International Cooperation in Foreign Reserve Policies in the Presence of Competitive Hoarding

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Abstract

This paper analyzes international reserve accumulation in economies facing keeping-up-with-the-Joneses externalities. To examine this competitive hoarding hypothesis, I introduce a value-weighted Joneses index so that the standard Joneses variable—the sum of reserve-to-GDP ratios of neighboring countries in the same geographical region—is weighted according to each country's relative market capitalization. Using this refined index, I find a significant Joneses effect in developing countries, particularly persistent in Asia and Latin America since the early 2000s. This peer-pressure motive could encourage excess reserve hoarding, providing a rationale for international cooperation. I develop a simple theoretical model of borrowing economy featuring the Joneses effect as well as the interdependence between risk-free reserves and risky domestic capital investment. Quantitative results show that the cooperation can induce welfare-enhancing allocations with fewer reserves and greater investment and relax the external debt constraint, thereby effectively internalizing negative externalities inherent in competitive hoarding.

Keywords: Competitive hoarding; Financial crisis; International cooperation; International reserves

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1. Introduction

International reserves offer a buffer for trade imbalances and self-insurance against future sudden stops in capital flows, but holding on to a large amount of them as protection from an infrequent crisis event can be costly.[1] In fact, for most countries, international reserve assets—primarily held in highly liquid foreign government securities—earn a return that is lower than their market rate of interest at which the reserve purchases are typically financed. Nevertheless, a large body of the preceding literature has mostly focused on justifying the high demand for reserves in emerging market and developing economies.

Two most popular arguments are a precautionary motive to hedge against sudden capital inflow reversals (Ben-Bassat and Gottlieb, 1992a; Durdu et al., 2009; Jeanne and Ranciere, 2011) and a mercantilist motive to improve external competitiveness and promote export growth (Dooley et al., 2003; Aizenman and Lee, 2007). However, these two rationales cannot fully account for the recent upsurge in reserve accumulation in developing countries. Other justifications include the exchange rate stabilization (Calvo and Reinhart, 2002; Hviding et al., 2004; Aizenman and Riera-Crichton, 2008) and the prevention of capital flight by domestic residents (Obstfeld et al., 2010).[2]

This paper studies a competitive motive, called the catching-up-with-the-Joneses effect, first advocated by Machlup (1966) and formally examined by Bastourre et al. (2009), Cheung and Qian (2009), Cheung and Sengupta (2011), and Aizenman et al. (2015). The idea of keeping a war chest of reserves as large as those of neighboring economies for a self-insurance purpose

[1] For earlier work on the buffering role of reserves to smooth balance-of-payment shocks and adjustment processes, see Heller (1966), Kelly (1970), Frenkel and Jovanovic (1981), and Flood and Marion (2002).
[2] See Ghosh et al. (2014) for changing motives for holding reserves in emerging markets since the 1980s.

has received considerable attention especially after a series of contagious financial crises in developing countries in the 1990s. The paper revisits this issue and makes the following contributions: First, the paper reexamines the competitive hoarding hypothesis using a large sample of developing countries based on a refined Joneses variable that takes into account countries' relative size of financial market. Second, the paper develops a simple theoretical model of borrowing economy featuring the Joneses effect as well as the interdependence between risk-free reserves and risky domestic capital investment. In particular, the case for international cooperation is considered to explore whether it can reduce the potentially inefficient peer pressure for reserve accumulation and lead to welfare-enhancing resource allocations.

To empirically test the presence of rivalry-driven reserve hoarding, the existing studies mentioned above use the simple sum of reserve-to-GDP ratios of neighboring countries within the same geographical region as a proxy for the Joneses index. The main rationale is that a country's massive reserve holdings relative to its peer group with otherwise similar economic characteristics may signal a better solvency position. This can help avoid a negative judgment of foreign investors on the local financial market by diverting it to the neighboring economies when financial turmoil sweeps through the region (Cheung and Qian, 2009).[3]

While the standard definition of the Joneses variable is intuitive, it is a less-than-perfect indicator because it ignores differences in the relative importance of each country in the region. In this paper, I introduce a value-weighted Joneses index so that the standard Joneses variable is

[3] An alternative interpretation for the Joneses effect is monetary mercantilism; Aizenman and Lee (2008) argue that competitive hoarding can be triggered by the desire to preempt any competitive gains of the other export-competing country. However, following the views that recent accumulation trends seem more closely linked to precautionary variables than to mercantilist factors (Aizenman and Lee, 2007) and that providing a "buffer for liquidity needs" is found to be reserve managers' most important motivation according to the recent IMF survey (International Monetary Fund, 2011), this paper focuses on a self-insurance interpretation of the Joneses effect.

weighted according to each country's relative market capitalization. This alternative definition of the Joneses index may be justified by the following two reasons.

First, the large representative financial markets tend to have timely information that global investors may use to evaluate financial conditions of the overall region (Cheung and Sengupta, 2011). Thus, financial indicators in large markets may receive more attention.

Second, with the growing importance of institutional investors such as mutual and hedge funds accounting for international capital flows, an economy may have a strong incentive to monitor market conditions of its neighbors, particularly those with large capital transactions. Given higher levels of exposure, the mutual funds have a much more need to adjust their portfolios in the larger markets during times of stress, which typically has broader repercussions in the region.[4] Therefore, to the extent that a country's reserve holdings signal its potential to stay resilient during the crisis, it may pursue aggressive accumulation in order to place it in a favorable position within global investors' portfolios.[5]

Using the standard and value-weighted Joneses indices, I find a significant and robust Joneses effect in the sample of 45 developing countries over the period 1990–2017, while controlling for a set of traditional macroeconomic and financial determinants of reserve demand. I also find that the goodness of fit is marginally higher when using the value-weighted Joneses index.

From the cross-regional analyses, both point and time-varying estimates suggest that competitive hoarding seems to be stronger and more persistent for developing countries in Asia

[4] For example, countries that were most affected due to massive withdrawals of U.S.-based mutual funds following the Mexican crisis in 1994 were Argentina, Brazil, and Mexico, the countries with the highest portfolio shares of the funds specialized in Latin America (Kaminsky et al., 2003).

[5] This assertion is empirically relevant: "[C]redit risk agencies monitor reserves, among other variables, in order to assign ratings to sovereign debt. Since such ratings influence investors' beliefs, there exists an important signaling effect of reserves." (Bastourre et al., 2009, p.865).

and Latin America compared to other regions, although the evidence in Latin America is not as salient as in Asia. These findings based on the more recent data reinforce the previous panel regression evidence for regional competition in reserve accumulation of emerging market economies in East Asia (Cheung and Qian, 2009) and Latin America (Cheung and Sengupta, 2011). However, in contrast to Cheung and Sengupta (2011), I find the significant Joneses effect in Latin America only when an estimation is based on the value-weighted Joneses index. Moreover, the economic impact of the Joneses effect in Asia and Latin America appears to be larger when using the value-weighted index relative to the standard index. This peer-pressure motive could account for the excessive demand for reserves beyond what is justified by conventional macro fundamentals in these countries, suggesting the presence of regional negative externalities.

Guided by the above empirical findings as well as other economic costs of holding large reserves, I explore theoretically whether the policy coordination can alleviate the pressure of horse racing in reserve accumulation and improve the efficiency of reserve management.[6] To test this hypothesis, the paper develops a simple model of borrowing economy. Specifically, I begin with the canonical two-period model of Aizenman and Marion (2004), with the endogenous probability of financial crisis that can depress output in the second period as in Cheung and Qian (2009) and Steiner (2014). Domestic capital investment, which is ignored in the previous theoretical studies of competitive hoarding, is added to the model so that the economy's real resources can be distributed into both risk-free and risky assets.[7]

[6] Some examples of the implicit costs as a result of the excessive demand for reserves in developing countries are: (i) the opportunity cost, defined as the spread between the cost of external debt and the return on reserves, around 1% of GDP according to Rodrik (2006); (ii) an inflationary pressure following an incomplete sterilization procedure; (iii) the diminishing marginal exchange rate stabilization effect during non-crisis times (Lee and Kim, 2019); and (iv) global imbalances (Bernanke, 2005).

[7] Aizenman and Marion (2003) consider a similar framework that encompasses an allocation between reserves and

Following Cheung and Qian (2009), the competitive motive is conveniently introduced to the model by modifying the crisis probability so that it depends positively on the amount of reserves held by a country's neighboring economies as well as its external debt and negatively on its own reserves. By design, this crisis probability embeds a regional peer pressure imposed by the other countries' reserve accumulation. To the extent that relative reserves signal a country's relative vulnerability to an external shock, the economy's rational response is to keep up with its neighbors' reserves. Due to an increased crisis probability in the presence of the Joneses effect and the resulting decline in the expected marginal return from capital and borrowing capacity, the model predicts that, compared to the benchmark case, there is a slight decline in investment even with a sharp rise in reserves. Consequently, the utility level falls when the competitive motive drives the stronger demand for reserves. This result provides the impetus for international cooperation in reserve management, which may be arranged by a global social planner in hopes of achieving more efficient resource allocations.

From the optimal solutions under cooperation, I find that having access to a larger pool of liquid reserve assets, which could enhance creditor confidence, decreases the crisis probability noticeably. Such an environment stimulates more investment and relaxes the external debt constraint, while keeping reserves low at around the benchmark or pre-competition level. By implication, the cooperation could induce more productive allocations between reserves and investment with welfare gains, thereby effectively internalizing negative externalities inherent in competitive hoarding.

In practice, numerous coinsurance mechanisms have been implemented around the world in the form of bilateral currency swap arrangements, including a network version of the Chiang Mai Initiative (CMI) in Asia, and liquidity assistance provided by a regional entity, like the Latin

capital investment, but it does not allow an endogenous crisis probability and the Joneses effect.

American Reserve Fund (FLAR). However, swap lines of the Federal Reserve have been extended selectively to countries with strong trade and financial linkages with the United States, and there is only a limited scope for ad hoc contingent swap agreements to replace reserve hoarding (Obstfeld et al., 2009; Aizenman et al., 2011). Despite the presence of CMI and FLAR, as well as a global lender of last resort like the International Monetary Fund, developing countries in Asia and Latin America have continued to build up remarkable amounts of reserves. These stylized facts and the theoretical results in this paper suggest that there is still room for deeper and broader regional cooperation to enhance the efficiency of central banks' asset management in developing countries.

In the next section, I document empirical evidence for the Joneses effect in the full sample and across regions using both standard and value-weighted Joneses indices. Section 3 presents a two-period precautionary savings model of reserves to characterize the optimal reserves and investment in the benchmark, Joneses, and cooperation cases. Section 4 presents numerical solutions of the model and the sensitivity analysis. Finally, Section 5 concludes.

2. Empirical procedure

2.1. Evolution of international reserves

For a review of international reserve-hoarding patterns around the world, Fig. 1 illustrates the evolution of reserves in the past four decades.[8] As shown in panel (a), average reserves (as a share of GDP) have remained relatively stable in advanced countries, with a recent upsurge after the global financial crisis in 2008. By contrast, the speed of reserve hoarding has been much faster in lower-income economies, and this accelerating pace has not slowed down in spite of the wide adoption of a more flexible exchange rate regime in the 1990s. Importantly, there is a noticeable disruption in this trend during the global financial crisis, but the reserve stocks have been rebuilt since then and continued to remain high at around 25% of GDP in developing countries.[9]

[Insert Fig. 1 here]

Divergent evolution of reserves in two country groups in panel (a) may reflect their differences in economic and financial stability, policy credibility, or access to global financial institutions. In that case, are the observed patterns for reserves in developing countries justifiable?

