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Jordan's International Reserve Position: Justifiably Strong

Saade Chami, Donal McGettigan, and Stanley Watt

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Jordan's International Reserve Position: Justifiably Strong

Prepared by Saade Chami, Donal McGettigan, and Stanley Watt[1]

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Abstract

Jordan has seen a large increase in its international reserve holdings in recent years. While a healthy reserve buffer is needed under a fixed exchange rate regime, determining optimal reserve levels is not straightforward. In this paper, we first use several traditional measures of reserves adequacy to compare Jordan's reserve holdings with other emerging market (EM) countries. Subsequently, we analyze Jordan's reserve holdings using a reserves-optimizing model, based on Jeanne and Ranciere (2006) (J-R), but extended to allow reserve holdings to influence the likelihood of a sudden stop. The overall analysis suggests that Jordan's reserve holdings provide sufficient support to sustain the dinar peg and to deal with the most extreme capital account disruptions.

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Authors' E-Mail Addresses: schami@imf.org; dmcgettigan@imf.org; and swatt@imf.org

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I. INTRODUCTION

Jordan's economy has strengthened substantially in recent years. Reflecting supportive economic policies under successive Fund-supported programs, Jordan's economic growth rate has been impressive, inflation has been cut, the public debt burden has been lowered substantially, the banking system is stronger, and international reserves have increased sharply, from less than US$½ billion in 1989 to more than US$6 billion at end-2006.

Despite these accomplishments, Jordan still faces some medium-term challenges, the most important being its large current account deficit, which, at 16 percent of GDP, is one of the highest in emerging market (EM) economies. Although the quality of external financing is high—mainly in the form of long-term foreign direct investment (FDI)—Jordan may nevertheless be vulnerable to sudden shifts in investor sentiment and regional political uncertainties.

Holding international reserves in the case of Jordan is desirable both to deal with possible sudden stops[2] and to support the exchange rate peg, which has been in place since the creation of the dinar in 1950, except for a short period in the late 1980s. Holding sufficient foreign exchange reserve also provides comfort to market participants and foreign investors.

This paper examines whether Jordan's holdings of international reserves are sufficient to deal with sudden capital account reversals, taking into account the impact of reserves on the probability of a sudden stop. In doing so, it attempts to analyze Jordan's reserve holding from a cross-country perspective using widely-used traditional measures of reserves adequacy and by formulating a model that allows for estimates of optimal reserve holdings for Jordan.

In our model, we adopt the J-R approach by allowing reserves not only to help rollover debt in a sudden stop crisis, but also to impact the probability of a sudden stop. Many papers have argued that such an effect exists (Hashimoto, 2007; Garcia and Soto, 2004; Chamon, Manasse, and Prati, 2006). If this is indeed the case, the crisis moderating aspect of reserves should be allowed to play a role in determining the optimal level of reserves.

In terms of our findings, although traditional measures of reserves adequacy (rules of thumb) do not suggest that Jordan's reserve holdings are out of line with its peers, model-based estimates of "optimal" reserves are much lower than actual reserve holdings. However, taking on board possible severe adverse shocks (including the possibility of large sudden stops and associated large output reductions) and sensible model extensions (factoring in heterogeneous consumers, longer-lasting output responses to sudden stops, and uncertainty) suggest that the gap between optimal and actual reserve holdings may not be that large. It is fair to say, however, that our detailed analysis provides support for the view that Jordan's

[2] Crises in emerging market economies provoked by "sudden stops" of capital inflows have become more prevalent since the 1990s. Typically, these crises result in large currency devaluations and severe output losses (Calvo, 2006).

reserve holdings are sufficient to cope with the most extreme of economic circumstances, and therefore provide important backing for the dinar peg to the U.S. dollar.[3]

The remainder of the paper proceeds as follows. Section II examines Jordan's reserve holdings in a cross-country context using several widely-used rules of thumb and simple reserve level comparisons. Although Jordan's reserve holdings are the highest in the EM sample compared to its short-term debt exposure, these holdings do not appear out of line according to other common metrics. Although peer comparisons are certainly useful, they provide little information on whether Jordan's reserve holdings are optimal unless one assumes that peers are, themselves, optimally managing reserves. Section III introduces a modified J-R model that incorporates the crisis-preventing attributes of reserves. In Section IV we calibrate the model and provide optimal reserve estimates for Jordan. Section V concludes.

II. Traditional Measures of Reserves Adequacy

This section attempts to examine how Jordan's reserve holdings compare with its EM counterparts using a variety of rules of thumb. These rules of thumb, and their various rationales, are presented in Table 1 below.

