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Hoarding of International Reserves: Mrs Machlup's Wardrobe and the Joneses

*Yin-Wong Cheung and Xingwang Qian**

Abstract

Motivated by the observed international reserve hoarding behavior in the post-1997 crisis period, we explore the Mrs Machlup's Wardrobe hypothesis and the related keeping up with the Joneses argument. It is conceived that, in addition to psychological reasons, holding a relatively high level of international reserves reduces the vulnerability to speculative attacks and promotes growth. A stylized model is constructed to illustrate this type of hoarding behavior. The relevance of the keeping up with the Joneses effect is examined using a few plausible empirical specifications and data from 10 East Asian economies. Panel-based regression results are suggestive of the presence of the Joneses effect, especially in the post-1997 crisis period.

1. Introduction

In the aftermath of the 1997 financial crisis, the East Asia economies in the crisis-inflicted region appear to have adjusted their policy behavior and have sharply boosted their international reserves. For instance, China, Japan, Korea, Malaysia, and Taiwan; the economies that are commonly mentioned in the recent discussion/debate of the extraordinary and puzzling accumulation of international reserves in the new millennium see their international reserves increased by, respectively, 388%, 135%, 119%, 138%, and 137% between 2000 and 2005.[1]

In general, it is perceived that some of these economies are holding international reserves at a level that is difficult to be rationalized by conventional factors. For instance, one traditional rule of thumb of international reserve adequacy is to maintain international reserves worth, say, three months of imports. Again, consider China, Japan, Korea, Malaysia, and Taiwan—their holdings of international reserves are much higher than the three-month benchmark. Specifically, at the end of 2005, the international reserves held by these economies cover, respectively, 14.93, 19.33, 9.66, 7.36, and 16.65 months of imports. While excessive international reserves offer some benefits, they carry substantial negative implications for both domestic economies and global imbalances, and thus can be a serious threat to the stability of the world economy.

Existing theories offer a few reasons for holding international reserves. One common explanation is the precautionary demand motivated by trade-financing considerations.[2]

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* Cheung: Department of Economics, E2, University of California, Santa Cruz, CA 95064, USA. Tel: 831 459 4249; Fax: 831 459 5077; E-mail: cheung@ucsc.edu. Qian: Department of Economics and Finance, SUNY Buffalo State College, Buffalo, NY 14222, USA. Tel: 716 878 6031; Fax: 716 878 6907; E-mail: qianx@buffalostate.edu. We thank Joshua Aizenman, Michel Beine, Bertrand Candelon, Ken Chan, Charles Engel, Jakob de Haan, Viktoria Hnatkovska, Mathias Hoffmann, Reuven Glick, Paul de Grauwe, Fred Kwan, Guy Meredith, Marc-Andreas Muendler, Assaf Razin, Eli Remolona, Gunther Schnabl, Pierre Siklos, Mark M. Spiegel, Yong Wang, Tom Willett, Frank Westermann, and participants of the Institute of Economics, Academic Sinica, seminar, the 2006 HKIMR Summer Workshop, the Hong Kong City University seminar, the 2007 CESifo Area Conference on Macro, Money and International Finance, the RIE–SCCIE Global Liquidity Conference, and the 2008 meeting of the Methods in International Finance Network for their helpful comments and suggestions. Cheung acknowledges the financial support of faculty research funds of the University of California, Santa Cruz.

The recent literature has extended the precautionary motive and considers accumulation of international reserves a policy to avoid crisis-induced output losses and investment contractions. Conditions in financial markets are also deemed important determinants of the holding of international reserves. For instance, the popular Greenspan–Guidotti rule recommends that developing economies should hold international reserves to cover the one-year amortized value of various types of liabilities over a wide range of possible outcome (Greenspan, 1999).

In a series of articles Dooley et al. (2005, 2009) argue that the large hoarding of international reserves by East Asian economies is a byproduct of the development strategy that promotes exports with an undervalued currency and a natural consequence of the presence of a revived Bretton Woods system in the region. Aizenman and Lee (2005), however, find that even though the mercantilist motive is confirmed by the data, it has little economic significance in explaining the build-up of international reserves in the post-crisis era.

In the current study, we explore an idea advanced by Machlup (1966) and assess the extent to which his idea is relevant for explaining the international reserve accumulation behavior of some East Asian economies. Fritz Machlup, after examining some measures of international reserves, argued that the observed holding patterns could not be explained by reasons offered "by either theorists or practitioners." Instead, he suggested monetary authorities' hoarding of international reserves can be driven by nonfundamental factors. Specifically, he used his wife's *need* for dresses as a metaphor to exemplify the monetary authorities' desire for more and more international reserves.

Apparently, the recent ascent in the holding of international reserves and some related official remarks lend credibility to the Mrs Machlup's Wardrobe analogy. For instance, an official in Korea's central bank said "[T]here is no such thing as too much foreign international reserves." On China's international reserve holding, a Chinese official argued that there is "no unified benchmark on the appropriate amount of forex international reserve a country should hold in both theory and practice" and "it could not be said to be 'excessive' or 'deficient'."[3] Even with the anecdotal evidence, is it reasonable to assert that the insatiable appetite of central banks for international reserves is the sole reason for the recent build-up of international reserves?

We postulate that the international reserve accumulation process pertaining to the Mrs Machlup's Wardrobe metaphor may serve some relevant economic purposes. It is quite noncontroversial to state that, on the other things being equal basis, international reserves help absorb unexpected (external) shocks and smooth current and capital account imbalances. The crisis experience and the development after the crisis appear to be consistent with the notion of accumulating international reserves to forestall future speculative attacks. The question, of course, is how high the level of international reserves an economy has to hold.

On his wife's dress need, Machlup (1966, p. 26) suggests that it depends "on the Joneses with whom she wishes to keep up." That is, besides some fundamental considerations, the build-up of international reserves depends on the behavior of neighboring economies. Ignoring the question of why Mrs Machlup has to keep up with the Joneses for a moment, the (implicit) rivalry among economies may give rise to a competitive hoarding mechanism that pushes the holding of international reserves to a level that is difficult to be explained by only traditional considerations.

Besides the pure psychological desire to feel good and not to be perceived as inferior, there are a few reasons why economies would like to keep up with their peers. Remarks by Feldstein (1999) and Fischer (1999), for example, offer some insight on the keeping up with the Joneses motivation. After the crisis, these two noted economists observed

that economies with a higher level of international reserves survived the East Asian financial crisis better than those with a lower level. Thus, a level of international reserves that is relatively higher than your neighbors may diffuse the speculative pressure on your own economy and divert it to the neighboring economies and, hence, reduce the chance of bearing the full cost of an attack. In other words, when a financial crisis is brewing in the region, if two economies have similar economic fundamentals, the one with a higher level of international reserves is less likely to be attacked and more likely to survive the crisis.

