of global commodity prices thus account for a large share of these countries' terms-of-trade shocks, which can have a major influence on the value of their currencies. The "commodity currency" literature demonstrates the strong and robust real exchange rate response to global commodity price fluctuations and emphasizes transmission mechanisms such as terms-of-trade adjustment, the income effect, and the portfolio balance channel.[1] While an increase in the world prices of primary commodities brings about higher export revenue for their exporters, an induced corresponding real currency appreciation can crowd out the exports of non-commodity industries by undermining their price competitiveness in the world market. This so-called "Dutch Disease" consideration underscores the importance of understanding the exchange rate response to world commodity price movements as it may inform strategies for growth and policy decisions.[2]

While the literature emphasizes a generally robust exchange rate response to commodity price movements, especially for commodity exporters with a floating nominal exchange rate, little attention is paid to the wide range of response magnitudes and the reasons behind it.[3] This paper seeks to understand this variation from diverse perspectives. First, the paper explores an intermediate role of structural and policy factors in determining the strength of real exchange rate-commodity price connection. Second, the paper makes a clear distinction of workings of commodity currencies between in the short- and long-run, which is often neglected in the

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[1] Currencies that respond significantly to the world prices of their corresponding country's commodity exports are called "*commodity currencies*". See Edwards (1986), Amano and van Norden (1995), Chen and Rogoff (2003, 2012), MacDonald and Ricci (2004) and Cashin et al. (2004) for empirical exploration covering a range of developed and developing countries. Ricci et al. (2008), Coudert et al. (2008), and Bodart et al. (2011, 2012) are examples of commodity currency analysis using a panel data approach.

[2] See Corden and Neary (1982) for the core model of the Dutch disease. Using the model characterized by a non-traded good (services) and two traded goods (energy and manufactures), they address the effects of a boom in the energy sector on the distribution of income and on the size and profitability of the manufacturing sector. For a broader coverage of the effect of natural resource exports on elements of the balance of payments, see Harding and Venables (2013).

[3] For example, Cashin et al. (2004) finds 19 commodity currencies with the long-run elasticity estimates ranging between 0.16 for Iceland and 2.03 for Ecuador.

literature. Lastly, the paper documents differences in commodity currencies and oil currencies in terms of their responses to a commodity/oil price shock.

As a preview, Figure 1.1 illustrates the large heterogeneity in the domestic currency responses to movements of world commodity prices across 63 major commodity-exporting countries. Regressing country-by-country the real effective exchange rate (*REER*) on the country-specific real commodity price index (*RCP*), we find 39 countries to have a statistically significant commodity price coefficient at the 5 percent level.[4] Elasticity estimates range from −4.96 (Libya) to 7.63 (Ghana) with a median value of 0.84.[5] What may account for this heterogeneity? To answer this question, we first present a standard small-open economy, traded/non-traded goods model in the next section. Our model suggests that three factors affect the link between *REER* and *RCP*: the nation's degree of openness (both trade and financial), monetary policy choices (in the form of inflation-targeting, nominal exchange rate flexibility and international reserves management) and its export market structure (i.e., its degree of commodity export dependency and its export share in world markets). Our empirical results broadly support this theoretical view. More specifically, the long-run reaction of the real exchange rate to a commodity boom would be larger if a country is characterized by any of the following traits: i) open financial market, ii) low degree of trade openness, iii) fixed nominal exchange rate, iv) low level of international reserves, v) heavy commodity export dependency and vi) possession of a dominant share of the global commodity production. Furthermore, our estimation results demonstrate a strong long-run *REER*-*RCP* connection, generalizing the commodity currency phenomenon in a large group of developing countries. However, in contrast to previous studies based on the currencies of a small set of developed countries, we find much weaker evidence of the commodity currency phenomenon in the short-run.[6] We also find a weaker *REER*-*RCP* relation in a group of oil-exporting countries than the non-oil commodity counterparts.

[4] In this paper, we use the real effective exchange rate (*REER*) as a measure of the international competitiveness of a country against all of its trade partners. We interpret an increase in the real effective exchange rate as a real appreciation of the domestic currency relative to its trade partners. The real commodity price index (*RCP*) is defined as the world nominal price of country's commodity exports deflated by the price index of manufactured exports of industrial economies. Note that *REER* and *RCP* are in logarithm in all of our empirical procedures. More information about the *REER* and *RCP* including their construction and data sources is presented in Appendix.

[5] Reported median here is from a distribution including both short- and long-run elasticity estimates. The median would be 1.07 if we consider the significant long-run elasticity estimates only. Note that short-run elasticity estimates have a narrower distribution ranging from -0.63 (Venezuela) to 2.44 (Brazil) with a median value of 0.67.

[6] Chen et al. (2010) exploits short-run asset pricing dynamics, focusing on five developed economies including Australia, Canada, New Zealand, South Africa and Chile.

During our sample period between 1980 and 2010, many developing countries in the globe experienced a significant structural change in policies including exchange rate reforms and inflation targeting. A series of currency crises also have affected macroeconomic conditions of this country group. All of these have a potential to affect the level of the real exchange rate and consequently a relationship between *REER* and *RCP*. We thus test the robustness of our main results and find they are robust to structural shift consideration.

While high commodity prices of any type bring about higher export revenue for a country exporting that commodity, they may also lead to the inflationary pressure, inflow of large hot money, and deterioration of the price competitiveness of non-commodity sectors in the world trade market. Therefore, effectively managing these adverse consequences of commodity price fluctuations is a natural interest of policy makers in commodity exporting countries. Results in this paper help them to find appropriate policy responses to stabilize their economy by effectively dampening rather than amplifying the costly commodity price shocks.

The remainder of this paper is organized as follows. Section 2 sets out the structural model that examines the theoretical factors influencing the commodity price elasticity of real exchange rate. Section 3 explains the estimation procedure including an empirical model specification and data diagnosis. Section 4 presents the estimation results based on our non-stationary panel data set and their robustness. Section 5 concludes.

2 Determinants of commodity price elasticity

In this section, we present a theoretical framework that highlights the impact of commodity price shocks on the real exchange rate in a commodity exporting country.[7] The model allows us to discuss the effect of economic determinants including structural factors and policy choices of a country on the strength of exchange rate-commodity price connection.

2.1 The baseline model

Consider a small open economy that produces two types of goods, non-tradables (*N*) and exportables (*X*), using labor (*L*) and capital (*K*) in a competitive market. Production functions in each sector are given by:

[7] For the purpose of our work, we adopt the models presented in Obstfeld and Rogoff (1996) and Cashin et al. (2004).

$$Y_N = A_N L_N^{\alpha} K_N^{1-\alpha} \tag{1.1}$$
$$Y_X = A_X L_X^{\beta} K_X^{1-\beta} \tag{1.2}$$

where Y_N and Y_X are output of the non-tradable and exportable goods; $A_i, L_i,$ and K_i are productivity shocks, labor and capital in sector i, $i = N, X$; $0 < \alpha < 1$ and $0 < \beta < 1$. In our framework, exportables are primary commodities unless otherwise noted and domestic residents do not consume these goods. Capital is allowed to move between sectors and countries, but labor is assumed to be mobile only between sectors within the country. The total domestic labor supply is inelastically given by $L = L_N + L_X$. Because capital is internationally mobile, the domestic marginal product of capital is given by the world interest rate (r^*), while perfect labor mobility between industries ensures wage (w) equalization across sectors.

Let p_X be the world price of exportable commodities exogeneously given to the small open economy, and p_N be the domestic price of non-traded goods. We assume that the law of one price holds for the exportable goods so that:

$$Ep_X = p_X^* \tag{1.3}$$

where E is the nominal exchange rate, defined as the price of domestic currency in terms of foreign currency, and an asterisk denotes a foreign value. Let us also define the capital-labor ratio in both sectors as $k_i \equiv K_i/L_i$, $i = N, X$. Then, the firm's profit maximizing first-order conditions for labor and capital in both sectors are given by the following functions:

$$\alpha p_N A_N k_N^{1-\alpha} = w \tag{1.4a}$$
$$(1-\alpha) p_N A_N k_N^{-\alpha} = r \tag{1.4b}$$

in the non-tradable sector and

$$\beta p_X A_X k_X^{1-\beta} = w \tag{1.5a}$$
$$(1-\beta) p_X A_X k_X^{-\beta} = r \tag{1.5b}$$

in the exportable sector. By combining first-order conditions in each sector, we derive zero-profit conditions for both sectors:

$$p_N A_N k_N^{1-\alpha} = w + rk_N \quad (1.6)$$
$$p_X A_X k_X^{1-\beta} = w + rk_X \quad (1.7)$$

Taking a log-differentiation of equations (1.6) and (1.7) making use of (1.4b) and (1.5b) yields:

$$\hat{p}_N = \frac{\mu_{LN}}{\mu_{LX}}\left(\hat{p}_X + \hat{A}_X\right) - \hat{A}_N \quad (1.8)$$

where a hat above a variable denotes a logarithmic derivative and $\mu_{LN} \equiv wL_N/p_N Y_N$ and $\mu_{LX} \equiv wL_X/p_X Y_X$ be labor income share in the non-tradable and exportable sectors, respectively. Empirically, non-traded goods tend to be at least as labor-intensive as exportable goods, implying that $\frac{\mu_{LN}}{\mu_{LX}} \geq 1$. Note that with perfect international capital mobility and free movements of labor and capital across sectors, the relative price of non-tradables is entirely determined by the production side of the model and is independent of demand side factors as in the standard Balassa-Samuelson model.

2.1.1 Consumption

The economy is inhabited by a continuum of identical individuals that supply labor and consume two goods – non-tradables (*N*) and importables (*T*). Let's assume that domestic residents derive utility by consuming γ share of non-tradables and $(1-\gamma)$ share of importables (*T*), where the law of one price holds for the latter only. A representative consumer's utility function takes the Cobb-Douglas form:

$$U = \tau C_N^{\gamma} C_T^{1-\gamma} \quad (1.9)$$

where C_i is consumption of good *i*, *i* = *N*, *T*; $0 < \gamma < 1$ and $\tau = 1/\gamma^{\gamma}(1-\gamma)^{(1-\gamma)}$. Hence, consumption-based consumer price index (*p*) is given by

$$p = p_N^{\gamma} p_T^{1-\gamma} \tag{1.10}$$

2.1.2 How is the real exchange rate determined?

We now define the real exchange rate as the foreign price of the domestic basket of consumption (Ep) relative to the foreign consumer price index in foreign currency (p^*). Using the relations derived in (1.8) and (1.10) and assuming $\gamma = \gamma^*$, we can write the real exchange rate (Q), the relative price of domestic consumption basket in terms of foreign consumption basket, as follows:[8]

$$Q = \frac{Ep}{p^*} = \frac{Ep_N^{\gamma} p_T^{1-\gamma}}{\left(p_N^*\right)^{\gamma^*} \left(p_T^*\right)^{1-\gamma^*}} = \left(E \frac{f\left(p_X\right)}{p_N^*}\right)^{\gamma} \tag{1.11}$$

The equation (1.11) shows that, given p_N^*, the real exchange rate in the home country appreciates in response to an increase in the price of exportable commodities, with the extent of this appreciation depending on the variables/parameters present in the equation.

2.2 Factors influencing the commodity price elasticity

2.2.1 Degree of openness

Trade Openness (*TO*). Equation (1.11) shows that the elasticity of the real exchange rate with respect to the price of exportable commodities depends on γ, which captures a share of non-tradables in a basket of domestic consumption. Therefore, if the economy's consumption depends heavily on imported goods with large $(1-\gamma)$, the real exchange rate response to an increase in the price of exportable commodities would be relatively small. This makes sense intuitively because, given demand, the domestic price of importables is likely to be lower if a country allows a greater volume of imports with less trade restrictions, resulting in the lower overall domestic price level and the less appreciation pressure on the real exchange rate.

[8] Following Cashin et al. (2004), we assume that the foreign economy produces intermediate (*I*), non-traded (*N*), and final traded (*T*) goods using labor and capital but consumes γ^* and $(1-\gamma^*)$ shares of the last two goods only. Thus, the implied CPI is: $p^* = (p_N^*)^{\gamma^*}(p_T^*)^{1-\gamma^*})$. The foreign country's final traded good is a manufactured good, a fraction of which is exported and consumed by the home residents. We assume that the foreign firms use v share of intermediate goods and $(1-v)$ share of commodities imported from the home country to produce the final traded goods but the commodity share is small enough that world price changes in commodities have negligible effect on CPI of the foreign economy.

Financial Openness (*FO*). A commodity price boom is expected to attract foreign capital to the exportable goods sector, raising marginal productivity of labor and wages of that sector by equation (1.5a). Through the channels described in equations (1.6) and (1.7), this should eventually generate an increase in wage and price of non-tradables under the free labor mobility between sectors according to equation (1.8), resulting in an equilibrium real exchange rate appreciation. This is how the Balassa-Samuelson channel works. Let's now introduce financial market frictions in the form of restricted capital inflow to a commodity-exporting country. The real appreciation pressure caused by an increase in price of the exportables would be relatively small as improvement of the marginal productivity of labor in exportables is likely to be constrained with inelastic supply of capital. This suggests a stronger real exchange rate-commodity price connection in a country with higher degree of financial openness.

2.2.2 Monetary/exchange rate polices

Inflation Targeting (*IT*) and *Exchange Rate Regime* (*EXR*). Monetary/exchange rate policy options designed to control the movements of nominal exchange rate (E) or domestic price level (p) are also important candidates influencing the commodity price elasticity. Under the perfect cross-border capital mobility, however, a monetary authority faces a trade-off between pegging the exchange rate and keeping autonomous monetary policy decisions.[9] Recognizing this interdependent nature of monetary/exchange rate policy choices, we interpret the role of them together as a group rather than individually. In theory, a direction of the real exchange rate changes in response to the commodity price boom is ambiguous for a country with a certain policy choice, either an inflation targeting or a currency peg.[10] This is because we do not know a priori how much the domestic price level in the commodity-dependent economy should adjust relative to the nominal exchange rate when the commodity price increases. Empirical evidence in the literature is also mixed. For example, Broda (2004) shows that in

[9] The Mundell-Fleming model predicts that under a credible fixed exchange regime and free capital mobility, the central bank loses an ability to make autonomous adjustments in monetary policy: the (risk-adjusted) domestic interest rate must be equal to the foreign interest rate. See Shambaugh (2004) and Obstfeld et al. (2005) that discuss about the presence of open-economy trilemma across different countries and regimes.

[10] While we admit that a monetary policy should be neutral in the long-run, it may have a long-run effect in practice as massive international reserve holdings allow a country to pursue both a high level of exchange rate stability and a relatively high weighted average of the other two trilimma policy objectives. Also note that, although our model emphasizes a transmission of commodity price shocks to the real exchange rate only, a nominal exchange rate adjustment channel should not be overlooked. In fact, Chen (2002) finds commodity currencies in Australia, Canada, and New Zealand using their nominal exchange rate data.

response to a decline in terms-of-trade, the real exchange rate depreciation is small and slow in pegs but large and immediate in floats. On the contrary, Bodart et al. (2011) finds that a flexible exchange rate regime tends to decrease the effect of commodity price shocks on the real exchange rate.

International Reserves (*RES*). Hoarding large international reserves may relax the open-economy trilemma. Aizenman et al. (2013) supports this view by documenting the presence of loose compatibility amongst three objectives, namely exchange rate stabilization, capital mobility, and domestic monetary autonomy, in emerging markets with ample international reserves. In addition, Aizenman et al. (2012)'s empirical results based on the data for commodity-dependent Latin American countries show that large reserves help effectively lower the volatility of the real exchange rates in the face of commodity terms-of-trade shocks.

2.2.3 Export market structure

Commodity Export Dependency (*CEX*). Let's extend a production side of our model by introducing the manufacturing sector to the home country. Now the home country produces three types of goods, non-tradables, exportable commodities and exportable manufactures (*M*) using labor and capital in a competitive market such that $Y = Y_N^{\gamma} Y_X^{\delta} Y_M^{1-\gamma-\delta}$. From the domestic firms' profit maximizing first-order conditions in the three sectors, one can show that the price of non-tradables depends on the price of exportable commodities and manufactures. Therefore, a larger share of exportable commodities in the domestic production implies a greater impact of commodity price shocks on the real exchange rate through a larger factor-price adjustment effect from the commodity sector to the non-tradable sector.

World Market Share (*MSH*). In our model, we assume that the domestic economy is so small that it takes the price of exportable commodities from the rest of the world. This assumption may not hold if a country has a dominant market share of global commodity production and, as a result, has some degree of market power.[11] Consider a country that has a monopoly power in the world market for a commodity in the sense that a large volume of its

[11] Examples of countries with a sufficiently large market share of commodity exports include Cote d'Ivoire (Cocoa), Chile (copper), Malaysia (palm oil), and Philippines (coconut oil). Each of these countries often accounts for more than one third of world production of its primary commodity.

exports places downward pressure on the world price of the commodity. Domestic producers in such a country would expand production and export more to increase their revenue if a domestic currency depreciates. As a result, the world price of the commodity is expected to fall due to the large supply. Based on this logic, we can derive the production of exportables as a negative function of real exchange rate:

$$Y_X = Y_X\left(\overset{(-)}{Q}\right) \tag{1.12}$$

Furthermore, in the export market of this commodity, the world price depends on the supply of the world leading producer. Therefore, the world commodity price is given by:

$$p_X^* = p_X^*\left(\overset{(-)}{Y_X}\right) \tag{1.13}$$

holding everything else that possibly influences the price of exportables constant. Thus, from equations (1.11) and (1.12), we find that a commodity boom appreciates the country's currency, and as this squeezes its exports, the supply of commodity in the world export market falls. But the reduction of exports pushes up the world price further by (1.13) as, by assumption, the country is large. This logic suggests that the exchange rate-commodity price connection appears to be stronger when the commodity prices are endogenously determined.

The theoretical effect of factors influencing the commodity price elasticity of the real exchange rate $\left(\frac{\hat{Q}}{\hat{p}_X}\right)$ discussed in this section can be summarized as follows:

$$\frac{\hat{Q}}{\hat{p}_X} = g\left(\overset{-}{TO}, \overset{+}{FO}, \overset{+/-}{IT}, \overset{+/-}{EXR}, \overset{-}{RES}, \overset{+}{CEX}, \overset{+}{MSH}\right) \tag{1.14}$$

The signs above the variables indicate the expected effect of these variables on the commodity price elasticity.

3 Empirical procedures

3.1 Baseline regression model

To empirically test the above theoretical determinants of commodity price elasticities of real exchange rate, we begin with the standard regression model used in the commodity currency literature:

$$REER_t = \alpha_0 + \alpha_1 RCP_t + \varepsilon_t \tag{1.15}$$

where $t = 1,\ldots,T$ indexes the time-series, $REER_t$ and RCP_t are the real effective exchange rate and real commodity price index respectively for each country, and the error term ε_t is i.i.d. over periods. The parameter that determines whether a country has a commodity currency is α_1. Our goal is to identify factors that may explain a large variation in α_1's across countries. More formally, we want to explain the parameter α_1 using a set of variables X such that

$$\hat{\alpha}_{1i} = h\left(X_i\right) = \beta_1 + X_i \boldsymbol{\beta_2} \tag{1.16}$$

where i indexes cross-sectional units, X includes seven factors of commodity currencies introduced in the previous section, and $\boldsymbol{\beta}_2$ is a vector of coefficients. Combining (1.15) and (1.16) under the exogeneity assumption, our empirical model is as follows:[12]

$$REER_{it} = \alpha_0 + \beta_1 RCP_{it} + RCP_{it} X_{it} \boldsymbol{\beta_2} + u_{it} \tag{1.17}$$

From the model (1.17), we know that β_1 is the elasticity of the *REER* with respect to *RCP* and $\boldsymbol{\beta}_2$ measures marginal impact of *RCP* changes on *REER* conditional on structural/policy factors *X*. Our primary interest centers on the coefficient vector $\boldsymbol{\beta}_2$: a significant positive coefficient implies that a positive *RCP* shock puts larger appreciation pressure on the *REER* given structural/policy factors.

[12] The model (1.15) is in a time-series dimension while the model (1.16) in a cross-sectional dimension. We admit that combining these two models into a single panel model is unjustifiable. However, we present these steps here to show our motivation for the empirical estimation strategy.

3.2 Data description and characteristics

Our empirical analysis is based on a quarterly panel data set of 63 commodity exporters during the period from 1980q1 to 2010q4. A description of data and their sources are presented in Table A1.2 in Appendix. A majority of our control variables are available only at an annual frequency and interpolated to a quarterly frequency through "constant-match average". For our main variables *REER* and *RCP*, which are available at a monthly frequency, we use "last observation" method that sets the quarterly observation equal to the value in the last of the corresponding monthly observations. Table A1.6 in Appendix contains descriptive statistics for the sample data used in our empirical estimation.

As a preliminary step, we show in Figure 1.2 the time-series of the *REER* and *RCP* using a small set of countries from our sample. Two developed (Australia and Canada) and two developing (Ghana and Peru) commodity-exporting countries are selected.[13] Visual inspection of the figure suggests that each of the *REER* and *RCP* does not appear to move around a given long-run equilibrium level, suggesting the possibility of having unit-roots in both series. Despite wild fluctuations of the exchange rate and commodity prices individually, we observe a close co-movement between these two series over a long period of time in selected countries, except for Peru. Furthermore, the relationship between the *REER* and *RCP* exhibits structural shifts in countries such as Ghana and Peru.[14] Selected shift dates are largely consistent with an economic event of a country in that period. For example, the *REER* of Ghana experienced a steep depreciation from the period after the Structural Adjustment Programme (SAP) in 1983, which included exchange rate reforms until 1990. Peru, on the other hand, experienced a dramatic appreciation of its domestic currency because of the hyperinflation episodes in the late 1980's.

In addition to these time series properties, cross-sectional dependence is likely to be important and present in our case because common shocks such as global recession and spillover effects could affect the *REER* of trade partners as a group. Moreover, by the nature of its construction, *REER*s are interdependent between trade partners.

[13] See Table A1.7 in Appendix to learn major commodities exported by the selected four countries (and the rest of countries in our sample) and their share in aggregate commodity exports.

[14] Structural shift dates are indicated in Figure 1.2 by dashed lines and reported in column 9 of Table A1.1 in Appendix. Gregory-Hansen (1996) cointegration test is used to locate regime shift dates and is discussed in detail in section 4.3.