Jordan's reserves are by far the highest of the sample when compared to short-term external debt (Figure 1). Jordan's reserves cover its short-term external debt (by remaining maturity) more than seven times, reflecting, among other things, Jordan's deliberate and well-aimed policy of avoiding short-term public borrowing on commercial terms. But other measures do not suggest that reserves are out of line with other EMs. Reflecting Jordan's financial depth, and its extensive dollarization, reserve cover to both broad money and foreign exchange deposits falls in the lower half of the sample.[4] While reserve-to-import cover is in the upper half, Jordan has far lower coverage using a more comprehensive measure that factors in the current account deficit (adjusted for FDI flows) and foreign currency deposits in the banking system. Although no one of these measures fully captures the motivations for reserves, they provide a useful background against which to compare the results from a more formal model.

[3] Our analysis does not incorporate other benefits of reserves sometimes acknowledged in the literature. For example, Christofides, Mulder, and Tiffin (2003) cite reduced borrowing costs as a benefit to increased reserve holdings, and Hviding, Nowak, and Ricci (2004) find that reserves can curb currency volatility. These factors are, however, not that important for Jordan, a country with an exchange rate peg and little international borrowing on commercial terms.

[4] This remains true even if we exclude the Asian sample countries.

Table 1. Traditional Measures of International Reserves Adequacy

Measure	Description
Reserves/short-term external debt	This is the single most widely used reserves indicator for emerging market countries, providing a good indicator of liquidity risk from the rollover of foreign credit lines.
Reserves/broad money	This is a measure of reserve adequacy in the case of possible runs on the currency by domestic residents. The measure is, however, more appropriate for pegged exchange rate regimes (under a float, the currency can move to reflect demand for foreign assets from domestic sources). The ratio tends to trend lower as the degree of financial intermediation increases.
Reserves/FX deposits	This measure of reserves adequacy is particularly relevant in a dollarized economy. Its limitation is that, in the case of a run on the banking system itself, residents will also have recourse to withdrawing domestic currency deposits and exchanging the proceeds into foreign currency.
Reserves/imports	This is a more useful measure for less developed economies where potential reserve drains typically relate to the trade balance, rather than to capital flows. Typically, the guideline for these countries is that reserves should cover at least three to four months of imports.
Reserve cover	This measures reserve cover of short-term debt, the current account deficit (adjusted for FDI inflows), and foreign currency deposits in the banking system.