Another reason for keeping up with the Joneses is that international reserves can have a positive impact on an economy's output prospects. If the level of international reserves is a barometer of financial health, an economy has an additional incentive to keep up with the Joneses to compete for international capital and foreign direct investment, which tend to have a level of productivity proficiency higher than the domestic capital. For developing economies, the output effect of international reserves also arises from their ability to reduce costs of borrowing in the international capital market and provide needed liquidity when there is a reversal of capital flows. A relatively high level of international reserves will, thus, provide a catalyst for economic growth and enhance output prospects, which in turn will improve the market sentiment and, hence, reduce an economy's vulnerability to attack.

2. International Reserve Hoarding and Keeping up with the Joneses

In this section, we present a sequence of models to illustrate the demand for international reserves in the presence of keeping up with the Joneses due to (a) the consideration of speculative attack, and (b) the feedback effect of international reserves on output. The first model serves as a benchmark, the second one modifies the speculative attack probability to accommodate the notion of keeping up with the Joneses, and the third one introduces a positive output effect of international reserves.

A caveat is in order. The following discussion highlights two possible situations that lead to the keeping up with the Joneses effect. Similar to the implicit psychological motivation in Machlup (1966), any mechanisms that give rise to competitive hoarding behavior will generate the keeping up with the Joneses effect described in this and the next section.

The Benchmark Model

In this subsection, we derive the baseline demand for international reserves. The basic structure is essentially the model used by Aizenman et al. (2007). A few modifications were implemented to simplify the presentation and to highlight the issue we would like to analyze.

We consider a two-period model. In period one the economy has an output endowment Y_1. Without loss of generality, the initial endowment is normalized to 1; that is, $Y_1 = 1$. The output in the second period Y_2 is a random variable given by

$$Y_2 = \begin{cases} 1+\delta & \text{with probability} \quad 1-p \\ 1-\varepsilon & \text{with probability} \quad p \end{cases}; \quad \delta, \varepsilon > 0, \text{and } 0 < p < 1. \tag{1}$$

The output shocks δ and ε are not necessarily the same. The probability that the economy suffers output losses due to a speculative attack is p. For simplicity, we ignore attacks that do not have any output implications.[4] For the benchmark model, we assume p is given by

$$p = \phi + \alpha \frac{B}{R}, \quad \alpha > 0, \tag{2}$$

where R and B are, respectively, the level of international reserve holding and the amount of foreign borrowing in period 1. In essence, (2) assumes the probability of suffering a speculative attack that leads to an output loss is inversely related to the level of international reserves and directly proportional to the level of indebtedness; α is a scale parameter and ϕ is a catch-all parameter representing other factors that affect the attack probability. We label the occurrence of $1 + \delta$ a good state and that of $1 - \varepsilon$ a bad state.

During the first period, given the output Y_1, the economy makes decisions regarding consumption (C_1), international reserve accumulation (R), and borrowing in the international capital market (B), and is subject to the budget constraint

$$C_1 = 1 + B - R. \tag{3}$$

The international borrowing carries a contractual interest rate r and, thus, the required repayment in period 2 is $(1 + r)B$.

Because of a possible default in the second period, the economy faces a credit ceiling that limits the amount it can borrow internationally. The credit ceiling can be determined as follows. In the case of default, we assume the international lender can confiscate a share of Y_2, denoted by θY_2, $0 < \theta < 1$, from the economy. However, the international lender does not have access to the economy's international reserves. If the repayment $(1 + r)B$ is larger than the penalty θY_2, then the economy has an incentive to default. Thus, the international lender would determine the lending amount knowing that the repayment he is going to receive in period 2 is

$$S = \min[(1 + r)B; \theta Y_2], \tag{4}$$

where $\min[\cdot, \cdot]$ is the minimum operator. Let the (international) risk-free interest rate be r^*. It is assumed that $r > r^*$.[5] Under risk neutrality, the expected repayment is given by

$$\mathrm{E}[S] = (1 + r^*)B. \tag{5}$$

The credit ceiling, $\bar{B}$, faced by the economy is the level of debt that will lead to a default in both good and bad states. Thus, it is given by

$$\bar{B} = \frac{(1 - p)\theta(1 + \delta) + p \cdot \theta(1 - \varepsilon)}{1 + r^*} = \frac{\theta(1 + \delta) - p\theta(\delta + \varepsilon)}{1 + r^*}. \tag{6}$$

The credit ceiling is increasing with the positive production shock δ and the ability to confiscate θ, and is decreasing with the adverse production shock ε, the probability of an attack that leads to output losses p, and the risk-free rate r^*.

Assuming (a) $(1 + r)B \leq \theta(1 + \delta)$, (b) $(1 + r)B > \theta(1 - \varepsilon)$ with the probability q, and (c) international reserves earn an interest rate of r^*, the budget constraint for the second period is[6]

$$C_2 = \begin{cases} C_{2,g} = 1 + \delta - (1 + r)B + (1 + r^*)R & \text{with probability} \quad 1 - p, \\ C_{2,b} = 1 - \varepsilon - (1 + r)B + (1 + r^*)R & \text{with probability} \quad p \cdot (1 - q), \\ C_{2,b,d} = (1 - \theta)(1 - \varepsilon) + (1 + r^*)R & \text{with probability} \quad p \cdot q, \end{cases} \tag{7}$$

where $C_{2,g}$, $C_{2,b}$, $C_{2,b,d}$ are, respectively, the levels of consumption in period 2 when the economy is in the good state, in the bad state with no default, and in the bad state and defaulted.

The economy has to choose the levels of consumption C_1 and C_2 to maximize its representative consumer's expected utility, which is given by

$$U(\cdot) = C_1 + \frac{1}{1+\rho}[(1-p)C_{2,g} + p[(1-q)C_{2,b} + qC_{2,b,d}]], \tag{8}$$

where ρ is the discount rate and is assumed to be larger than the risk-free rate r^*. Maximizing the expected utility $U(\cdot)$ subject to the conditions (2), (3), and (7), we should obtain the optimal levels of borrowing and international reserves along with the optimal consumption path.