3.2.1 Order of integration: Panel unit-root tests

To formally test whether the *REER* and *RCP* are stationary or not, we consider three panel unit root tests: the Levin-Lin-Chu (2002) (LLC) test, Im-Pesaran-Shin (2003) (IPS) test, and Pesaran's (2007) cross-sectionally augmented IPS (CIPS) test. The first two are the popular first generation panel unit root tests based on the ADF (augmented Dicky-Fuller) test. Formally, their base-line regression model takes the form,

$$\Delta y_{it} = \alpha_i + \beta_t + \gamma_i t + \rho_i y_{i,t-1} + \varepsilon_{it} \tag{1.18}$$

where the errors ε_{it} (i = 1, 2, …, N, t = 1, 2, …, T) are independently distributed across both i and t, with zero means and finite heterogeneous variances, σ_i^2.

The LLC test assumes that all cross-sectional units have a common autoregressive parameter although it allows for individual effects, time effects and a time trend. The test may be viewed as a pooled Dickey-Fuller (DF) or Augmented Dickey-Fuller (ADF) test with the null hypothesis of $H_0\colon \rho_i = 0\forall_i$, against the alternative that all series are stationary, $H_1\colon \rho_i < 0\forall_i$. This restrictive assumption is relaxed in the IPS test by allowing only a fraction (but not all) of the panel is stationary under the alternative ($H_1\colon \rho_i < 0$ for at least one i). However, the first generation tests ignore the cross-sectional dependence amongst units included in the sample, possibly generating significant size distortion in test statistics.

3.2.2 Cross-sectional dependence test

Cross-sectional dependence is likely to be important in our case as mentioned earlier. Driscoll and Kraay (1998) note that standard error estimates of commonly applied co-variance matrix estimation techniques such as OLS, White and Rogers by erroneously ignoring spatial correlation in panel regressions are biased and hence statistical inference that is based on such standard error is invalid. Typically, ignoring cross-sectional dependence leads to overly optimistic standard error estimates. We thus conduct Pesaran (2004)'s cross-sectional dependence (CD) test and Table 1.1-a shows the test results. The null of cross-sectional independence is rejected at the 1 percent significance level, indicating that the regression residuals are cross-sectional dependent.

These findings motivate the implementation of the second generation panel unit-root test allowing for cross-sectional dependence (Pesaran, 2007). To eliminate the cross-sectional dependence, the ADF regressions are augmented with the cross-section average of lagged levels and first-differences of individual series. The CIPS test is based on the following cross-sectionally augmented Dicky-Fuller regression:

$$\Delta y_{it} = \alpha_i + \beta_t + \gamma_i t + \rho_i y_{i,t-1} + \delta_0 \bar{y}_{t-1} + \delta_1 \bar{y}_t + \varepsilon_{it} \qquad (1.19)$$

where $\bar{y}_{t-1}$ and $\Delta\bar{y}_t$ are proxies for the unobserved common factors. Parallel to the IPS test, heterogeneity in the autoregressive coefficient is allowed under the alternative hypothesis ($H_1: \rho_i < 0$ for at least one *i*) and the test is based on the mean of individual DF (or ADF) *t*-statistics of each unit in the panel. All tests are normally distributed under the null hypothesis of non-stationarity. Panel unit-root test results are reported in Table 1.1-b, informing that we cannot reject the null of unit-root for *REER* and *RCP* at their levels and both series are integrated of order one.

3.2.3 Panel cointegration tests

If two variables are found to be integrated of order greater or equal to one, then it is possible for those two series to be cointegrated. Figure 1.2 also shows the possible common trend between *REER* and *RCP* in the long-run. In this subsection, we implement three panel cointegration tests to see whether there indeed exists the common trend. We apply Kao (1999), Pedroni (2004), and Westerlund (2007) panel conintegration tests.[15] Under the null hypothesis of no cointegration, the Kao (1999) test assumes cointegrating vectors to be homogeneous across individuals while Pedroni (2004) allows heterogeneity in the cointegrating vectors as well as fixed effects and trends in the data. Among the seven Pedroni's tests, four are based on within-dimension and the rest are based on between-dimension. Alternative hypotheses for Pedroni's are common AR coefficients for within-dimension and individual AR coefficients for between-dimension. The two cointegration tests mentioned above do not allow for the presence of cross-sectional correlation that is detected by the Pesaran (2004)'s CD test. Thus, we proceed with the

[15] A theoretical background for each of panel non-stationarity and cointegration test can be found in Baltagi (1995). See Chapter 12 of his book and references therein for more details.

Westerlund (2007) error-correction-based cointegration test. It is designed to test for the absence of cointegration by determining whether there exists error correction for individual countries or for the panel as a whole. This test is more general than Pedroni (2004) by allowing for a large degree of heterogeneity and dependence within as well as across the cross-sectional units. Table 1.1-c shows the results in favor of cointegration, suggesting existence of long-run relation between *REER* and *RCP*.

3.3 Additional empirical specifications

We estimate equation (1.17) using the (country) fixed effect model to reduce the omitted variable bias caused by unobserved country-specific factors. In addition, fixed effects are necessary in our case because *REER* measures are country-specific indexes, making a cross-country comparison impossible. Moreover, in order to avoid a potential identification problem resulting from ignoring cross-sectional dependence, we report Driscoll and Kraay (1998) standard errors to correct for spatial correlation, autocorrelation and heteroskedasticity throughout our estimation procedures. Lastly, all structural/policy factors are converted into binary dummy variables using the sample median as a threshold value for each series.[16]

3.4 Long-run vs. short-run estimation methods

Recognizing non-stationarity and the presence of cointegration for *REER* and *RCP*, we apply DOLS (Dynamic Ordinary Least Squares), extended to a panel data analysis by Kao and Chiang (2000) and Mark and Sul (2003), to estimate the cointegrating parameter. The DOLS procedure brings contemporaneous, leads and lags of changes of cointegrated regressor to remove their deleterious short-run dynamic effects on the estimation of long-run cointegrating vector.[17] For country i and time period t, the long-run estimation is carried out based on the following model:

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[16] For example, we set *CEX* = 1 if *CEX* > median(*CEX*) and *CEX* = 0 otherwise. The same rule applies to *FO*, *RES*, and *MSH* variables. For a trade openness measure (*TO*), we use the threshold set in Aizenman et al. (2012): A county is highly trade-dependent when a ratio of trade (= *EX* + *IM*) to 2×*NGDP* is greater than 0.3. For an exchange rate regime measure, our binary *EXR* takes a unity if IRR (2008)'s coarse classification code is equal to 1 or 2 (peg).

[17] An alternative methodology widely used in a panel analysis with non-stationary data is FMOLS (Fully Modified Ordinary Least Squares). Kao and Chiang (2000) compares the performance of panel FMOLS and DOLS and

$$REEER_{it} = \alpha_i + \beta_1 RCP_{it} + \sum_{j=-p}^{p} \Delta RCP_{i,t+j}\gamma_j + RCP_{it} X_{it}\boldsymbol{\beta_2} + u_{it} \quad (1.20)$$

where α_i is the country fixed effect, β_1 is the long-run cointegrating coefficient, Δ denotes the first-difference operator, γ_j is a coefficient vector of leads and lags of the changes in real commodity price index, X_{it} is a set of structural/policy factors, $\boldsymbol{\beta_2}$ is a vector of coefficients for interaction terms and u_{it} is the disturbance term.

In order to study the short-run effect under a cointegration setting, we employ a simple error correction model (ECM) that allows separating short-term from long-term effects. The model takes the following form:

$$\Delta REER_{it} = \alpha_i + \sum_{j=1}^{p} \Delta REER_{i,t-j}\varphi_j + \sum_{j=0}^{p} \Delta RCP_{i,t-j}\delta_j + \left(\Delta RCP_{it}\right) X_{it}\boldsymbol{\theta_2} + \lambda EC_{i,t-1} + \varepsilon_{it} \quad (1.21)$$

where φ_j, δ_j, and $\boldsymbol{\theta_2}$ are coefficient vectors for corresponding regressors, the error correction term (*EC*) is defined as $EC_{i,t-1} = REER_{i,t-1} - \alpha_i - \hat{\beta}_1 RCP_{i,t-1}$ with $\hat{\beta}_1$ being the cointegrating parameter estimate, and λ measures the speed of adjustment to the long-run equilibrium level of *REER*.

4 What makes a commodity currency?

4.1 Commodity currency in the long-run

4.1.1 Main results

First of all, we note that there is a strong and robust link between *REER* and *RCP* in the long-run across the different specifications from columns (1) to (5) in Table 1.2. Indeed, there is almost one-for-one cointegrating relation between them and this relation is strongly significant. For example, one percent permanent increase in commodity price index will cause the real effective exchange rate to appreciate by 0.929 percent according to the specification (1). The effect of globalization is presented in column (2). A higher trade dependency tends to dampen

reports that the DOLS is superior in removing finite sample bias. Note also that FMOLS requires a balanced panel and the estimation has to rely on substantially reduced sample size for our case. For these reasons, we do not consider the FMOLS procedure in this paper.

the effect of *RCP* shocks on *REER* while a greater degree of financial openness is found to be amplifying the shock, in accordance with the theoretical prediction of section 2. For policy variables in column (3), we find the response of *REER* to the *RCP* fluctuations tends to be larger under a peg and smaller with large international reserve holdings. The results in column (3) suggest that a flexible exchange rate regime better insulates the economy from commodity price shocks by stabilizing the real exchange rate in the long-run. Our results also confirm the buffering role of foreign reserves in mitigating the impact of external shocks on the real exchange rate. Results in column (4) show that the larger the commodity export concentration, the larger the commodity price elasticity of the real exchange rate, consistent with the empirical finding by Bodart et al. (2012). From the market share interaction term, we obtain a positive coefficient indicating that the monopoly pricing power of a commodity-exporting country tends to make a transmission of *RCP* shocks to the *REER* larger. Estimation results including all conditional variables are reported in column (5) just as a robustness check where we find the similar results to the earlier specifications.

The interaction variable model tends to increase the likelihood of the multicollinearity. In the presence of a high multicollinearity, it is often the case that the regressors of primary interest are jointly uninformative. We thus perform a F-test for each specification to see if interaction terms are jointly significant. So, for example, the null hypothesis of a F-test for the specification (2) in Table 1.2 is $H_0: \beta_{RCP\times TO} = \beta_{RCP\times FO} = 0$ and the alternative is H_1: at least one $\beta \neq 0$. For the all specifications in the DOLS(1,1) estimation in Table 1.2, we find that the data overwhelmingly reject the joint null hypothesis and conclude that interaction terms are jointly significant and informative in explaining the long-run *REER* behavior.

4.1.2 Non-oil commodity vs. oil exporters

Although there are common features between the price of oil and the price of non-oil commodities, authors in the commodity currency literature tend to investigate two groups of countries separately, reflecting a general recognition of distinctive movements of oil prices.[18] The price of oil is very sensitive to changes in global business cycle as oil is the most widely used industrial input. At the same time, oil prices are under the influence of an oil cartel such as OPEC (Organization of the Petroleum Exporting Countries). We thus attempt to separate oil

[18] See Coudert et al. (2008) for an extensive literature review.

countries from the non-oil commodity exporters and look at if there exist any noticeable differences in real exchange rate responses to commodity/oil price changes. Countries included in oil exporters are the ones whose oil share in aggregate commodity exports is greater than 50% on average over the sample period 1980-2010. They are Algeria, Kuwait, Libya, Mexico, Nigeria, Norway, Oman, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Venezuela.

As shown in Table 1.3, a commodity currency phenomenon is much stronger in non-oil commodity exporters than oil exporters in terms of the magnitude of the *RCP* elasticity and statistical significance. This result corroborates Coudert et al. (2008)'s empirical findings of the lower long-run *REER* elasticity with respect to the terms-of-trade for oil-exporting countries than for non-oil counterparts. Turning to a role of structural/policy factors, inflation targeting appears effective for non-oil commodity exporters in that it dampens a transmission of a commodity price shock to the exchange rate, which is not a case for oil countries. In fact, amongst all oil exporters in our sample, only Mexico and Norway adopted inflation targeting in 2001. On the other hand, trade openness and international reserves play a much bigger role for oil exporters in lowering the commodity price elasticity than the non-oil commodity exporters.

4.2 Commodity currency in the short-run

Table 1.4 shows the short-run commodity currencies across different country groups using the error correction model (ECM). δ_0,θ_2 and λ in equation (1.10) are the parameters of our interest. From the estimation results using the full sample (column (1)), the error-correction term (*EC*) has an expected sign at the l% level of statistical significance, verifying the presence of long-run cointegration. However, we note that the estimated quarterly adjustments towards the long-run equilibrium level of *REER* seem very slow, in line with the PPP puzzle argument in the literature. Furthermore, in contract to Chen and Rogoff (2003) who find a strong short-run commodity currency in Australia and New Zealand, we find weak evidence of short-run *REER*-*RCP* relationship in our full sample with the poor goodness-of-fit measure.

We extend our approach to a sub-sample, presented in columns (2) and (3), and find only non-oil commodity countries to have a significant short-run commodity currency relationship. We thus present the effect of interaction terms using only the non-oil country sample. As shown in columns (4)-(6), the effect of structural/policy factors is much weaker in the short-run than in the long-run. Two factors worth mentioning in the short-run are financial openness and fixed exchange rate regime. With the world financial market integration and development of financial instruments, the effect of the cross-border capital flows on commodity currencies is prominent even in the short-run. Fixed exchange rate regime, which tends to amplify commodity price shocks in the long-run, seems to achieve its original policy objective of stabilization when the long-run price adjustment is excluded.

Overall, the magnitude of the short-run commodity price elasticity, even when significant, is much smaller than the one in the long-run. One plausible explanation based on our theory for this weak real exchange rate response is that all factors are indeed sector specific in the short-run, making the factor price adjustment nearly impossible.

4.3 Robustness checks

In this subsection, we test the robustness of our main results. First, we consider the potential presence of structural shifts in the long-run cointegrating relationship between *REER* and *RCP*. Abrupt changes in real effective exchange rate would blur the cointegrating relationship between *REER* and *RCP* and need to be properly controlled. Gregory-Hansen (1996) proposes a cointegration test that allows for regime shifts at an unknown point in time. We consider a level shift in the long-run relationship between *REER* and *RCP* as government interventions in developing countries typically aim at affecting the level of the real exchange rate. Gregory-Hansen (1996) test is based on the following model:

$$REER_t = \beta_0 + \beta_1 \vartheta_t + \beta_2 RCP_t + \varepsilon_t \tag{1.22}$$

where β_0 is the intercept in the original cointegrating relationship, β_1 is coefficient of the dummy variable ϑ_t that models structural change as follows:

$$\vartheta_t = \begin{cases} 0 & \text{if } t \leq [T\pi] \\ 1 & \text{if } t > [T\pi] \end{cases} \tag{1.23}$$

where T is the sample size, $\pi \in (0,1)$ is a fraction parameter that determines a timing of the level shift and [ ] denotes an integer part. Following Gregory and Hansen (1996), we use trim (π) of 0.15, which specifies the fraction of the data range that skips either end when examining possible break points. The test is applied to each country to detect shift dates, allowing for a level shift and lag length chosen based on AIC (Akaike Information Criterion). The null hypothesis of the test is no cointegration against the alternative of cointegration with a single shift at an unknown point in time. Columns (8) and (9) of Table A1.1 in Appendix report the Gregory-Hansen $Z(t)$ statistics and the shift dates selected by the test. Selected shift dates are largely associated with the country specific macroeconomic events such as hyperinflation, exchange rate crisis, and nominal exchange rate adjustment program including remarkable devaluation of the CFA franc by 50 percent in early 1994. The regression results presented in Table 5 include dummy variables controlling for country-specific structural shift dates. After controlling for regime shifts in the cointegrating relationship, the DOLS(1,1) regression results are very similar to the main results in Table 2 and we conclude that our results are robust to structural shift consideration.

Next, as a robustness check for a short-run commodity currency estimation, we run an ECM regression after accounting for structural shifts. Column (1) in Table 1.6 shows that controlling for structural shifts does not make a noticeable difference in the short-run commodity currency relation from the result in column (1) in Table 1.4. The commodity price coefficient remains insignificant while the error correction term is significant with an expected sign. We then look at the robustness of short-run results for a group of non-oil commodity countries controlling for structural shift dates and they are found robust as shown in columns (2)-(5) in Table 1.6.[19]

5 Concluding remarks

Although the price of commodity exports has a strong influence on their real exchange rates in a group of commodity-exporting countries, the magnitude of the real exchange rate response varies widely across countries. The main objective of this paper is to understand this variation from diverse perspectives. Our empirical results suggest that the long-run response of the real exchange rate to a commodity boom, largely in accordance with our structural model

[19] In addition, we note that our long-run DOLS estimation results are robust to longer leads and lags of cointegrated *RCP* variable, validating our choice of lead and lag in a DOLS specification. For our short-run ECM estimation results, higher-order lag terms of $\Delta REER$ and ΔRCP upto $t-4$ are also considered but the main results not sensitive to the inclusion of additional lags. Moreover, we try including structural/policy factors in the DOLS(1,1) regression as additional main effects. In such an exercise, we have to interpret coefficients of conditional factors and of the interaction term together to fully understand the role of those factors. Results for these exercises are available upon request and some are available in Online Appendix at https://sites.google.com/site/leedwec/home/research.

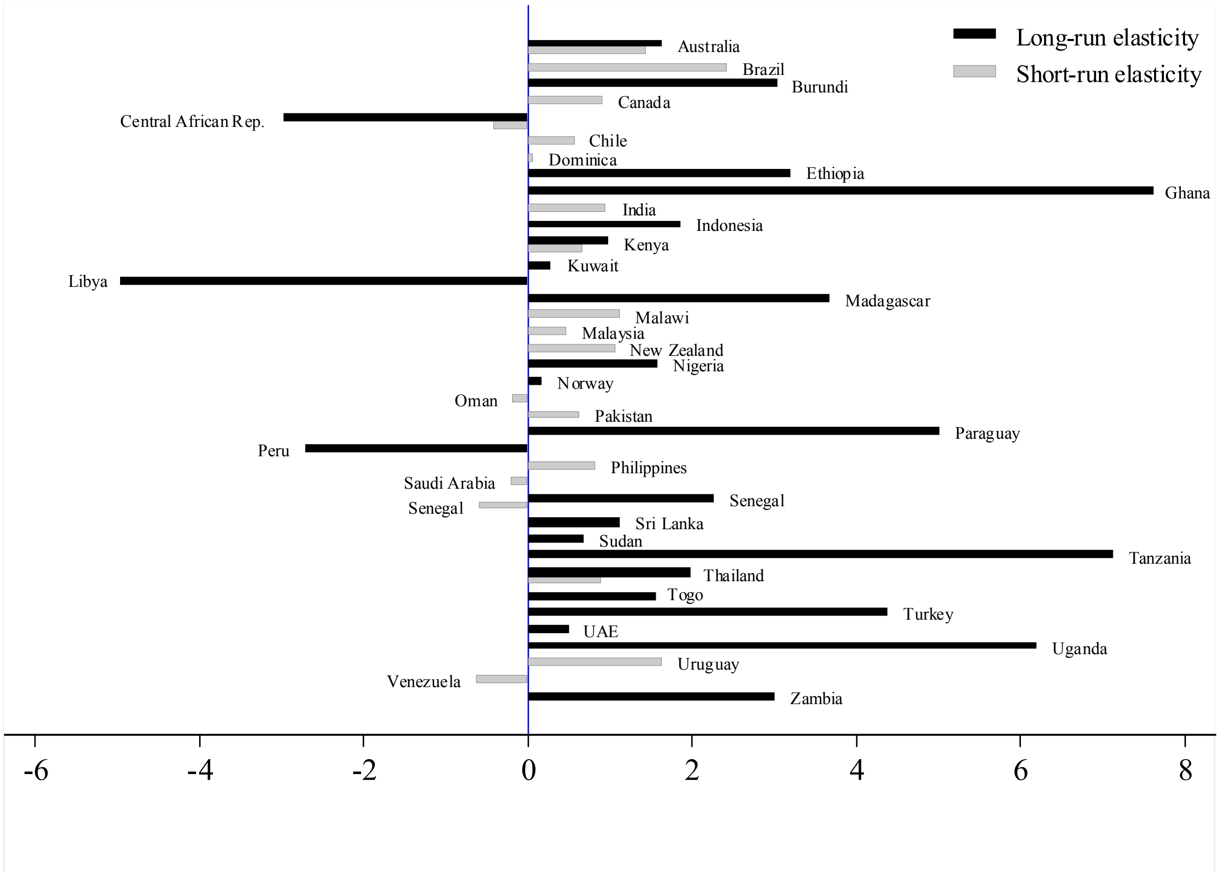
prediction, would be larger if a country is characterized by any of the following traits: i) open financial market, ii) low degree of trade openness, iii) fixed nominal exchange rate regime, iv) small international reserve holdings, v) heavy commodity export dependency and vi) possession of a dominant share of global commodity production. Inflation targeting tends to lower a long-run commodity price shock but this policy effect is found only in the non-oil commodity exporting countries. Furthermore, our estimation results demonstrate a strong long-run *REER-RCP* connection, generalizing the commodity currency phenomenon in a large group of developing countries. However, in contrast to previous studies based on the currencies of a small set of developed countries, we find that a commodity price-exchange rate connection is much weaker in the short-run than in the long-run. This connection also appears to be weaker in oil-exporting countries than the non-oil commodity counterparts.

Facing a rising commodity price trend mainly driven by the strong global demand during the past decade, commodity-dependent countries are recently exposed to a real appreciation pressure. This is likely to induce high volatility in aggregate output and the price level, consequently incurring high macroeconomic adjustment costs. Given concerns for the Dutch disease or resource curse that operate through the real exchange rate, our findings in this paper are of particular relevance for monetary policy-making and for globalization strategy in commodity-exporting developing economies.