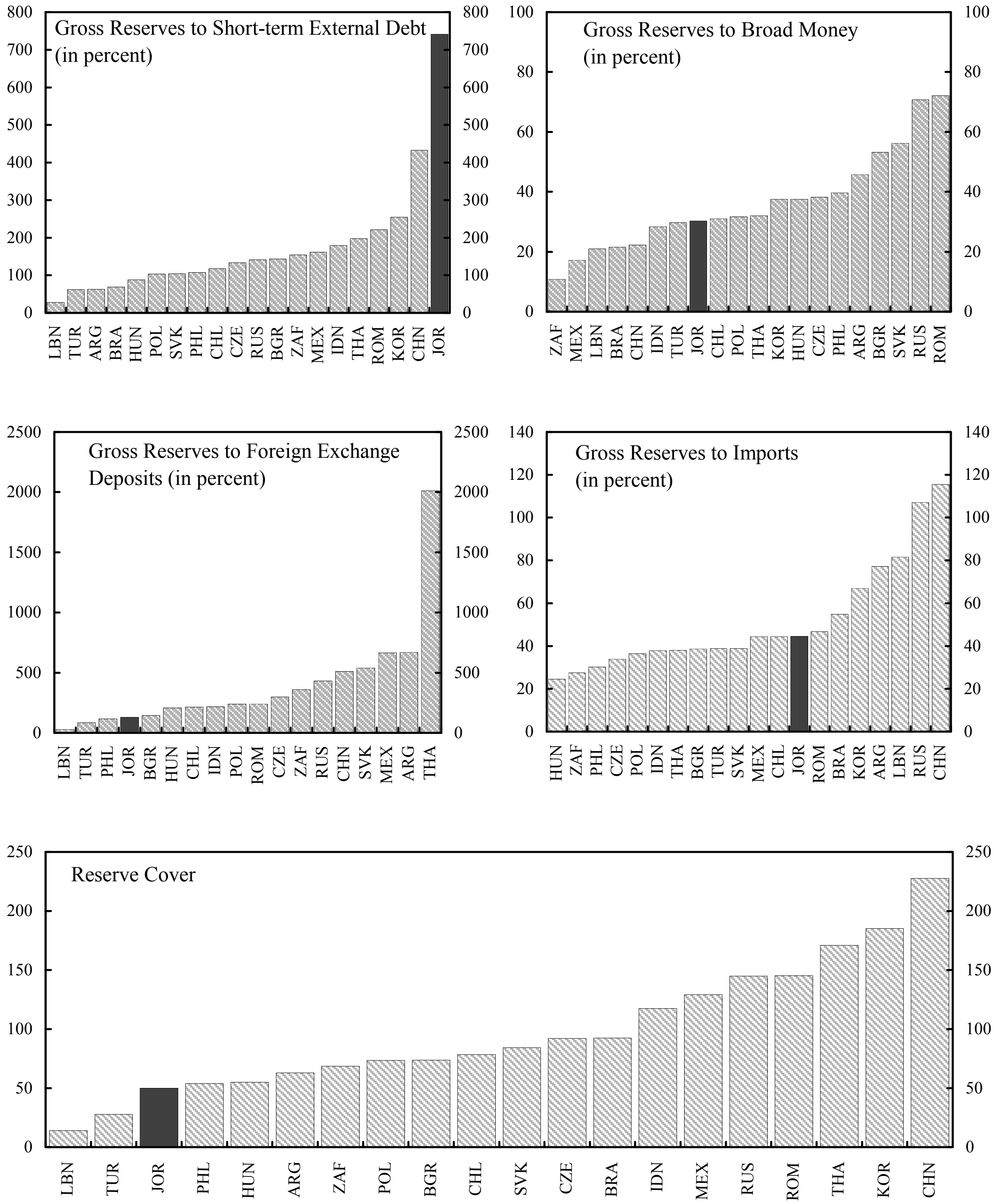
III. Modified J-R Model

We next present a model of sudden stops that closely follows the work of J-R. However, as explained above, we include an extension that allows reserves to have the additional effect of helping to prevent the onset of a sudden stop. By allowing for this additional benefit of holding reserves, the optimal level of reserves calculated in our model is higher than that predicted in the J-R model.

This modification is potentially important for Jordan where confidence factors might play a major role. This is very much in line with existing literature on optimal reserves. Bussière and Mulder (1999); Mody and Taylor (2002); Garcia and Soto (2004); Sachs, Tornell, and Velasco (1996); Chamon, Manasse, and Prati (2006); and Hashimoto (2007) all argue and find support for the proposition that reserves may lower the likelihood of a crisis. Countries with large holdings of reserves may inspire confidence and be less susceptible to panic leading to self-fulfilling crises.[5] This is consistent with the approach of the major credit-rating agencies, which factor in reserve holdings when determining sovereign credit ratings.

[5] Even in first generation models, such as Krugman (1979), additional reserves affect the timing of a crisis.

Figure 1. Jordan Reserve Benchmark Indicators (as of end-2005)



Sources: IFS; PDR Vulnerability Exercise; and staff calculations.

Thus, while J-R incorporates the consumption-smoothing role of reserves between sudden stop and non-sudden stop states, with government risk aversion providing the justification for holding a high level of reserves, our modification attempts to capture *both* the crisis-preventing attributes of reserves and their consumption-smoothing benefits. Unlike the J-R model, we assume for simplicity that the government issues only short-term debt instead of long-term debt (see below).

Consumers and the Government

Like J-R, we model a single open economy in discrete time. Domestic production in the economy is assumed to be exogenous and to grow at rate *g* each period. Thus, production at time *t*, Y_t, is equivalent to $Y_0(1+g)^t$ where Y_0 is domestic production in the initial period. Total private consumption in the economy obeys the following budget constraint:

$$C_t = Y_t + L_t - (1+r)L_{t-1} + Z_t \qquad (1)$$

where L_t is the amount of private foreign debt incurred by the domestic economy, Z_t is a transfer from the government, and *r* is the prevailing interest rate.

For simplicity, we assume that the path of L_t, private foreign borrowing, is exogenous so that private consumption in the economy is determined by the amount of government transfers (since, given *g*, the path of Y_t is exogenous). Although private foreign borrowing is exogenous, public borrowing by the government will be optimally chosen.

The government's function in the economy is very simple. Its only role is to acquire foreign reserves, which we denote as R_t. In order to acquire reserves, it issues a series of short-term debt to foreigners, which expire every period. In period *t*, the government sells the security, which pays one unit of consumption to the foreign bondholder in period *t+1* in the event that a sudden stop has not occurred. If a sudden stop has occurred, the security pays nothing to foreign bondholders and instead distributes these resources to domestic consumers. We denote the amount of the short-term security the government issues as N_t. Thus, the price of each security every period is

$$P_t = \frac{1-\pi_t(R_t)}{1+r+\delta} \qquad (2)$$

where π_t is the probability of a sudden stop, *r* is the interest rate, and δ is what J-R call a term premium. We assume that the probability of a sudden stop depends on the level of reserves, and so π_t is a function of R_t, the main difference between our model and that of J-R.

The model also differs here from J-R who treat government-issued debt as long term. Because in our model, the probability of a sudden stop varies every period, for analytical simplicity we assume that the government issues only short-term debt. Although the assumption is made for simplicity, long-term debt can be seen as the perpetual rolling over of short-term debt. This framework allows us to forego expressions that include the future probabilities of sudden stops.[6]

If there is no sudden stop, the government obeys the following budget constraint:

$$Z_t + R_t + N_t = P_t N_t + (1+r)R_{t-1}. \qquad (3)$$

Because we assume that the government issues this short-term debt only to finance reserves, $R_t = P_t N_t$.[7] When a sudden stop occurs, because the government does not fulfill its short-term debt obligations to foreigners, the budget constraint is simply $Z_t = (1+r)R_{t-1}$.