[8] Sample countries included in this exercise are reported in Online Appendix Table A.1. Note that I will simply call "developing countries" for all non-advanced countries in this paper without distinguishing low-income developing countries from emerging market economies.

[9] For a discussion about the precautionary demand for reserves in developing countries to hedge against the global financial crisis, see Bussière et al. (2015), Dominguez et al. (2012), Frankel and Saravelos (2012), and Gourinchas and Obstfeld (2012). By contrast, Blanchard et al. (2009) and Rose and Spiegel (2011) find little evidence that reserves provided a crucial buffering role during the global financial crisis.

Three conventional rules of thumb for reserve adequacy ratios suggest that countries hold liquid reserves worth (i) three months of imports, (ii) a full coverage of short-term external debt maturing within a year (a.k.a. the Greenspan-Guidotti rule), or (iii) 5–20% of broad money (Wijnholds and Kapteyn, 2001). The logic behind these reserve adequacy benchmarks is to smooth trade imbalances, resist a sudden withdrawal of foreign capital, and prevent a capital flight by domestic residents, respectively. However, as shown in panels (b)−(d) of Fig. 1, the recent stock of reserves in developing countries has far exceeded any of the traditional benchmark levels, especially since the mid-1990s. An increasing trend is prevalent in developing countries across geographical regions, with occasional reversals during the major international financial crises in the late 1990s and the late 2000s.[10] Some heterogeneity exists in reserve-hoarding patterns across regions, suggesting a cross-regional analysis in the estimation procedure that follows.

As a potential factor contributing to the observed strong demand for reserves besides an economy's own fundamentals, this paper reassesses the negative externality arising from other countries' reserve accumulation.

2.2. Data and baseline regression model

My annual data cover an unbalanced panel of 45 developing countries from 1990 to 2017. The lack of data availability for some key macroeconomic variables, particularly stock market capitalization and short-term external debt, restricts the sample period and countries. As

[10] Evidently, having access to swap lines with the Fed in the midst of the global financial crisis helped some emerging market economies (e.g., Korea) to avoid a large depletion of their reserves.

displayed in Fig. 1, seemingly excessive holdings of reserves in developing countries have been more pronounced since the mid-1990s, providing support for the sample period to begin in 1990.

In order to examine the competitive hoarding hypothesis, I adopt a panel fixed-effect regression model commonly used in the literature. The baseline specification is described below:

$$R_{i,t} = \boldsymbol{X_{i,t-1}\beta_1} + \beta_2 J_{i,t-1} + c_i + \varepsilon_{i,t} \quad (1)$$

where $R_{i,t}$ is the log of the ratio of international reserves to GDP in country *i* at time *t*; $\boldsymbol{X_{i,t}}$ is a vector of standard determinants of demand for reserves; $J_{i,t}$ is a Joneses variable; c_i is a country fixed effect; and $\varepsilon_{i,t}$ is an i.i.d. disturbance term.[11] Lagging independent variables by one year helps prevent a potential endogeneity bias associated with reverse causality.

The Joneses variable captures evolution of reserve accumulation by neighboring countries that are individually indexed by *k*. In the baseline regression model of Cheung and Qian (2009), they define it as the sum of reserve-to-GDP ratios of neighboring countries in a given region excluding country *i*'s own reserves:[12]

$$J_{i,t} = \sum_{k \neq i} R_{k,t} \quad (2)$$

[11] Scaling reserves by GDP facilitates a comparison across countries. Unless stated, "reserves" in Section 2 refer to a reserve-to-GDP ratio.

[12] I sort countries into four regions: Asia, Europe, Latin America, and Middle East. These groups correspond to East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, and Middle East & North Africa, respectively, according to the World Bank's classification.

If a rivalry motive drives the strong demand for reserves beyond what can be explained by other traditional reserve determinants, the coefficient estimate of the Joneses index in Eq. (1), β_2, will be significantly positive.

Although this standard approach to measuring the Joneses index is intuitive, it is an imperfect proxy for the competitive hoarding behavior. This paper attempts to refine the standard index by introducing the relative financial market size of each country. As noted in the introduction, financial indicators, such as reserves, in large markets may receive more attention.

To capture the importance of relative market size, I compute the value-weighted sum of reserve-to-GDP ratios of neighboring countries as follows:

$$\tilde{J}_{i,t} = \sum_{k \neq i} \left(MC_k / \sum_{k \neq i} MC_k\right) R_{k,t} \tag{3}$$

where MC_k represents country k's stock market capitalization in U.S. dollars (sources: World Bank WDI and St. Louis Fed's FRED databases). The weights used in Eq. (3) are held fixed over time using the 2010 values of market capitalization to exclude the time-varying impacts of market size on the evolution of the Joneses' reserve accumulation.[13] In the rest of the paper, Eq. (2) is called a "standard Joneses" variable and Eq. (3) a "value-weighted Joneses" variable.

For other control variables in vector $\boldsymbol{X_{i,t}}$ in Eq. (1), I refer to Obstfeld et al. (2010) and Aizenman et al. (2015) and define two groups of variables. Traditional macroeconomic determinants include the real GDP per capita, imports as a share of GDP, and the volatility of reserve growth. Moreover, financial factors include broad money (M2) as a share of GDP, the

[13] See Online Appendix Table A.2 for each country's share of stock market capitalization in 2010. The main reason to select 2010 as a base year is that the time-series information for market capitalization in about a third of sample countries is unavailable until the early 2000s. I have also built a Joneses index using the average market capitalization over time as a weight and confirmed that my main results stay robust to this alternative formulation of the Joneses variable.

ratio of short-term external debt to GDP, de jure measure of financial openness, and exchange rate regimes (hard and crawling pegs). All variables are measured in logarithms except for reserve volatility, financial openness, and exchange rate regime dummy variables. Table A.3 in Online Appendix summarizes all variables used in the baseline empirical analysis with their brief descriptions and data sources, and Table A.4 reports their summary statistics.

2.3. Panel regression evidence for the Joneses effect

2.3.1. Full sample results

This subsection presents the main empirical results based on the panel fixed-effect model specified in Eq. (1). As noted earlier, the statistically significant and positive coefficient of the Joneses variable implies the presence of peer-pressure motive in reserve accumulation.

Table 1 reports the main estimation results using the full sample. In column (1), I first present the results when the specification includes three traditional macroeconomic determinants. As a scale variable, GDP per capita has an expected positive effect on the demand for reserves with a high level of statistical significance. A positive coefficient on the ratio of imports to GDP indicates that a country is expected to hold large reserves as its vulnerability to external trade shocks increases with its propensity to import. In contrast to empirical evidence in the buffer stock model of Frenkel and Jovanovic (1981), I find a significantly negative coefficient on reserve volatility. Aizenman et al. (2015) relate this finding with "the anecdotal observation that large variations in a developing country's IR [international reserves] are usually caused by large drawn downs." With country fixed effects, these three traditional macroeconomic determinants

explain 72.6% of the variation in observed reserve holdings in my sample of developing countries.

[Insert Table 1 here]

Next, I extend the traditional model by adding both standard and value-weighted Joneses variables. In support of earlier findings in Cheung and Qian (2009), Cheung and Sengupta (2011), and Aizenman et al. (2015), I find a significantly positive coefficient of the standard Joneses variable in column (2). Using the value-weighted index, I also find strong evidence for the Joneses effect in column (3) with other traditional macro variables keeping their significance patterns.

I now consider a model that controls for financial factors. As reported in column (4), an increase in the ratio of M2 to GDP, a proxy used to capture financial depth, tends to raise reserve holdings to stabilize a foreign exchange market whose disruption could be caused by sudden capital flight by domestic investors (Obstfeld et al., 2010). Similarly, a high ratio of short-term external debt to GDP signifies greater financial fragility to external shocks, escalating the demand for reserves particularly for countries with financing constraints. Financial openness has an expected positive sign but only weakly significant; the increased likelihood of both internal and external drains with lower regulatory barriers to financial transactions tends to increase the precautionary demand for reserves. Interestingly, I find a significant and negative sign for a hard currency peg variable, a prediction against the conventional theory. A plausible reason for this finding is that if a shift to a flexible exchange regime is accompanied by a greater extent of capital mobility, countries may increase reserves beyond their level under the peg to hedge against the risk of more frequent capital flow reversals (Flood and Marion, 2002). Maintaining a

crawling peg regime, however, is expected to raise reserve holdings, though not statistically significant. In other words, the effect of exchange rate regimes seems to be difficult to identify with precision due in part to their little time variation in the data. With country fixed effects, these five financial determinants explain 71.5% of the variation in observed reserve holdings in my sample countries.

When the "financial model" is extended with the two Joneses variables, I find the significant Joneses effect similar to the "traditional model" results. A strong peer-pressure motive in reserve accumulation is again confirmed using the standard Joneses index in column (5) and the value-weighted index in column (6).

Lastly, I consider the full specification that encompasses both traditional macroeconomic and financial variables, and report estimation results in columns (7)−(9). The inclusion of a large number of regressors with possible collinearity among them may lessen the power of the statistical inference for some of the estimates.[14] Nevertheless, the main result remains significant and quantitatively meaningful.

For example, when the standard Joneses variable increases by one standard deviation (+7.184), the result in column (8) suggests that the reserve-to-GDP ratio is expected to rise by 0.15 log points in the next year. When the value-weighted Joneses variable increases by one standard deviation (+0.714), the result in column (9) implies that the reserve-to-GDP ratio is expected to rise by 0.09 log points in the following year. Thus, the rivalry motive induces economically significant accumulation of reserves in the full sample, with the impact more pronounced when using the standard Joneses variable. Moreover, adding the Joneses variables

[14] Online Appendix Table A.5 documents the correlations between the regressors, which are not too high to cause a severe multicollinearity concern.

slightly increases the *R*-squared measure of goodness of fit, with the increment marginally higher for the value-weighted Joneses index.

2.3.2. Robustness check accounting for other reserve determinants

In this subsection, I introduce additional macroeconomic variables that possibly affect the demand for reserves and test the robustness of our main results. Missing potentially relevant factors, especially if they are strongly correlated with the Joneses variable, would make our baseline results biased. Here, I consider three relevant factors: a financial crisis, gross saving, and the opportunity cost of holding reserves. The variable definitions and data sources closely follow the work of Aizenman et al. (2015).

The crisis variable captures country-level banking/currency crises as well as the 2008–09 global financial crisis, and it is defined as the sum of crisis years in the past five years from $t-5$ to $t-1$. Gross national saving is measured as a share of GDP. The opportunity cost is proxied by the difference between the country's lending interest rates and the U.S. 10-year government bond yields. The information for crisis is taken from Laeven and Valencia (2013, 2018), and gross saving and the opportunity cost from IMF World Economic Outlook, St. Louis Fed's FRED, and World Bank WDI databases.

Table 2 displays the estimation results while controlling for three additional variables. The Joneses effect is robust to controlling for crisis as shown in columns (1) and (2), and gross saving as shown in columns (3) and (4).