Figure 1.1 Distribution of commodity price elasticity of the real exchange rate across countries[20]

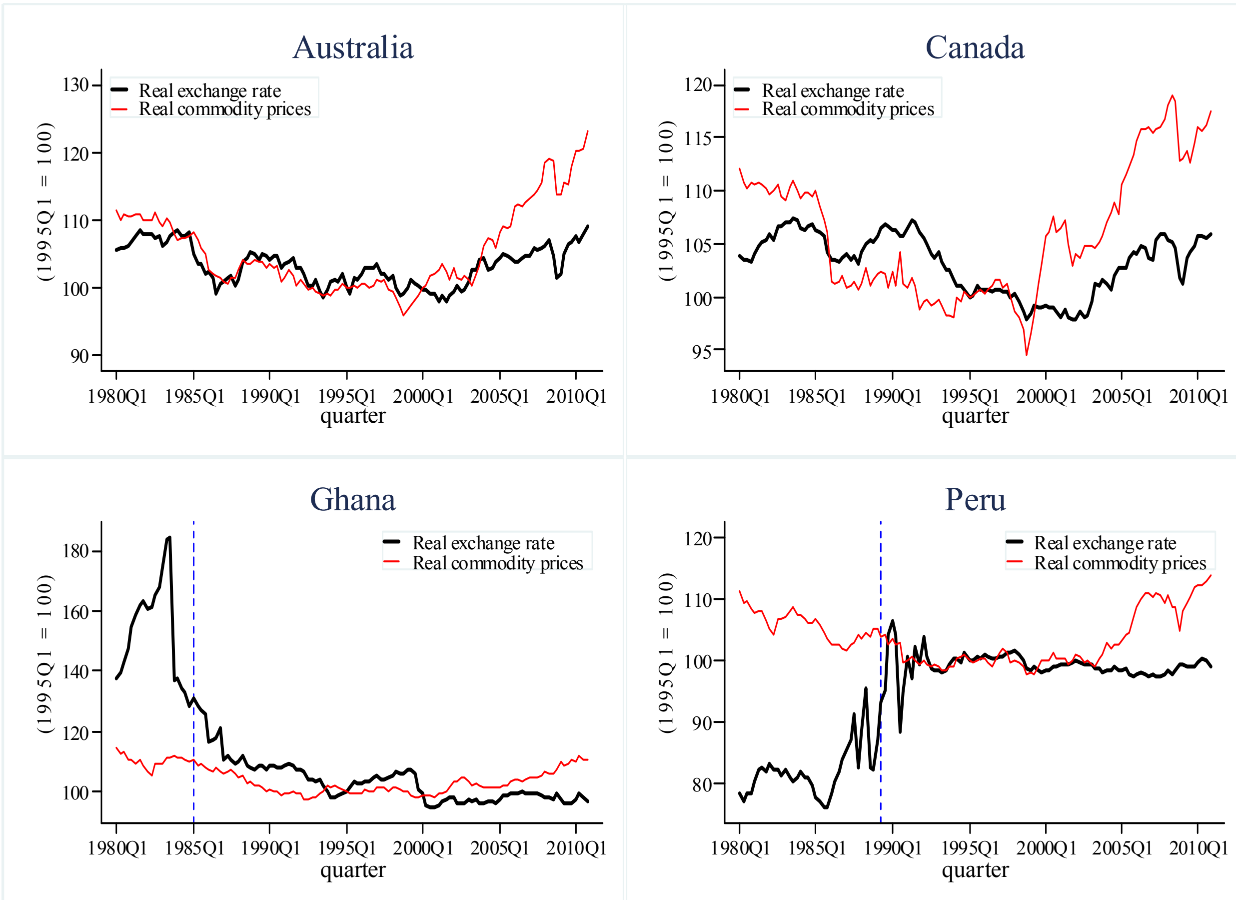
$$\text{DOLS(1,1)}: REER_t = \alpha_0 + \beta_1 RCP_t + \sum_{j=-1}^{1} \Delta RCP_{t+j}\gamma_j + u_t$$

$$\text{First differencing}: \Delta REER_t = \alpha_1 + \delta_1 \Delta RCP_t + \varepsilon_t$$



[20] We estimate the long-run elasticity by the dynamic OLS and short-run elasticity by first differences based on the time series test results reported in Table A1.1 in Appendix. According to the country-by-country analysis, commodity prices and the real exchange rates are non-stationary but cointegrated for the majority of countries in our sample.

Figure 1.2 Time series plots of real effective exchange rate and real commodity prices[21]



[21] Vertical dashed lines in plots for Ghana and Peru indicate the structural shift dates detected by the Gregory and Hansen (1996) test.

Table 1.1 Cross-sectional dependence, panel unit-root and cointegration tests

a. Cross-sectional dependence test

Specification	CD test statistic	Average absolute value of the off-diagonal elements
(1)	121.22***	0.445
(2)	32.721***	0.139

b. Panel unit-root tests

Method	*REER*		*RCP*	
	Levels	1st differences	Levels	1st differences
LLC test				
t^*-statistic	3.520	-52.872***	8.615	-40.329***
	(0.999)	(<.01)	(1.00)	(<.01)
IPS test				
W-statistic	2.395	-48.216***	9.207	-51.619***
	(0.992)	(<.01)	(1.00)	(<.01)
CIPS test				
Z[t-bar] statistic	0.992	-7.447***	2.634	-11.718***
	(0.839)	(<.01)	(0.996)	(<.01)

c. Panel cointegration tests

Method			
Kao test			
ADF t-statistic	-1.894** (0.029)		
Pedroni test			
Within-dimension		*Between-dimension*	
Panel ν-statistic	3.408*** (<.01)	Group ρ-statistic	-4.898*** (<.01)
Panel ρ-statistic	-7.357*** (<.01)	Group PP-statistic	-6.138*** (<.01)
Panel PP-statistic	-7.521*** (<.01)	Group ADF-statistic	-2.133** (0.017)
Panel ADF-statistic	-3.186*** (<.01)		
Westerlund test			
G_t	-2.274*** (<.01)		
G_a	-9.179*** (<.01)		
P_t	-14.762*** (<.01)		
P_a	-6.789*** (<.01)		

Note: In panel a, Pesaran (2004)'s cross-sectional dependence (CD) test statistic is based on the residuals of the regression model specifications (1) $REER_{it} = \alpha_i + \beta_1 RCP_{it} + u_{it}$ and (2) $\Delta REER_{it} = \alpha_i + \delta_1 \Delta RCP_{it} + \varepsilon_{it}$ where *REER* and *RCP* are in logarithm. In panel b, for the series in levels, we include individual trends and individual intercepts, while only country-specific intercepts are included for the series in first differences. In panel c, for the Kao test, an individual intercept is included only, while the individual intercept and individual trend are included for the Pedroni test. For the Westerlund test, we set the width of Bartlett-kernel window at 4 and allow for a constant but no deterministic trend in the cointegrating relationship. In all panels, the associated p-values of the test statistics are given in parentheses. *** and ** indicate rejection of the null hypothesis (cross-sectional independence, unit-root and no cointegration for panels a, b and c, respectively) at the 1 and 5 percent significance levels. Lag lengths are automatically selected based on the modified Akaike Information Criterion (MAIC) for all panel-unit root and cointegration tests except for the Westerlund test that uses AIC.

Table 1.2 Long-run elasticity and interaction effects: Full sample

Dependent variable: $REER_t$					
	(1)	(2)	(3)	(4)	(5)
RCP_t	0.929**	1.023**	1.023***	0.588**	0.559***
	(0.415)	(0.410)	(0.367)	(0.228)	(0.198)
$RCP_t \times TO_t$		-0.206***			-0.123***
		(0.028)			(0.016)
$RCP_t \times FO_t$		0.043**			0.038**
		(0.017)			(0.015)
$RCP_t \times IT_t$			-0.023		0.024
			(0.025)		(0.021)
$RCP_t \times EXR_t$			0.047***		0.077***
			(0.016)		(0.015)
$RCP_t \times RES_t$			-0.078***		-0.046**
			(0.02)		(0.019)
$RCP_t \times CEX_t$				0.063***	0.058***
				(0.02)	(0.014)
$RCP_t \times MSH_t$				0.032*	-0.0004
				(0.017)	(0.018)
F-statistic		31.26***	30.59***	6.47***	14.53***
Within R^2	0.07	0.14	0.09	0.06	0.12
# of countries	63	63	63	63	63
Observations	7349	7108	6869	5946	5550

Note: DOLS(1,1) procedure includes contemporaneous, 1 lead and 1 lag of changes of cointegrated commodity price variable although they are suppressed to save a space. The specification also includes country fixed effects. Driscoll-Kraay standard errors are reported in parentheses. F-statistic and its significance level are reported to show if interaction terms are jointly significant. ***, **, * indicate significance at the 1%, 5%, and 10%, respectively.

Table 1.3 Long-run elasticity and interaction effects: Non-oil commodity vs. oil exporters

Dependent variable: $REER_t$	Non-oil commodity exporters				Oil exporters			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RCP_t	1.526***	1.492***	1.451***	0.931***	0.035	0.83**	0.798*	0.086
	(0.441)	(0.421)	(0.379)	(0.220)	(0.337)	(0.341)	(0.414)	(0.232)
$RCP_t \times TO_t$		-0.164***				-0.761***		
		(0.024)				(0.129)		
$RCP_t \times FO_t$		0.049***				-0.018		
		(0.016)				(0.071)		
$RCP_t \times IT_t$			-0.042**				0.045	
			(0.020)				(0.068)	
$RCP_t \times EXR_t$			0.055***				-0.045	
			(0.014)				(0.094)	
$RCP_t \times RES_t$			-0.053***				-0.509***	
			(0.016)				(0.100)	
$RCP_t \times CEX_t$				0.054***				0.085
				(0.016)				(0.096)
$RCP_t \times MSH_t$				0.049**				-0.037
				(0.020)				(0.032)
F-statistic		26.37***	29.82***	8.64***		17.71***	16.39***	2.19
Within R^2	0.12	0.17	0.13	0.09	0.03	0.29	0.18	0.03
# of countries	51	51	51	51	12	12	12	12
Observations	5927	5790	5738	4805	1422	1318	1131	1141

Note: DOLS(1,1) procedure includes contemporaneous, 1 lead and 1 lag of changes of cointegrated commodity price variable although they are suppressed to save a space. The specification also includes country fixed effects. Driscoll-Kraay standard errors are reported in parentheses. *F*-statistic and its significance level are reported to show if interaction terms are jointly significant. ***, **, * indicate significance at the 1%, 5%, and 10%, respectively.

Table 1.4 Short-run elasticity, dynamic adjustment and interaction effects

Dependent variable: $\Delta REER_t$						
	Full	Non-oil	Oil	Non-oil		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔRCP_t	0.057	0.145***	-0.081	0.137	0.37***	0.207**
	(0.043)	(0.046)	(0.084)	(0.119)	(0.133)	(0.101)
$EC_{t\text{-}1}$	-0.043***	-0.052***	-0.023*	-0.054***	-0.057***	-0.059***
	(0.011)	(0.014)	(0.011)	(0.015)	(0.015)	(0.010)
$\Delta REER_{t\text{-}1}$	-0.022	-0.034	0.055	-0.039	-0.041	-0.042
	(0.029)	(0.028)	(0.075)	(0.029)	(0.028)	(0.042)
$\Delta RCP_{t\text{-}1}$	-0.0004	0.013	-0.011	0.02	0.006	0.003
	(0.042)	(0.055)	(0.056)	(0.055)	(0.057)	(0.047)
$\Delta RCP_t \times TO_t$				-0.112		
				(0.112)		
$\Delta RCP_t \times FO_t$				0.185**		
				(0.084)		
$\Delta RCP_t \times IT_t$					0.39	
					(0.257)	
$\Delta RCP_t \times EXR_t$					-0.329***	
					(0.111)	
$\Delta RCP_t \times RES_t$					-0.02	
					(0.077)	
$\Delta RCP_t \times CEX_t$						-0.121
						(0.12)
$\Delta RCP_t \times MSH_t$						0.136
						(0.126)
F-statistic				3.04*	4.79***	2.02
Within R^2	0.03	0.04	0.02	0.04	0.04	0.04
# of countries	63	51	12	51	51	51
Observations	7400	5968	1432	5828	5776	4842

Note: Column (1) shows the ECM estimation results using the full sample. Countries included in columns (2) and (3) are non-oil commodity exporters and oil exporters, respectively. Estimation results in columns (4)-(6) include non-oil commodity exporting countries only. Country fixed effects are included in all specifications. Driscoll-Kraay standard errors are reported in parentheses. *F*-statistic and its significance level are reported to show if interaction terms are jointly significant. ***, **, * indicate significance at the 1%, 5%, and 10%, respectively.

Table 1.5 Robustness I: Long-run results controlling for structural shifts

Dependent variable: $REER_t$					
	(1)	(2)	(3)	(4)	(5)
RCP_t	0.93**	1.024**	1.021***	0.587**	0.559***
	(0.415)	(0.411)	(0.368)	(0.228)	(0.198)
$RCP_t \times TO_t$		-0.206***			-0.123***
		(0.029)			(0.016)
$RCP_t \times FO_t$		0.043**			0.037**
		(0.017)			(0.015)
$RCP_t \times IT_t$			-0.023		0.024
			(0.025)		(0.021)
$RCP_t \times EXR_t$			0.047***		0.077***
			(0.016)		(0.015)
$RCP_t \times RES_t$			-0.079***		-0.046**
			(0.02)		(0.019)
$RCP_t \times CEX_t$				0.063***	0.058***
				(0.02)	(0.014)
$RCP_t \times MSH_t$				0.031*	-0.001
				(0.017)	(0.018)
F-statistic		30.62***	30.61***	6.45***	14.45***
Within R^2	0.07	0.14	0.10	0.06	0.12
# of countries	63	63	63	63	63
Observations	7349	7108	6869	5946	5550

Note: DOLS(1,1) procedure includes contemporaneous, 1 lead and 1 lag of changes of cointegrated commodity price variable although they are suppressed to save a space. The specification includes country fixed effects as well as level shift dummies to control for structural shift dates identified by the Gregory and Hansen (1996) test (Bolivia, 1985q4; Burundi, 2002q4; Cameroon, 1993q2; Central African Republic, 1993q2; Costa Rica, 1992q1; Ethiopia, 1993q1; Ghana, 1985q1; Kenya, 2000q4; Libya, 1994q1; Madagascar, 1986q4; Norway, 1992q2; Oman, 1986q1; Papua New Guinea, 1998q3; Paraguay, 1987q3; Peru, 1989q2; Saudi Arabia, 1986q1; Senegal, 1993q3; Syria, 1989q2; Togo, 1993q2; Tunisia, 1986q3; Uganda, 1990q1; Zambia, 1987q4). Driscoll-Kraay standard errors are reported in parentheses. *F*-statistic and its significance level are reported to show if interaction terms are jointly significant. ***, **, * indicate significance at the 1%, 5%, and 10%, respectively.

Table 1.6 Robustness II: Short-run results controlling for structural shifts

Dependent variable: $\Delta REER_t$					
	Full	Non-oil			
	(1)	(2)	(3)	(4)	(5)
ΔRCP_t	0.051	0.144***	0.136	0.371***	0.202*
	(0.041)	(0.046)	(0.118)	(0.131)	(0.103)
$EC_{t\text{-}1}$	-0.043***	-0.051***	-0.053***	-0.056***	-0.058***
	(0.011)	(0.014)	(0.015)	(0.015)	(0.01)
$\Delta REER_{t\text{-}1}$	-0.031	-0.046	-0.052	-0.053	-0.067
	(0.03)	(0.032)	(0.033)	(0.033)	(0.05)
$\Delta RCP_{t\text{-}1}$	0.0001	0.015	0.024	0.009	0.009
	(0.042)	(0.056)	(0.056)	(0.058)	(0.049)
$\Delta RCP_t \times TO_t$			-0.115		
			(0.114)		
$\Delta RCP_t \times FO_t$			0.191**		
			(0.085)		
$\Delta RCP_t \times IT_t$				0.399	
				(0.256)	
$\Delta RCP_t \times EXR_t$				-0.329***	
				(0.111)	
$\Delta RCP_t \times RES_t$				-0.026	
				(0.076)	
$\Delta RCP_t \times CEX_t$					-0.116
					(0.12)
$\Delta RCP_t \times MSH_t$					0.148
					(0.126)
F-statistic			3.07*	4.82***	2.12
Within R^2	0.03	0.04	0.04	0.05	0.05
# of countries	63	51	51	51	51
Observations	7400	5968	5828	5776	4842

Note: Column (1) reports the ECM estimation results for the full sample and columns (2)-(5) show results for non-oil commodity exporting countries only. All specifications include country fixed effects as well as level shift dummies to control for structural shift dates identified by the Gregory and Hansen (1996) test (Bolivia, 1985q4; Burundi, 2002q4; Cameroon, 1993q2; Central African Republic, 1993q2; Costa Rica, 1992q1; Ethiopia, 1993q1; Ghana, 1985q1; Kenya, 2000q4; Libya, 1994q1; Madagascar, 1986q4; Norway, 1992q2; Oman, 1986q1; Papua New Guinea, 1998q3; Paraguay, 1987q3; Peru, 1989q2; Saudi Arabia, 1986q1; Senegal, 1993q3; Syria, 1989q2; Togo, 1993q2; Tunisia, 1986q3; Uganda, 1990q1; Zambia, 1987q4). Driscoll-Kraay standard errors are reported in parentheses. *F*-statistic and its significance level are reported to show if interaction terms are jointly significant. ***, **, * indicate significance at the 1%, 5%, and 10%, respectively.

Chapter 2: Benefits of Reserve Pooling Arrangements

1 Introduction

A series of financial crises that have hit many parts of the world in 1990s and more recently in 2008 have led to a major change in asset holdings in emerging economies. In order to lower the possibility that the nation may face a dollar liquidity crisis as result of massive capital outflow and surging demand for the hard currency, emerging countries started hoarding international reserves without limit. Practically, excessive reserve hoarding has been observed in emerging economies, most of which is concentrated in East Asia. Precautionary and mercantilist views are proposed motives behind this observation. Recognizing that the macroeconomic factors are not sufficient to empirically support an excess reserve hoarding in emerging economies in East Asia (Aizenman and Marion, 2003; Jeanne and Ranciere, 2006), there has been an approach looking at the country' psychological motive for a reserve accumulation. One such an example is the keeping-up-with-the-Joneses effect suggested by Cheung and Qian (2011). They argue that the large level of reserves can signal the foreign investors that the country is healthier in terms of its solvency. A neighboring country that does not want to fall behind in attracting foreign capital flows is interested in catching up with its neighbor's reserve levels, generating a negative externality.

In this paper, I examine the expected benefits of reserve-pooling arrangements between emerging economies in order to see if this bilateral coordination can help lower the degree of externality associated with the Joneses effect. I develop a two-period, two-states-of-nature precautionary savings model where agents have imperfect access to international financial markets, and countries engage in competitive hoarding of reserves. To maximize utility, countries face a choice between hoarding larger *relative* reserves which lower the probability of a speculative attack in the second period, at the expense of foregone returns from the domestic capital accumulation. I compare resource allocations based on Nash- versus cooperative-equilibrium to investigate the possible gains from a multi-country collective management of reserves. Preliminary simulation results show that the level of reserve holdings and the probability of speculative attack decline noticeably under the cooperative equilibrium, while a level of domestic capital investment declines with the lower reserves. This result suggests that reserve co-management can effectively reduce the externality generated by the "keeping-up-with-the-Joneses" effect in reserve accumulation, and help relax the external credit constraint faced by emerging economies in a crisis.

2 Stylized facts

In this subsection, I collect data for international reserves and relevant macroeconomic indicators to present some stylized facts during the recent three decades.[22] Sample countries included in this exercise are reported in Table 2.1.

Figure 2.1 displays a recent trend of reserve accumulation by central banks in the two groups of countries, emerging and advanced. As evident from the figure, a sharp rise in reserve-to-GDP ratio has been obverted in emerging economies since early 1990s. This accelerating pace of reserve accumulation has not slowed down even after a number of emerging countries have turned to the flexible exchange rate regime in the past decade. Emerging economies spent some reserves during the 2007-2009 crisis, but reserves stocks have been rebuilt since then.

However, a recent increase in reserves is not symmetric even amongst emerging market economies as shown in Figure 2.2. Emerging Asia now holds international reserves that are equivalent to over 6% of global GNP. Among emerging economies in Asia, China ranks top, following Taiwan, Republic of Korea, Hong Kong, India and Singapore in order.[23] Although an increase in reserve holdings has been observed in other emerging economies such as emerging Europe and Latin American countries, the increase is not as dramatic as the pattern observed in emerging Asia countries.

Two conventional reserve adequacy ratios suggest that countries hold reserves worth i) three months of imports or ii) a full coverage of short-term external debt that is due one year (Greenspan-Guidotti rule). However, as shown in Figure 2.3, the current level of reserves in emerging economies far deviates from any of the traditional benchmark levels. Again, this deviation is much larger for emerging Asia than other rest of emerging economies.

[22] I collect data (all in US dollars) from the following sources: IMF IFS and World Bank WDI. IMF IFS provides total reserves excluding gold and WB WDI provides NGDP, short-term external debt (which has an original maturity of one year or less), imports and exports of goods and services.

[23] Note that Japan is ranked next to China according to March, 2014 level.

3 Related literature

3.1 Demand for international reserves

The academic interest in central bank's foreign reserves management has focused primarily on explaining the surging demand for the reserves and the adequacy of their levels.

Earlier empirical studies focus on the buffer stock model. According to the buffer stock model, average reserves are increasing with GDP and reserve volatility and decreasing with adjustment costs, the opportunity costs of holding reserves, and exchange rate flexibility (Heller (1960), Kenen and Yudin (1965), Kelly (1970), and Frenkel and Jovanovic (1981)). A standard buffer stock model loses, in some degree, its popularity since the late 1990's because the countries have raised the level of international reserves even when they face greater exchange rate flexibility.

Since the 1997-1998 Asian financial crisis, the research attention has focused on a strong motive for the precautionary saving through large international reserve accumulation. Aizenman and Marion (2003), using a generalized precautionary saving model, suggests that the excess demand for reserves in the aftermath of Asian financial crisis is due to a high sovereign risk and costly tax collection. They also find the negative effect of political uncertainty or corruption on the demand for reserves (Aizenman and Marion, 2004). The precautionary demand also comes from countries' attempt to mitigate the probability of costly output loss induced by sudden short-term capital flight and to cushion the economy from the shortages of fiscal resources in bad states of nature (Aizenman, et al. 2007). The precautionary motive becomes a predominant view in explaining the high demand for reserves in the aftermath of Asian financial crisis.

Another popular argument for a large stockpile of reserves is the mercantilist. This view suggests that the large international reserves accumulation may be motivated by an exchange rate management. Large reserves enable a country to maintain its currency undervalued and to enjoy a price-competitiveness in international trade. However, Aizenman and Lee (2007) finds an economically insignificant mercantilist motive in accounting for the buildup of international reserves in the post-crisis period, supporting the literature's dominating precautionary motive. In addition, as shown in Figure 4, the growth of reserves appears much faster than the growth of net exports for emerging economies. And it is often the case that the higher level reserves do not always guarantee an increase in net exports, weakening the mercantilist argument.