We note that in this model reserves are financed purely through the financial account by accumulating government debt. Of course, in practice, reserves are often built up through current account surpluses. In the case of Jordan, however, despite a large current account deficit reserves have been recently increasing through large capital inflows. Thus, in view of the recent experience of Jordan, this assumption seems reasonable.

Sudden Stops

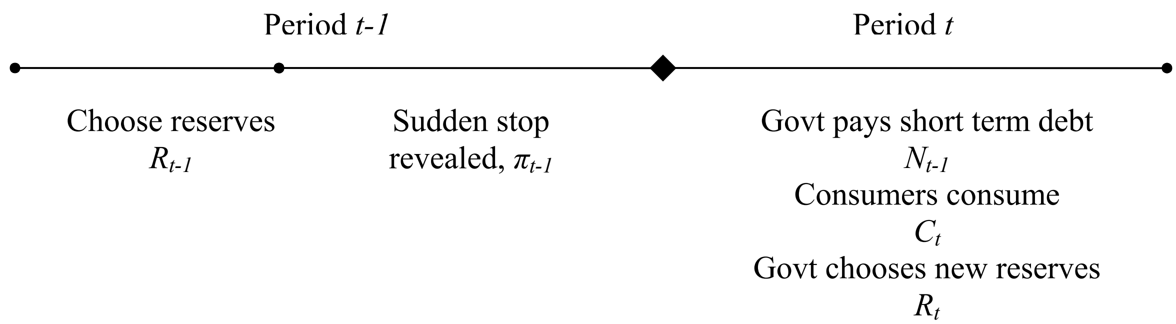
In every period there is a risk of a sudden stop, which will occur with probability π_t. The sudden stop is modeled as a liquidity crisis for domestic consumers such that they are not able to borrow in that period. Thus, when a sudden stop occurs, foreign private borrowing by domestic consumers, L_t, falls to zero. We also assume that this is coupled with an exogenous output shock as a sudden drop in liquidity will affect domestic production. Thus, during a sudden stop, output suffers a penalty γ, and $Y_t = Y_{t-1}(1+g)(1-\gamma)$.

The timing of the model is as follows. In period $t-1$, the government sells its security, N_{t-1}, and accumulates its reserves, R_{t-1}. Then, the outcome of a sudden stop, occurring with probability π_{t-1}, is known. In the next period, the government pays its obligations to foreigners (if there is no sudden stop), N_{t-1}, private consumers consume, C_t, and the government chooses a new level of reserves, R_t (Figure 2).

[6] In the Jeanne and Ranciere (2006) model, the probability of a sudden stop is assumed to be constant and exogenous. However, Jeanne and Ranciere's (2006) empirical calibration of the model includes an estimation where the probability of sudden stop actually changes period over period. Assuming the government debt to be short term simplifies the analysis where sudden stop probabilities are not constant.

[7] With this framework, the cost of holding reserves is explicit. Although the government earns a return of r on its reserves, it pays its creditors a return of $\frac{1+r+\delta}{1-\pi_t} - 1 = \frac{r+\delta+\pi_t}{1-\pi_t} > r$.

Figure 2. Timing of the Model



During a sudden stop, domestic private consumption falls as foreign lending evaporates and as production slows. However, during the sudden stop, the government ameliorates the consumption loss by distributing its sum of reserves to domestic consumers. Reserves serve as insurance to smooth consumption between sudden stop and non-sudden stop periods. This is useful if the government or domestic consumers are risk averse. If reserves can also help prevent the onset of a sudden stop, accumulating reserves has an extra beneficial effect.

Solving equation (3) for Z_t in terms of R_{t-1} gives consumption in periods without a sudden stop:

$$C_t^{wo} = Y_{t-1}(1+g) + L_t - (1+r)L_{t-1} - R_{t-1}\left[\frac{1+r+\delta}{1-\pi_{t-1}} - (1+r)\right]. \qquad (4)$$

In periods with a sudden stop,

$$C_t^{ss} = Y_{t-1}(1+g)(1-\gamma) - (1+r)L_{t-1} + R_{t-1}(1+r). \qquad (5)$$

We assume that the government maximizes the following discounted utility function:

$$\max_{R_0, R_1, R_2 \ldots} \sum_{t=0}^{\infty} (1+r)^{-t} u(c_t) \qquad (6)$$

where $u(c_t) = \dfrac{C_t^{\,1-\sigma} - 1}{1-\sigma}$, and σ is the coefficient of relative risk aversion.

Because R_t only appears in the expression for C_{t-1}, maximizing period by period will suffice. One should note that this assumes that in every period, t, the maximization problem is identical. Thus, a sudden stop in period $t-1$ will not affect the outcomes in period t. This assumption is made for analytical simplicity, and we discuss the consequences of this simplification in our section on limitations.