[Insert Table 2 here]

Moreover, the crisis variable has an expected positive sign in columns (1) and (2), but it is statistically insignificant. On the other hand, gross saving displays a significantly positive effect in columns (3) and (4), supporting the view that developing countries with a high national saving rate typically run current account surpluses and amass large reserves (Aizenman et al., 2015).

In columns (5) and (6), I add the opportunity cost of holding reserves to the full specification. Note that data unavailability for lending interest rates in some low-income economies limits the sample size to 39 countries in this exercise. Nevertheless, I continue to find a significantly positive coefficient for the Joneses variables. In addition, I find significant evidence for a negative impact of opportunity cost on the demand for reserves, which is consistent with the earlier finding in Ben-Bassat and Gottlieb (1992b).

In support of the main result in Table 1, I also find that the value-weighted Joneses variable marginally improves the goodness of fit relative to the standard Joneses variable. Although it is not surprising to see little marginal improvement in the model fit, I think it is important to use the value-weighted index to estimate the strength of regional competition in reserve accumulation with more precision.

2.4. The Joneses effect: cross-regional heterogeneity

2.4.1. Regional evidence during the full sample period

In order to check cross-regional heterogeneity in the extent of competitive hoarding, I disaggregate the sample into four different regions and rerun the full specification of Table 1 for each region. The subsample results are reported in Table 3.

[Insert Table 3 here]

Reviewing the coefficient estimates for the first two variables in columns (1)−(8), the Joneses effect continues to remain significant with an expected positive sign in Asia and the Middle East using the standard index, and in Asia and Latin America using the value-weighted index. From the results in columns (1) and (2), I also find that, in contrast to the full sample result in Table 1, the economic impact of the Joneses effect in Asia appears to be greater when using the value-weighted index. For example, when the standard and value-weighted Joneses variables increase by one standard deviation (+3.778 and +0.554, respectively) in Asia, the results in columns (1) and (2) suggest that the reserve-to-GDP ratio is expected to rise by 0.09 and 0.14 log points, respectively.

Likewise, in Latin America, the regression estimates based on the value-weighted Joneses index in column (6) exhibit not only a stronger statistical significance and better fit but also a greater economic importance of the Joneses effect compared to the result with the standard Joneses index in column (5).[15]

Unlike evidence in the other regions, I find a significantly negative coefficient for the Joneses variables in columns (3) and (4), meaning that the competitive motive is not one of the driving forces behind active reserve accumulation in developing countries in Europe.

In columns (7) and (8), I find opposite signs for the Joneses coefficients, although they are not strongly significant. This makes it hard for me to draw a firm conclusion on the Joneses effect in the Middle East region.

[15] The standard deviations of the standard and value-weighted Joneses variables in Latin America are 2.693 and 0.432, respectively.

In sum, cross-regional evidence in Table 3 reveals that the strong Joneses effect is found only among countries in Asia and Latin America during the sample period. This finding is intuitive in that many countries in these two regions have undergone destructive and contagious financial crises in the 1990s, causing them to be more risk-averse and responsive to changes in the financial conditions of neighboring economies, particularly those with a large market size.

2.4.2. Time-varying evidence across regions

The regression results thus far were based on the full sample period and might disguise potential time variations in the Joneses effect in each region. This subsection presents time-varying evidence using rolling-window regressions between 1980 and 2017 with a window size of 20 years. Since each regression has to rely on a relatively small sample size, which raises concerns regarding a lack of degrees of freedom and asymptotic bias, a parsimonious approach is taken by keeping the regressors that turn out to be significant at the 10% level from the results in Table 3. In each region, I use the same set of control variables for both standard and value-weighted Joneses regression specifications.

Fig. 2 shows the time-varying estimates for the Joneses variable across geographical regions with 90% confidence intervals. I present the results using a standard Joneses index in panel (a) and a value-weighted index in panel (b).

[Insert Fig. 2 here]

Consistent with the results in Table 3, the Joneses effect seems to be stronger and more persistent in Asia and Latin America compared to the two other regions. In particular, it has

continued to remain statistically different from zero in Asia since the early 2000s, with the persistence pattern more apparent using the value-weighed Joneses index in panel (b). While the evidence is not as salient as in Asia, the estimation results in Latin America using the value-weighted index in panel (b) indicate that there is some suggestive evidence for the persistent Joneses effect. A similar prediction is found using the standard Joneses index in Latin America, but the effect seems to disappear during the latter part of the sample period. For both Europe and the Middle East, the competitive motive has not played a significant role in driving reserve accumulation, and even if it has existed, the effect would have been short-lived.

Overall, empirical evidence reported in Section 2 demonstrates the presence of the robust and persistent Joneses effect, particularly salient for developing countries in Asia and somewhat weaker in Latin America. This peer-pressure motive could push reserve stockpiling beyond the desired level in these countries, suggesting the possible existence of negative externalities in the region.

3. The model

In this section, I present a stylized model to rationalize empirical evidence for the competitive accumulation of reserves and illustrate how policy cooperation in reserve management may improve the economy's resource allocations.

I employ a simple two-period precautionary savings model of reserves. Three cases—benchmark, the Joneses, and the cooperation—are considered for the purpose of comparison. In the benchmark case, I build on a canonical model of Aizenman and Marion (2004) by adding

domestic capital investment as a country's alternative asset choice. I then follow Cheung and Qian (2009) and extend the benchmark model by introducing the Joneses effect through the crisis probability that depends on the neighbors' reserves. Lastly, I offer international cooperation as a possible resolution to internalize negative externalities associated with inefficient competitive hoarding.

In this paper, I do not purport to explicitly model every relevant economic agent nor, for simplicity, distinguish the government from private entrepreneurs. Moreover, the model does not consider possibly different maturity structures between reserves and capital investment. Abstracting it from the other, less relevant economic factors, the model's prime focus is on the roles of reserves, capital investment, and their interactions in an open economy with the peer-pressure externalities in reserve hoarding under the non-cooperative and cooperative settings.

3.1. Basic setup

3.1.1. Output

Suppose that a developing country is subject to output shocks only in period 2. In period 1, the economy receives an exogenous capital endowment K and produces output Y using capital as the only input:

$$Y_1 = f(K) \tag{4}$$

where the production function satisfies usual properties, $f' > 0$ and $f'' < 0$. The second period's output based on the investment I from the first period is subject to a state-contingent productivity

shock. Specifically, there is a probability p that the economy suffers from a sudden stop in capital inflows, resulting in a negative productivity shock and a loss of output. The second period's output is thus given by

$$Y_2 = \begin{cases} (1+\delta)f(K+I) & \text{with prob. } (1-p) \\ (1-\varepsilon)f(K+I) & \text{with prob. } p \end{cases}; \quad \delta > 0, \quad \varepsilon > 0, \quad 0 < p < 1 \tag{5}$$

where δ and ε capture the size of good and bad productivity shocks, respectively.

3.1.2. Consumption

The country can borrow amount D from foreign creditors in period 1. The foreign borrowing and initial output are used to finance consumption C, risky domestic investment I, and riskless international reserves R. The budget constraint in period 1 is therefore given by

$$C_1 = f(K) + D - I - R \tag{6}$$

Since there is output uncertainty in period 2 as shown in Eq. (5), the country may default on its external debt. Without penalty, the country has no incentive to repay its borrowing. Hence, I assume that an international lender can confiscate a fraction of the second period's output, given by ηY_2 with $0 < \eta < 1$, when the country defaults.[16] Note that the output loss is the only cost of default as the model ends in the second period. For computational ease, the default is assumed to

[16] Following Aizenman and Marion (2003), the economy's reserve holdings are assumed to be beyond the creditors' reach even in default states.

take place under a bad state with an exogenously given probability q. The budget constraints in period 2 reflect these assumptions and are given as follows:

$$C_{2,g} = (1+\delta)f(K+I) - (1+r)D + \left(1+r_f\right)R \qquad \text{with prob. } (1-p) \tag{7}$$

$$C_{2,b} = (1-\varepsilon)f(K+I) - (1+r)D + \left(1+r_f\right)R \qquad \text{with prob. } p(1-q) \tag{8}$$

$$C_{2,b,d} = (1-\varepsilon)f(K+I)(1-\eta) + \left(1+r_f\right)R \qquad \text{with prob. } pq \tag{9}$$

where r is the cost of external borrowing; r_f is the risk-free return on reserves; and subscripts g, b, and d stand for good, bad, and default states, respectively.

From the budget constraints in Eqs. (7)−(9), no default under a good economic state means that $(1+r)D \leq \eta(1+\delta)f(K+I)$, while a default under a bad state implies that $(1+r)D > \eta(1-\varepsilon)f(K+I)$ with probability q.

Following Garcia and Soto (2004), Jeanne (2007), and Cheung and Qian (2009), I model the probability of crisis as a positive function of external debt and a negative function of reserves:[17]

$$p(D,R) = \beta_0 + \beta_1 \frac{D}{R}; \qquad \beta_0 > 0, \qquad \beta_1 > 0 \tag{10}$$

where β_0 is a parameter to capture all other factors possibly affecting the crisis probability and β_1 measures the responsiveness of the crisis probability to changes in the debt-to-reserve ratio. By design, the crisis probability declines as the country's reserves increase relative to its

[17] Gourinchas and Obstfeld (2012) also provide empirical support for a buffering role of reserves by documenting that an increase in reserves (relative to GDP) tends to lower a probability of sovereign default, banking, and currency crises in emerging market economies.

indebtedness, reflecting that reserves can serve as collateral for external liabilities. Therefore, sufficient reserves can boost creditors' confidence in the borrowing country's ability to service its debt and help reduce the likelihood of a sudden stop. By contrast, insufficient reserves relative to foreign borrowing are an indicator of a higher probability of a sudden stop.

One may view the first period's constraint in Eq. (6) as the country's portfolio allocation between risky and riskless assets, given the external debt and initial output. The implied tradeoff between these two assets in period 1, however, may become weaker through their interdependence in period 2. When looking at the second period's constraints in Eqs. (7)−(9) together with the crisis probability in Eq. (10), reserves seem to have a crisis-prevention role by decreasing the probability of adverse shock and a crisis-mitigation role by smoothing consumption when the economy is hit by an output collapse. Because of the crisis-prevention effect, reserves may exhibit a complementary relationship with capital investment; given external debt, chances of realizing a higher marginal return from capital increase with relatively larger reserves.

3.1.3. Debt ceiling

During the crisis in period 2, an economy has an incentive to default on its debt if the repayment is more costly than the default penalty, that is, $(1+r)D > \eta Y_2$. Therefore, the net resource transfer to foreign creditors in the second period will be given by:

$$L = \min[(1+r)D, \eta Y_2] \tag{11}$$

where $\min[\cdot]$ is the minimum operator. Given that the international credit market is characterized by risk-neutral agents, the lending interest rate r is determined by an arbitrage condition in which the expected return on debt is equal to the risk-free return:

$$\mathrm{E}[L] = \left(1 + r_f\right)D \tag{12}$$

where $\mathrm{E}[\cdot]$ is an expectation operator.