Cheung and Qian (2009) finds an empirical evidence for the presence of the competitive hoarding, so called "the Joneses effect", in East Asia after the 1997 financial crisis. They explain the high demand for international reserves using a seemingly non-economic reason, the Mrs.Machlup's wardrobe hypothesis. According to the Mrs.Machlup's wardrobe hypothesis, countries accumulate reserves not only because the larger the better, but also because other neighboring countries do so (Machlup, 1996). In addition to this psychological desire, economies keep up with the Joneses because a country with a relatively higher stock of reserves than its neighbors is more likely to be immune from the speculative attacks as a relative size of reserves indicates its relative vulnerability to sudden stops.

3.2 Cost of reserve accumulation

Despite of its beneficial role which is a popular topic in the literature, self-insurance through a reserve collection is not costless.

First of all, imperfect monetary policy during reserve growth may promote inflation. To obtain international reserves, the government buys dollars from its exporters and gives them a local currency in exchange. The government must sell the domestic bonds to stabilize the domestic price level by reducing money supply, which may lead to inflation if it is imperfectly done.

Second, holding reserves has the opportunity cost. Opportunity cost of keeping reserves can be defined as a foregone rate of return from investment in domestic capital. A majority of international reserves held by developing countries are kept in U.S. treasury bills that earn a significantly lower rate of return than the rate of return from domestic bonds or domestic capital. Rodrik (2006) reports that the cost of excess reserves is around 1% of GDP for a group of developing countries.

Nevertheless, U.S. treasury bills have been the largest fraction of central banks' bond holdings in East Asia as they have high liquidity and low risk. The level of international reserves, at least in theory, should be low if the opportunity cost of holding reserves is high. Ben-Bassat and Gottlieb (1992) shows that as far as the opportunity cost is measured according to the theoretical definition (that is, the difference between the real rate of return on domestic capital and on reserves), the opportunity cost has a significant explanatory power for determining the demand for reserves. However, most empirical studies find that the opportunity cost does not play a significant role in determining the demand for reserves (e.g., Flood and Marion, 2001; Aizenman and Marion, 2004). This result may be, on the one hand, due to the difficulty in measuring the opportunity cost precisely[24] and, on the other hand, due to the countries' general perception that the opportunity cost of holding large reserves is far less than the cost of experiencing a financial crisis. A discussion about the measurement of opportunity cost is likely to remain controversial because of inability to obtain the cross-country samples that satisfy a theoretical definition.

Apparently, a large reserve accumulation is not the most efficient way of preventing speculative attacks as it can involve a substantial opportunity cost.[25] Furthermore, Blanchard et al. (2009) shows no evidence that a sizable level of international reserves helps weather the impact of the recent financial crisis. The next section presents the model to understand the effect of collective reserve management in the form of reserve pooling on the level of reserves and aggregate welfare.

4 The model and equilibrium

In this section, I consider a deliberately minimalist model to understand the role of external borrowing, international reserves, domestic investment and their interactions by abstracting from the less relevant other economic variables. Following Aizenman et al. (2004), I develop a two-period, two-states-of-nature precautionary savings model where agents have imperfect access to international financial markets and countries engage in competitive hoarding of reserves. I extend the base model by incorporating the Joneses effect (Cheung and Qian (2009)) and the domestic capital investment in order to account for the opportunity cost of holding reserves.[26] I then present the cooperative equilibrium model to show the effect of reserve pooling arrangement.

[24] International reserves are kept in various forms of currencies and assets but a standard empirical measure of the opportunity cost does not reflect the currency compositions in general.

[25] Recognizing this high cost of reserve holdings when kept in the form of Treasury bills, Feldstein (2002) suggests a significant portion of reserves to be held in the form of diversified portfolios including foreign equities.

[26] Unlike Aizenman et al. (2004), Cheung and Qian (2009) assume that the economy can face different productivity shocks δ and ε depending upon the states of nature in the second period. Furthermore, the probability of bad state is not necessarily equal to 0.5 in the Cheung and Qian's setup.

4.1 The benchmark model

Suppose that an economy produces output employing its domestic capital at the given level of technology A. In period $t = 1$, the private agent and monetary authority borrow amount B from the foreign creditors to finance domestic consumption, investment and accumulate reserves:

$$C_1 = AK_0^{\eta} + B - I - R \tag{2.1}$$

Foreign reserves are in the form of liquid but low-return risk-free assets while domestic investment can generate higher return with greater risks. The economy can produce output in period $t = 2$ only but it is subject to a productivity shock. A positive productivity shock (normal state) takes place with a probability $(1 - p)$ and an adverse productivity shock (crisis state) occurs with a probability p, where p is the probability of output loss induced by a sudden capital stop.

Then the production in period $t = 2$ is given by the following:

$$Y = \begin{cases} Y_{2g} = F(\alpha K_0 + I)(1 + \delta) & \text{with probability } (1 - p) \\ Y_{2b} = F(\alpha K_0 + I)(1 - \varepsilon) & \text{with probability } \quad p \end{cases} \tag{2.2}$$

where K_0 is the initial capital stock, α is the capital stock available at the beginning of the period 2 after depreciation $(\alpha = 1 - \text{depreciation rate})$, $F(K) = AK^{\eta}$ with $0 < \eta < 1$, $\delta, \varepsilon > 0$ and $0 < p < 1$.

For the benchmark model, the probability of speculative attack is given by

$$p = v + w\frac{B}{R} \tag{2.3}$$

where B and R are external borrowing and foreign reserves obtained in the first period and $v > 0,\ w > 0$. By its construction, the speculative attack probability increases as the amount of foreign borrowing increases and decreases as the level of international reserves increases. This is because international reserves can serve as international means of repayment. w is a scale parameter and v serves as a catch-all parameter representing all other variables affecting an adverse shock probability. The cost of international borrowing is at the interest rate r and thus $(1+r)B$ has to be repaid in period 2. And the international reserves R earn a risk-free return r_f. It is assumed that $r > r_f$.[27]

As a country faces output uncertainty in the second period, it is subject to a default risk. Assume that a country defaults under a bad state. A default must not be free and default penalty is defined as θ fraction of the second period output, $0 < \theta < 1$. In other words, θY_2 can be officially taken away by an international creditor when the economy fails to repay its debt. It is also assumed that the economy's international reserve holdings are beyond the reach of international creditors. If the repayment is more costly than the default penalty, $(1+r)B > \theta Y_2$, then the economy has an incentive to default on its debt. A bad productivity shock in the second period is assumed to be large enough so that the borrowing country chooses to default on its external debt and rather pay a relatively cheaper default penalty. Knowing this possibility, the international creditor would determine the lending amount by expecting that her return from the borrower in period 2 would be

$$S = min[(1+r)B, \theta Y_2] \tag{2.4}$$

where min[·,·] is the minimum operator. Under risk neutrality, the cost of borrowing in the global capital market is determined by the condition that the expected return on the debt is equal to the risk-free return:

$$E[S] = \left(1 + r_f\right)B \tag{2.5}$$

Therefore, the credit ceiling $(\bar{B})$, the upper bound for debt that the economy can borrow internationally, is given by

$$\begin{aligned} \bar{B} &= \frac{(1-p)\theta F(\alpha K_0 + I)(1+\delta) + p\theta F(\alpha K_0 + I)(1-\varepsilon)}{1 + r_f} \\ &= \frac{\theta F(\alpha K_0 + I)(1 + \delta - (\delta + \varepsilon)p)}{1 + r_f} \end{aligned} \tag{2.6}$$

[27] This is because the economy with the default risk has to pay a risk-premium in the international borrowing.

Because a borrower always has an incentive to default on its debt, the international creditor sets the credit ceiling that is the highest level of debt the creditor would lend facing the borrower's default risk.

Assuming (i) no default in the good state: $(1+r)B \leq \theta F(\alpha K_0 + I)(1+\delta)$ and (ii) default in the bad state: $(1+r)B > \theta F(\alpha K_0 + I)(1-\varepsilon)$ with the probability p, the economy in period 2 is subject to the following budget constraints:

$$C_2 = \begin{cases} C_{2g} = F(\alpha K_0 + I)(1+\delta) - (1+r)B + \left(1+r_f\right)R & \text{with probability } (1-p) \\ C_{2b} = F(\alpha K_0 + I)(1-\varepsilon)(1-\theta) + \left(1+r_f\right)R & \text{with probability } p \end{cases} \tag{2.7}$$

where C_{2g} and C_{2b} represent the levels of consumption in the second period under the good productivity shock and under the bad productivity shock with default, respectively. Note that international reserves saved in the first period would allow the economy to smooth consumption in the second period when output is volatile. Moreover, the domestic investment in the first period would boost the second period output (and thus consumption) although it is subject to the productivity shock unlike international reserves.

The economy maximizes its representative agent's expected utility and it is given by:

$$\max\ E\left[U\left(C_1, C_{2g}, C_{2b}\right)\right] = C_1 + \frac{1}{1+\rho}\left[(1-p)C_{2g} + pC_{2b}\right] \tag{2.8}$$

where ρ is the discount factor. When the economy borrows at the ceiling level, $B = \bar{B}$, the contractual repayment is:

$$B(1+r)|_{B=\bar{B}} = \theta F(\alpha K_0 + I)(1+\delta) \tag{2.9}$$

Combining the expected utility (2.8) with (2.1), (2.7) and (2.9), the expected utility can be rewritten as:

$$\max\ E[U(\cdot)|_{B=\bar{B}}]$$
$$= AK_0^{\eta} + B - I - R$$
$$+ \frac{1}{1+\rho}\left[F(\alpha K_0 + I)\{(1-\theta)(1+\delta-(\delta+\varepsilon)p)\} + \left(1+r_f\right)R\right] \tag{2.10}$$

Taking the derivative of equation (2.10) with respect to R and I generates the conditions to determine the optimal level of reserves and capital investment:

$$1 - \left.\frac{dB}{dR}\right|_{B=\bar{B}} = \frac{1}{1+\rho}\left[-F(\alpha K_0 + I)(1-\theta)(\delta+\varepsilon)\left.\frac{dp}{dR}\right|_{B=\bar{B}} + \left(1+r_f\right)\right] \tag{2.11}$$

$$1 - \left.\frac{dB}{dI}\right|_{B=\bar{B}} = \frac{1}{1+\rho}\begin{bmatrix} F_I(\alpha K_0 + I)(1-\theta)(1+\delta-(\delta+\varepsilon)p) \\ -F(\alpha K_0 + I)(1-\theta)(\delta+\varepsilon)\left.\frac{dp}{dI}\right|_{B=\bar{B}} \end{bmatrix} \tag{2.12}$$

4.2 Competitive hoarding

In order to describe the recent competitive hoarding of international reserves among the emerging economies in East Asia, Cheung and Qian (2009) extends the benchmark model by including the "keeping-up-with-the-Joneses" effect ("Joneses effect" hereafter). The Joneses effect comes into play through the speculative attack probability and it can be expressed as

$$p_j = v + w\frac{B_j}{R_j} + x\frac{\tilde{R}_0}{R_j} \tag{2.13}$$

where the subscript "j" indicates the presence of the Joneses effect, $\tilde{R}_0$ stands for the average of international reserves held by the Joneses (peer countries) at period 0, and $v > 0,\ w > 0,\ x > 0$. Now the probability of suffering a speculative attack that leads to an output loss to the economy is positively related to the level of average international reserves held by its peer group as well as its own external debt. This set up reflects the idea that international investors are likely to attack the economy by looking at its relative reserve position compared to its other peer groups. In other words, if a country has a relatively low level of reserves, the international speculators tend to perceive the country to be relatively more vulnerable to external shocks and, as a result, the country will have a higher probability of being attacked by international speculators. Due to the difficulty obtaining the current information about the international reserves held by other economies, lagged, instead of current, level of reserves for peer groups is considered.

To find the optimal level of reserves in the presence of Joneses effect, consider the economy which maximizes expected utility (2.10) subject to a modified probability of speculative attack (2.12). The first-order conditions with respect to R_j and I_j are:

$$1-\left.\frac{dB_j}{dR_j}\right|_{B_j=\bar{B}_j}=\frac{1}{1+\rho}\left[-F\left(\alpha K_0+I_j\right)(1-\theta)(\delta+\varepsilon)\left.\frac{dp_j}{dR_j}\right|_{B_j=\bar{B}_j}+\left(1+r_f\right)\right] \tag{2.14}$$

$$1-\left.\frac{dB_j}{dI_j}\right|_{B_j=\bar{B}_j}=\frac{1}{1+\rho}\left[\begin{array}{c}F_I\left(\alpha K_0+I_j\right)(1-\theta)\left(1+\delta-(\delta+\varepsilon)p_j\right)\\ -F\left(\alpha K_0+I_j\right)(1-\theta)(\delta+\varepsilon)\left.\frac{dp_j}{dI_j}\right|_{B_j=\bar{B}_j}\end{array}\right] \tag{2.15}$$

The important intuition here is that, as expected, the level of international reserves demanded by the economy is larger when the Joneses effect exists. The economy's rational response, when it knows that the international reserves held by others will increase the probability of output loss due to speculative attack, would be to raise the level of reserves to catch up with its rival country to avoid a potential sudden stop. Apparently, this competition is inefficient if it leads economies to accumulating reserves more than necessary.

4.3 Reserve pooling arrangement

The non-cooperative reserve management policies lead to an unnecessarily high level of reserves, implying that an economy is forgoing an opportunity to realize a greater spread between the rate of return from domestic capital and the risk free rate. Thus, a natural question to ask is "what if emerging countries manage international reserves together?" If there is significant welfare improvement for participating countries, there is an incentive for them to cooperate under the reserve pooling arrangement.

In the previous sub-sections, the levels of international reserves chosen are Nash equilibrium solutions as the economy makes a best response given the other economy's choice of reserves. It can be thought of as an arms race between military superpowers. However, a buildup of excess international reserves is not an efficient outcome as it involves non-trivial opportunity costs, which is often measured by the spread between country's own bond yield and the return on U.S. Treasury bills. If countries who participate in the pooling arrangement can hold the lower level of reserves without increasing the probability of sudden stops, they would have been better off collectively by allocating financial resources in a more productive way.

Consider now a cooperative equilibrium in which optimal reserves are chosen by maximizing the sum of individual economies' expected utility. That is, a fictional worldwide social planner chooses R_c and R_c^* jointly to maximize the sum of (2.8) over home and foreign countries subject to condition (2.7) for both countries. Now the model becomes a two-country, two-period, two-states-of-nature model. Note that the subscript "*c*" represents cooperation between countries, each of which is involved in the cooperative hoarding. All terms associated with the foreign country are denoted by a star. The default penalty rate θ is assumed to be the same across countries. And the speculative attack probability for home and foreign countries are given by

$$p_c = v + w\frac{B_c}{R_c} + x\frac{R_c^*}{R_c} \quad \text{and} \quad p_c^* = v^* + w^*\frac{B_c^*}{R_c^*} + x^*\frac{R_c}{R_c^*} \tag{2.16}$$

The objective function, after substituting the budget constraints, is:

$$\max\ E\left[V\left(C_1, C_{2g}, C_{2b}, C_1^*, C_{2g}^*, C_{2b}^*\right)\right] = E\left[\frac{1}{2}U(\cdot)\Big|_{B_c=\bar{B}_c} + \frac{1}{2}U^*(\cdot)\Big|_{B_c^*=\bar{B}_c^*}\right]$$

$$= \frac{1}{2}\left[\begin{array}{c} AK_0^{\eta} + \bar{B}_c - I_c - R_c \\ + \dfrac{1}{1+\rho}\{F(\alpha K_0 + I_c)\{(1-\theta)(1+\delta-(\delta+\varepsilon)p_c)\} + \left(1+r_f\right)R_c\} \end{array}\right]$$

$$+\frac{1}{2}\left[\begin{array}{c} A^*K_0^{*\eta} + \bar{B}_c^* - I_c^* - R_c^* \\ + \dfrac{1}{1+\rho^*}\{G(\alpha^* K_0^* + I_c^*)\{(1-\theta)(1+\delta^*-(\delta^*+\varepsilon^*)p_c^*)\} + \left(1+r_f\right)R_c^*\} \end{array}\right] \tag{2.17}$$

where $G(K) = AK^{\gamma}$ with $0 < \gamma < 1$ is a production function for a foreign country. We first let each economy, home and foreign, choose the domestic capital investment and then the hypothetical social planner chooses R_c and R_c^*. Four optimal conditions will give us a cooperative equilibrium level of reserves and investment that jointly maximize expected utility of both home and foreign economies.[28]

5 Numerical results

Table 2.3 shows the optimal level of reserves, domestic investment, and probability of speculative attack in the benchmark, Joneses and pooling models. The numerical solutions are based on the parameter values presented in Table 2.2.

In deriving solutions for the Joneses model, I use the optimal reserves in the benchmark model as an approximation for the average level of reserves held by peer group's in the past period ($\tilde{R}_0$). My model predicts that the keeping-up-with-the-Joneses effect raises the reserve level as expected. The competitive hoarding raises the probability of capital reversal as well, meaning that it makes the economy more vulnerable to the external shocks even with the larger reserves.

Under the pooling arrangement, I assume two countries (home and foreign) are symmetric. I choose the credit ceiling and domestic investment at the levels the Joneses model generates. International policy coordination for reserves in the form of pooling enables countries to hold a lower level of reserves. However, domestic capital investment decreases, which indicates that reserves and domestic investment are imperfect substitutes and may rather be complements. In my framework, higher reserves increase the probability of having a normal (good) state and realizing the domestic investment with a positive output shock. Nonetheless, the joint reserve management makes the economy less vulnerable to sudden stops as participating countries under the pooling arrangement have an access to the large pool of reserves. This coordination reduces probability of speculative attack lower than the competitive hoarding case.

[28] A pooling arrangement in practice should be made with a caution and may take the following form; countries break reserves into two parts (emergency needs vs. excess reserves) and keep the former in a liquid form of foreign assets but invest the latter more aggressively.

6 Conclusion

This chapter examines the expected benefits of reserve-pooling arrangements between emerging economies. I compare resource allocations based on Nash- versus cooperative-equilibrium to investigate the possible gains from a multi-country collective management of reserves. Preliminary simulation results show that the level of reserve holdings and the probability of speculative attack decline noticeably under the cooperative equilibrium, while a level of domestic capital investment declines with the lower reserves. This result suggests that reserve co-management can effectively reduce the externality generated by the "keeping-up-with-the-Joneses" effect in reserve accumulation, and help relax the external credit constraint faced by emerging economies in a crisis.

Figure 2.1 International reserves accumulation in emerging and advanced economies: 1980-2012