To simplify the presentation, we follow Aizenman et al. (2007) and assume that the economy has a discount rate high enough to set the borrowing at the ceiling level $\bar{B}$. When $B = \bar{B}$, the contractual (not the expected) repayment is $B(1+r)|_{B=\bar{B}} = \theta(1+\delta)$ and the expected utility $U(\cdot)$ can be written as

$$U(\cdot)|_{B=\bar{B}} = (1+\bar{B}-R) + \frac{1}{1+\rho}\{(1-\theta)(1+\delta) + (1+r^*)R - p(1-\theta)(\delta+\varepsilon)\}. \tag{9}$$

Thus, the first-order condition with respect to R is

$$1 - \left.\frac{dB}{dR}\right|_{B=\bar{B}} = \frac{1}{1+\rho}\left[(1+r^*) - (1-\theta)(\delta+\varepsilon)\left.\frac{dp}{dR}\right|_{B=\bar{B}}\right], \tag{10}$$

which equates the marginal cost of increasing one unit of R in period 1 to the resulting (discounted) benefit obtained in period 2. Next, we derive $dp/dR|_{B=\bar{B}}$ and $dB/dR|_{B=\bar{B}}$ from (2) and (6) and substitute the results in (10) to obtain the optimal level of international reserves:

$$R_b = \left\{\frac{(\delta+\varepsilon)[(1+r^*)+\theta(\rho-r^*)][\alpha\theta(1+\delta)-\alpha\theta\phi(\delta+\varepsilon)]}{(1+r^*)^2(\rho-r^*)}\right\}^{\frac{1}{2}} - \frac{\alpha\theta(\delta+\varepsilon)}{1+r^*}. \tag{11}$$

The subscript "b" indicates that the expression is going to be used as a benchmark for comparison. From (11), it can be verified that the hoarding of international reserves is (a) positively related to $(\delta+\varepsilon)$, the benefit of not being attacked, and θ, the share of output being confiscated when it defaults, and (b) negatively related to $(\rho - r^*)$, the opportunity cost, and ϕ, the catch-all parameter that determines the economy's vulnerability. It is also noted that $\bar{B}$ is positively related to R_b since $\bar{B}$ is negatively related to p (equation (6)) and p is negatively related to R (equation (2)).

The Joneses

To capture the idea of "keeping up with the Joneses," we modify the probability that the economy suffers an output-loss-causing attack to

$$p_J = \phi + \alpha\frac{B_J}{R_J} + \beta\frac{\tilde{R}_0}{R_J}, \quad \alpha, \beta > 0, \tag{12}$$

where subscript "J" indicates the presence of the Joneses effect. $\tilde{R}_0$ is the average of international reserves held by its peer group (the Joneses) at period 0.[7]

Equation (12) incorporates the effect of international reserves held by other economies. It captures the notion that, *ceteris paribus*, speculators tend to attack an economy with a relatively low level of international reserves, which are powerful ammunition against speculative attacks. In addition to its own level of international reserves, an economy has to be aware of its relative position among its peer group. Attacks can be triggered by self-fulfilling expectations that are not related to fundamentals and speculators will look for a target that has a relatively (rather than an absolutely) high level of vulnerability. Lagged rather than current international reserves in other economies are considered because current information about other economies' international reserves is typically hard to obtain. Indeed, Mrs Machlup's desire for dresses is likely to be instigated by seeing her contemporaries' collection.

With the output loss probability specified by (12), the demand for international reserves in the presence of the Joneses effect can be derived by maximizing the expected utility $U(\cdot)$ in (8) subject to conditions (12), (3), and (7). We follow a similar strategy and consider borrowing at the ceiling. In this case, the optimal level of international reserves is

$$R_J = \left\{ \frac{(\delta+\varepsilon)[(1+r^*)+\theta(\rho-r^*)]\left[\alpha\theta(1+\delta)-\alpha\theta\phi(\delta+\varepsilon)+(1+r^*)\beta\tilde{R}_0\right]}{(1+r^*)^2(\rho-r^*)} \right\}^{\frac{1}{2}} - \frac{\alpha\theta(\delta+\varepsilon)}{1+r^*}, \tag{13}$$

where subscript "*J*" is used to indicate the presence of the Joneses effect. Similar to R_b in (11), the demand for international reserves in the presence of the Joneses increases with $(\delta+\varepsilon)$ and θ, and decreases with $(\rho-r^*)$ and ϕ. Through their impact on the attack probability, the international reserves held by others have a positive implication for an economy's own hoarding of international reserves. Further, an economy's level of international reserves is positively related to its sensitivity to the Joneses effect as measured by β.

Comparing (11) and (13), it can be seen that R_J is larger than R_b—the demand for international reserves is higher in the presence of the Joneses effect, *ceteris paribus*. An economy's optimal level of international reserves is higher than the one justified by fundamentals alone when the chance of being attacked is adversely affected by international reserves held by others. Given the possibility of being victimized and suffering output losses from speculative attacks with a relatively low level of international reserves, an economy's rational response is to incorporate others' behavior into its own decision-making process.

Feedback on Output Outlook

In this subsection, we incorporate the output effect of international reserves in the model. It is shown that economies will be encouraged to accumulate international reserves if the accumulation can improve their output outlook.

Intuitively, holding of international reserves can affect output via a few channels. For instance, international reserves can smooth trade imbalances and, hence, consumption. For most developing economies, a high level of international reserves helps reduce the premium they have to pay for borrowing in the global financial market. Both a smooth consumption stream and a low borrowing cost are good for economic growth. Further, the level of international reserves can serve as an indicator of an

economy's financial health and stability. Thus, a high level of international reserves helps developing economies to attract foreign direct investment, which tends to boost domestic growth.

To illustrate the implication for international reserve demand in the current framework, we refine equation (1) and specify output shocks in the second period as

$$\begin{aligned}\delta &= \delta^* + R_{J,F}/\tilde{R}_0,\\ \varepsilon &= \varepsilon^* - R_{J,F}/\tilde{R}_0.\end{aligned} \tag{14}$$

The subscript "*J,F*" signifies that both the Joneses effect and the feedback on output are under consideration. The expression $R_{J,F}/\tilde{R}_0$ is introduced to the output shocks to capture the output effect of international reserves. We assume the effects of international reserves on output are the same in both the good and bad states to simplify derivation and they depend on the relative rather than the absolute holding level of international reserves.[8] For instance, in making a foreign direct investment decision, an entrepreneur would consider if the financial health of an economy is better than the alternatives. Thus, if the level of international reserves is an indicator, then the relative level will determine which economy will get the investment, *ceteris paribus*. If the positive output effect of international reserves outweighs the output loss induced by speculative attack, i.e. $\varepsilon^* < R_{J,F}/\tilde{R}_0$, we have the result described by Aizenman and Lee (2005).