Because a full repayment of the external debt is not guaranteed ex ante, the country faces credit ceiling $\overline{D}$. This is the level of debt that is high enough to induce default in both good and bad states of nature, and can be derived from a condition that the expected repayment equals the confiscated output in both states:

$$\overline{D} = \frac{\eta(1-p)(1+\delta)f(K+I) + \eta p(1-\varepsilon)f(K+I)}{1+r_f} \tag{13}$$

Eq. (13) shows that raising the default penalty rate (or the bargaining power of foreign lenders) η increases the borrowing limit, as do a greater positive productivity shock δ and capital investment I. A higher crisis probability p, negative productivity shock ε, and risk-free rate r_f lower the debt ceiling.

3.1.4. Utility function

Under risk neutrality, the country's expected utility function takes the following linear form:

$$\mathrm{E}[U(\cdot)] = C_1 + \frac{1}{1+\rho}\left[(1-p)C_{2,g} + p\big((1-q)C_{2,b} + qC_{2,b,d}\big)\right] \tag{14}$$

where ρ is the discount rate. If the discount rate is assumed to be high enough to push the borrowing to the ceiling level, the "contractual" repayment is equal to:

$$D(1+r)|_{D=\bar{D}} = \eta(1+\delta)f(K+I) \tag{15}$$

With debt ceiling, the probability of default in a bad state q becomes 1. Now, substituting Eqs. (6), (7), (9), and (15) into (14), the expected utility can be rewritten as follows:

$$\max_{R,I}\ \mathrm{E}[U(\cdot)]|_{D=\bar{D}} = f(K) + \bar{D} - I - R + \frac{1}{1+\rho}\left[(1-\eta)f(K+I)\big(1+\delta-p(\delta+\varepsilon)\big) + \big(1+r_f\big)R\right] \tag{16}$$

The country chooses optimal levels of reserves and capital investment to maximize the expected utility given in Eq. (16) subject to the endogenous crisis probability given in Eq. (10).

3.2. Benchmark case

For the optimal level of reserves in the benchmark case, I take a derivative of Eq. (16) with respect to reserves and obtain the following first-order condition:

$$1 - \left.\frac{\mathrm{d}D}{\mathrm{d}R}\right|_{D=\bar{D}} = \frac{1}{1+\rho}\left[\big(1+r_f\big) - (1-\eta)(\delta+\varepsilon)f(K+I)\left.\frac{\mathrm{d}p}{\mathrm{d}R}\right|_{D=\bar{D}}\right] \tag{17}$$

The left-hand side of Eq. (17) shows the net marginal cost of holding an additional unit of reserves in period 1, which consists of the foregone consumption minus the marginal indebtedness of reserves (note that $\mathrm{d}D/\mathrm{d}R|_{D=\bar{D}} > 0$). The right-hand side displays the net marginal benefit that is a discounted value of the sum of the interest income from reserve holdings and the output gain due to a reduced crisis probability in period 2 (note that $\mathrm{d}p/\mathrm{d}R|_{D=\bar{D}} < 0$). Evaluating and substituting partial derivatives gives the optimal condition for reserves as follows:

$$R = \left[\frac{\overbrace{\eta\beta_1(\delta+\varepsilon)f(K+I)^2}^{\mathrm{S}} \overbrace{\left(1+\delta-\beta_0(\delta+\varepsilon)\right)}^{\mathrm{T}} \overbrace{\left(1+r_f+\eta\left(\rho-r_f\right)\right)}^{\mathrm{V}}}{\left(\rho-r_f\right)\left(1+r_f\right)^2} \right]^{1/2} - \frac{\eta\beta_1(\delta+\varepsilon)f(K+I)}{\left(1+r_f\right)} \tag{18}$$

where S summarizes the expected output cost of the default; T represents a crisis-adjusted productivity shock; and V captures the sum of the risk-free interest income and a confiscated share of the opportunity costs of holding reserves. Expressions S, T, and V will frequently appear in the subsequent optimal conditions and will be useful in making qualitative comparisons between them.

For the optimal solution for capital investment, I take a derivative of Eq. (16) with respect to investment and find the following first-order condition:

$$1 - \left.\frac{\mathrm{d}D}{\mathrm{d}I}\right|_{D=\bar{D}} = \frac{1}{1+\rho}\left[(1-\eta)\left(\left(1+\delta-p(\delta+\varepsilon)\right)f' - (\delta+\varepsilon)f(K+I)\left.\frac{\mathrm{d}p}{\mathrm{d}I}\right|_{D=\bar{D}}\right)\right] \tag{19}$$

where f' is the marginal product of capital. In Eq. (19), the left-hand side shows the net marginal cost of putting an additional unit of investment (note that $\mathrm{d}D/\mathrm{d}I|_{D=\bar{D}} > 0$), while the right-hand side displays the net marginal benefit that is the discounted value of the expected marginal product of capital minus the output loss associated with an increased crisis probability (note that $\mathrm{d}p/\mathrm{d}I|_{D=\bar{D}} > 0$). Further simplifying Eq. (19) gives:

$$f(K+I) = \frac{R}{\eta\beta_1(\delta+\varepsilon)}\left[\left(\left(\frac{1+r_f}{1+\rho}\right)f'\mathrm{TV}\right)^{1/2} - \left(1+r_f\right)\right] \tag{20}$$

where T and V are expressions defined in Eq. (18).

3.3. The Joneses effect

The Joneses effect is introduced to the model as in Cheung and Qian (2009) so that the crisis probability is positively related to the amount of reserves held by a country's peer group as well as its external debt and negatively to its own reserves:

$$p(D,R,R^J) = \beta_0 + \beta_1\frac{D}{R} + \beta_2\frac{R^J}{R}; \qquad \beta_0 > 0, \qquad \beta_1 > 0, \qquad \beta_2 > 0 \tag{21}$$

where R^J stands for the Joneses' holdings of reserves at the beginning of period 1 and β_2 captures the sensitivity of crisis probability to competitive hoarding. An underlying logic for the competitive hoarding reflected in Eq. (21) is that falling behind the rivals' reserves gives

international investors an impression that a country is relatively more vulnerable to external shocks and has a higher probability of suffering from sudden stops during volatile times.

Evaluating and substituting partial derivatives in Eqs. (17) and (19) with the crisis probability given in Eq. (21) yields the following optimal conditions for reserves and investment:

$$R = \left[\frac{\left(\mathrm{ST} + \beta_2(\delta+\varepsilon)f(K+I)\left(1+r_f\right)R^J\right)\mathrm{V}}{\left(\rho - r_f\right)\left(1+r_f\right)^2}\right]^{1/2} - \frac{\eta\beta_1(\delta+\varepsilon)f(K+I)}{\left(1+r_f\right)} \tag{22}$$

$$f(K+I) = \frac{R}{\eta\beta_1(\delta+\varepsilon)}\left[\left(\left(\frac{1+r_f}{1+\rho}\right)f'\left(\mathrm{T} - \beta_2(\delta+\varepsilon)\frac{R^J}{R}\right)\mathrm{V}\right)^{1/2} - \left(1+r_f\right)\right] \tag{23}$$

The optimal reserves in Eq. (22) appear to be higher than its benchmark counterpart in Eq. (18); the additional demand for reserves comes from the expected output cost of crisis induced by the peer-pressure motive, as reflected in $\beta_2(\delta+\varepsilon)f(K+I)\left(1+r_f\right)R^J$, which is a positive function of the sensitivity to the Joneses effect β_2 and the regional rivals' reserves R^J.

The higher reserves in the presence of the Joneses effect, however, seem to lead to less capital investment as shown in Eq. (23); compared to the benchmark solution in Eq. (20), the crisis-adjusted productivity shock T is lowered by $\beta_2(\delta+\varepsilon)R^J/R$, the term capturing a productivity loss as a result of higher crisis probability triggered by reserve competition.

Apparently, the rivalry motive is inefficient if it places extraordinary demands on reserves and at the same time deteriorates the economy's overall welfare.

3.4. International cooperation

As a possible resolution to remove negative externalities associated with the inefficient competitive hoarding, I consider that policy makers in two countries, home and foreign, act cooperatively for reserve accumulation. I assume that the foreign country is one of the Joneses and has the economic characteristics similar to the home country. To model the cooperation, I let a global social planner maximize two countries' joint welfare function as follows:

$$\max_{R,R^*} \ \mathrm{E}\left[\frac{1}{2}U\left(C_1, C_{2,g}, C_{2,b,d}\right)\Big|_{D=\bar{D}} + \frac{1}{2}U^*\left(C_1^*, C_{2,g}^*, C_{2,b,d}^*\right)\Big|_{D^*=\bar{D}^*}\right] \tag{24}$$

Under symmetry, the probability of crisis for both home and foreign countries are given by

$$p(D,R,R^*) = \beta_0 + \beta_1\frac{D}{R} + \beta_2\frac{R^*}{R}; \qquad \beta_0 > 0, \qquad \beta_1 > 0, \qquad \beta_2 > 0 \tag{25}$$

$$p^*(D^*,R^*,R) = \beta_0 + \beta_1\frac{D^*}{R^*} + \beta_2\frac{R}{R^*}; \quad \beta_0 > 0, \qquad \beta_1 > 0, \qquad \beta_2 > 0 \tag{26}$$

where a superscript asterisk denotes a foreign variable. All other constraints of the model follow the basic setup in Section 3.1.

Following the same derivation procedures as before with crisis probabilities given in Eqs. (25) and (26), one can find an optimal condition for reserves as follows:

$$R = \left[\frac{\mathrm{S}\left(\mathrm{T} - \beta_2(\delta+\varepsilon)\right)\mathrm{V}}{\left(\rho - r_f\right)\left(1+r_f\right)^2}\right]^{1/2} - \frac{\eta\beta_1(\delta+\varepsilon)f(K+I)}{\left(1+r_f\right)} \tag{27}$$

Note that optimal reserves under cooperation in Eq. (27) appear to be smaller than the Joneses counterpart in Eq. (22) because of the term $-\beta_2(\delta+\varepsilon)$, which quantifies the effect of contracting the competition-induced productivity shocks in the foreign country (note that $\beta_2=\beta_2^*$, $\delta=\delta^*$, and $\varepsilon=\varepsilon^*$ under symmetry). The underlying mechanism is that higher home reserves tend to raise the peer pressure-induced crisis probability in the foreign country (i.e., $\mathrm{d}p^*/\mathrm{d}R|_{D^*=\bar{D}^*}>0$) and, therefore, reduce its borrowing capacity (i.e., $\mathrm{d}D^*/\mathrm{d}R|_{D^*=\bar{D}^*}<0$). When these effects are taken into consideration in the global social planner's choice of home and foreign reserves to maximize the joint welfare, both countries would optimally hold lower reserves and effectively internalize peer-pressure externalities.

Given optimal reserves for home and foreign countries under cooperation, let me consider that each country now chooses capital investment to maximize its own welfare. The optimal condition for investment in the home country is then displayed below:

$$f(K+I) \tag{28}$$
$$=\frac{R}{\eta\beta_1(\delta+\varepsilon)}\left[\frac{f'}{1+\rho}\left(\left(\mathrm{T}-\beta_2(\delta+\varepsilon)\right)\mathrm{V}+\left\{\eta\beta_1(\delta+\varepsilon)\left(\rho-r_f\right)\left(\mathrm{T}-\beta_2(\delta+\varepsilon)\right)\mathrm{V}\right\}^{1/2}\right)\right.$$
$$\left.-\left(1+r_f\right)\right]$$

In comparison to Eq. (23), the optimal investment under cooperation in Eq. (28) seems to be greater mainly due to the term $\eta\beta_1(\delta+\varepsilon)\left(\rho-r_f\right)\left(\mathrm{T}-\beta_2(\delta+\varepsilon)\right)\mathrm{V}$, which is a decreasing function of the Joneses parameter β_2. This result implies that the reduced need for holding reserves under cooperation allows the economy's resources to be redirected toward riskier yet more productive investments with possible welfare gains. I further explore theoretical implications by parameterizing the model and solving it numerically in the next section.