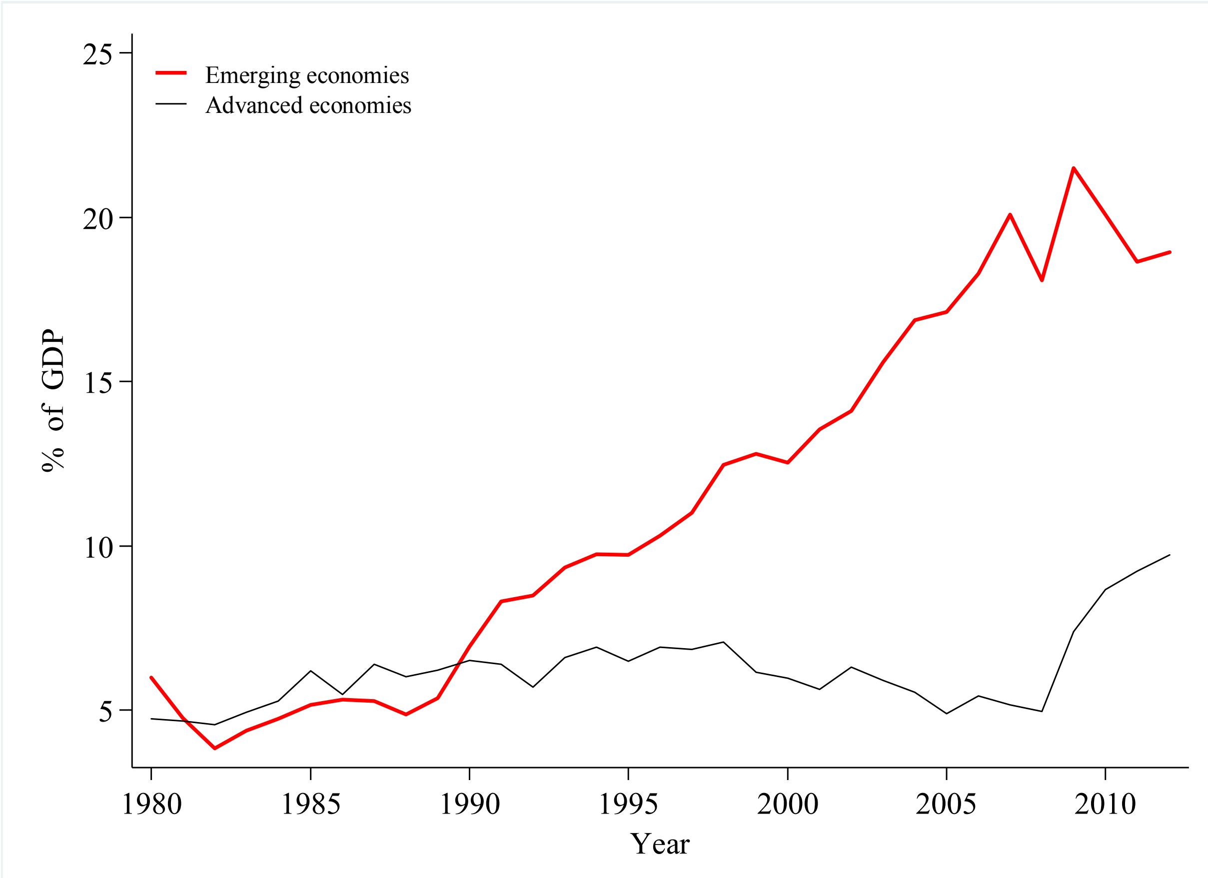
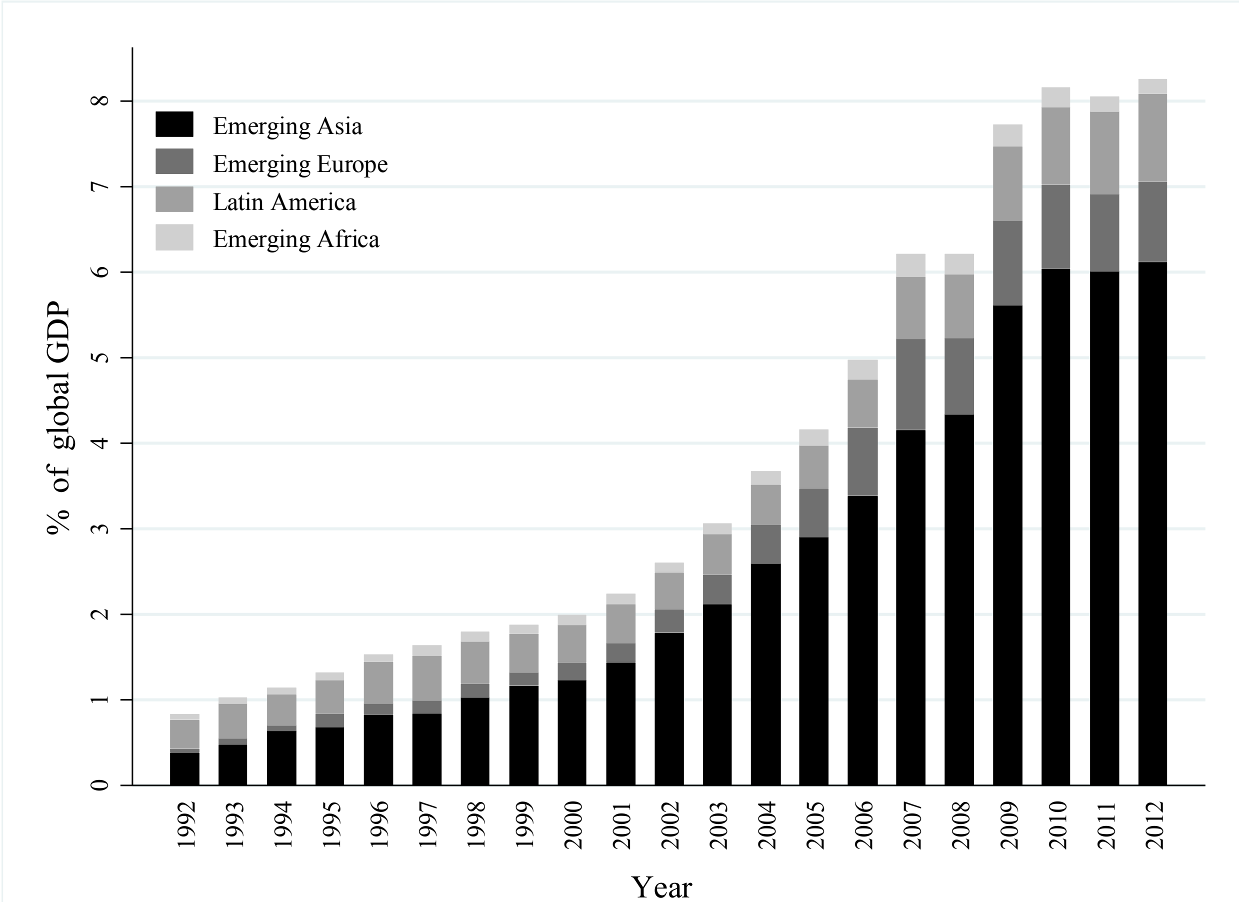
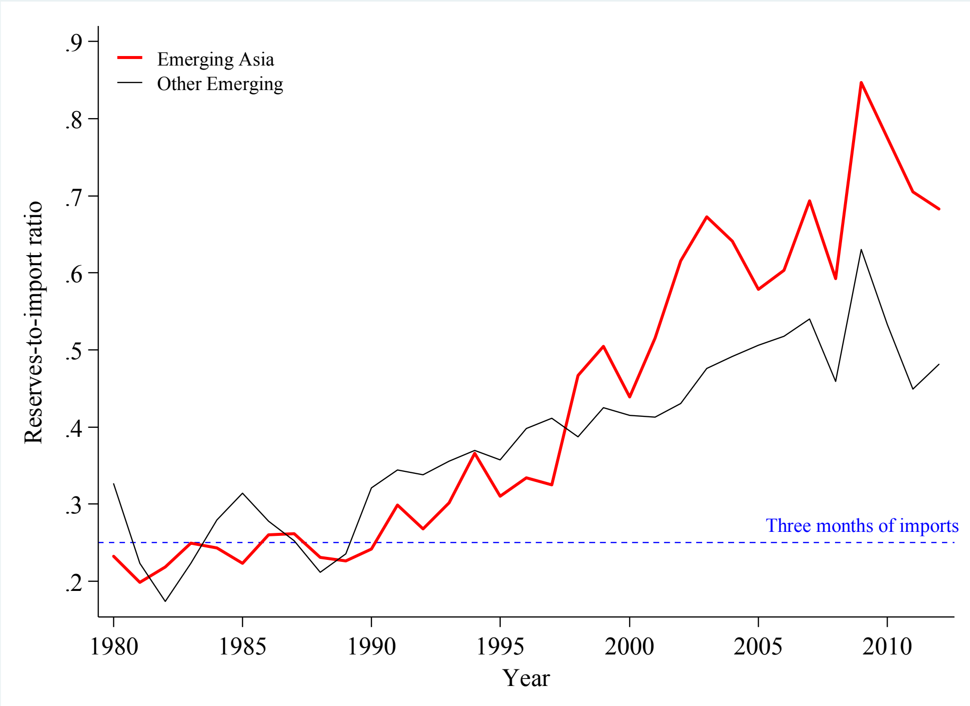


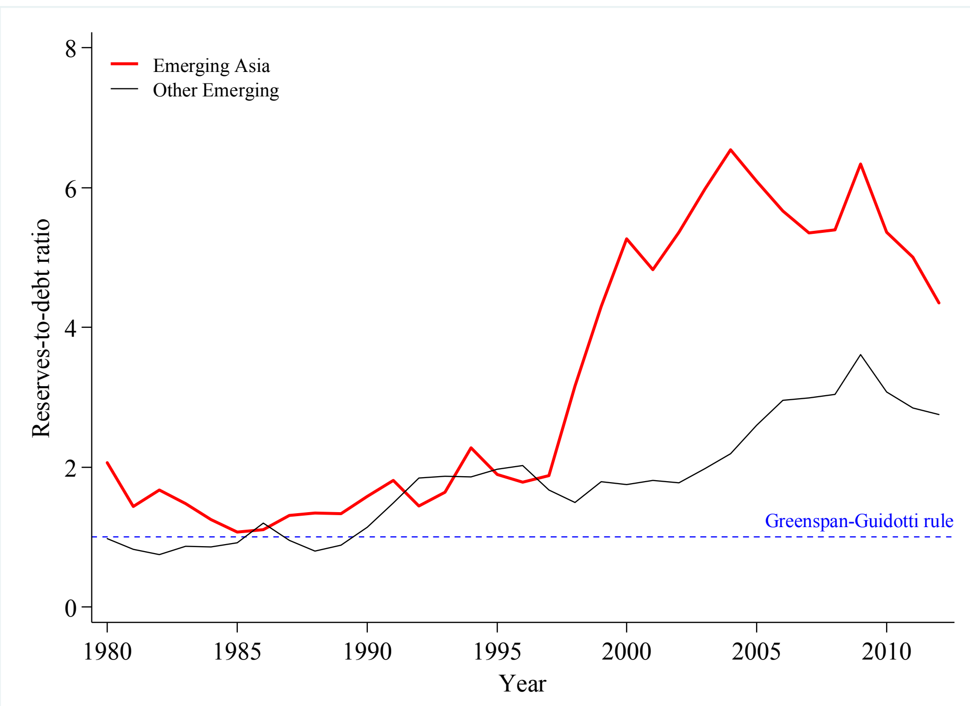
Figure 2.2 A sharp increase in international reserves in emerging Asia[29]



[29] The IMF IFS does not have continuous time series data for international reserves during 1980s for a few European countries including Bulgaria (80-90), Hungary (80-82), Luxembourg (80-83), Russia (80-92), and Ukraine (80-91). Furthermore, the WB WDI has many missing observations in nominal GDP during 1980s for Poland (80-84), Russia (80-88) and Ukraine (80-86). Therefore, we choose to ignore 1980s in this cross-regional comparison.

Figure 2.3 Evidence of excess reserves in emerging Asia[30]





[30] For the upper panel graph, we exclude a few outliers such as Cote d'Ivoire, Morocco, Nigeria and Panama that show extraordinary reserves-to-short term debt ratio for certain time periods. For example, Nigeria had a reserves-to-debt ratio of 9,119.52 in 2005 and even higher in the subsequent years due to the underreporting of the country's external debt stock. Similar issues are found in the other three countries at different time periods.

Figure 2.4 Reserves and net exports across different income groups

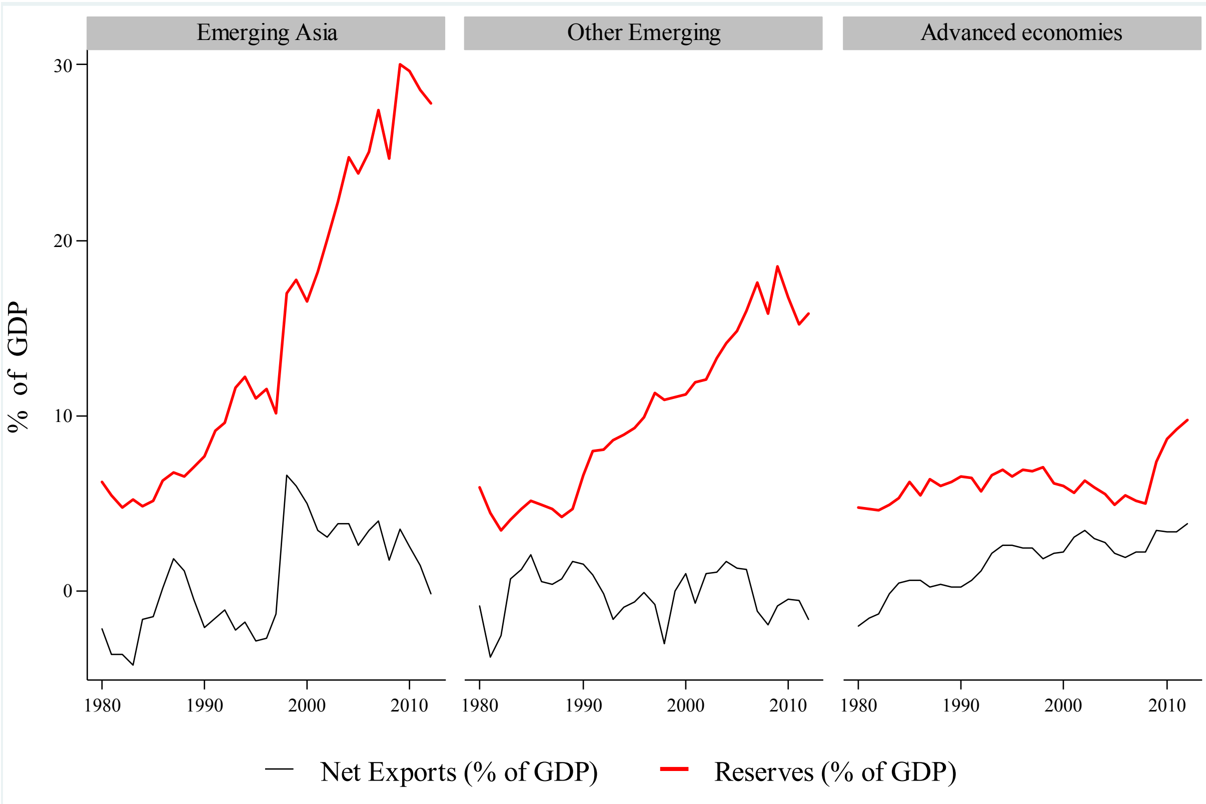


Table 2.1 Sample countries[31]

Income group/Region	Countries
Advanced	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States
Emerging Africa	Cote d'Ivoire, Egypt, Morocco, Nigeria, South Africa, Tunisia
Emerging Asia	China, India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Thailand
Emerging Europe	Bulgaria, Hungary, Poland, Russia, Ukraine
Latin America	Argentina, Brazil, Chile, Colombia, Dominican Republic, Ecuador, El Salvador, Mexico, Panama, Peru, Uruguay, Venezuela

[31] Our annual data set covers the past three decades between 1980 and 2012 and includes 55 countries.

Table 2.2 Definitions of parameters[32]

Parameters	Definitions	Baseline
r_f	risk free rate	0.02
r	borrowing cost	0.05
ρ	discount factor	0.05
θ	default penalty rate	0.14
δ or δ^*	good output shock	0.065
ε or ε^*	bad output shock	0.1
w or w^*	scale parameter	0.05
v or v^*	catch-all parameter	0.05
K_0 or K_0^*	initial capital	1
α or α^*	$1 -$ capital depreciation rate	0.9
η or γ	capital share	0.33
A or A^*	technological knowledge	0.3
x or x^*	sensitivity to the Joneses effect	0.05

Note: All terms associated with the foreign country are denoted by a star.

Table 2.3 Numerical solutions

	Benchmark	Joneses	Pooling
International reserves (R)	0.028	0.043	0.026
Domestic investment (I)	0.057	0.087	0.054
Probability of attack (P)	0.059	0.09	0.069

[32] The baseline scale parameter and catch-all parameter are chosen such that the probability of speculative attack is 10% when $B = R$.

Chapter 3: Financial Openness, Exchange Rate Risk and Portfolio Rebalancing (with Kyungkeun Kim)

1 Introduction

In contrast to the conventional belief that a country's currency value and equity market return tend to move together, Hau and Rey (2006) finds an opposite result; when the foreign equity market outperforms domestic market, the domestic currency is expected to appreciate due to a global portfolio manager's reaction. Facing a higher foreign exchange risk from the increased foreign share in her portfolio, the fund manager repatriates some of her foreign equity holdings and uses the proceeds to buy domestic equity assets, leading to a domestic currency appreciation.[33] This portfolio rebalancing is a relatively new channel explaining the equilibrium exchange determination by linking the equity and foreign exchange markets, which has attracted much academic attention since the portfolio holdings data became available in 2000s.

While discovering international investor's portfolio allocation strategies in the form of risk rebalancing or return chasing and testing the portfolio balance model have been the main focus of the literature (Hau and Rey, 2006, 2008; Curcuru et al., 2011), there has been a lack of research effort to analyze investors' heterogeneous allocation strategies across different destination countries in response to a systemic change in their asset market performance.[34] Using the fund-level data for 44 countries around the globe, we first show that global fund managers respond to return changes in destination countries by rebalancing its portfolio.[35] However, we observe a large variation in the degree or strength of rebalancing as shown in Figure 3.1. Out of 44 countries in our sample, we find 35 countries that have a return differential coefficient statistically significant and negative at the 10 percent level. Three exceptions show a return

[33] Of course, portfolio rebalancing can also occur due to expected changes in equity risk as well as currency risk or due to a combination of both risks of an investment destination country.

[34] Chaban (2009), on the other hand, finds a weak portfolio rebalancing motive for commodity-exporting countries. Due to a heavy commodity export dependency in Australia, Canada, and New Zealand, a commodity boom induced by a positive shock in the U.S. stock market leads to an increase in the domestic equity returns in those commodity exporters, reducing the need to rebalance portfolios as equity markets tend to be synchronized.

[35] Due to the identification advantage, there is a growing interest in both finance and economics to study capital flows based on micro-level fund flow data. The micro-level data enable us to overcome endogeneity issues typically present in studies based on the aggregate capital market data. An increase in capital inflow to a country can be caused by either an increase in global liquidity or an increase in demand for the country asset, whose distinction is not clear in the aggregate capital market data due to the wealth effect (Curcuru et al., 2011). Fund level micro-level data resolve this issue by providing the fund's portfolio allocation weight information.

chasing strategy by fund managers. A main objective of this paper is to understand this variation in the degree of fund manager's rebalancing motive across different investment destination countries.

Although it has been greatly acknowledged that large equity inflow generally helps the recipient countries by financing domestic investment projects, higher equity returns, and developing domestic financial system, it can also increase the probability of sudden stops, which can cause a higher currency risk, a decline in the physical investment, depletion of central bank's reserve assets and a prolonged economic instability. Figure 3.2 displays that when the degree of rebalancing is high by having foreign investors being more responsive to return changes, the flow volatility in a country's equity market tends to increase. We examine the determinants of equity flow of a country by investigating the *micro-level* fund manager's portfolio strategies given market conditions.

In the following section, we present a three-period portfolio balance model where a representative mutual fund manager is assumed to observe the equity return in the second period before reallocating assets across countries to maximize her terminal wealth. We decompose the realized return from the foreign equity investment into the equity return in foreign currency and exchange rate return. Our model is also characterized by a costly portfolio reallocation procedure at the end of second period due to the presence of capital outflow barrier. Holding a rebalancing motive true throughout our theoretical framework, we show that the magnitude of fund manager's rebalancing depends on a destination country's market environment such as the degree of financial market openness, exchange rate flexibility and country's equity market return volatility, which may affect fund mangers' perception of the risk.

Next, we test the empirical relevance of our theoretical findings. First, our fund-level panel data analysis based on 44 countries over the period 1999m01-2010m12 suggests a strong rebalancing motive. Global fund managers on average rebalance their portfolio risks by lowering the portfolio weight of the country that experiences the excess returns over the fund-average. In addition, consistent with our theory, our empirical results suggest that financial liberalization and higher nominal exchange rate flexibility tend to reinforce the risk rebalancing motive. Furthermore, this rebalancing motive appears larger for a country with the larger volatility of its total equity market return, where the exchange rate return volatility plays a dominant role.

During our sample period, there was a global liquidity shock in late 2008 caused by the U.S. financial market turbulence. It has caused a dramatic decrease in the demand for all types of financial assets around the world during the peak of the crisis. As shown in Figure 3.3, equity inflow has become noticeably volatile during the peak of 2008 crisis and the sudden and large equity outflow was observed in all countries in the world. This outflow was much larger and more persistent in developed countries than emerging market countries. We control the effect of 2008 crisis and find our empirical results are largely robust to the inclusion of recent financial crisis episodes. We also control the equity market size to check the robustness of our main results and find the inclusion of equity market size does not alter our main results.

2 Portfolio balance model

2.1 Optimal portfolio weight and portfolio rebalancing

We begin with the three-period mean-variance portfolio balance model to understand the rebalancing behavior. We then derive three testable implications by examining how sensitive rebalancing motive is in response to financial liberalization, exchange rate flexibility and volatility of the realized return, each of which can affect fund mangers' perception of the portfolio risk. In our model, a representative fund manager holds equity mutual funds that are invested in J countries.[36] As a result, she bears both equity and currency risks. She makes an allocation decision of her portfolio at the end of periods 1 and 2 to maximize the terminal wealth in period 3. Unlike period 1, the fund manager observes the equity return of all countries in period 2 and then reallocates assets across countries to maximize her portfolio return of periods 2 and 3. For this reason, the portfolio reallocation in period 2 is likely to be more active than in period 1 and thus we assume it involves positive liquidation costs. For each time period t, the realized rate of return r_t^j in investor's currency from an equity investment in country j consists of stock (equity) return s_t^j in local (or destination) currency and exchange rate return e_t^j:

$$r_t^j = s_t^j + e_t^j \tag{3.1}$$

[36] The model can be applied to a case when both equities and bonds are available as an asset class. Since our empirical procedure is based on the equity fund flow data only, we assume the fund managers invest in the equity market only.

One-period equity and exchange rate returns are independent, unpredictable and normalized to zero for all countries. Thus, for each country j, distributions of the expected returns are given by:

$$\begin{aligned} s_t &\sim N(0, \sigma_s^2) \\ e_t &\sim N(0, \sigma_e^2) \\ r_t &\sim N(0, \sigma_s^2 + \sigma_e^2) \end{aligned} \tag{3.2}$$

where, by assumption, $cov(s_t, e_t) = 0$. Normality assumptions are useful to obtain linear asset demand functions in a mean-variance framework. The fund manager maximizes the expected return of her wealth for a given level of risk measured by the variance as follows:

$$\max_{W} L = \boldsymbol{W}'E[\boldsymbol{R}] - \frac{\lambda}{2}\boldsymbol{W}'\boldsymbol{\Sigma}\boldsymbol{W} \tag{3.3}$$
$$\text{s.t. } \boldsymbol{W'I} = 1$$

where W is a $(J \times 1)$ vector of country weight where w_t^j is the j^{th} element, $E[]$ is the standard expectation operator, R is a $(J \times 1)$ vector of country returns (in investor's currency), λ is the coefficient of risk aversion, Σ is the variance-covariance matrix of expected returns, and I is a unity column vector.[37] The non-negativity constraint for a portfolio weight $w_t^j \geq 0$ implies that short sales are not allowed in our model.