With the modified output Y_2 given by (14), the budget constraint (7) is modified to

$$C_2 = \begin{cases} C_{2,g} = 1+\delta-(1+r)B_{J,F}+(1+r^*)R_{J,F} & \text{with probability} \quad 1-p_{J,F},\\ C_{2,b} = 1-\varepsilon-(1+r)B_{J,F}+(1+r^*)R_{J,F} & \text{with probability} \quad p_{J,F}\cdot(1-q_{J,F}),\\ C_{2,b,d} = (1-\theta)(1-\varepsilon)+(1+r^*)R_{J,F} & \text{with probability} \quad p_{J,F}\cdot q_{J,F}. \end{cases} \tag{15}$$

By maximizing $U(\cdot)$ in (8) subject to (12), (3), (15), and (14), we incorporate the Joneses factor induced by both the speculative attack consideration and the output effect of international reserves. An expression of the optimal demand for international reserves, $R_{J,F}$, assuming the borrowing is at the ceiling, is given by

$$\begin{aligned}&\frac{(\delta^*+\varepsilon^*)[(1+r^*)+\theta(\rho-r^*)]\left[\alpha\theta\left(1+\delta^*+R_{J,F}/\tilde{R}_0\right)-\alpha\theta\phi(\delta^*+\varepsilon^*)+(1+r^*)\beta\tilde{R}_0\right]}{(\rho-r^*)[(1+r^*)R_{J,F}+\alpha\theta(\delta^*+\varepsilon^*)]^2}\\ &\quad=\frac{1}{(1+r^*)}-\frac{[(1+r^*)+\theta(\rho-r^*)]R_{J,F}}{(1+r^*)R_{J,F}+\alpha\theta(\delta^*+\varepsilon^*)}.\end{aligned} \tag{16}$$

The optimal $R_{J,F}$ can be derived from (16), which is a quadratic equation in $R_{J,F}$. Instead of solving for a rather complex expression, we just note that the optimal $R_{J,F}$ is larger than the R_J expression given in (13). The result is quite intuitive. For instance, R_J is increasing in the output shocks δ and $-\varepsilon$, which are larger than their counterparts δ^* and $-\varepsilon^*$.[9] In a word, the beneficial output effect strengthens the Joneses effect and effectuates a high level of international reserves. While most discussions focus on cushioning effects during an attack, the hoarding of international reserves can be motivated by their (indirect) contributions to economic performance during noncrisis periods. The output effect can be a significant factor for developing economies in designing their policies.

3. Empirical Evidence

In the previous section, we used a theoretical structure to elaborate Machlup's (1966) contention about international reserve demand behavior. Specifically, we illustrate the Mrs Machlup's Wardrobe and keeping up with the Joneses argument and the dependence of an economy's international reserve behavior on others' holdings of international reserves. Admittedly, the models in section 2 are quite stylized and are only meant to demonstrate a plausible relationship between international reserves held by an economy and by its neighboring economies. In the current section, we present some empirical evidence on the relevance of the Mrs Machlup's Wardrobe and keeping up with the Joneses argument.

Annual data from 10 Asian economies—namely China, India, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand—are used to assess the keeping up with the Joneses effect. These economies are located in the 1997 crisis-inflicted region. They are either adversely affected by the crisis and/or cited in the recent debate on excessive accumulation of international reserves. The sample period is from 1980 to 2004.

The demand for international reserves is investigated using the regression equations

$$Y_{it} = c + X_{it}'\alpha + \varepsilon_{it}, \tag{17}$$

$$Y_{it} = c + X_{it}'\alpha + \delta J_{i,t-1} + \varepsilon_{it}, \tag{18}$$

$$Y_{it} = c + X_{it}'\alpha + \delta J_{i,t-1} + \psi \mathrm{I}(t-1>97) * J_{i,t-1} + \varepsilon_{it}, \tag{19}$$

where i and t are the economy and time indices, respectively, Y_{it} is the ratio of international reserves to gross domestic product (GDP), X_{it} is the vector containing the traditional economic variables used in the literature to explain the demand for international reserves, and $J_{i,t-1}$ is the variable capturing the keeping up with the Joneses effect. Henceforth, we label $J_{i,t-1}$ "the Joneses" variable for brevity and define it later. $\mathrm{I}(\cdot)$ is the indicator function. The interactive Joneses term $\mathrm{I}(t-1>97) * J_{i,t-1}$ is included to investigate if there is a change in the Joneses effect in the post-1997 crisis period.[10] The joint estimation of δ and ψ helps determine if there is a change in the behavior of demand for international reserves after the 1997 East Asian financial crisis and if the Joneses effect only shows up after the crisis.

Equation (17) is a canonical specification and includes economic variables commonly considered in empirical studies of demand for international reserves. We normalize international reserves with GDP to facilitate comparison across economies of different sizes. The variables in the X_{it} vector are (a) the per capita GDP in logarithms, (b) the average propensity to import given by the imports to GDP ratio, (c) the exchange rate volatility measured by the standard deviation of monthly exchange rate data, (d) the volatility of international reserve holding measured by the standard deviation of monthly data on international reserves, and (e) the financial openness variable given by the sum of absolute values of capital inflow and outflow divided by GDP. The Taiwanese data were retrieved from the Central Bank of China (Taiwan) website and all other data were retrieved from the World Bank WDI and the IMF databases.[11]

The Joneses effect is assessed using equations (18) and (19). The key issue is how to define the Joneses variable. We do not have a foolproof way to handle it because we do not have information on who are the Joneses. As a first attempt, we consider the Joneses variable J_{it} defined by

$$J_{it} = \sum_{k \neq i} Y_{kt}. \tag{20}$$

That is, all the other economies in the sample are the Joneses. Later, we consider a few alternative definitions of the Joneses variable.

Basic Results

The results of estimating (17) to (19) using the panel data technique are presented in Table 1. Under specification (17), in the absence of Joneses variables, most of the traditional factors in X_{it} are significant. The per capita output is a measure of the level of development and is significantly positive—a result similar to the one reported in Lane and Burke (2001). The import propensity is the average (rather than marginal) propensity. Thus, it is a proxy for trade openness and the degree of vulnerability to external shocks and has the expected positive coefficient (Frenkel, 1974).

The effect of financial openness on the holding of international reserves is similar to the one of trade openness—a high level of openness increases an economy's vulnerability to external shocks. Even though both openness variables have a positive coefficient estimate, only the financial openness estimate is statistically significant. A similar financial openness effect is reported in, for example, Flood and Marion (2002). Frenkel and Jovanovic (1981) illustrate the effect of international reserve volatility in a stochastic inventory control setting. The estimation result is in accordance with the positive impact of international reserve volatility on hoarding of international reserves.

Table 1. Demand for International Reserves and the Joneses Effect

	Model (17)	*Model (18)*	*Model (19)*
ln *gdppc*	0.1437***	0.0605***	0.0682***
	(9.65)	(3.10)	(3.63)
mp	0.4374	0.0015	–0.0164
	(1.08)	(0.04)	(–0.41)
F_open	0.2105***	0.1704***	0.1564***
	(4.86)	(4.20)	(4.01)
E_vol	0.0000**	0.0000**	0.0000
	(2.00)	(2.22)	(1.49)
R_vol	0.0025***	0.0014**	0.0010
	(3.72)	(2.14)	(1.60)
Joneses		0.0681***	0.0298**
		(6.27)	(2.21)
I > 97 ∗ *Joneses*			0.0242***
			(4.45)
Constant	–0.9794***	–0.4236***	–0.4206***
	(–8.73)	(–3.03)	(–3.14)
Adjusted *R*-squared	0.5561	0.6211	0.6535
Observations	235	228	228

Notes: The table reports the results of estimating models (17) to (19) in the text using the panel data technique. ln *gdppc* is log per capita GDP, *mp* is propensity to import, *F_open* is financial openness, *E_vol* is exchange volatility, and *R_vol* is international reserve volatility. *Joneses* is the Joneses variable defined by equation (20) in the text. I > 97 ∗ *Joneses* is the interactive Joneses variable $\mathrm{I}(t-1>97) * J_{i,t-1}$. *t*-Statistics are in parentheses. *** and ** denote significance at the 1% and 5% levels, respectively.