4. Quantitative analysis

This section first presents the optimal solutions of the model for reserves, investment, external debt, crisis probability, and utility levels in the benchmark, the Joneses, and cooperation cases under the baseline parameter values. I then conduct some sensitivity analyses.

4.1. Baseline numerical solutions

My choice of baseline parameter values are listed in Table 4. Whenever possible, I selected the values close to those of similar models in the prior literature.

[Insert Table 4 here]

The risk-free rate r_f is sourced from Bianchi et al. (2013), discount rate ρ from Aizenman and Marion (1999), good productivity shock δ and crisis catch-all parameter β_0 from Jeanne and Ranciere (2011), and default penalty η, bad productivity shock ε, and crisis responsiveness to debt-to-reserve ratio β_1 from Steiner (2014).[18] Without having a good reference source, the sensitivity to the Joneses effect β_2 is assumed to be as strong as the crisis responsiveness to debt-to-reserve ratio. The baseline value for initial capital K is selected to produce economically relevant (i.e., positive) solutions.

To numerically solve the model, a simple square root function is adopted for the production function, which substantially reduces computational complexity and yet satisfies the

[18] According to the probit regression result in Table 3 of Steiner (2014), the marginal effect of debt-to-reserve ratio on a financial crisis probability is estimated to be 0.019 in emerging markets.

usual properties of capital. Note that when deriving numerical solutions for the Joneses case, I use the benchmark optimal reserves as a proxy for the Joneses' reserves at the beginning of period 1.

Panel A in Table 5 displays the optimal levels of reserves, capital investment, and external debt in the benchmark, Joneses and cooperation settings using the baseline parameter values in Table 4. Comparing the numerical solutions in the first two columns, I find that the Joneses effect raises the reserve level by 18.84% as expected while decreasing the investment by 0.07%. Despite higher reserves, lower investment and higher crisis probability reduce the optimal level of debt ceiling by 0.15% in the presence of the Joneses effect.

[Insert Table 5 here]

While it makes sense for there to be a large increase in reserves as the model is extended to capture the rivalry motive, there is only a slight decrease in investment, which deserves more explanations. Firstly, an increased crisis probability in the presence of the Joneses effect and the resulting decline in the expected marginal return from capital and borrowing capacity weaken potential complementarity between reserves and investment. Then, why did the tradeoffs between the two assets not push the investment to an even lower level? This is partly attributed to the concavity of the production function. In my numerical exercise, it is relevant that the smaller the level of current capital stock, the larger the loss in output from a unit decrease in capital. As a result, the model correctly predicts the fall in investment, but only by a minuscule amount even with a sharp rise in reserves.

As shown in the last column of Table 5, international cooperation enables participating countries to internalize the peer-pressure externality: notably, the optimal reserves decline by 15.12% and investment rises by 3.63%, compared to the Joneses case solutions. The optimal debt ceiling also rises by 0.92% under cooperation.

In order to examine how the resource allocations reported in panel A lead to different aggregate outcomes in the economy, I turn to evaluating the crisis probability and the level of utility across different cases. Panel B in Table 5 displays model predictions for the optimal levels of these variables.

By the model design, the competitive motive raises the probability of crisis relative to the benchmark case. It makes the economy more vulnerable to external shocks even with larger reserves and reduces the economy's optimal levels of investment and external debt. Consequently, compared to the benchmark solution, the economy's optimal utility declines by 0.18% in the Joneses case.

If it is publicly known that the home and foreign countries' reserves are managed together by a supranational authority under cooperation, the crisis probability of each country will be updated as follows:

$$p(D, R, R^*) = \alpha + \beta_1 \left(\frac{D}{R + R^*} \right) \quad \text{where } \alpha = \beta_0 + \beta_2 \tag{29}$$

The probability function in Eq. (29) reflects an elimination of the competitive motive as well as access to a larger pool of reserves under cooperation. With the larger pool of reserve assets signaling access to a greater volume of liquid collateral, the model prediction in the last column of panel B in Table 5 shows that the crisis probability noticeably declines under cooperation. The

lower crisis probability also means a greater chance of a favorable productivity shock in period 2, supporting higher investment and debt ceiling. Accordingly, the reserve policy coordination raises the economy's utility by 0.12% compared to the Joneses case, demonstrating welfare-enhancing allocations between riskless reserves and risky capital investment.

4.2. Sensitivity analysis

As the final step of the quantitative investigation, I undertake a sensitivity analysis by allowing variations in some parameters of interest as presented in the last column of Table 4 while keeping other parameters of the model at their baseline values.

As a first sensitivity analysis, Fig. 3 illustrates the optimal solutions for reserves, investment, external debt, and utility at various degrees of sensitivity to the Joneses effect, β_2. This parameter highlights a country's sensitivity to competition in reserve accumulation, whose magnitude might become greater as the rival's market size is relatively large in the region (as the empirical result in Section 2 suggests when using the value-weighted Joneses index).

[Insert Fig. 3 here]

The model predictions in the Joneses case, depicted by short-dashed lines, show rising reserves and slightly falling investment and debt levels as the competitive incentive becomes stronger. As a result, utility levels decline with a rise in sensitivity to the Joneses effect. Relative to the Joneses case predictions, international cooperation, depicted by long-dashed lines, yields higher optimal levels of investment, external debt, and utility while keeping the reserves low at

around the benchmark level across a range of values for β_2. It is worth noting that, unlike the Joneses case, the optimal reserves under cooperation are negatively associated with β_2, reflecting the effect of policy coordination designed to remove inefficient competition in reserve accumulation.

Figs. 4−7 plot optimal solutions while varying the other key parameters of interest. The general pattern found is that optimal reserves under both the Joneses and cooperation cases rise with an increase in bad productivity shock ε, default penalty η, crisis responsiveness to debt-to-reserve ratio β_1, and risk-free rate r_f. The reasons for these findings are that the higher risk-free rate increases the rate of return for holding reserve assets, and the greater values for the other parameters promote the precautionary demand for reserves. As in Fig. 3, the model continues to predict that the optimal reserves under cooperation closely replicate those of the benchmark levels and are sufficiently lower than the levels that the Joneses case suggests.

[Insert Fig. 4−Fig. 7 here]

Model solutions also reveal that optimal investment always stays higher under cooperation than under the Joneses case whose prediction remains marginally lower than that of the benchmark case. Expectedly, optimal investments under both the Joneses and cooperation cases fall when there is an increase in ε, β_1, and r_f, owing to a decline in the expected marginal return from capital or to a rise in the opportunity cost of investing in capital. By contrast, there seems to be a positive relationship between optimal investment and η. This is because a higher default penalty tends to push up the debt ceiling one for one, which relaxes the external credit constraint and tradeoffs between reserves and investment in period 1.

Finally, I find that the optimal solutions for external debt and utility are consistently higher under cooperation than under the Joneses case. These robust results confirm that there exist welfare gains from cooperation by encouraging more productive allocations between risky and riskless assets.

5. Concluding remarks

This paper is motivated by the observation that the rapid growth of international reserves in developing economies has continued since the 1990s with no sign of stopping, and part of the excessive demand for reserves may come from peer-pressure motives. In this study, I reinforce empirical evidence of the keeping-up-with-the-Joneses effect in reserve accumulation, particularly persistent in developing countries in Asia and Latin America, using the proposed value-weighted Joneses index.

Holding massive reserves could entail potentially large costs such as forgone returns from more profitable assets, inflationary pressures following an incomplete sterilization procedure, and global imbalances, among others. These economic costs as well as the empirical findings of the paper have guided a theoretical exploration to test whether the policy coordination can alleviate the need for competitive hoarding and lead to more efficient asset allocations.

The quantitative analyses based on a simple two-period model show that, compared to the Joneses case, the optimal level of reserves declines noticeably under international cooperation while the capital investment and external borrowing increase. This result suggests greater demand for regional pooling arrangements (Rajan et al., 2005) given that reserve co-management

can lead to welfare improvement and effectively internalize competitive hoarding externalities. Furthermore, the reduced reserve holdings in developing countries under cooperation could contribute to lessening the extent of global imbalances and the risk of a financial crisis in the reserve currency country (Steiner, 2014).

There are some critical caveats to my approach. In practice, implementing a regional coordination for reserve management could involve various costs of arrangement and operation, potential moral hazard among participants, and contract enforceability concerns of supranational legal authorities.[19] These important issues are not explicitly addressed in this paper and left for future research.

[19] For relevant discussions, see Eichengreen (2007).

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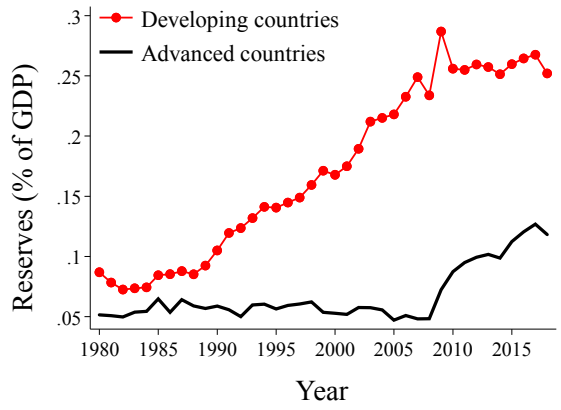
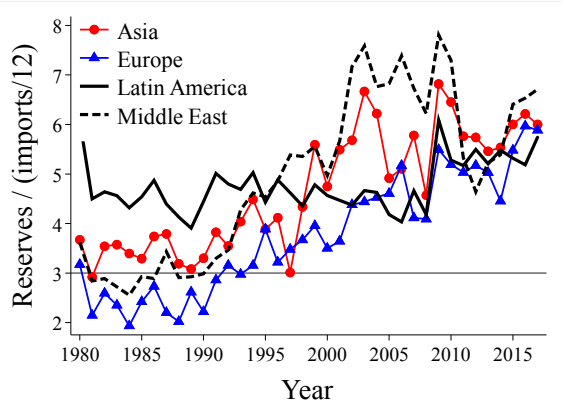
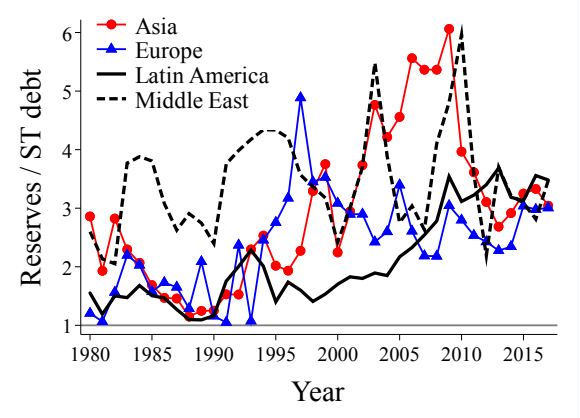