The optimal portfolio weight for the fund manager is

$$\boldsymbol{W} = \frac{1}{\lambda}\boldsymbol{\Sigma}^{-1}\left\{E[\boldsymbol{R}] - \frac{\boldsymbol{I}'\boldsymbol{\Sigma}^{-1}E[\boldsymbol{R}] - \lambda}{\boldsymbol{I}'\boldsymbol{\Sigma}^{-1}\boldsymbol{I}}\boldsymbol{I}\right\} = \frac{1}{\lambda}\boldsymbol{\Sigma}^{-1}E[\boldsymbol{R}] \tag{3.4}$$

or

[37] λ is originally from the exponential utility function (not presented here though) where the Arrow-Pratt index of absolute risk aversion is given by $-U''(C)/U'(C) = \lambda$. Also note that, although it is not emphasized and in fact ignored in our model, we admit that the covariance structure of expected returns may be a non-trivial factor that would affect the portfolio adjustment. For example, if a country j's return is more correlated with the rest of the world, meaning that other countries' returns tend to move together with the country j's, a fund manager is less likely to adjust her portfolio weight of country j.

$$\begin{bmatrix} w_t^1 \\ \vdots \\ w_t^J \end{bmatrix} = \frac{1}{\lambda} \begin{bmatrix} Var(r_t^1) & \cdots & Cov(r_t^1, r_t^J) \\ \vdots & \ddots & \vdots \\ Cov(r_t^J, r_t^1) & \cdots & Var(r_t^J) \end{bmatrix}^{-1} \begin{bmatrix} E[r_t^1] \\ \vdots \\ E[r_t^J] \end{bmatrix} \tag{3.5}$$

Given the optimal portfolio weight of (3.5), we can now find country *j*'s optimal weight for each time period *t* = 1, 2 as follows:

$$w_1^j = \frac{1}{\lambda} \frac{E[R^j]}{Var(R^j)} = \frac{(1 + E[r_2^j] + E[r_3^j])}{\lambda[2(\sigma_s^j)^2 + 2(\sigma_e^j)^2]} = \frac{1}{\lambda[2(\sigma_s^j)^2 + 2(\sigma_e^j)^2]} \tag{3.6}$$

$$w_2^j | r_2^j, \tau^j = \frac{1}{\lambda} \frac{E[R^j | r_2^j] - \tau^j(r_2^j)}{Var(R^j | r_2^j)} = \frac{(1 + s_2^j + e_2^j + E[r_3^j]) - \tau^j}{\lambda[(\sigma_s^j)^2 + (1 + s_2^j)^2 (\sigma_e^j)^2]}$$

$$= \frac{(1 + r_2^j) - \tau^j}{\lambda[(\sigma_s^j)^2 + (1 + \theta r_2^j)^2 (\sigma_e^j)^2]} \tag{3.7}$$

where $R^j = (1 + s_2^j + s_3^j)(1 + e_2^j + e_3^j)$ is the realized return from a country *j* at the end of period 3 and τ^j is the convex portfolio adjustment cost in period 2 which satisfies $\tau' > 0$ and $\tau'' > 0$.[38] Unconditional variance of cross-product terms, $s_3^j e_2^j$ and $s_3^j e_3^j$ are set equal to zero for simplicity. We also assume, in period 2, the stock return contributes θ share of total realized return from a country j, i.e., $s_2^j = \theta r_2^j$.

We now take a rebalancing as a fund manager's portfolio management strategy as informed by our empirical evidence found in Figure 3.1. When a country *j*'s equity market performs better than other countries, a fund manager would face relatively higher exposure to the exchange rate risk, thereby lowering the country *j*'s weight to rebalance her portfolio towards an original or desired level of risk. Formally, using the optimal weight in period 2 (equation (3.7)), the portfolio rebalancing implies

[38] The convex portfolio adjustment cost can be thought of as a tax imposed on the equity outflow from a destination country. This cost is likely to be high when the excess return is high.

$$\frac{\partial w_2^j | r_2^j, \tau^j}{\partial r_2^j} = \beta^j$$

$$= \frac{1 - (\tau^j)'}{\lambda[(\sigma_s^j)^2 + (1 + \theta r_2^j)^2 (\sigma_e^j)^2]} - \frac{2\theta(1 + r_2^j - \tau^j)(1 + \theta r_2^j)(\sigma_e^j)^2}{\lambda\left[(\sigma_s^j)^2 + (1 + \theta r_2^j)^2 (\sigma_e^j)^2\right]^2} < 0 \qquad (3.8)$$

Equation (3.8) indicates that the contemporary return effect is dominated by the risk effect, suggesting a portfolio rebalancing motive of the investor who faces a potential currency risk. Thus, β^j measures a degree of portfolio rebalancing.

2.2 Testable implications

In this subsection, we derive three testable implications to understand the theoretical factors influencing the magnitude of rebalancing from a fund manager's standpoint.

2.2.1 The effect of financial liberalization on portfolio rebalancing

Consider two countries *A* and *B*, where *B* is financially more open than *A*. A country that has a more open financial market (including equity market) would have a lower barrier for an asset trade and therefore we can assume, for a given level of realized return in period 2, $\tau^A > \tau^B$ and $(\tau^A)' > (\tau^B)'$. If rebalancing motive suggested by equation (3.8) holds for both countries, we can show

$$\frac{\partial w_2^A}{\partial r_2^A} > \frac{\partial w_2^B}{\partial r_2^B} \qquad (3.9)$$

or

$$|\beta^A| < |\beta^B|$$

Equation (3.9) means that a fund manager has a greater rebalancing motive for the country *B* that requires the lower cost of portfolio adjustment than the country *A*. This makes sense because the fund manager is likely to respond to the portfolio adjustment cost, in particular, when the adjustment cost is an increasing and positive function of the realized return and international investors perceive this capital tax as a permanent financial friction.

2.2.2 The effect of exchange rate flexibility on portfolio rebalancing

Countries with a currency peg or crawling peg with a narrow bound would eliminate or lower the currency risk from the portfolio risk. If the variance of exchange rate risk σ_e^j is given by close to zero for the country with a fixed exchange rate regime, an investor would find a less rebalancing motive as suggested by equation (3.8):

$$\frac{\partial w_2^{peg}}{\partial r_2^{peg}} > \frac{\partial w_2^{floating}}{\partial r_2^{floating}} \tag{3.10}$$

or

$$|\beta^{peg}| < |\beta^{floating}|$$

Equation (3.10) is valid as long as the exchange rate policy is exogeneously made regardless of the equity market performance of a country. A persistent peg policy would lower or even eliminate the expected currency risk, measured by exchange rate volatility, and make the rebalancing motive smaller, holding all other things constant.[39]

2.2.3 The effect of return volatility on portfolio rebalancing

The volatility of equity portfolio return comes from two sources: equity return and currency return. Thus, we examine those two volatility effects separately and then infer the implication for the realized return volatility. Taking a derivative of equation (3.8) with respect to equity return variance $Var(s_2^j)$ and currency return variance $Var(e_2^j)$, we get the following:

$$\frac{\partial \beta^j}{\partial Var(s_2^j)} = \frac{-1 + (\tau^j)'}{\lambda Var(R^j)^2} + \frac{4\theta(1 + r_2^j - \tau^j)(1 + \theta r_2^j)(\sigma_e^j)^2}{\lambda Var(R^j)^3} > 0 \tag{3.11}$$

$$\frac{\partial \beta^j}{\partial Var(e_2^j)} = \frac{-(1 - (\tau^j)')(1 + s_2^j)^2 - 2\theta(1 + r_2^j - \tau^j)(1 + s_2^j)}{\lambda Var(R^j)^2}$$

[39] However, if the exchange policy is endogenesouly determined, the degree of rebalancing between fixed and flexible exchange rate regimes depends on the relative variance of the equity return and currency return. We assume an exogeneous exchange rate policy making in this paper.

$$+\frac{4\theta(1+r_2^j-\tau^j)(1+s_2^j)^3(\sigma_e^j)^2}{\lambda Var(R^j)^3}<0 \quad (3.12)$$

Given that the rebalancing motive (equation (3.9)) holds for a country j, results in equation (3.11) and (3.12) imply that a fund manager's degree of rebalancing depends on the relative size of the equity risk and currency risk.[40] In particular, the fund manager would find a more rebalancing motive for a country where the exchange rate return volatility is a major source of the portfolio risk.

In sum, our theory suggests that the fund manager who allocates her fund into a number of countries around the globe find a greater rebalancing motive for a country with relatively open financial market, high degree of nominal exchange rate flexibility, and high perceived risk of currency return relative to the equity return.

3 Empirical strategy

3.1 Dependent and explanatory variables

In order to measure an active rebalancing behavior of fund managers, we use the following expression as our dependent variable, which eliminates the valuation effect from the observed weight changes. Our dependent variable in the empirical model, a change in a fund *i*'s country *j* weight at time *t* is defined as follows:

$$\Delta w_{ij,t}=w_{ij,t}-w_{ij,t-1}\underbrace{\left(\frac{1+r_{jt}}{1+r_{it}}\right)}_{\text{Valuation effect}} \quad (3.13)$$

where r_{it} is the fund *i*'s total portfolio (weighted average) return at time *t* defined as $r_{it}=\sum_{j=1}^{J}w_{ij,t-1}r_{ij,t}$. When a country *j*'s equity market outperforms the fund *i*'s average portfolio performance, equation (3.13) shows that the fund *i*'s country *j* weight automatically rises due to the valuation effect. So, the second term in right-hand-side of equation (3.13) is often called a buy-and-hold weight or passive holding.

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[40] Determining the sign of the equation (3.12) requires $1>\frac{2\left(1+s_2^j\right)^2\sigma_e^2}{Var(R^j)}$. We assume this condition to be true based on the numerical experiments using the mean values for variables from our data set.

Since the portfolio weight of a country *j* would change only when its equity market performance relative to the fund's portfolio return changes, our explanatory variables should be in a relative scale. So, for a fund *i*, country *j* and time *t*, control variables are defined as follows:

- Return differential: $\Delta r_{jt} = (r_{jt} - r_{it})$
- Financial openness: $FO_{jt} = 1$ if $FO_{jt} > FO_{it}$
- Exchange rate regime: $EXR_{jt} = 1(\text{float})$ if $EXR_{jt} > EXR_{it}$
- Country (aggregate) return variance: $VAR_{jt}^{total} = \left[VAR\left(r_{jt}^{\$}\right) - VAR\left(r_{it}^{\$}\right)\right] \times 100$
- Equity return variance (in local or destination currency): $VAR_{jt}^{s} = \left[VAR\left(s_{jt}\right) - VAR(s_{it})\right] \times 100$
- Exchange rate return variance: $VAR_{jt}^{e} = \left[VAR\left(e_{jt}\right) - VAR(e_{it})\right] \times 100$
- Stock market size: $Mkt_{jt} = Mktsize_{jt} - Mktsize_{it}$

where variables with "*it*" subscripts are weighted average at the fund level. For example, FO_{it} is an weighted average of stock market liberalization index for all countries included in the fund *i*'s portfolio where the portfolio country shares are used as a weight. Exchange rate regime information is used as a proxy for the country's exchange rate stability.

3.2 Regression model

Fund managers are heterogeneous in many dimensions. For example, they trade assets at a different time. In addition, they have a different threshold for a portfolio reallocation, implying that their portfolio change can be different even when they are exposed to the same risk. Hence, our empirical procedure based on a panel data set tries to discover the average tendency of fund managers' reaction to return changes.

Based on our theoretical results in section 2, we use the following panel regression models to test our hypotheses:

$$\Delta w_{ij,t} = \alpha_{ij} + \beta_1\left(r_{jt} - r_{it}\right) + u_{ijt} \tag{3.14}$$

$$\Delta w_{ij,t} = \alpha_{ij} + \beta_1 (r_{jt} - r_{it}) + \boldsymbol{\beta_2 X_t} (r_{jt} - r_{it}) + \boldsymbol{\beta_3 X_t} + \varepsilon_{ijt} \tag{3.15}$$

where $\Delta w_{ij,t}$ is an active change of the portfolio weight, α_{ij} controls a time-invariant fund-country specific fixed-effect, $(r_{jt} - r_{it})$ is a relative equity market performance of a country j compared to the fund i's total portfolio return, $\boldsymbol{X}_t$ is a vector of control variables that are proxy for τ^j, σ_e^j, $Var(R^j)$, $Var(s_2^j)$, and $Var(e_2^j)$ from our theoretical framework in section 2, which includes the degree of stock market openness, exchange rate stability, and equity and currency return volatility.[41] Our prime interest from this empirical excise is to test our three theoretical propositions by looking at the coefficients β_1 and $\boldsymbol{\beta_2}$ from equations (3.14) and (3.15):

$$\frac{\partial \Delta w_{ij,t}}{\partial (r_{jt} - r_{it})} = \beta_1 \tag{3.16}$$

$$\frac{\partial \Delta w_{ij,t}}{\partial (r_{jt} - r_{it}) \partial \boldsymbol{X_t}} = \boldsymbol{\beta_2} \tag{3.17}$$

where $\boldsymbol{X}_t = [FO_{jt}, EXR_{jt}, VAR_{jt}^{total}, VAR_{jt}^{s}, VAR_{jt}^{e}]$, β_1 measures a magnitude of rebalancing as long as $\beta_1 < 0$ (return chasing if $\beta_1 > 0$), and $\boldsymbol{\beta_2}$ measures a sensitivity of rebalancing in response to changes of variables in $\boldsymbol{X}_t$.

3.3 Data and sources

We include 23 developed and 21 emerging market countries (total of 44 countries) according to the 2014 MSCI (Morgan Stanley Capital International) Market Classification. Table 1 lists a full set of countries. Emerging Portfolio Fund Research (EPFR) database provides total net asset (TNA), country allocation weights and portfolio return data at the fund level. Table 3.2 shows the number of funds that invest in target regions around the world. Our sample includes 799 funds. The data for equity market return, in both daily and monthly, for each country and

[41] We assume that the portfolio adjustment cost is inversely related to the degree of financial liberalization. Forbes et al. (2012) uses the Chinn-Ito index (2006) to select countries with a capital flow barrier. They set the following selection standard: capital flow barrier exists if a value of country's Chinn-Ito index is smaller than the mean of index less one standard deviation.

region are from MSCI index, daily spot exchange rate from Bloomberg, stock market liberalization index from Kaminsky and Schmukler (2008), and exchange rate regime from Ilzetzki, Reinhart, and Rogoff (2010; IRR, hereafter).[42] The country j's return r_{jt} is measured by $\log(\frac{MSCI_{jt}}{MSCI_{jt-1}})$. Due to the unavailability of a fund's portfolio return volatility in a monthly frequency, we use a variance of daily regional MSCI index. The stock market size is measured by a country stock market capitalization of listed companies, which is the overall size of the stock market in U.S. dollars as a percentage of GDP. Market capitalization (also known as market value) is the share price times the number of shares outstanding.[43] Summary statistics for key variables are reported in Table 3.3. Our sample period covers from 1999m01 to 2010m12.[44]

4 Estimation results

4.1 Main results

The main estimation results are reported in Table 3.4. Throughout the specifications columns (1) to (5), we observe the strong evidence of portfolio rebalancing in our sample in line with the literature (Hau and Rey, 2006, 2008; Curcuru et el., 2011). Regarding the effects of the conditional factors, estimation results are consistent with our theoretical predictions. In other words, fund managers are likely to find a greater rebalancing motive for a country characterized by an open stock market with a lower capital flow barrier, higher exchange rate flexibility, and large volatility of country return. In fact, the variance terms measure the degree of risk and the fund managers tend to respond to the perceived risk factors. Decomposing the total country return into i) equity return in local (or destination) currency and ii) exchange rate return, we do not find the former significant but the latter significant in column (3). Consistent with our theory, higher exchange rate risk reinforces the (risk) rebalancing motive and exchange rate risk dominates the local-currency equity risk. Controlling control variables as additional main

[42] The data for Kaminsky and Schmukler (2008)'s stock market liberalization index (value of 1 being the most liberalized and 3 being the least liberalized) is available on the Schmukler's website at https://sites.google.com/site/sschmukler/journal-articles and IRR's exchange rate regime classification is available at http://personal.lse.ac.uk/ilzetzki/IRRBack.htm.

[43] Note that the data for Taiwan is not available.

[44] Regarding EPFR fund level data, we drop funds whose total number of observations is less than 12 months. Moreover, small funds whose initial net asset value is less than $15 million are also dropped. Elton, Gruber, and Blake (2001) admit that these funds do not report the data or report at less frequent intervals, which may cause an upward bias in returns data.

variables as in column (5), we cannot identify the role played by both equity risk and currency risk.

4.2 Robustness checks

In order to evaluate the robustness of our main results, we perform two investigations. First of all, as indicated in Figure 3.2, there is a disruption of equity inflow in our sample countries during the recent global crisis. Raddatz and Schmukler (2012) finds that, using the same data set as ours, mutual fund flows are pro-cyclical and this pro-cyclicality is prominent in equity funds during crises, moving away from countries experiencing turmoil. To control the recent global crisis episode, we include crisis time dummy variables (c_t) taking a unity for each month between 2008m09 to 2008m12. Columns (1) to (3) in Table 3.5 include crisis dummy variables as main effects only while columns (4) to (6) include these time dummy variables as both main and interaction effects. Two things are worth mentioning from the result in Table 3.5. First, the coefficient values remain significant with the same sign as before for the majority of variables but the variances. Now, all of variance measures lose their statistical significance by including global shock variables. One plausible explanation is due to the high collinearity between crisis and variance terms. Second, while the sign of the crisis dummy variables do not necessarily capture the effect of crisis itself on equity flow changes,[45] the significant and negative coefficient of crisis-return interaction variables reported in columns (4) to (6) in Table 3.5 show that fund managers are more sensitive to return changes during the crisis period by taking an active allocation decision to lower their portfolio risk.

Next, we conduct the robustness of our results by controlling the stock market size across countries. As noted by Bekaert and Harvey (2000) and Chan et al. (2005), bigger markets are easy to observe and tend to attract a greater volume of capital flows. Indeed, some of the markets with a large magnitude of portfolio rebalancing motive in Figure 3.1 are big financial centers in the world or recently expanded markets. Robust results with the inclusion of stock market size variable (Mkt_{jt}) are presented in Table 3.6. Our main results are robust to controlling the stock market size. Furthermore, the market size tends to strengthen the rebalancing motive but the size of this reinforcing effect is negligible.

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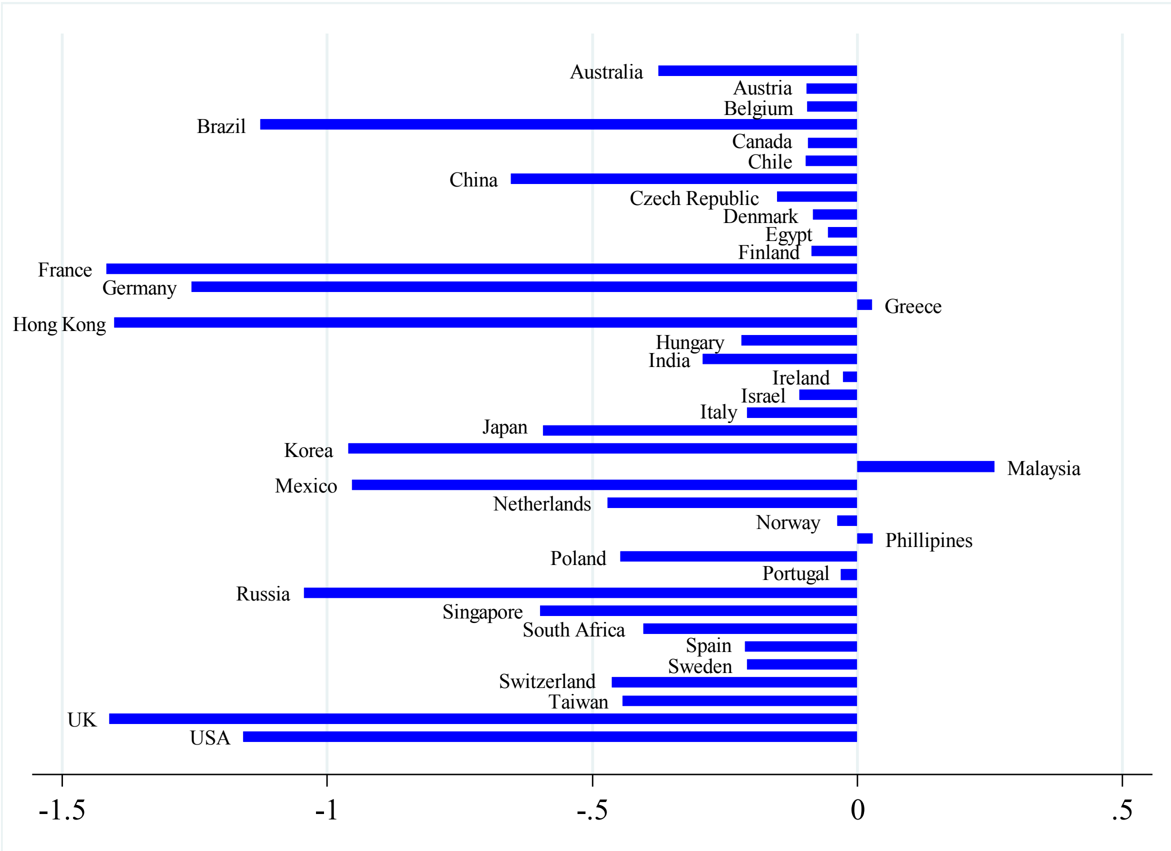
[45] This is because the country weights in each portfolio should sum to one.

5 Concluding remarks

Using a large number of sample countries which include both developed and emerging economies, we find that global fund managers rebalance their portfolio risks by lowering the portfolio weight of the country that experiences the excess returns over the fund-average. However, the degree of rebalancing motive differs across countries. In addition, consistent with our theory, our empirical results suggest that financial openness with a lower capital flow barrier and higher nominal exchange rate flexibility tend to reinforce the risk rebalancing motive. In addition, this rebalancing motive appears larger for a country with the larger volatility of its total equity market return, where the exchange rate return volatility plays a dominant role. Our novel data set allows us to look at the fund-level portfolio allocation decisions given certain economic conditions of a country. Fund specific factors, such as the degree of risk tolerance, are likely to play an important role in affecting the fund manager's risk rebalancing decisions and we leave this exercise as our future research.

Figure 3.1 Heterogeneous fund manager responses to a country's equity market performance[46]

$$\Delta country\ weight_{it} = \alpha + \boldsymbol{\beta} \cdot \Delta return_{it} + \varepsilon_{it}$$



[46] Countries included in this figure are the ones with a return differential coefficient statistically significant at the 10 percent level. Obviously, a country weight in a given portfolio is likely to change only when the country's equity market performs differently from the portfolio average return, so the return differential is defined as a country's relative performance. See section 3 for details.