Similarly, the international reserve holding is found to be negatively affected by exchange rate volatility.

Overall, these five variables explain the international reserve behavior quite well—in total they explain 56% of the variation in international reserve holdings of these 10 economies.

Estimation results pertaining to specifications (18) and (19) buttress the presence of keeping up with the Joneses effect among these East Asian economies between 1980 and 2004. Under specification (18) the coefficient estimate of the Joneses variable is highly significant with a value of 0.068. In addition to statistical significance, the Joneses effect is of practical relevance. According to the estimate, a dollar increase in the international reserves held by one economy will lead to an increase of about \$0.6 by the other nine "peer economies." The inclusion of the Joneses variable lifts the adjusted *R*-squared from 56% to 62%. Compared with the results of (17), the coefficient estimates of the traditional explanatory variables are smaller and have a lower level of significance in the presence of the Joneses variable.

The interactive term $\mathrm{I}(t-1>97)*J_{i,t-1}$ in specification (19) is positively significant alongside the Joneses variable $J_{i,t-1}$. The Joneses effect is not unique to the post-1997 crisis period but it is stronger after the East Asian financial crisis. The inclusion of the interactive Joneses term nonetheless lowers the impact of the original Joneses variable. It also weakens the significance of the traditional explanatory variables with the exception of the per capita output. Indeed, with both the Joneses variable and its interactive term, the per capita output and the financial openness are the only two traditional explanatory variables that are significant at the 5% level.

The coefficient estimate of the interactive term is quite comparable to that of the Joneses variable—suggesting that the keeping up with the Joneses effect is amplified quite noticeably after the Asian financial crises. The two estimates indicate that, with a dollar increase in one economy's holding of international reserves, the other peer economies will boost their international reserves by slightly less than \$0.3 before the crisis but by slightly larger than \$0.5 after the crisis. The strengthening of the effect appears in accordance with the anecdotal evidence mentioned in the introduction. Apparently, the dramatic adverse effect of the crisis sways policymakers' behavior and makes them more strategic in positioning their holdings of international reserves among their peers. An interesting observation is the presence of the keeping up with the Joneses effect even before the crisis.

One uncertainty is that we do not know, from these economies' point of view, who are their Joneses. Equation (20) implicitly asserts that all the economies in the sample are the Joneses. To check the robustness of the estimation results, we consider an alternative specification of the Joneses variable. Instead of trying all the possible combinations, we reckon the possibility that an economy may identify just a few representatives in the region as the Joneses. Such a strategy may be justified by monitoring costs and by the belief that the representative economies have timely information and have good assessment of the regional economic conditions.

Thus, to investigate the robustness of the results, we consider that the Joneses variable comprises international reserve data from only China, Japan, Korea, and Taiwan; i.e.

$$J_{it} = \sum_{k=\text{China, Japan, Korea, and Taiwan}} Y_{kt}. \tag{21}$$

These four are arguably the major economies in the region. For any one of these four economies, the Joneses variable is defined to be the sum of the other three economies'

Table 2. Demand for International Reserves with an Alternative Definition of the Joneses Variable

	Model (18)	*Model (19)*
ln *gdppc*	0.1107***	0.0905***
	(6.72)	(5.82)
mp	0.0474	0.0068
	(1.15)	(0.18)
F_open	0.0846**	0.0598*
	(2.57)	(1.95)
E_vol	0.0000**	0.0000
	(2.13)	(1.36)
R_vol	0.0016**	0.0009
	(2.40)	(1.40)
Joneses_4	0.1173***	0.0372*
	(6.10)	(1.70)
I > 97 ∗ *Joneses_4*		0.0946***
		(6.25)
Constant	–0.7671***	–0.5593***
	(–6.27)	(–4.75)
Adjusted *R*-squared	0.5867	0.6498
Observations	228	228

Notes: The table reports the panel regression results of models (18) and (19) in the text. ln *gdppc* is log per capita GDP, *mp* is propensity to import, *F_open* is financial openness, *E_vol* is exchange volatility, and *R_vol* is international reserve volatility. *Joneses_4* is the Joneses variable defined by equation (21) in the text. I > 97 ∗ *Joneses*_4 is the interactive Joneses variable $\mathrm{I}(t-1>97) * J_{i,t-1}$. *t*-Statistics are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

international reserves. The estimation results based on the alternative definition of the Joneses variable are presented in Table 2.

Compared with Table 1, the Joneses effect based on the four-economy specification is stronger. For the whole sample estimation, the Joneses variable coefficient is 0.117 in Table 2 versus 0.068 in Table 1. Since only four economies in the sample contribute to the Joneses effect, the pattern of response to an increase in international reserves is slightly different from the one obtained from Table 1. Specifically, the response will be relatively strong in the first period and be relatively moderate in the subsequent periods. To gauge the magnitude of the Joneses effect in this setting, we consider the case in which one of the four Joneses economies increases its international reserves by one dollar. The increase of total international reserves in the first period is slightly over one dollar. In the second period, the total international reserves move up by a moderate amount of $0.4.

Apparently, the significance of the four-economy Joneses variable is mainly driven by its effect in the post-crisis period. The Joneses variable $J_{i,t-1}$ is significant only at the 10% but not at the 5% level in the presence of the significant interaction term $\mathrm{I}(t-1>97) * J_{i,t-1}$.

In terms of overall explanatory power, the two specifications with a four-economy Joneses variable have an adjusted *R*-squared estimate slightly lower than those reported in Table 1. Even though the pattern of the Joneses effect changes as we modify

the way to construct the Joneses variable, the change appears to be a matter of magnitude rather than of the nature of the effect. Specifically, both Joneses variables indicate that the Joneses effect is stronger in the post-crisis period.

Additional Analyses

A few additional analyses are conducted to evaluate the robustness of the empirical Joneses effect.

First, we consider the Joneses variable defined by the five economies directly inflicted by the East Asian crisis; i.e.

$$J_{it} = \sum_{k=\text{Thailand, Malaysia, Philippines, Indonesia and Korea}} Y_{kt}. \tag{22}$$

It may be argued that China, Japan, and Taiwan are quite different from other economies in the sample. Economies in the region, instead, may use the five crisis-inflicted economies to formulate their international reserve hoarding strategies. To accommodate this possibility, we present the panel estimation results based on the Joneses variable defined by (22) in Table 3. For any one of these five economies, the Joneses variable is defined to be the sum of the international reserves held by the other four economies.