The maximization problem becomes:

$$\max_{R_t} \left(1 - \pi_{t-1}(R_{t-1})\right) u(c_t^{wo}) + \pi_{t-1}(R_{t-1}) u(c_t^{ss}). \qquad (7)$$

This gives the following first order condition:[8]

$$-\frac{\partial \pi_{t-1}}{\partial R_{t-1}} u(c_t^{wo}) - \left(1-\pi_{t-1}(R_{t-1})\right)u'(c_t^{wo})\left[\frac{1+r+\delta}{1-\pi_{t-1}} - (1+r)\right] + \frac{\partial \pi_{t-1}}{\partial R_{t-1}} u(c_t^{ss}) + \pi_{t-1}(R_{t-1})u'(c_t^{ss})(1+r) = 0 \quad (8)$$

In calibrating the model, we will take $\partial \pi_{t-1} / \partial R_{t-1}$ and π_{t-1} from probit estimates of sudden stop probabilities.

IV. Econometric Results

Effect of Reserves in Preventing Crises

We next turn to calibrating our model to calculate "optimal" reserve holdings for Jordan. To do that, we first attempt to identify $\partial \pi_{t-1} / \partial R_{t-1}$, that is, how the probability of a sudden stop is affected by the level of reserve holdings. One difficulty here is that if reserve increases do reduce the probability of a sudden stop, countries more prone to sudden stops may hold more reserves, hence a potential problem of reverse causality. Thus, the estimated effect of reserves upon the probability of a sudden stop will be smaller than the true underlying relationship.[9]

To carry out this analysis, we follow the main empirical specification of J-R and include reserves (excluding gold holdings) as a fraction of short-term external debt as an additional regressor. We include reserves as a fraction of short term debt because higher values for this variable, all other things being equal, allow countries to service their debt more easily. External lenders, knowing this, are more confident that loans will be repaid and will, therefore, be less likely to withdraw capital at a first sign of panic or instability. In addition, prior empirical studies find better empirical support using this variable. Sudden stop episodes are taken directly from J-R and are defined as instances where the capital account as a percentage of GDP has fallen by more than 5 percent relative to the previous year.

The sample includes 34 emerging market countries (including Jordan) from 1980 to 2003.[10] The dependent variable is the occurrence of a sudden stop, and additional explanatory variables comprise the real effective exchange rate (deviation from the Hodrick-Prescott

[8] We assume that the government takes the prices of its bonds as given.

[9] Of course, a decline in reserves can also be a symptom of a sudden stop which would overstate our estimates. Most specifications, including ours, add several lags to address this problem.

[10] These countries are Argentina, Bolivia, Botswana, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Guatemala, Honduras, Hungary, Jamaica, Jordan, Korea, Malaysia, Mexico, Morocco, Paraguay, Peru, Philippines, Poland, Romania, South Africa, Sri Lanka, Thailand, Tunisia, Turkey, and Uruguay.

smoothed series), the ratio of public debt to GDP, the ratio of foreign liabilities in the banking sector to money, the absolute value of gross inflows as a ratio of GDP, and GDP growth that has been averaged to account for business cycles. These explanatory variables have been taken directly from J-R.[11]

Appreciation in the *real effective exchange rate* typically leads to a deterioration of the current account, making foreign debt repayment more difficult. A high *public debt burden* renders governments susceptible to debt rollover problems, making foreign investors more nervous. *Foreign liabilities in the banking sector* as a fraction of the money stock help determine the resilience of the banking sector. Large gross *capital inflows* may lead to more volatile capital inflows especially if large inflows include inflows of less quality. Finally, strong *GDP growth* ensures better prospects for debt repayment. Although one could consider many other variables that affect a sudden stop, J-R find that these 5 variables out of 24 considered seem to have the most important effects. We lag these variables (and also include the lagged level of reserves to short-term debt) in an attempt to address potential reverse causality problems.

We find a negative and significant relationship between reserves and the probability of a sudden stop (Table 2).[12] Admittedly, this relationship is dependent on the chosen specification.[13] However, we interpret these results not as proof that sudden stops depend on the level of reserves. Instead, if one believes that reserves are important as the literature seems to suggest, we take these results as a first pass estimate of the general magnitude of the effect.[14] When we calibrate the model to calculate the optimal level of reserves for Jordan, we will vary this parameter and observe how much our calculation of optimal reserves changes.

[11] Data are taken from the *International Financial Statistics, World Development Indicators, and Global Development Finance.*

[12] This excludes two outlier countries, Botswana and Morocco. Botswana had very low amounts of short-term debt during the sample period, pushing average reserves to short-term debt to several hundred standard deviations higher than the mean of the rest of the sample. The sudden stop episode for Morocco in 1995 was coupled with a drastic contraction of short-term debt pushing reserves to short-term debt to more than 16 times the standard deviation of the rest of the sample.