Figure 3.2 Strength of portfolio rebalancing and equity flow volatility

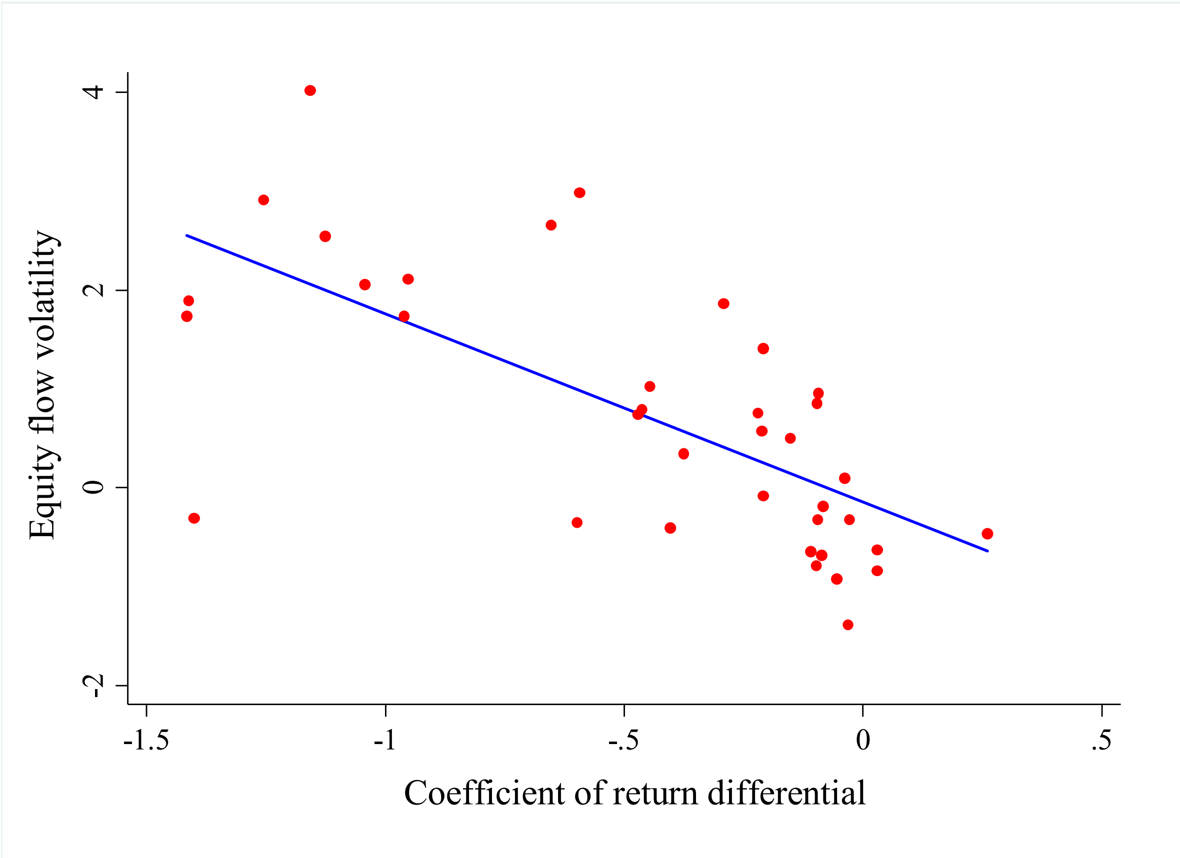


Figure 3.3 Equity flow during the crisis

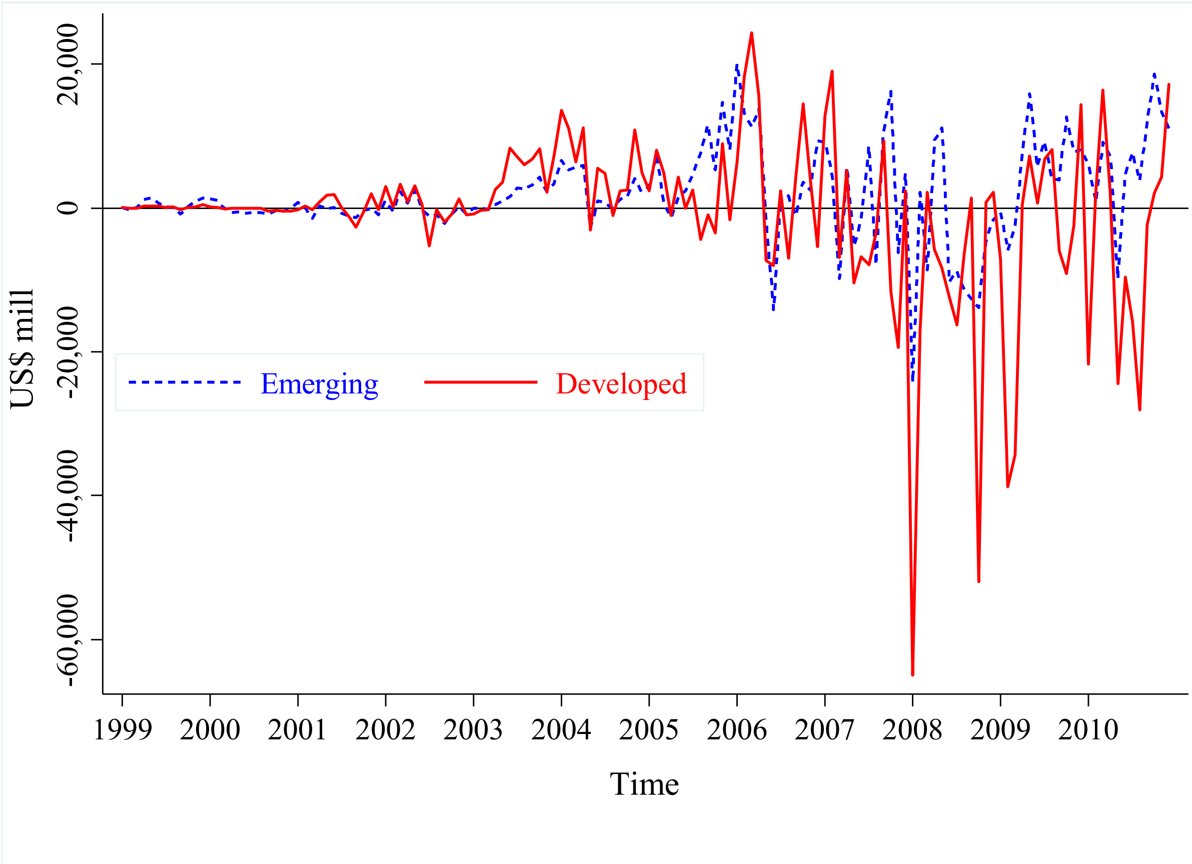


Table 3.1 Sample countries

Region	*Developed markets*	*Emerging markets*
Americas	Canada, United States	Brazil, Chile, Colombia, Mexico, Peru
Europe, Middle East & Africa	Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom	Czech Republic, Egypt, Greece, Hungary, Poland, Russia, South Africa, Turkey
Asia & Pacific	Australia, Hong Kong, Japan, New Zealand, Singapore	China, India, Indonesia, Korea, Malaysia, Philippines, Taiwan, Thailand

Table 3.2 EPFR equity funds statistics (1999m01-2010m12)

Target region	# of funds
Asia ex-Japan	142
BRIC	15
Emerging Europe	62
Emerg. Europe, Middle East, Africa	36
Europe	139
Global Emerging	153
Global	102
Global ex-US	58
Latin America	58
Pacific	34
Total	799

Table 3.3 Summary statistics for key variables

Variable	Obs	Mean	Std. Dev.	Min	Max
$\Delta w_{ij,t}$	2193620	0.009	0.648	-78.14	79.27
Δr_{jt}	2293588	-0.003	0.068	-0.83	0.766
FO_{jt}	1355302	0.782	0.413	0	1
EXR_{jt}	1730836	0.51	0.5	0	1
VAR_{jt}^{total}	2278152	0.012	0.047	-0.712	2.599
VAR_{jt}^{s}	2239268	-0.002	0.04	-1.027	2.765
VAR_{jt}^{e}	2241461	-0.00001	0.167	-37.85	1.471

Table 3.4 Main results: Panel fixed effect

Dependent variable: $\Delta w_{ij,t}$					
	(1)	(2)	(3)	(4)	(5)
Δr_{jt}	-0.336***	-0.112***	-0.131***	-0.117***	-0.133***
	(0.007)	(0.022)	(0.021)	(0.022)	(0.021)
$\Delta r_{jt} \times FO_{jt}$		-0.144***	-0.138***	-0.134***	-0.136***
		(0.023)	(0.023)	(0.023)	(0.023)
$\Delta r_{jt} \times EXR_{jt}$		-0.182***	-0.164***	-0.184***	-0.165***
		(0.021)	(0.021)	(0.021)	(0.021)
$\Delta r_{jt} \times VAR_{jt}^{total}$		-0.625***		-0.408***	
		(0.116)		(0.122)	
$\Delta r_{jt} \times VAR_{jt}^{s}$			0.106		0.014
			(0.169)		(0.176)
$\Delta r_{jt} \times VAR_{jt}^{e}$			-0.731**		-0.367
			(0.292)		(0.33)
FO_{jt}				0.002	0.004*
				(0.002)	(0.002)
EXR_{jt}				0.003	0.002
				(0.004)	(0.004)
VAR_{jt}^{total}				0.103***	
				(0.018)	
VAR_{jt}^{s}					-0.03
					(0.022)
VAR_{jt}^{e}					0.097**
					(0.043)
Observations	2193620	949818	918360	949818	918360

Note: All specifications include fund-country fixed effects. Newey-West standard errors reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10%, respectively.

Table 3.5 Robustness I: Controlling global financial crisis

Dependent variable: $\Delta w_{ij,t}$						
	(1)	(2)	(3)	(4)	(5)	(6)
Δr_{jt}	-0.302***	-0.131***	-0.137***	-0.293***	-0.137***	-0.141***
	(0.007)	(0.022)	(0.021)	(0.007)	(0.022)	(0.021)
$\Delta r_{jt} \times FO_{jt}$		-0.099***	-0.094***		-0.069***	-0.064***
		(0.023)	(0.023)		(0.023)	(0.023)
$\Delta r_{jt} \times EXR_{jt}$		-0.178***	-0.155***		-0.173***	-0.148***
		(0.021)	(0.021)		(0.021)	(0.021)
$\Delta r_{jt} \times VAR_{jt}^{total}$		-0.112			-0.029	
		(0.118)			(0.119)	
$\Delta r_{jt} \times VAR_{jt}^{s}$			0.214			0.233
			(0.17)			(0.17)
$\Delta r_{jt} \times VAR_{jt}^{e}$			-0.473			-0.42
			(0.292)			(0.293)
$\Delta r_{jt} \times C_{2008m09}$				-0.184***	-0.158*	-0.185**
				(0.067)	(0.091)	(0.092)
$\Delta r_{jt} \times C_{2008m10}$				0.042	-0.237***	-0.248***
				(0.046)	(0.071)	(0.072)
$\Delta r_{jt} \times C_{2008m11}$				-0.088	-0.376***	-0.349***
				(0.07)	(0.094)	(0.093)
$\Delta r_{jt} \times C_{2008m12}$				-0.494***	-0.395***	-0.388***
				(0.057)	(0.075)	(0.075)
$C_{2008m09}$	0.05***	0.041***	0.042***	0.046***	0.04***	0.04***
	(0.005)	(0.008)	(0.008)	(0.006)	(0.008)	(0.008)
$C_{2008m10}$	0.186***	0.157***	0.15***	0.192***	0.138***	0.128***
	(0.005)	(0.008)	(0.008)	(0.008)	(0.01)	(0.01)
$C_{2008m11}$	0.034***	0.035***	0.033***	0.033***	0.035***	0.033***
	(0.005)	(0.008)	(0.007)	(0.005)	(0.007)	(0.007)
$C_{2008m12}$	-0.012**	-0.004	0.001	-0.003	0.002	0.008
	(0.005)	(0.007)	(0.007)	(0.005)	(0.007)	(0.007)
Observations	2193620	949818	918360	2193620	949818	918360

Note: All specifications include fund-country fixed effects. Newey-West standard errors reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10%, respectively.

Table 3.6 Robustness II: Controlling equity market size

Dependent variable: $\Delta w_{ij,t}$			
	(1)	(2)	(3)
Δr_{jt}	-0.359***	-0.076***	-0.109***
	(0.008)	(0.023)	(0.022)
$\Delta r_{jt} \times FO_{jt}$		-0.174***	-0.176***
		(0.024)	(0.023)
$\Delta r_{jt} \times EXR_{jt}$		-0.251***	-0.222***
		(0.022)	(0.022)
$\Delta r_{jt} \times VAR_{jt}^{total}$		-1.353***	
		(0.142)	
$\Delta r_{jt} \times VAR_{jt}^{s}$			-0.219
			(0.184)
$\Delta r_{jt} \times VAR_{jt}^{e}$			-2.251***
			(0.395)
$\Delta r_{jt} \times Mkt_{jt}$	-0.001***	-0.002***	-0.001***
	(0.0001)	(0.0001)	(0.0001)
Mkt_{jt}	0.0001	0.0001	0.0001***
	(0.00002)	(0.00003)	(0.00003)
Observations	1612758	931117	899712

Note: All specifications include fund-country fixed effects. Newey-West standard errors reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10%, respectively.

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APPENDIX

Appendix for Chapter I

1. Choice of countries

We keep commodity-dependent developing countries whose export earnings in nonfuel primary products accounted for more than half of total export earnings for the years 1988-1992.[47] From 73 countries based on this classification, 21 countries are excluded because times series data on either the real effective exchange rate or UN COMTRADE commodity exports are not available for a sufficiently long period of time. In addition, following Coudert et al. (2008), Ecuador and Nicaragua are excluded from our sample because of its dollarization that began in 2001 and unusual 1000% appreciation at the beginning of the sample period, respectively. Zimbabwe is dropped as well due to the hyperinflation during the significant part of sample period (since 2002) that could distort an appropriate measure of exchange rate. Five commodity-dependent developed countries (Australia, Canada, Iceland, Norway and New Zealand) and nine major oil exporters (Algeria, Bahrain, Kuwait, Libya, Nigeria, Oman, Saudi Arabia, United Arab Emirates, and Venezuela) are added. This procedure leaves a total of 63 countries including both oil and non-oil commodity exporting countries. Note that the majority of countries in our sample are developing economies (58 countries). The full list of countries is available in Table A1 in Appendix.

2. Variable Definitions

2.1 Real effective exchange rate (*REER*) and real commodity price index (*RCP*)

We obtain real effective exchange rate (*REER*), an average of the bilateral real exchange rates between the country and its trading partners weighted by the respective trade shares of each trading partner, from the International Monetary Fund's (IMF) International Financial Statistics (IFS) and Information Notice System (INS). From its definition, an increase in real effective exchange rates implies a real appreciation of the domestic currency.

[47] This is the classification originally set in the International Monetary Fund's World Economic Outlook (IMF, 1996) and adopted in Cashin et al. (2004).

We define a real commodity price index as the world (nominal) price of country's commodity exports relative to the world price of manufactured goods exports. It is a common practice to measure the terms-of-trade of countries with high commodity export dependence in this way because the majority of their imports are manufactured goods that usually account for more than half of their total imports.[48] The annual commodity trade data are taken from the UN COMTRADE and the monthly world commodity price data are from the IMF Primary Commodity Prices and the World Bank Pink Sheet. We construct monthly commodity price indices using 58 commodities for 63 commodity-exporting countries.[49] For each country *i*, commodity *j*, and time *t*, a country specific index of nominal commodity price is defined as

$$\ln NCP_{it} = \sum_{j=1}^{J} W_{ij}\left(\ln P_{jt}\right), \text{ where } W_{ij} = \frac{\frac{1}{T}\sum_{t=1}^{T} X_{ij,t}}{\frac{1}{T}\sum_{t=1}^{T} CX_{it}}$$

where *X* is an export volume of individual commodity *j* and *CX* is an aggregate export volume of commodities. The weights (*W*) remain constant over time in order to eliminate the quantity effect from the price index. This definition is similar to Cashin et al. (2004) but we use the period-average values of commodity exports between 1980 and 2010. Commodity prices are expressed in real terms (*RCP*) through deflation by the IMF's unit value index of manufactured exports (MUV) of industrial economies. Note that throughout the paper, both *REER* and *RCP* are in log forms.

2.2 Openness measures

Financial Openness (*FO*). Financial openness represents a country's degree of capital account openness. In order to measure a country's degree of capital account openness, we use

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[48] Ricci et al. (2008) alternatively use a commodity-based terms-of-trade index which is defined as the ratio of aggregate indexes of commodity exports and imports. In their real exchange rate regression estimation using a sample of 48 countries, the commodity terms-of-trade coefficient shows an expected positive sign at the 1 percent level of statistical significance.

[49] We include all traded commodities as long as their prices are available in the IMF Primary Commodity Prices and World Bank Pink Sheet. However, platinum, plywood and steel are excluded because we have no information about the corresponding SITC codes. See Table A3 for a list of commodities employed in the construction of *RCP* indices.

Chinn-Ito index (2006).[50] This index measures "the extent and intensity of capital controls based on the information from the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (AREAER)."[51] The index runs from -1.84 to 2.48, where higher values indicate that a country is more open to cross-border capital transactions.

Trade Openness (*TO*). Trade openness measures the degree of trade dependency reflecting how much the economy relies on tradable goods. We use the ratio of exports plus imports to GDP as a measure of trade dependency in our empirical procedure.[52]

2.3 Monetary/exchange rate policy measures

Inflation Targeting (*IT*). Since the 1990s, a number of central banks in both developed and developing economies have adopted inflation targeting (*IT*) as an instrument to achieve the low and stable average inflation. Commodity exporters were not an exception.[53] The exact adoption dates of inflation targeting are from Roger (2009).

Exchange Rate Regime (*EXR*). We use Ilzetzki et al. (2008; called IRR hereafter)'s coarse classification for a country's exchange rate regime choice.[54] This has six regimes, namely, hard peg, soft peg, managed floating, freely floating, freely falling, and dual market.[55] The larger the code, the more flexible the regime is. Countries with the hard and soft pegs (IRR code = 1 and 2) are defined as fixed exchange rate regime economies.

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[50] A data set for financial openness index is from http://web.pdx.edu/~ito/Chinn-Ito_website.htm.

[51] Published annually since 1967, the *AREAER* offers a summary table with binary indicators for four types of de facto controls: (i) multiple exchange rates, (ii) restrictions on current account transactions, (iii) restrictions on capital account transactions, and (iv) regulatory requirements of the surrender of export proceeds. In 1998, the *AREAER* expanded the four subcategories and now offers fourteen binary indicators for de facto controls on: capital market securities, collective investment instruments, commercial credits, foreign direct investment, and real estate transactions among others. Chinn-Ito index (2006) is an intensity-modified index of capital controls by taking all four types of controls into account instead of focusing only on capital account transaction controls.

[52] In the theoretical model in section 2, we use a share of importables $(1-\gamma)$ in a representative consumer's consumption bundle to capture the degree of trade openness. Our empirical estimation results are robust to the use of this theory-consistent definition of trade openness (namely, import-to-NGDP ratio) and are available upon request.

[53] See Table A4 in Appendix for inflation targeting adopting countries and adoption dates in our sample.

[54] An updated classification is obtained from Ilzetzki's webpage at http://personal.lse.ac.uk/ilzetzki/IRRBack.htm.

[55] See Table A1.5 in Appendix for details.

International Reserves (*RES*). We extract data for international reserves from IMF IFS and nominal GDP from World Bank WDI to construct a *RES* (= international reserves / NGDP) variable.

2.4 Export market structure measures

Commodity Export Dependency (*CEX*). We define a country's commodity export dependency as follows: for each country *i* and time *t*,

$$CEX_{it} = \frac{\text{Total commodity exports}_{it}}{\text{Total goods exports}_{it}}$$

Hence, a high value of *CEX* indicates a country's heavy reliance on commodity exports and a low degree of export diversification.

World Market Share (*MSH*). We introduce a world market share of commodity exports as a proxy for market power. For each country *i*, commodity *j*, and time *t*, the world market share is defined as

$$MSH_{it} = \sum_{j=1}^{J} W_{ij,t}\left(Share_{ij,t}\right),$$

where $W_{ij,t} = \dfrac{\text{Commodity exports}_{ij,t}}{\text{Total commodity exports}_{it}}$ and $Share_{ij,t} = \dfrac{\text{Commodity exports}_{ij,t}}{\text{World supply of commodity}_{jt}}$

Since a country's export basket typically includes multiple commodities, we construct a weighted index of market share to better identify the impact of a country's potential pricing power on its aggregate commodity price index.