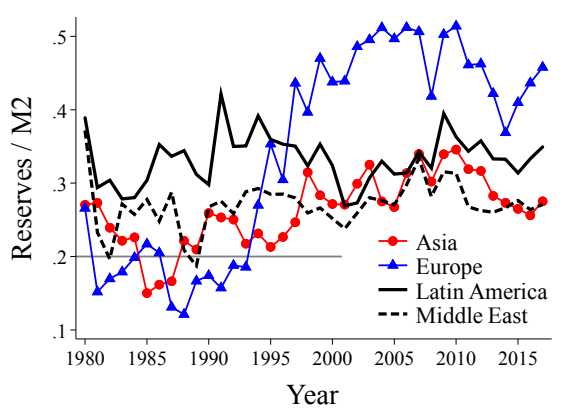
(a) Reserve-to-GDP ratio by income levels



(b) Reserve-to-import ratio



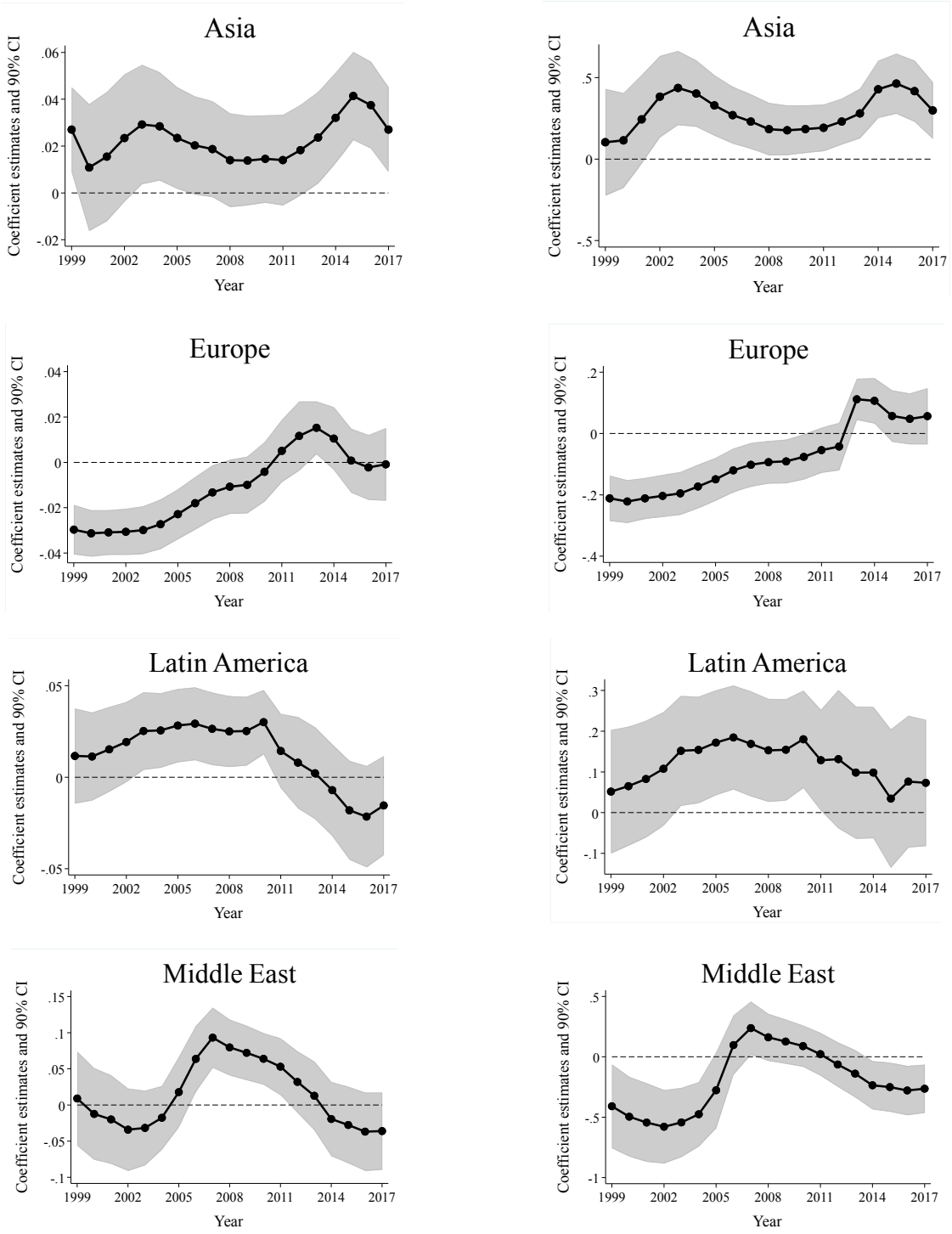
(c) Reserve-to-ST debt ratio



(d) Reserve-to-M2 ratio

Fig. **1**. Evolution of international reserves, 1980-2017.

Notes: Panel (a) uses the 20 advanced countries and 45 developing countries. Panels (b), (c), and (d) use the same set of developing countries used in panel (a). Horizontal lines in panels (b), (c), and (d) indicate conventional reserve adequacy ratios.



(a) Estimations using a standard Joneses index

(b) Estimations using a value-weighted Joneses index

Fig. 2. Time-varying evidence for the Joneses effect across regions.

Notes: The time-varying Joneses effects are estimated using rolling-window regressions between 1980 and 2017 with a window size of 20 years. The results based on a standard Joneses index with 90% confidence intervals are displayed in panel (a) and a value-weighted Joneses index in panel (b).

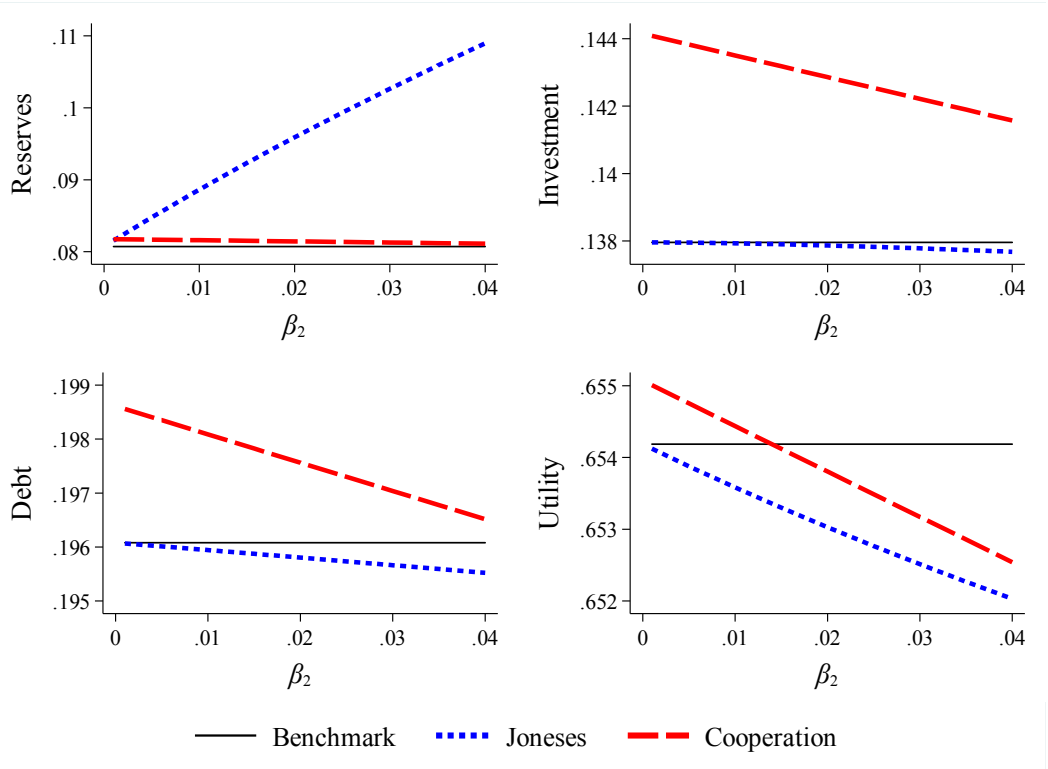


Fig. **3**. Optimal solutions at various levels of sensitivity to the Joneses effect β_2.

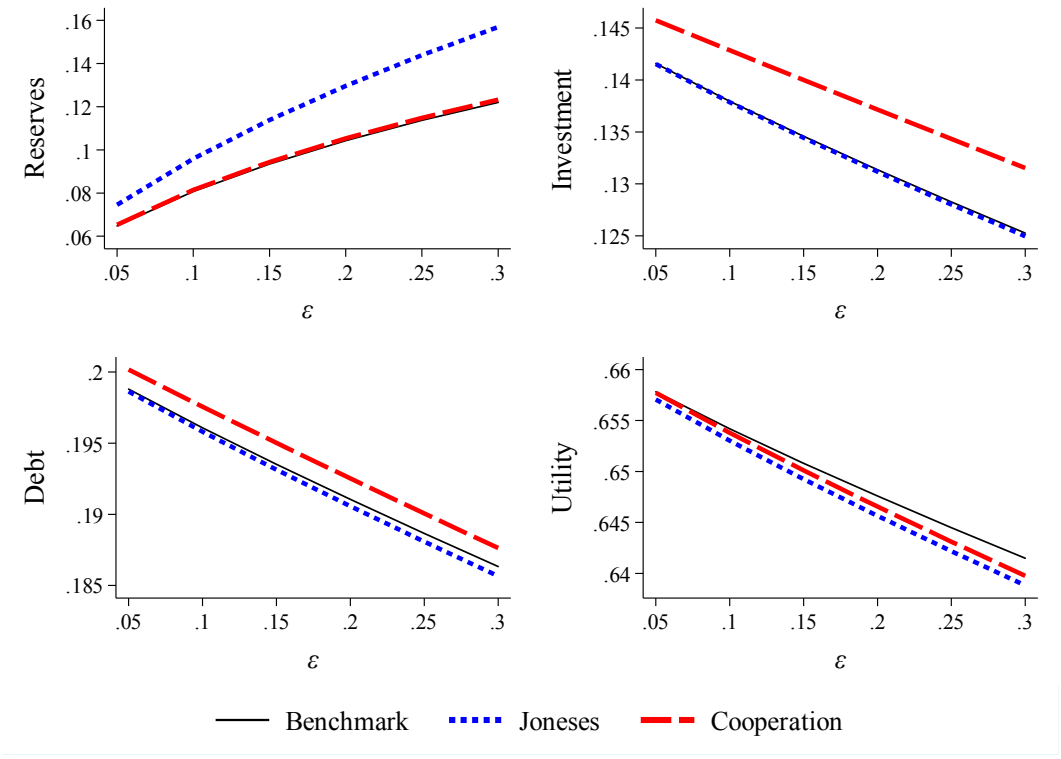


Fig. **4**. Optimal solutions at various levels of bad productivity shock ε.