[13] We have also clustered the standard errors at the country level. This assumption allows for covariance in the error terms within each country. The assumption of homoskedasticity and White's correction for heteroskedasticity are special cases where this covariance term is zero. Results are robust to just using White's correction for heteroskedasticity.

[14] We attempted using a few instrumental variables, including broad money and errors and omissions, the results were not conclusive.

Calibration

To calculate the level of optimal reserves suggested by the model, we simply solve equation (8) numerically for Jordan.[15] In the baseline, we take $\partial \pi_{t-1} / \partial R_{t-1}$ from the results given in Table 2.[16] For the rest of the parameters, we borrow calibrations from J-R, apart from growth. The average real growth rate (g) is assumed to be 6 percent, closer to recent Jordanian outturns, rather than the 3.3 percent EM average used by J-R. (This assumption makes small differences to the results.) Accordingly, we set the average output loss during a sudden stop (γ) at 9.2 percent.[17] As for the other assumptions, the risk free rate (r) is set at 5 percent, the term premium (δ) at 1.5 percent, and the coefficient of risk aversion (σ) at 2. For the purposes of calibration, we assume that, for the representative EM country, during a sudden stop net capital flows decrease by 11 percent of GDP (i.e. $\lambda = 0.11$), as calculated by J-R.

Table 3, column 2 gives the calculated optimal level of reserves as a percentage of GDP for the baseline case. Except for a few periods in the late 1980s, Jordan's reserve levels are estimated to be consistently higher than the calculated optimum.[18] In addition, starting in the mid-1990s Jordanian reserves increased sharply, from about 15 percent of GDP to over 50 percent of GDP, further adding to the reserves buffer.

How sensible are these results? To help answer this question, we first translate these model-based findings into widely used rules of thumb. We then undertake sensitivity analysis. Finally, we examine model extensions that serve to increase optimal reserve holding estimates. These three considerations suggest that the gap between the model and actual reserve holdings is far smaller than suggested by the above baseline suggestion alone.

Consideration 1: Rules of Thumb Revisited

Taken literally, the baseline model results suggest that Jordan should hold reserves in an amount equivalent to about 14 percent of GDP (Table 3, column 2). Translating that into today's values suggests that Jordan's optimal level of reserves is about US$2¼ billion. But this translates in turn into just over 2¼ months of imports and just 10 percent of broad money.

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[15] Although equation (8) is not strictly scale-invariant, we find that changing the scale has minimal effect on the results. Calibrations are denominated in billions of U.S. dollars.

[16] The results in Table 2 are simply coefficients in the probit regression and not marginal probabilities. Marginal probabilities are calculated from these coefficients to give $\partial \pi_{t-1} / \partial R_{t-1}$.

[17] J-R use a figure of 6.5 percent since they assume that trend growth is about 3.3 percent.

[18] To extend the sample period for calibration purposes, we assume that the effect of reserves on crisis probabilities is concurrent rather than lagged.

However, because our model focuses only on the consumption-smoothing and sudden stop-preventing attributes of reserves, common metrics like import coverage and money base are not considered. Taking our estimations literally implies that Jordan would not only fall short of the conventional "3 months of imports" rule but would also leave Jordan's holdings well short of EM peers. Although none of these other metrics are necessarily the "gold standard" in evaluating adequate reserves, it is important to note the danger of considering our baseline calculations in isolation.

Consideration 2: Sensitivity Analysis

As explained below, sensitivity analysis also suggests that Jordan's reserve holdings may be much closer to optimal levels once certain adverse shocks are factored in.

In our first stress test, we check how predicted optimal reserve levels would change *if the holding of reserves had a greater impact on the probability of a sudden stop*, i.e. we use the lower 95 percent confidence interval as our estimate for $\partial \pi_{t-1} / \partial R_{t-1}$. The results using this increased sensitivity are given in column 4. Given higher *crisis-preventing effects of reserves*, optimal reserve holdings increase by about half a percent of GDP relative to the baseline (increasing optimal reserve estimates by about 2.5 percent of GDP relative to the case where there is no impact of reserves on the probability of a sudden stop, column 3).

We next examine the calculation's sensitivity to an increase in *relative risk aversion*. An increase in relative risk aversion should increase the level of reserves since reserves in the model act as a way to smooth consumption between sudden stop states and non-sudden stop states. Doubling the coefficient on relative risk aversion (column 5) increases the level of optimal reserves by about 0.6 percentage point of GDP. Further increasing risk aversion to 6 yields marginal additional increases.

Another way to test the sensitivity of optimal reserve holdings is to increase the *output cost associated with a sudden stop*. J-R calculate that for the average EM sudden stop episode, real GDP growth falls by about 6.5 percent relative to trend growth. Assuming a higher average growth rate for Jordan suggests that real GDP growth falls by about 9.2 percent. During the 1989 episode real GDP growth fell by 13.4 percent or 19.7 percent below trend.[19] Column 6 gives results when GDP is expected to fall by this higher level during sudden stops. This assumption greatly affects the baseline results, as optimal level of reserves increases by 8 percent of GDP in 2004.