Table A1.1 Commodity price elasticity estimates, unit-root and cointegration tests

Country	Elasticity estimates		DF-GLS unit-root test				Cointegration test		
			REER		*RCP*				
	DOLS	1st differencing	Trend	No Trend	Trend	No Trend	AEG *Z*(*t*)	G-H *Z*(*t*)	Shift date
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Algeria	-0.84 (0.57)	0.03 (0.33)	-1.58 (1)	0.04 (1)	-0.75 (5)	-0.71 (5)	-1.11 (1)	-4.59*	
Argentina		0.05 (0.46)	-2.09 (1)	-1.16 (1)	-1.44 (1)	-1.35 (1)	-2.69 (1)	-3.35	
Australia	1.64*** (0.24)	1.46*** (0.41)	-1.38 (2)	-1.37 (2)	0.04 (1)	-0.16 (1)	-3.08* (1)	-4.54*	
Bahrain		0.05 (0.12)	-2.35 (1)	-0.42 (11)	-1.15 (1)	-1.12 (1)	-0.58 (1)	-3.5	
Bangladesh		0.08 (0.15)	-1.36 (2)	-1.55 (2)	-1.41 (8)	0.06 (7)	-1.34 (2)	-3.19	
Bolivia	1.27 (0.87)	1.73 (1.27)	-1.61 (12)	-0.73 (12)	-0.55 (6)	-0.66 (6)	-1.79 (3)	-7.7***	1985q4
Brazil		2.44*** (0.66)	-2.09 (1)	-2.02* (1)	-0.01 (3)	-0.41 (3)	-2.48 (1)	-2.97	
Burundi	3.04*** (0.35)	0.17 (0.24)	-2.41 (1)	-0.89 (1)	-0.75 (3)	-1.01 (11)	-1.30 (1)	-4.66**	2002q4
Cameroon	-0.53 (0.32)	-0.13 (0.09)	-1.93 (1)	-1.00 (1)	-0.75 (2)	-0.88 (2)	-1.74 (1)	-4.66**	1993q2
Canada		0.92*** (0.30)	-1.64 (3)	-1.68 (3)	-0.67 (1)	-0.75 (1)	-1.58 (1)	-3.44	
Central African Rep.	-2.98** (1.14)	-0.43** (0.21)	-1.64 (1)	-0.50 (1)	-1.79 (10)	-1.31 (10)	-1.55 (2)	-5.06**	1993q2
Chile		0.58** (0.23)	-0.56 (2)	-0.26 (2)	-1.27 (1)	-1.26 (1)	-2.16 (1)	-3.93	
Colombia		0.35* (0.19)	-1.30 (1)	-0.86 (1)	-0.40 (2)	-0.70 (2)	-1.38 (1)	-3.69	
Costa Rica	0.58* (0.34)	-0.05 (0.13)	-0.42 (8)	-0.58 (8)	-0.99 (7)	-0.70 (7)	-5.77*** (4)	-5.58***	1992q1
Cote d'Ivoire		-0.13 (0.24)	-2.32 (1)	-1.30 (1)	-0.60 (1)	-0.63 (1)	-2.65 (1)	-3.8	
Dominica		0.08** (0.04)	-1.60 (2)	-1.48 (1)	-1.56 (11)	-1.43 (11)	-1.17 (1)	-2.85	
Ethiopia	3.22*** (0.57)	-0.57 (0.61)	-1.95 (1)	-0.50 (1)	-1.25 (5)	-1.09 (11)	-1.58 (1)	-5.24***	1993q1
Ghana	7.63*** (1.70)	0.61 (0.76)	-3.71*** (1)	-1.38 (1)	-0.42 (9)	-0.60 (9)	-1.36 (1)	-4.84**	1985q1
Guatemala		0.21 (0.25)	-1.27 (1)	-1.15 (1)	-0.62 (5)	-0.72 (5)	-2.49 (1)	-3.34	
Honduras		-0.003 (0.26)	-1.39 (4)	-1.34 (4)	-1.01 (7)	-0.62 (7)	-2.51 (2)	-4.11	
Iceland		0.06 (0.43)	-2.19 (6)	-0.34 (6)	-1.46 (1)	-0.71 (1)	-1.80 (1)	-2.66	
India		0.97*** (0.34)	-0.91 (4)	-0.59 (4)	-0.34 (4)	-0.66 (4)	-0.42 (1)	-4.08	
Indonesia	1.87** (0.78)	0.54 (0.57)	-1.74 (4)	-0.89 (1)	-0.58 (1)	-0.74 (1)	-1.89 (1)	-4.46*	
Kenya	1.00*** (0.26)	0.67** (0.28)	-0.69 (6)	-0.68 (6)	-1.46 (5)	-0.86 (5)	-1.59 (1)	-4.98**	2000q4
Kuwait	0.29*** (0.09)	0.19 (0.17)	-2.17 (4)	-1.44 (1)	-0.76 (5)	-0.77 (5)	-2.19 (1)	-4.45*	
Libya	-4.96*** (0.24)	-0.33 (0.33)	-1.44 (1)	-0.28 (5)	-0.77 (5)	-0.78 (5)	-3.04 (1)	-5.82***	1994q1
Madagascar	3.69*** (0.56)	-0.58 (0.36)	-1.95 (1)	-0.89 (1)	-1.96 (5)	-0.46 (5)	-2.78 (1)	-5.23***	1986q4
Malawi		1.14** (0.51)	-3.79*** (1)	0.01 (6)	-1.42 (1)	-1.04 (1)	-1.41 (2)	-4.06	
Malaysia		0.48** (0.19)	-2.05 (2)	-0.35 (1)	-0.67 (1)	-0.84 (1)	-1.30 (1)	-4.05	
Mali		-0.59 (0.44)	-0.81 (2)	0.44 (3)	0.21 (5)	-0.49 (1)	-0.11 (3)	-3.48	
Mauritania		0.14 (0.14)	-2.10 (1)	0.18 (1)	-0.07 (4)	0.10 (4)	-1.28 (1)	-2.84	
Mauritius		0.04 (0.06)	-1.92 (2)	-0.70 (1)	-1.79 (1)	-1.51 (1)	-1.93 (1)	-4.33	
Mexico		0.30 (0.20)	-2.52 (1)	-2.32** (1)	-0.61 (5)	-0.72 (5)	-2.69 (1)	-3.1	
Morocco		0.02 (0.08)	-0.79 (5)	0.44 (5)	-0.98 (12)	-0.93 (12)	-3.03 (1)	-4.22	
Mozambique		0.16 (0.39)	-1.88 (2)	-1.73 (2)	-2.25 (1)	-1.06 (1)	-2.08 (3)	-3.53	

Table A1.1 (continued)

Country	Elasticity estimates		DF-GLS unit-root test				Cointegration tests		
			REER		*RCP*				
	DOLS (1,1)	1st differencing	Trend	No Trend	Trend	No Trend	AEG	G-H *Z*(*t*)	Shift date
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
New Zealand		1.07*** (0.38)	-2.44 (4)	-1.93* (4)	-1.02 (7)	-0.64 (7)	-2.49 (1)	-3.33	
Niger		0.02 (0.12)	-0.91 (1)	0.34 (1)	-0.48 (1)	-0.72 (1)	-1.16 (1)	-3.69	
Nigeria	1.58*** (0.54)	-0.35 (0.29)	-1.57 (1)	-0.89 (1)	-0.75 (5)	-0.77 (5)	-1.67 (1)	-4.35*	
Norway	0.19*** (0.05)	0.28 (0.18)	-1.98 (5)	-1.82* (5)	-0.69 (5)	-0.73 (5)	-3.13*(1)	-4.71**	1992q2
Oman	-0.16 (0.30)	-0.19** (0.08)	-1.95 (2)	-0.21 (7)	-0.74 (5)	-0.76 (5)	-1.29 (1)	-4.94**	1986q1
Pakistan		0.64*** (0.18)	-0.67 (2)	0.39 (1)	-0.73 (6)	-0.68 (6)	-1.07 (1)	-3.18	
Papua New Guinea	0.51 (0.34)	-0.24 (0.26)	-0.78 (8)	-0.89 (1)	-0.48 (1)	-0.78 (1)	-1.73 (1)	-4.92**	1998q3
Paraguay	5.02*** (0.52)	-0.08 (0.38)	-1.08 (3)	-0.48 (3)	-1.83 (2)	-1.44 (2)	-3.78** (1)	-4.87**	1987q3
Peru	-2.72*** (0.81)	-0.70 (0.80)	-1.29 (11)	-0.15 (11)	-0.46 (2)	-0.78 (2)	-1.81 (1)	-7.03***	1989q2
Philippines		0.84*** (0.28)	-1.14 (6)	-0.55 (6)	-0.41 (10)	-0.69 (10)	-1.92 (1)	-3.84	
Saudi Arabia	0.06 (0.34)	-0.20** (0.08)	-1.21 (1)	0.12 (3)	-0.76 (5)	-0.77 (5)	-1.54 (1)	-5.48***	1986q1
Senegal	2.28*** (0.48)	-0.60** (0.29)	-1.86 (1)	-0.12 (1)	-0.08 (6)	-0.54 (6)	-0.96 (1)	-5.45***	1993q3
South Africa		0.44 (0.64)	-2.28 (2)	-1.19 (3)	-0.21 (2)	-0.29 (2)	-2.08 (1)	-3.54	
Sri Lanka	1.14*** (0.20)	0.17 (0.14)	-1.52 (1)	-1.02 (1)	-1.40 (12)	-1.01 (12)	-2.01 (1)	-4.6*	
St. Vincent Gr	0.33 (0.40)	0.11 (0.07)	-1.99 (4)	-1.34 (4)	-0.85 (11)	-0.83 (11)	-0.93 (4)	-4.44*	
Sudan	0.69*** (0.06)	0.03 (0.07)	-2.13 (4)	0.42 (5)	-0.70 (5)	-0.75 (5)	-3.37* (1)	-4.05	
Suriname		0.48 (0.41)	-0.88 (1)	-0.83 (1)	-0.91 (1)	-0.92 (1)	-1.86 (1)	-2.5	
Syria	-0.72 (0.60)	0.004 (0.27)	-1.64 (1)	-1.19 (1)	-0.73 (5)	-0.78 (5)	-1.25 (1)	-4.78**	1989q2
Tanzania	7.14*** (1.18)	1.39 (1.05)	-2.00 (1)	-1.00 (1)	0.13 (4)	-0.64 (4)	-0.89 (1)	-4.51*	
Thailand	2.01*** (0.39)	0.98*** (0.35)	-1.57 (2)	-0.63 (2)	-0.32 (1)	-0.74 (1)	-1.55 (1)	-4.39*	
Togo	1.58*** (0.56)	-0.37 (0.32)	-1.58 (4)	-0.36 (3)	-0.33 (6)	-0.76 (10)	-1.98 (2)	-5.31***	1993q2
Tunisia	-0.09 (0.41)	0.05 (0.07)	-1.18 (1)	0.07 (5)	-0.79 (5)	-0.81 (5)	-1.47 (1)	-6.25***	1986q3
Turkey	4.40*** (0.84)	0.64 (0.84)	-2.47 (5)	0.17 (4)	-0.37 (1)	-0.69 (1)	-3.54** (1)	-4.32	
Uganda	6.21*** (0.84)	0.15 (1.25)	-0.96 (6)	-0.07 (10)	-0.90 (5)	-0.99 (11)	-3.85** (1)	-4.85**	1990q1
United Arab Emirates	0.50*** (0.07)	-0.04 (0.09)	-2.25 (1)	-1.51 (1)	-0.62 (5)	-0.70 (5)	-3.51** (1)	-3.27	
Uruguay		1.65*** (0.41)	-1.06 (2)	-1.13 (2)	-0.36 (5)	-0.55 (5)	-1.89 (1)	-3.12	
Venezuela, RB		-0.63** (0.26)	-1.46 (1)	-1.37 (1)	-0.74 (5)	-0.77 (5)	-3.01 (1)	-3.83	
Zambia	3.02*** (0.32)	0.54 (0.39)	-2.43 (3)	-0.08 (3)	-1.41 (1)	-1.36 (1)	-3.60** (1)	-6.07***	1987q4

Note: Columns (1) and (2) present commodity price elasticity estimates with Newey-West HAC standard errors in brackets. Structural shift dummies are included in estimation procedures. Columns (3)-(6) report test statistics of DF-GLS unit-root test (Elliot et al., 1996) for the real effective exchange rate and real commodity prices with and without a deterministic trend term. The lag length is automatically chosen due to the minimum of the modified Akaike information criterion (MAIC) and presented in parentheses. Column (7) presents the Augmented Engel-Granger (AEG) cointegration test statistic and its level of significance (based on the critical values from MacKinnon (1990, 2010)) with the number of optimal lags chosen by the Schwarz Bayesian information criterion (SBIC) reported in parentheses. Columns (8) and (9) report the Gregory and Hansen (1996) test statistics and associated structural shift dates. For all columns, ***, **, * indicate statistical significance at the 1%, 5%, and 10%, respectively.

Table A1.2 Description of data

Variable	Description	Data sources	Freq
Real effective exchange rate	CPI based Real effective exchange rate (base 2005 =100)	IMF IFS and INS	M
Nominal commodity price	World market prices of 58 primary commodities	IMF Primary Commodity Prices; World Bank Pink Sheet	M
Commodity export	Trade value of each commodity export reported by individual country	UN COMTRADE	A
Total export	Total goods exports by individual country	UN COMTRADE	A
MUV (manufactured unit value index) of export	A unit value index of exports from 20 industrial countries with country weights based on the countries' total 1995 exports of manufactures (base 1995 = 100)	IMF IFS	M
Inflation targeting	Effective inflation targeting adoption dates	Roger (2009)	M
Exchange rate regime	Coarse classification	Ilzetzki, Reinhart and Rogoff (2008)	M
Total reserves	Total reserves excluding gold	IMF IFS	A
Nominal GDP	GDP in current dollars	World Bank WDI	A
Financial openness	Chinn-Ito index	Chinn and Ito (2006)	A
Trade openness	(Export + Import) / NGDP	World Bank WDI	A

Table A1.3 List of commodities employed in the construction of commodity price indices

Type	Commodity
Agricultural food	Bananas, Barley, Beef, Cocoa, Coconut oil, Coffee, Copra, Fish, Fishmeal, Groundnuts (peanuts), Groundnut oil, Lamb, Maize, Olive oil, Oranges, Palm kernel oil, Palm oil, Poultry (chicken), Rapeseed oil, Rice, Shrimp, Sorghum, Soybean meal, Soybean oil, Soybeans, Sugar, Sunflower oil, Swine, Tea, Tobacco, Wheat
Agricultural raw materials	Cotton, Hard logs, Hard sawnwood, Hides, Rubber, Soft logs, Soft sawnwood, Woodpulp, Wool (coarse), Wool (fine)
Fertilizers	Phosphate rock, Potash, TSP (triple superphosphate), Ureas
Metals	Aluminum, Copper, Gold, Iron ore, Lead, Nickel, Silver, Tin, Uranium, Zinc
Non-oil energy	Coal, Natural gas
Oil	Crude oil (petroleum)

Table A1.4 Adoption dates of inflation targeting (Roger, 2009)

Country	Effective IT adoption date
Australia	1993Q2
Brazil	1999Q2
Canada	1991Q1
Chile	1999Q3
Colombia	1999Q3
Ghana	2007Q2
Guatemala	2005Q1
Iceland	2001Q1
Indonesia	2005Q3
Mexico	2001Q1
New Zealand	1990Q1
Norway	2001Q1
Peru	2002Q1
Philippines	2002Q1
South Africa	2000Q1
Thailand	2000Q2
Turkey	2006Q1

Table A1.5 IRR coarse classification codes[56]

IRR code	Exchange rate regime classification
1	No separate legal tender
1	Pre announced peg or currency board arrangement
1	Pre announced horizontal band that is narrower than or equal to +/-2%
1	De facto peg
2	Pre announced crawling peg
2	Pre announced crawling band that is narrower than or equal to +/-2%
2	De factor crawling peg
2	De facto crawling band that is narrower than or equal to +/-2%
3	Pre announced crawling band that is wider than or equal to +/-2%
3	De facto crawling band that is narrower than or equal to +/-5%
3	Moving band that is narrower than or equal to +/-2%
3	Managed floating
4	Freely floating
5	Freely falling
6	Dual market in which parallel market data is missing.

Table A1.6 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Median
REER	7526	4.774	0.391	3.362	8.615	4.684
RCP	7812	1.212	0.448	0.302	3.992	1.149
TO	7552	0.652	0.343	0.063	2.511	0.586
FO	7748	-0.179	1.436	-1.864	2.439	-1.169
IT	7812	0.094	0.292	0	1	0
EXR	7326	2.401	1.251	1	6	2
RES	7584	0.112	0.118	0	1.583	0.087
CEX	6168	0.490	0.258	0.01	0.997	0.505
MSH	6328	0.079	0.081	0	0.630	0.049

[56] Ilzetzki, Ethan, Carmen Reinhart and Kenneth Rogoff, 2008, Exchange rate arrangements entering the 21st century: Which anchor will hold?, mimeo, University of Maryland and Harvard University

Table A1.7 Primary exporting commodities and their share in aggregate commodity exports

Country	Primary commodities					Share in commodity exports				
	1	2	3	4	5	1	2	3	4	5
Algeria	Crude oil	Natural gas				0.59	0.41			
Argentina	Soy meal	Wheat	Maize	Soybeans	Crude oil	0.18	0.12	0.10	0.10	0.09
Australia	Coal	Iron	Beef	Gold	Wheat	0.21	0.11	0.09	0.09	0.08
Bahrain	Aluminum	Natural gas	Crude oil	Iron	Urea	0.74	0.40	0.27	0.17	0.14
Bangladesh	Shrimp	Tea	Urea	Fish	Beef	0.69	0.27	0.12	0.08	0.05
Bolivia	Natural gas	Zinc	Tin	Soy meal	Gold	0.40	0.15	0.10	0.07	0.07
Brazil	Iron	Coffee	Soy meal	Natural gas	Soybeans	0.18	0.13	0.10	0.10	0.09
Burundi	Coffee	Gold	Tea	Sugar	Hides	0.56	0.39	0.04	0.02	0.01
Cameroon	Crude oil	Cocoa	Coffee	Aluminum	Hard sawnwood	0.48	0.13	0.10	0.07	0.06
Canada	Crude oil	Natural gas	Soft sawnwood	Woodpulp	Wheat	0.17	0.16	0.12	0.10	0.07
Central African Rep	Hard logs	Cotton	Hard sawnwood	Coffee	Soft logs	0.38	0.32	0.17	0.15	0.05
Chile	Copper	Natural gas	Woodpulp	Fish	Fishmeal	0.67	0.11	0.07	0.07	0.06
Colombia	Coffee	Crude oil	Coal	Bananas	Gold	0.39	0.37	0.14	0.07	0.03
Costa Rica	Bananas	Coffee	Fish	Beef	Natural gas	0.48	0.34	0.06	0.06	0.05
Cote d'Ivoire	Cocoa	Coffee	Crude oil	Hard sawnwood	Rubber	0.49	0.14	0.11	0.07	0.05
Dominica	Bananas	Oranges	Coconut oil	Soy oil		0.94	0.04	0.01	0.01	
Ethiopia	Coffee	Hides	Gold	Sugar	Beef	0.79	0.11	0.10	0.02	0.01
Ghana	Gold	Cocoa	Natural gas	Hard sawnwood	Aluminum	0.45	0.38	0.28	0.07	0.05
Guatemala	Coffee	Sugar	Bananas	Natural gas	Crude oil	0.41	0.19	0.15	0.14	0.08
Honduras	Coffee	Bananas	Shrimp	Palm oil	Sugar	0.40	0.30	0.09	0.05	0.03
Iceland	Fish	Aluminum	Fishmeal	Shrimp	Beef	0.60	0.26	0.09	0.04	0.01
India	Iron	Rice	Shrimp	Tea	Crude oil	0.18	0.13	0.12	0.12	0.09
Indonesia	Crude oil	Natural gas	Rubber	Copper	Coal	0.35	0.22	0.07	0.06	0.06
Kenya	Tea	Coffee	Fish	Palm oil	Gold	0.53	0.32	0.04	0.02	0.01
Kuwait	Crude oil	Natural gas	Urea	Gold	Shrimp	0.95	0.34	0.09	0.03	0.01
Libya	Crude oil	Natural gas	Urea			0.98	0.02	0.01		
Madagascar	Shrimp	Coffee	Sugar	Cocoa	Hard sawnwood	0.52	0.39	0.06	0.04	0.02
Malawi	Tobacco	Tea	Sugar	Uranium	Coffee	0.68	0.12	0.11	0.07	0.02
Malaysia	Crude oil	Palm oil	Natural gas	Rubber	Hard logs	0.28	0.20	0.16	0.10	0.08
Mali	Gold	Cotton	Lamb	Groundnut oil		0.56	0.48	0.04	0.01	
Mauritania	Iron	Fish	Crude oil	Copper	Gold	0.63	0.27	0.16	0.15	0.13
Mauritius	Sugar	Fish	Tea	Wheat		0.92	0.05	0.01	0.01	

Table A1.7 (continued)

Mexico	Crude oil	Natural gas	Coffee	Silver	Copper	0.77	0.20	0.04	0.03	0.03
Morocco	Phosphate rock	Oranges	TSP	Fish	Lead	0.40	0.18	0.10	0.09	0.05
Mozambique	Aluminum	Shrimp	Sugar	Cotton	Tobacco	0.48	0.12	0.11	0.08	0.07
New Zealand	Beef	Wool (fine)	Aluminum	Fish	Wool (coarse)	0.39	0.10	0.09	0.07	0.06
Niger	Uranium	Gold	Lamb	Rice	Sugar	0.81	0.12	0.09	0.01	0.01
Nigeria	Crude oil	Natural gas	Cocoa			0.97	0.21	0.01		
Norway	Crude oil	Natural gas	Aluminum	Fish	Nickel	0.59	0.21	0.08	0.06	0.02
Oman	Crude oil	Natural gas	Copper	Fish	Urea	0.92	0.05	0.02	0.02	0.01
Pakistan	Rice	Cotton	Natural gas	Shrimp	Crude oil	0.53	0.25	0.13	0.05	0.04
Papua New Guinea	Copper	Crude oil	Gold	Coffee	Palm oil	0.39	0.22	0.17	0.11	0.06
Paraguay	Soybeans	Cotton	Beef	Soy meal	Soy oil	0.38	0.23	0.11	0.08	0.05
Peru	Copper	Gold	Fishmeal	Zinc	Lead	0.26	0.17	0.14	0.14	0.08
Philippines	Coconut oil	Copper	Bananas	Shrimp	Sugar	0.26	0.23	0.12	0.07	0.07
Saudi Arabia	Crude oil	Natural gas				0.96	0.03			
Senegal	Fish	Groundnut oil	Phosphate rock	Crude oil	Cotton	0.26	0.24	0.19	0.09	0.09
South Africa	Coal	Aluminum	Iron	Woodpulp	Oranges	0.33	0.17	0.15	0.05	0.04
Sri Lanka	Tea	Rubber	Fish	Shrimp	Tobacco	0.73	0.13	0.03	0.03	0.02
St. Vincent Gr	Bananas	Wheat	Rice	Fish		0.55	0.26	0.18	0.01	
Sudan	Crude oil	Cotton	Gold	Lamb	Beef	0.46	0.23	0.21	0.21	0.06
Suriname	Rice	Nickel	Aluminum	Silver	Soy oil	0.55	0.29	0.19	0.17	0.14
Syria	Crude oil	Cotton	Lamb	Phosphate rock	Wheat	0.82	0.08	0.04	0.02	0.02
Tanzania	Gold	Fish	Coffee	Tobacco	Cotton	0.40	0.14	0.13	0.10	0.07
Thailand	Rice	Rubber	Shrimp	Sugar	Crude oil	0.25	0.23	0.14	0.10	0.04
Togo	Phosphate rock	Cotton	Cocoa	Coffee	Gold	0.46	0.26	0.09	0.08	0.07
Tunisia	Crude oil	Olive oil	TSP	Phosphate rock	Shrimp	0.59	0.17	0.11	0.03	0.03
Turkey	Tobacco	Aluminum	Wheat	Lamb	Gold	0.22	0.11	0.11	0.09	0.08
Uganda	Coffee	Fish	Gold	Tea	Tobacco	0.49	0.16	0.09	0.07	0.07
United Arab Em	Crude oil	Aluminum	Natural gas	Gold	Rice	0.62	0.37	0.16	0.08	0.04
Uruguay	Beef	Rice	Fish	Wool (coarse)	Soybeans	0.41	0.20	0.11	0.07	0.05
Venezuela, RB	Crude oil	Natural gas	Aluminum	Iron	Coal	0.90	0.08	0.06	0.01	0.01
Zambia	Copper	Sugar	Cotton	Tobacco	Maize	0.86	0.04	0.03	0.03	0.01

Note: Reported are top five major commodities exported by each country between 1980 and 2010. Period-average shares of each commodity in total commodity exports greater than or equal to 0.01 (1%) are included only. We admit that major commodities listed for South Africa may not well represent its actual export basket due to underreporting of gold exports during the sample period. Calculations in this table are based only on the data available from the UN COMTRADE.

VITAE

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