Table 3. Demand for International Reserves with the Joneses Variable Defined by Crisis-5 Economies

	Model (18)	*Model (19)*
ln *gdppc*	0.0648***	0.0870***
	(3.26)	(4.40)
mp	0.0185	0.0228
	(0.44)	(0.57)
F_open	0.1377**	0.1427***
	(3.27)	(3.53)
E_vol	0.0000**	0.0000
	(2.11)	(1.48)
R_vol	0.0014**	0.0012*
	(2.19)	(1.83)
Joneses_5	0.1288***	0.0152
	(5.79)	(0.45)
I > 97 ∗ *Joneses_5*		0.0719***
		(4.34)
Constant	–0.4139***	–0.5413***
	(–2.82)	(–3.76)
Adjusted *R*-squared	0.6121	0.6439
Observations	228	228

Notes: The table reports the panel regression results of models (18) and (19) in the text. ln *gdppc* is log per capita GDP, *mp* is propensity to import, *F_open* is financial openness, *E_vol* is exchange volatility, and *R_vol* is international reserve volatility. *Joneses_5* is the Joneses variable defined by the crisis-5 economies; namely, Indonesia, Korea, Malaysia, Philippines, and Thailand as stated in equation (22) in the text. I > 97 ∗ *Joneses_5* is the interactive Joneses variable $I(t-1>97) * J_{i,t-1}$. *t*-Statistics are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 4. Demand for International Reserves with both the Joneses Variable and the Common Growth Element

	Model (18)	*Model (19)*
ln *gdppc*	0.0461**	0.0691***
	(2.27)	(3.35)
mp	–0.0049	–0.0163
	(–0.12)	(–0.40)
F_open	0.1619***	0.1567***
	(4.01)	(4.00)
E_vol	0.0000	0.0000
	(1.53)	(1.47)
R_vol	0.0013**	0.0010
	(2.10)	(1.59)
Joneses	0.0774***	0.0287*
	(6.73)	(1.68)
I > 97 ∗ *Joneses*		0.0246***
		(3.76)
PC_gdp_growth	–0.0764**	0.0041
	(–2.28)	(0.11)
Constant	–0.3229**	–0.4261***
	(–2.22)	(–2.96)
Adjusted *R*-squared	0.6302	0.6536
Observations	228	228

Notes: The table reports the panel regression results of models (18) and (19) in the text. ln *gdppc* is log per capita GDP, *mp* is propensity to import, *F_open* is financial openness, *E_vol* is exchange volatility, and *R_vol* is international reserve volatility. *Joneses* is the Joneses variable defined by equation (20) in the text. I > 97 ∗ *Joneses* is the interactive Joneses variable $I(t-1>97) * J_{i,t-1}$. *PC_gdp_growth* is the principal component of the sample economies' GDP growth rates. *t*-Statistics are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

One noticeable difference between results in Table 3 and those in Tables 1 and 2 is that the Joneses effect defined by the crisis-5 economies is only statistically significant in the post-1997 period, while the other two specifications of the Joneses variable are significant in both the pre- and post-1997 periods. That is, the evidence suggests that the recent East Asian financial crisis has put the international reserves of these five economies in the spotlight. One possible interpretation is that other economies do not want to repeat the experiences of these crisis-inflicted economies and, thus, pay attention to their levels of international reserves.

Two additional observations on the crisis-5 Joneses variable results are in order. First, it is noted that the use of the crisis-5 Joneses variable does not have a large impact on coefficient estimates of the standard economic factors in, say, Table 1. Secondly, the adjusted *R*-squared in Table 4 are comparable to the corresponding ones in Tables 1 and 2; indicating that models with the crisis-5 Joneses variable offer explanatory power similar to models with the other specifications of the Joneses variable.

The empirical Joneses effect appears robust to the few ways we defined "the Joneses." One possible concern about the empirical Joneses variable is that it measures some common latent dynamics that drive the economies in the sample and, hence, their hoarding of international reserves. If it is the case, then the reported Joneses effect is

spurious. To guide against this possibility, we re-examine the Joneses effect in the presence of a common output growth variable. It is perceived that output growth is a reasonable proxy for general economic conditions and, thus, a common output growth variable is a reasonable proxy for common latent factors that affect international reserve hoarding behavior.

Table 4 presents the Joneses effect in the presence of a common output growth variable, which is given by the principal component of GDP growth rates of the economies in the sample. It is quite encouraging to observe that the Joneses effect revealed in Table 4 is quite comparable to the one reported in, say, Table 1. The common output growth variable has a significantly negative coefficient under model (18) and an insignificant one under (19). The coefficient estimates of other variables are similar to those in Table 1. According to the adjusted R-squared estimates, the inclusion of the common output growth variable marginally improves the models' goodness of fit.

The panel regression technique adopted in Tables 1 and 4 improves estimation efficiency by pooling data across economies. However, the technique restricts the economies to display the same responses to explanatory variables. The restriction may not be appropriate for a diverse group of economies. An alternative approach is to estimate economy-specific international reserve demand equations. Such an approach offers only 24 or fewer observations per economy. Notwithstanding the relatively small number of observations, economy-specific estimation results shed some light on economy-specific behavior and its possible implications for the Joneses effect.

To conserve space, we only briefly discuss the economy-specific results, which are reported in Cheung and Qian (2007). As expected, there is a considerable degree of heterogeneity across the empirical economy-specific international reserve demand equations, including the observed Joneses effect. Despite the difference in the Joneses effect intensity, the economy-specific results are, in general, supportive of the notion that an economy's international reserve demand behavior is affected by other economies' action.

Indeed, for the specifications considered in Tables 1 and 2, the economy-specific empirical Joneses effect is quite comparable to the corresponding panel regression results; the effect is more prevalent and prominent in the post-1997 crisis sample than the pre-1997 sample. Further, adding a lagged dependent variable to the list of explanatory variables yields qualitatively similar Joneses effects. The economy-by-economy regression results also suggest that (a) the Joneses effect attributed to the crisis-5 economies mainly show up in the post-1997 period, and (b) the significance of the Joneses variable is not materially affected by the inclusion of the common output growth variable.

So far, our empirical analyses do not include interest rate factors. Theoretically, the demand for international reserves depends on the opportunity cost of holding them. The cost is the difference between the foregone marginal return on domestic investments and the return on international reserves. Empirically, however, the opportunity cost variable is often found to have a coefficient estimate that is either insignificant or has a wrong sign. In the current case, when the interest rate differentials (relative to the US Treasury rate) were included in the regression, the interest rate variable was insignificant and has limited impact on the reported Joneses effect.[12]

The interdependence of their holdings of international reserves mirrors the comparable exchange rate stabilization strategies adopted by East Asian economies before and after the Asian financial crisis (McKinnon and Schnabl, 2004a,b). The apparent joint soft-dollar peg pursued by these economies is in accordance with the observation

that the region is essentially a dollar zone from the trading invoicing perspective. Thus, the US interest rate itself may be a relevant control variable in the international reserve regression.