In another sensitivity test, the size of the assumed *sudden stop size* is increased. J-R assume that, during a sudden stop, capital inflows fall by about 11 percent of GDP. This is quite similar to the average Jordanian experience starting from 1980. However, in 1992 Jordanian

[19] Trend real GDP growth during periods that are not a sudden stop or periods immediately after a sudden stop was about 3.5 percent.

capital inflows fell by 38 percent.[20] Column 8 gives the optimal level of reserves if one were to expect such a large fall in capital flows during a sudden stop. The optimal level of reserves increases substantially, although still below actual current reserve holdings.

Column 9 assumes *both* the *severe output cost* of 19.7 percent and an *increased sudden stop size* (again, 38 percent of GDP). This increases the optimal level of reserves to GDP by 29 percentage points relative to the baseline and brings optimal reserves very close to actual holdings. It appears that by assuming severe adverse shocks for a Jordanian sudden stop, our model is able to generate optimal reserve holdings in line with actual holdings.

Column 10 includes the *severe adverse shocks* but strengthens the positive impact of reserves in helping prevent sudden stops. Compared to Column 9, the optimal amount of reserves decreases in recent years. Why is this? In a scenario with severe adverse shocks, consumption-smoothing considerations call for high optimal reserves. However, with such high reserve levels, the probability of a sudden stop falls drastically when we assume that reserves have a greater impact in helping prevent sudden stops. Therefore, on balance, the need to hold reserves for consumption-smoothing purposes is less.

Consideration 3: Extensions

As with every model, ours is highly stylized and abstracts from many real world details.

First, our model assumes a *representative consumer*. To the extent that consumers are heterogeneous, our calculations are likely to be a systematic underestimate of true optimal holdings. If different consumers experience proportionally different consumption losses during a sudden stop, the proper government maximization function will be the weighted average of individual utility functions rather than the utility of the "average" consumer. Given risk aversion, optimal reserves calculated over the utility of the average consumer will understate the optimal holdings. A rough approximation that assumes two types of domestic consumers gives optimal reserves that are higher by about 1 percentage point of GDP.

Like J-R, we have also assumed that the consequences of a sudden stop are not permanent for analytical simplicity. If one believes that a *sudden stop permanently (or at least for several periods) changes the trajectory of output*—as in Cerra and Saxena (2005)—this would increase the costs of a sudden stop, and the optimal level of reserves holdings will increase. Rough approximations assuming that the output loss associated with a sudden stop extends for two periods gives optimal reserves that are higher by about 3½ percentage points of GDP, and for three periods that optimal reserves are higher by about a further 3½ percentage points.

Finally, all the *consequences of a sudden stop in reality are unknown ex ante.* We assume that sudden stop consequences are known for certain to be the sample means in our model. However, with risk aversion, uncertainty associated with the sudden stop should lead to

[20] We note that during this sudden capital reversal, Jordan actually experienced high real GDP growth.

higher holdings of optimal reserves. This effect also originates from risk aversion, and the order of this understatement should be similar to that of assuming representative consumers. Taken together, these extensions suggest that the baseline model results may be understated by about 9 percentage points of GDP.

Considerations: A Bottom Line

The three considerations just discussed—translating calculated optimal reserves into reserve levels, sensitivity analysis, and model extensions—suggest that optimal reserves are likely much higher than suggested by the calibration. Adding model extensions alone would increase reserve holdings to about 23 percent of GDP (a little over US$3½ billion, or 3¾ months of imports). Given the peg, the results of the sensitivity analysis, and the implications of traditional reserve indicators,[21] policymakers would likely want to be more cautious, increasing reserves above these "modified" reserve levels. But the bottom line is that formal analysis suggests that Jordan's reserve holdings are comfortable enough to cover even the most extreme of economic circumstances and provide solid support for the dinar peg.

V. Conclusions

In this paper we have set up a formal framework for analyzing Jordan's international reserve levels that factors in both the benefits and costs of holding reserves. Reserves can be used to deal with sudden stops, to support the exchange rate peg, and can provide comfort to market participants and foreign investors.

As part of our framework, we first use several traditional measures of reserves adequacy to compare Jordan's reserve holdings with other EM countries. Subsequently, we analyze Jordan's reserve holdings using a reserves-optimizing model, based on Jeanne and Rancière (2006) (J-R), but extended to allow reserve holdings to influence the likelihood of a sudden stop.