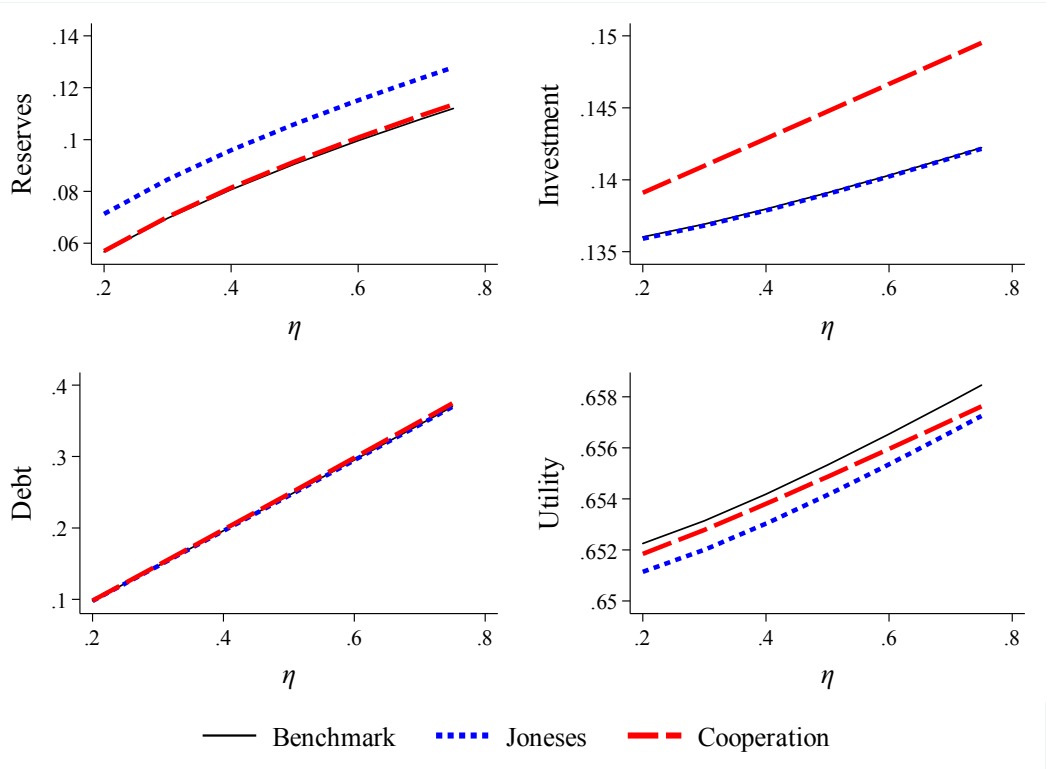


Fig. **5**. Optimal solutions at various levels of the default penalty η.

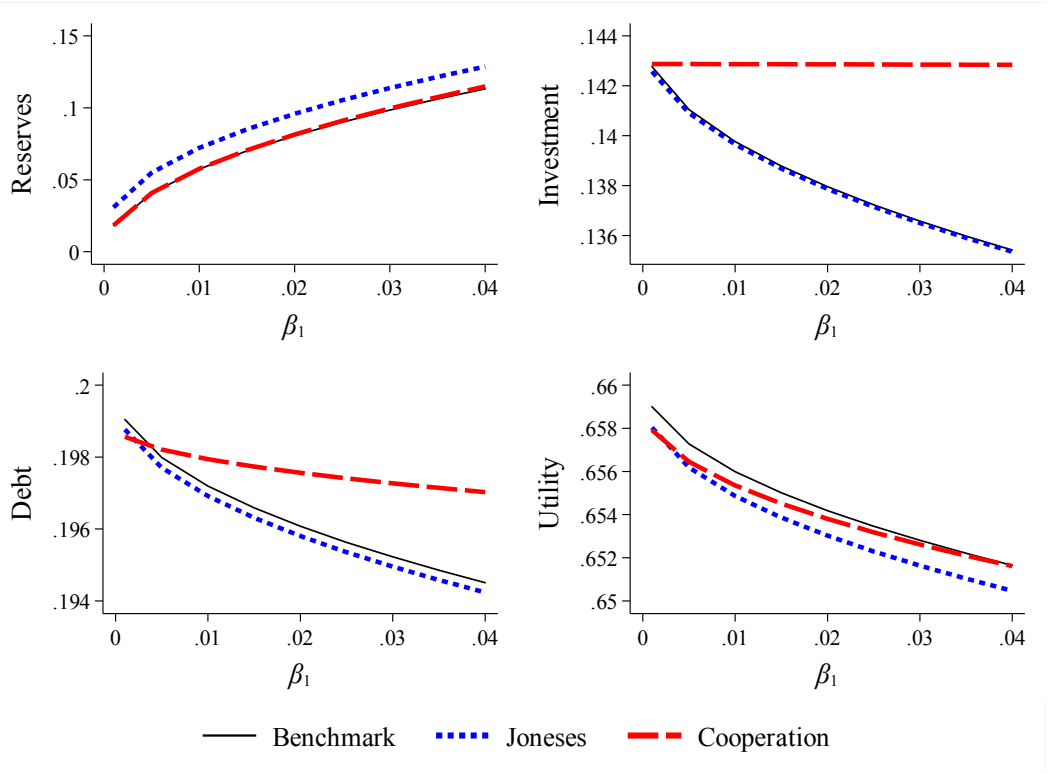


Fig. **6**. Optimal solutions at various levels of the crisis responsiveness to debt-to-reserve ratio β_1.

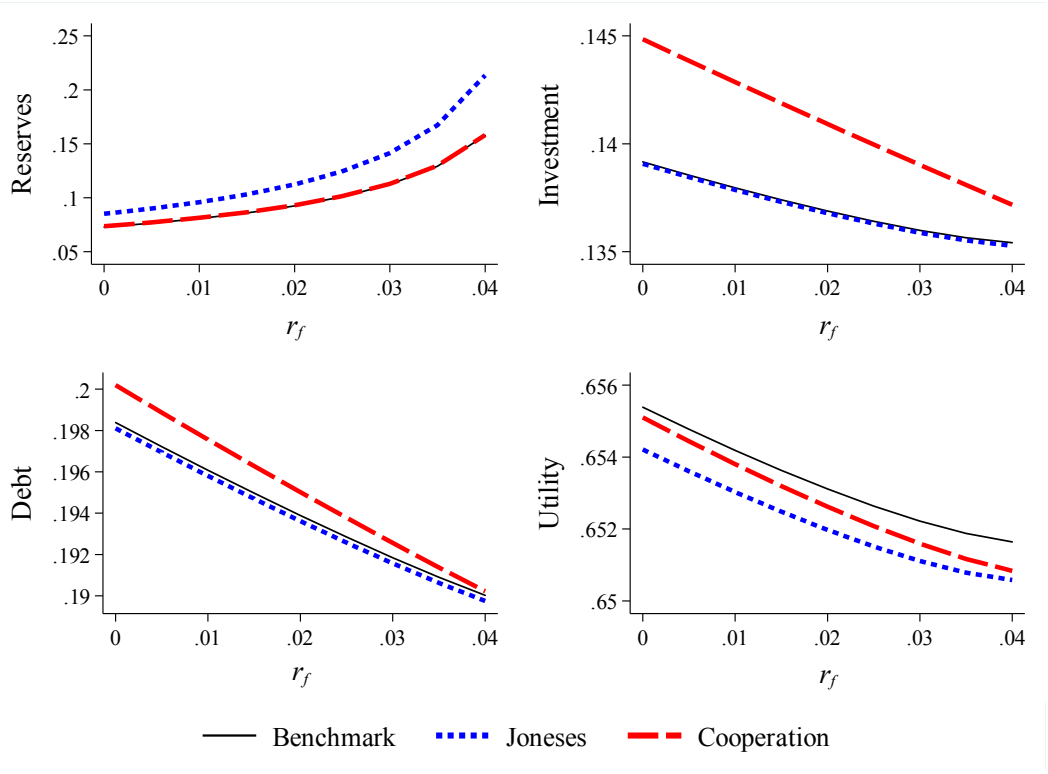


Fig. **7**. Optimal solutions at various levels of the risk-free rate r_f.

Table 1
The Joneses effect: main results.

Notes: The dependent variable is the log of the ratio of total reserves to GDP. The table reports coefficient estimates from panel fixed-effect regressions. Standard errors are reported in parentheses. All independent variables are lagged by one year except for "reserve volatility" that is constructed based on the information in the past five years from $t-5$ to $t-1$. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

	Traditional model			Financial model			Full model		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Standard Joneses		**0.025*****			**0.029*****			**0.021*****	
		(0.006)			(0.005)			(0.006)	
Value-weighted Joneses			**0.137*****			**0.173*****			**0.126*****
			(0.034)			(0.028)			(0.034)
ln[GDP/person]	0.617***	0.402***	0.427***				0.389***	0.232***	0.232***
	(0.054)	(0.072)	(0.072)				(0.069)	(0.080)	(0.080)
ln[imports/GDP]	0.771***	0.727***	0.724***				0.674***	0.652***	0.645***
	(0.066)	(0.066)	(0.067)				(0.068)	(0.068)	(0.068)
Reserve volatility	-0.122***	-0.107***	-0.105***				-0.059	-0.051	-0.048
	(0.032)	(0.032)	(0.032)				(0.038)	(0.038)	(0.038)
ln[M2/GDP]				0.632***	0.452***	0.460***	0.250***	0.214***	0.221***
				(0.046)	(0.054)	(0.054)	(0.061)	(0.061)	(0.061)
ln[ST debt/GDP]				0.149***	0.147***	0.139***	0.114***	0.119***	0.114***
				(0.020)	(0.020)	(0.020)	(0.021)	(0.020)	(0.020)
Financial openness				0.026*	0.005	0.012	-0.023	-0.032**	-0.027*
				(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Hard peg				-0.112**	-0.092*	-0.103**	-0.058	-0.049	-0.057
				(0.053)	(0.053)	(0.053)	(0.051)	(0.051)	(0.051)
Crawling peg				0.013	0.011	0.009	-0.053	-0.043	-0.045
				(0.041)	(0.040)	(0.040)	(0.039)	(0.039)	(0.039)
Observations	1,152	1,151	1,152	1,153	1,152	1,153	1,131	1,130	1,131
Adjusted R^2	0.726	0.729	0.729	0.715	0.723	0.724	0.747	0.748	0.750

Table 2
The Joneses effect: controlling for other reserve determinants.