When the US Treasury bill rate was added to equations (17) to (19), it had a negative coefficient estimate, which is contradictory to the notion that a high US interest rate increases the return on holding international reserves. The inclusion of the US interest rate makes the pre-crisis Joneses effect insignificant. The overall and the post-crisis Joneses effect estimates, however, are still highly significant and of similar magnitude.

The saving glut argument, for example, suggests that the US interest rate is possibly endogenous to the regression. We experimented with using data on the US output gap and budget deficits as instruments to investigate the interest rate effect. The use of these instruments gives mixed results—some US interest rate coefficient estimates are positive, some are negative, and some are insignificant. The Joneses effect, nevertheless, survives in these regressions with instrumental variables. The overall and the post-crisis Joneses effect estimates are significantly positive and comparable to those reported in the previous section; only in a few cases does the pre-crisis Joneses effect become insignificant.

4. Concluding Remarks

In this exercise, we explore a motive for hoarding international reserves that was advocated by Fritz Machlup in the 1960s. Specifically, we consider the Mrs Machlup's Wardrobe hypothesis and the related keeping up with the Joneses argument. Motivated by events that happened in the post-1997 crisis period, we speculate that, in addition to psychological reasons, there may be economic reasons underlying the keeping up with the Joneses behavior. For instance, if an economy is holding a level of international reserves that is relatively lower than the Joneses, it is more vulnerable to speculative attacks. Further, for developing economies, international reserves can have a positive impact on their growth prospects, which in turn can reduce their vulnerability to crises. We use a stylized model to illustrate these effects on the hoarding of international reserves.

A canonical empirical international reserve demand equation is used to investigate the presence of the Joneses effect in a group of East Asian economies. The regression results are suggestive of the presence of the Joneses effect, especially in the post-1997 crisis period.

There are a few caveats. First, the stylized model is used to highlight the Joneses effect. It does not, however, imply that other motivations for holding international reserves are not important. For instance, the increasing capital mobility and growing financial account liberalization around the world will boost the demand for international reserves to smooth out payment imbalances. However, our exercise demonstrates that one seemingly non-economic reason, the so-called Mrs Machlup's Wardrobe hypothesis, may help account for the part of international reserve accumulation that is not explained by standard macroeconomic variables. We realize that the Joneses effect varies across economies and does not necessarily affect all the economies around the world. However, there is a reason to believe that the Joneses effect is in play for some Asian economies.

Secondly, our empirical evidence is meant to be illustrative rather than definitive. For one thing, we do not have *a priori* information on "the Joneses" of a given economy. Our choice of economies is based on convenience and the recent discussions in the media. Further, there is a possibility that our Joneses variable is correlated with some

latent variables that drive demand for international reserves. To contemplate these issues, we consider three different definitions of the Joneses variable and two alternative approaches to capture latent variables. The empirical evidence, in general, is indicative of the presence of the Joneses effect. Arguably, the study of Joneses effects will be benefited by a more elaborate framework of demand for international reserves.

At the risk of repeating, we have to point out again that the empirical Joneses effect may be due to any mechanisms that give rise to competitive hoarding behavior, including the implicit psychological motivation mentioned in Machlup (1966). Instead of viewing the empirical results as definite evidence of the Joneses effect, we can say that, for some economies, there is evidence of interdependence of their holdings of international reserves, and the evidence is robust to the presence of standard macro determinants, a few controls, and a few alternative specifications of the "Joneses" variable. Unfortunately, without a formal model to separate the potential causes of competitive behavior, it is hard to empirically disentangle them. Further analyses of these arguments, which are beyond the scope of the current study, will shed additional insights into the Joneses effect.

Appendix

The Risk Premium

Because of the default risk, the home economy has to pay a risk premium to borrow in the global capital market. This leads the foreign debt interest rate that home country has to pay to be higher than the world interest rate. To illustrate the point, suppose the home economy defaults only in the bad state of nature. The expected debt service is

$$\mathrm{E}[S] = (1-p)(1+r)B + p\cdot[(1-q)(1+r)B + q\cdot\theta\cdot(1-\varepsilon)]. \tag{A1}$$

With (5) in the text,

$$(1+r^*)B = (1-p)(1+r)B + p\cdot[(1-q)(1+r)B + q\cdot\theta\cdot(1-\varepsilon)]. \tag{A2}$$

Rearranging, we obtain

$$(1+r)(1-pq)B = (1+r^*)B - pq\theta(1-\varepsilon). \tag{A3}$$

Since the default occurs when $(1+r)B > \theta(1-\varepsilon)$, (A3) can be rewritten as

$$(1+r)(1-pq)B > (1+r^*)B - pq(1+r)B,$$

which can be simplified to $(1+r)B > (1+r^*)B$, and, thus, for a positive borrowing B,

$$r > r^*. \tag{A4}$$

The Output Effect of International Reserves

The Aizenman and Lee (2005) model, which is based on the work of Diamond and Dybvig (1983), is used to illustrate the output effect of international reserves. In this setting, international reserves help cushion the output effect of liquidity shocks. Consider an economy that finances a long-term project via bank loans. The representative agent is both the entrepreneur and the banker who does the financing and investment.

In period 1, the risk-neutral central planner borrows B in the global capital market and makes a deposit in the bank. The deposit B has two components—one component

is international reserve holding, R, that does not go into the production process and the other component $(B - R)$ is used to finance the long-term investment. The long-term investment is undertaken prior to the realization of a liquidity shock. Note that it is the central planner who decides on the allocation of B between international reserves R and productive capital $(B - R)$. The reprehensive agent only does the financing and investment.

At the beginning of period 2, a stochastic liquidity (sudden stop) shock is realized with the aggregate value of Z. The shock, say, is affected by a speculative attack. If the realization Z is less than the holding of international reserves, R, the economy uses the international reserve holding R to fill in the sudden drop in liquidity and produces with capital $(B - R)$. Thus, the economy does not suffer from output losses.