Although traditional measures of reserves adequacy do not suggest that Jordan's reserve holdings are out of line with its peers, a simple reading model-based estimates of "optimal" reserves suggest that these are much lower than actual reserve holdings. However, translating optimal reserve estimates into actual reserve holdings (and comparing to commonly used rules of thumb), undertaking a comprehensive sensitivity analysis, and extending the model in various ways all suggest that the gap between optimal and actual reserve holdings may not be that large. The overall analysis suggests, however, that Jordan's reserve holdings provide sufficient support to sustain the dinar peg and to deal with the most extreme capital account disruptions.

[21] In the case of Jordan, if reserves are held solely to finance short-term external debt (the Greenspan-Guidotti criterion), then one might claim that reserves are excessive since they cover more than seven times maturing external debt. But if reserves are also held to avoid interruptions in the domestic payments system or to insure import viability—both legitimate aims—then the ratio to money stock (M2) or import cover may perhaps be more relevant criteria.

Table 2. Effect of Reserves on Sudden Stop

Reserves to Short Term Debt	-0.123
	(0.047)**
Real Exchange Rate (deviation from HP trend)	0.01
	(0.008)
Public Debt to GDP	0.506
	(0.227)*
Foreign Liability to Money	-0.001
	(0.046)
Real GDP Growth	-2.329
	(1.420)
Gross Inflows to GDP	6.781
	(1.751)**
Constant	-1.677
	(0.205)**
Observations	647

+ indicates signicance at 10% level, * at 5% level, and **at 1% level.
Standard errors are clustered at country level.
Regression is a probit specification.
Reserves to short term debt are lagged two periods.
Real GDP Growth is the two year average of real growth rates in period *t-1* and *t-2.*
All other explanatory variables are lagged one period.

Table 3. Optimal Level of Reserves (as ratio of GDP)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Actual	Optimal Reserves								
Year	Reserves	Baseline	beta = 0	beta = -0.19	sigma = 4	gamma = 0.17	g = 0.1	lambda = 0.38	(6) + (8)	(4) + (6) + (8)
1981	0.244	0.135	0.124	0.140	0.143	0.218	0.140	0.352	0.438	0.440
1982	0.183	0.139	0.128	0.145	0.147	0.224	0.144	0.362	0.452	0.458
1983	0.164	0.145	0.133	0.152	0.153	0.234	0.151	0.379	0.473	0.477
1984	0.100	0.139	0.128	0.146	0.144	0.223	0.145	0.364	0.458	0.488
1985	0.083	0.152	0.140	0.158	0.162	0.246	0.158	0.398	0.495	0.498
1986	0.071	0.123	0.115	0.128	0.129	0.198	0.128	0.320	0.401	0.414
1987	0.065	0.137	0.127	0.142	0.151	0.226	0.142	0.368	0.459	0.461
1988	0.018	0.176	0.152	0.182	0.182	0.279	0.183	0.435	0.524	0.437
1989	0.114	0.217	0.199	0.227	0.228	0.350	0.226	0.568	0.711	0.733
1990	0.211	0.143	0.137	0.147	0.149	0.228	0.149	0.366	0.458	0.482
1991	0.197	0.106	0.104	0.108	0.109	0.166	0.110	0.263	0.327	0.341
1992	0.144	0.007	0.007	0.007	0.007	-	0.007	-	-	-
1993	0.292	0.140	0.128	0.145	0.153	0.229	0.146	0.371	0.462	0.454
1994	0.271	0.102	0.093	0.109	0.104	0.165	0.106	0.275	0.354	0.416
1995	0.293	0.140	0.127	0.146	0.150	0.227	0.146	0.366	0.456	0.450
1996	0.254	0.149	0.134	0.157	0.155	0.240	0.155	0.389	0.485	0.477
1997	0.304	0.145	0.129	0.151	0.155	0.235	0.151	0.377	0.468	0.450
1998	0.221	0.142	0.125	0.148	0.150	0.229	0.148	0.364	0.448	0.413
1999	0.323	0.145	0.127	0.151	0.157	0.236	0.151	0.379	0.470	0.448
2000	0.394	0.146	0.130	0.154	0.151	0.235	0.152	0.383	0.480	0.479
2001	0.341	0.137	0.114	0.152	0.140	0.226	0.143	0.380	0.479	0.454
2002	0.416	0.149	0.128	0.155	0.155	0.238	0.155	0.375	0.457	0.399
2003	0.511	0.147	0.129	0.154	0.153	0.236	0.153	0.378	0.467	0.437
2004	0.457	0.141	0.121	0.146	0.147	0.224	0.147	0.352	0.427	0.368

Notes:
In 1992, the predicted probability for a sudden stop in Jordan is extremely high (95 percent). This creates computational problems for some scenarios.
Due to data limitations, in order to get calculations for 2004, we assumed that capital inflows in 2003 were equal to capital inflows in 2002.
Beta is the sensitivity of reserves at preventing a sudden stop.
Sigma is the coefficient of relative risk aversion.
Gamma is the output loss in a sudden stop.
G is the average real GDP growth rate.
Lambda is the size of the sudden stop or the amount of private debt not rolled over in a sudden stop.

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