Notes: The dependent variable is the log of the ratio of total reserves to GDP. The table reports coefficient estimates from panel fixed-effect regressions. Standard errors are reported in parentheses. All independent variables are lagged by one year, except for "reserve volatility" and "crisis" that are constructed based on the information in the past five years from $t-5$ to $t-1$. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

	Add crisis		Add gross saving		Add opportunity cost	
	(1)	(2)	(3)	(4)	(5)	(6)
Standard Joneses	**0.021*****		**0.018*****		**0.012***	
	(0.006)		(0.006)		(0.006)	
Value-weighted Joneses		**0.123*****		**0.112*****		**0.088****
		(0.034)		(0.034)		(0.038)
ln[GDP/person]	0.230***	0.231***	0.198**	0.194**	0.113	0.090
	(0.080)	(0.080)	(0.081)	(0.081)	(0.078)	(0.079)
ln[imports/GDP]	0.646***	0.639***	0.696***	0.690***	0.659***	0.657***
	(0.068)	(0.069)	(0.070)	(0.070)	(0.065)	(0.065)
Reserve volatility	-0.062	-0.059	-0.052	-0.048	0.016	0.019
	(0.039)	(0.039)	(0.038)	(0.038)	(0.039)	(0.039)
ln[M2/GDP]	0.217***	0.224***	0.174***	0.182***	0.356***	0.362***
	(0.061)	(0.061)	(0.062)	(0.062)	(0.062)	(0.062)
ln[ST debt/GDP]	0.118***	0.113***	0.125***	0.121***	0.019	0.018
	(0.021)	(0.020)	(0.021)	(0.021)	(0.021)	(0.021)
Financial openness	-0.030**	-0.026*	-0.016	-0.013	-0.067***	-0.065***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.014)	(0.014)
Hard peg	-0.052	-0.059	-0.095*	-0.101**	0.001	0.004
	(0.051)	(0.051)	(0.052)	(0.052)	(0.051)	(0.051)
Crawling peg	-0.044	-0.045	-0.049	-0.050	-0.026	-0.026
	(0.039)	(0.039)	(0.040)	(0.040)	(0.038)	(0.038)
Crisis	0.015	0.015				
	(0.012)	(0.012)				
ln[gross saving/GDP]			0.203***	0.211***		
			(0.043)	(0.043)		
ln[1+opportunity cost]					-1.492***	-1.457***
					(0.185)	(0.187)
Number of countries	45	45	45	45	39	39
Observations	1,130	1,131	1,102	1,103	845	846
Adjusted R^2	0.749	0.750	0.751	0.753	0.803	0.805

Table 3
The Joneses effect: heterogeneity across regions.

Notes: The dependent variable is the log of the ratio of total reserves to GDP. The table reports coefficient estimates from panel fixed-effect regressions. Standard errors are reported in parentheses. All independent variables are lagged by one year, except for "reserve volatility" that is constructed based on the information in the past five years from $t-5$ to $t-1$. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

	Asia		Europe		Latin America		Middle East	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standard Joneses	**0.023****		**-0.017****		**0.005**		**0.050***	
	(0.010)		(0.007)		(0.011)		(0.027)	
Value-weighted Joneses		**0.249*****		**-0.081***		**0.140****		**-0.067**
		(0.074)		(0.043)		(0.070)		(0.118)
ln[GDP/person]	0.323***	0.226*	0.271	0.238	0.302*	0.120	0.097	0.579*
	(0.124)	(0.128)	(0.180)	(0.179)	(0.158)	(0.172)	(0.310)	(0.313)
ln[imports/GDP]	0.654***	0.621***	0.342**	0.337**	0.800***	0.789***	0.144	0.074
	(0.112)	(0.112)	(0.137)	(0.137)	(0.108)	(0.107)	(0.231)	(0.230)
Reserve volatility	0.017	0.038	0.007	0.003	-0.088	-0.086	0.209*	0.223**
	(0.088)	(0.087)	(0.054)	(0.054)	(0.063)	(0.062)	(0.110)	(0.111)
ln[M2/GDP]	0.433***	0.385***	0.249**	0.234*	0.070	0.053	0.372	0.676**
	(0.128)	(0.128)	(0.120)	(0.120)	(0.088)	(0.088)	(0.277)	(0.283)
ln[ST debt/GDP]	-0.174***	-0.160***	0.130***	0.134***	0.097***	0.096***	0.319***	0.345***
	(0.046)	(0.044)	(0.042)	(0.042)	(0.032)	(0.032)	(0.065)	(0.065)
Financial openness	-0.025	0.004	0.047	0.044	0.017	0.016	-0.029	0.007
	(0.047)	(0.048)	(0.032)	(0.032)	(0.023)	(0.022)	(0.045)	(0.044)
Hard peg	-0.072	-0.068	0.543***	0.551***	-0.651***	-0.644***	0.405**	0.369**
	(0.080)	(0.079)	(0.103)	(0.104)	(0.087)	(0.087)	(0.176)	(0.179)
Crawling peg	-0.123*	-0.111*	0.274***	0.273***	-0.256***	-0.251***	0.215	0.263
	(0.069)	(0.067)	(0.068)	(0.069)	(0.057)	(0.057)	(0.184)	(0.184)
Number of countries	12	12	11	11	14	14	8	8
Observations	313	314	243	243	370	370	204	204
Adjusted R^2	0.874	0.878	0.716	0.714	0.725	0.727	0.584	0.577

Table 4
Baseline parameters.

Parameters	Baseline	Range of variation
Risk-free rate	$r_f = 0.01$	[0, 0.04]
Discount rate	$\rho = 0.05$	
Default penalty	$\eta = 0.4$	[0.2, 0.75]
Initial capital	$K = 0.1$	
Good productivity shock	$\delta = 0.035$	
Bad productivity shock	$\varepsilon = 0.1$	[0.05, 0.3]
Crisis catch-all parameter	$\beta_0 = 0.1$	
Crisis responsiveness to D/R	$\beta_1 = 0.02$	[0.001, 0.04]
Sensitivity to the Joneses effect	$\beta_2 = 0.02$	[0.001, 0.04]

Table 5
Numerical solutions.

Notes: The numerical solutions in this table are obtained using the baseline parameter values in Table 4.

	Benchmark	Joneses	Cooperation
A. Optimal model solutions			
Reserves	0.0807	0.0959	0.0814
Investment	0.1380	0.1379	0.1429
Debt	0.1961	0.1958	0.1976
B. Implied crisis probability and utility			
Crisis probability	0.1486	0.1577	0.1443
Utility	0.6542	0.6530	0.6538

Online Appendix

"International Cooperation in Foreign Reserve Policies in the Presence of Competitive Hoarding"

Table A.1

Notes: Four regions for developing countries correspond to East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, and Middle East & North Africa, respectively, according to the World Bank's classification.

Developing countries				Advanced countries
Asia	Europe	Latin America	Middle East	
China	Armenia	Argentina	Egypt	Australia
Hong Kong	Bulgaria	Brazil	Israel	Austria
India	Czech Rep.	Chile	Jordan	Belgium
Indonesia	Georgia	Colombia	Lebanon	Canada
Korea	Hungary	Costa Rica	Morocco	Denmark
Malaysia	Kazakhstan	Ecuador	Saudi Arabia	Finland
Pakistan	Poland	El Salvador	Tunisia	France
Philippines	Romania	Guyana	United Arab Emirates	Germany
Singapore	Russia	Jamaica		Iceland
Sri Lanka	Turkey	Mexico		Ireland
Thailand	Ukraine	Panama		Italy
Vietnam		Paraguay		Japan
		Peru		Luxembourg
		Uruguay		Netherlands
				Norway
				Spain
				Sweden
				Switzerland
				United Kingdom
				United States

Table A.2
Relative market capitalization in each region.

Notes: This table presents a country's share (%) of stock market capitalization within each geographic region. Market capitalization data are taken from the observations in 2010, except for Czech Republic whose 2008 value is used instead due to the limited data availability. Sources: The author's calculations based on the World Bank WDI and St. Louis Fed's FRED databases.

Asia		Europe		Latin America		Middle East	
Country	Share	Country	Share	Country	Share	Country	Share
China	35.30	Armenia	0.01	Argentina	2.33	Egypt	9.16
Hong Kong	23.76	Bulgaria	0.46	Brazil	56.39	Israel	24.74
India	14.30	Czech Republic	2.56	Chile	12.47	Jordan	3.35
Indonesia	3.16	Georgia	0.05	Colombia	7.61	Lebanon	1.38
Korea	9.57	Hungary	1.73	Costa Rica	0.05	Morocco	7.52
Malaysia	3.58	Kazakhstan	1.67	Ecuador	0.17	Saudi Arabia	38.41
Pakistan	0.33	Poland	11.92	El Salvador	0.14	Tunisia	1.16
Philippines	1.38	Romania	0.89	Guyana	0.01	United Arab Emirates	14.29
Singapore	5.67	Russia	59.46	Jamaica	0.14		
Sri Lanka	0.17	Turkey	18.91	Mexico	16.58		
Thailand	2.43	Ukraine	2.34	Panama	0.30		
Vietnam	0.32			Paraguay	0.03		
				Peru	3.77		
				Uruguay	0.01		

Table A.3
Variable descriptions and data sources.

Notes: The exchange rate regime data from Ilzetzki et al. (2019) are available up to 2016 and the missing observations in 2017 are replaced by the 2016 values.

Variable name	Description	Source
Reserves	A ratio of total reserves (excluding gold) to GDP	WDI
GDP/person	GDP per capita, PPP (constant 2011 international $)	WDI
Imports/GDP	Imports as a share of GDP	WDI
Reserve volatility	Standard deviations of the growth of reserve-to-GDP ratio in the past five years from $t-5$ to $t-1$	WDI
M2/GDP	Broad money as a share of GDP	WDI
ST debt/GDP	Short-term external debt with a maturity of one year or less as % of GDP. If unavailable from WDI, I follow Dominguez et al. (2012) and use the data from JEDH where the short-term debt is the sum of ST liabilities to BIS banks, ST international debt securities, cross-border loans from BIS reporting banks, and international debt securities.	WB JEDH and WDI
Financial openness	De jure measure of capital account openness	Chinn and Ito (2006)
Hard peg	Dummy variable controlling for hard peg (coarse classification code = 1).	Ilzetzki et al. (2019)
Crawling peg	Dummy variable controlling for crawling peg (coarse classification code = 2).	Ilzetzki et al. (2019)

Table A.4
Summary statistics for all variables.

Variable	Observations	Mean	Std. Dev.	Min	Max
ln[reserves/GDP]	1,233	-1.939	0.849	-6.892	0.233
Standard Joneses	1,233	-20.682	7.184	-37.963	-5.902
Value-weighted Joneses	1,260	-1.899	0.714	-4.144	-0.442
ln[GDP/person]	1,259	9.316	0.783	7.285	11.629
ln[imports/GDP]	1,241	3.639	0.604	1.533	5.398
Reserve volatility	1,201	0.333	0.457	0.017	6.337
ln[M2/GDP]	1,217	3.988	0.640	1.920	5.981
ln[ST debt/GDP]	1,247	2.610	1.752	-6.398	7.350
Financial openness	1,220	0.438	1.317	-2	2
Hard peg	1,260	0.259	0.438	0	1
Crawling peg	1,260	0.354	0.478	0	1

Table A.5
Correlation matrix.

Notes: * indicates significance at the 5 percent level.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	ln[reserves/GDP]	1										
(2)	Standard Joneses	0.340*	1									
(3)	Value-weighted Joneses	0.369*	0.763*	1								
(4)	ln[GDP/person]	0.416*	0.199*	0.167*	1							
(5)	ln[imports/GDP]	0.595*	0.217*	0.195*	0.271*	1						
(6)	Reserve volatility	-0.201*	-0.114*	-0.271*	-0.236*	-0.041	1					
(7)	ln[M2/GDP]	0.631*	0.454*	0.505*	0.263*	0.456*	-0.218*	1				
(8)	ln[ST debt/GDP]	0.497*	0.040	0.080*	0.658*	0.582*	-0.179*	0.426*	1			
(9)	Financial openness	0.332*	-0.004	0.024	0.375*	0.390*	-0.189*	0.143*	0.444*	1		
(10)	Hard peg	0.157*	0.133*	0.017	0.107*	0.195*	-0.020	0.281*	0.197*	0.234*	1	
(11)	Crawling peg	-0.119*	0.046	0.072*	-0.290*	-0.014	0.033	-0.182*	-0.261*	-0.067*	-0.446*	1