On the other hand, if Z is greater than R, then it triggers a premature liquidation of amount $(Z - R)$. The liquidation is accompanied by an adjustment cost that is proportional to $(Z - R)$, say $\lambda(Z - R)$, $0 < \lambda < 1$. Therefore, when the level of international reserves is not large enough to cover the amount of sudden drop in liquidity, the economy suffers an output loss. The net capital for the production in period 2 is,

$$K_2 = \begin{cases} (B-R)-(1+\lambda)(Z-R) & \text{if} \quad Z > R, \\ B-R & \text{if} \quad Z \le R. \end{cases} \tag{A5}$$

The production technology of the long-term project in period 2 is given by

$$Y_2 = \begin{cases} A[(B-R)-(1+\lambda)(Z-R)] & \text{with probability} \quad p, \\ A[B-R] & \text{with probability} \quad 1-p, \end{cases} \tag{A6}$$

where A is the productivity parameter.[13] $A > 1 + r$ allows the economy at least to pay off the debt that carries an interest rate r. The probability of having a speculative attack that leads to output losses is p and, in this case, $p = \text{prob}(Z > R)$.

We express the liquidity shock in terms of B using $Z = zB$ and assume z follows a uniform distribution in [0, 1]. The expected output in period 2 is

$$\mathrm{E}(Y_2) = pA[(B-R)-(1+\lambda)(Z-R)]+(1-p)A[B-R]. \tag{A7}$$

Following the argument in section 2, the deposit ceiling $\bar{B}$ is given by

$$(1+r^*)\bar{B} = \theta \cdot pA\left[(\bar{B}-R)-(1+\lambda)(Z-R)\right]+\theta\cdot(1-p)A\left[\bar{B}-R\right] \tag{A8}$$

and $\mathrm{E}(Y_2)$ is

$$\mathrm{E}(Y_2) = (1+r^*)\bar{B}/\theta. \tag{A9}$$

To proceed, we assume the risk premium, $r - r^*$, is given by

$$r - r^* = \psi - \kappa \cdot \frac{R}{\tilde{R}_0}, \tag{A10}$$

where ψ and κ are the appropriate parameters, and $\tilde{R}_0$ is the average of international reserves held by the Joneses. In essence, we assume the additional amount of interest the economy has to pay in the international capital market is negatively (positively) related to its own (peers') level of international reserves. Suppose there are two economies seeking loans in the international capital market. Assume the two economies are identical with the exception that they hold different levels of international reserves. If lenders use international reserves as a measure of an economy's financial

wellbeing, then they are willing to offer the loan at a lower rate to the economy with a relatively higher level of international reserves. The parameter ψ captures all the other factors determining the interest rate differential.

At the credit ceiling, it can be shown that the contractual repayment equals the default penalty in the best state of nature; i.e. $\bar{B}(1+r) = \theta \cdot A(\bar{B} - R)$. Substituting in (A10), we have

$$\bar{B} = (\theta \cdot \lambda \cdot R) \big/ \left(1 + r^* + \psi - \kappa \cdot R / \tilde{R}_0\right). \tag{A11}$$

From (A9) and (A11), we have

$$\mathrm{E}(Y_2) = \lambda \cdot (1 + r^*) R \big/ \left(1 + r^* + \psi - \kappa \cdot R / \tilde{R}_0\right). \tag{A12}$$

Thus, (A12) shows that the expected output is positively associated with the economy's own level of international reserves and is negatively associated with its peer group's level. Further it can be shown that the effects of R and $\tilde{R}_0$ on output levels when $Z > R$ or $Z \leq R$ are the same as their effect on the expected output. That is, own (peers') international reserves have a positive (negative) impact on output in both the crisis and noncrisis periods. As stated in the text, specification (17) for output shocks is used to facilitate comparison with models in the first two subsections of section 2.

Alternative Presentation of the Optimal Levels of International Reserves

Let

$$\eta = -\frac{d \log p}{d \log R} = -\frac{R}{p}\frac{dp}{dR}$$

be the elasticity coefficient that measures the proportional change in speculative attack probability in response to a proportional change in the level of international reserves. With $\omega = \eta p$, we can rewrite R_b as

$$R_b = \omega(\delta + \varepsilon)\left[\frac{1}{\rho - r^*} + \frac{\theta}{1 + r^*}\right].$$

Similarly, we can rewrite R_J and $R_{J,F}$ as

$$R_J = \omega_J(\delta + \varepsilon)\left[\frac{1}{\rho - r^*} + \frac{\theta}{1 + r^*}\right]$$

and

$$R_{J,F} = \frac{\omega_J(\delta^* + \varepsilon^*)\tilde{R}_0\left[\frac{1}{\rho - r^*} + \frac{\theta}{1 + r^*}\right]}{\tilde{R}_0 - \left[\frac{1}{\rho - r^*} + \frac{\theta}{1 + r^*}\right]},$$

where ω_J is ω with P replaced by P_J. These representations are simpler than those given in the text but they contain endogenous variables and, thus, strictly speaking, are not the solutions to the model. Note that $\omega_J > \omega$ and $\tilde{R}_0 \big/ \left\{\tilde{R}_0 - [(1/\rho - r^*) + (\theta/1 + r^*)]\right\} > 1$, *ceteris paribus*. Thus, $R_b < R_J < R_{J,F}$.

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Notes

1. Based on data from the April 2006 IFS data CD.
2. See, for example, Grubel (1971), Flood and Marion (2002), Lee (2004), Jeanne and Rancière (2006), and Aizenman et al. (2007). Genberg et al. (2005) discuss some specifics related to Asia.
3. Day and Choi (2004) and Xinhua News Agency (2004).
4. That is, the probability $(1 - p)$ includes these events: (1) no speculative attack, (2) a speculative attack has been neutralized or defended without output loss, and (3) any other speculative attacks that do not induce an output drop.
5. The Appendix shows that the economy has to pay a premium in the international capital market; i.e. $r > r^*$.
6. The economy defaults in the bad state if $1 - \varepsilon - (1 + r)B < (1 - \theta)(1 - \varepsilon)$, which can be simplified to the condition $(1 + r)B > \theta(1 - \varepsilon)$. Thus, q is the default probability under the bad state and depends on the adverse output shock ε.
7. Strictly speaking, the model is extended to a three-period model. However, period 0 is added to accommodate $\tilde{R}_0$ and has no implications for other aspects of the model.
8. In the Appendix, we show that output levels in both states are increasing functions of the (relative) holding of international reserves. To simplify the presentation we work with (14).
9. The alternative representations of R_b, R_J, and $R_{J,F}$ given in the Appendix offer another way to compare these three variables.
10. We also considered the case in which the post-crisis period starts in 1999. The estimation results, especially the results on the Joneses effect, are qualitatively the same as those reported in the subsequent sections.
11. Some recent studies on the empirical international reserve demand behavior include de Beaufort Wijnholds and Kapteyn (2001), Lane and Burke (2001), Flood and Marion (2002), and Aizenman and Marion (2003), Ma and McCauley (2008), and Cheung and Ito (forthcoming). Earlier studies are reviewed in, for example, Grubel (1971).
12. For brevity, the empirical results pertaining to interest rate differentials and the US Treasury rate (discussed later) were not reported but are available from the authors.
13. Equation (A6) is an A-K model Cobb–Douglas function $Y = AK^{\alpha}$ with $\alpha = 1$.