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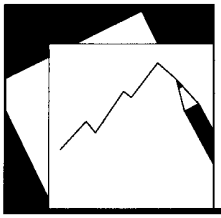

IMF Working Paper

International Reserve Adequacy in The Gambia

Eugen Tereanu

INTERNATIONAL MONETARY FUND

 WP/10/215

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Finance Department

International Reserve Adequacy in The Gambia[1]

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Abstract

This paper applies intertemporal models of precautionary saving to compute an optimal level of international reserves for The Gambia. The analysis focuses on current account shocks specific to a low-income economy with a significant import component and complements a more standard, rule-of-thumb reserve adequacy assessment. The results suggest a central range from 4.5 months to 7 months of imports, which is broadly aligned with the recent actual coverage. Notwithstanding parameter sensitivity, the simulations allow for more informed policy decisions that balance flexibility with a prudent approach to reserve use.

JEL Classification Numbers: F30, F31

Keywords: Precautionary savings, Reserve adequacy, Optimal reserves, Balance of payments

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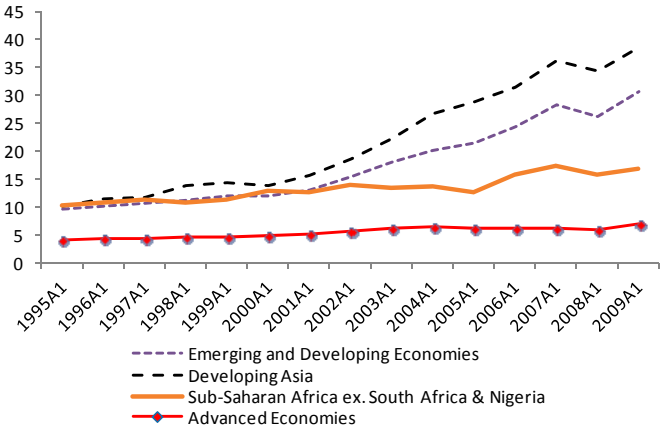
I. INTRODUCTION

The global financial and economic crisis has brought to the fore a renewed interest in the impact of international reserves on macroeconomic stability,[2] with consideration given to both the costs and the benefits of holding significant stocks of liquid foreign reserve assets.

The period following the Asian crisis witnessed an important increase in international reserves, mostly concentrated in emerging economies (Figure 1). More recently, low-income countries (LICs) have also followed an accelerated pattern of reserve accumulation which has helped in part to cushion the impact of the 2008 commodity price shock in those countries facing sizeable import demand for food and fuel.

Figure 1. Gross Reserves in Percent of GDP



Source: World Economic Outlook

This paper presents an application of both traditional indicators of reserve adequacy and theoretically grounded optimization models to The Gambia. In a small open economy where balance of payments vulnerabilities are characterized by exposure to current account shocks, import dependence and limitations on external borrowing, central bank policymakers may have a justified interest in targeting an optimal level of international reserves that allows for gradual adjustment of domestic demand in response to potential shocks without excessively tying up resources in low yielding, low risk foreign assets. Furthermore, combining standard indicators with model simulations allows for a more nuanced reserve adequacy assessment and helps to gauge the optimal stance conditional on country specific shocks.

The international reserves literature discusses several motives for holding foreign exchange reserves. A precautionary savings approach views reserves as a self insurance mechanism against balance of payments shocks with potentially sudden and significantly

[2] See IMF (2010).

disruptive effects on exchange rates and domestic demand.[3] Adequate international reserves may also help maintain confidence in existing policies and a country's capacity to sustain external balance.[4] However, holding international reserves is a potentially costly insurance decision as resources are diverted from other uses such as consumption of imported goods, productive domestic investment opportunities, alternative asset investment or repayment of foreign liabilities.[5]

As a small open economy with a significant import component and subject to external shocks, the precautionary and confidence motives of holding reserves apply directly to The Gambia. In addition, the authorities face a relatively high opportunity cost of holding reserves determined by costly domestic debt, with average treasury bill yields as high as 8 percent in real terms and interest costs consuming 15 percent of government revenue in 2009. Conditional on risks to the macroeconomic and foreign exchange inflows outlook, the Central Bank of The Gambia (CBG) could conceivably substitute part of its stock of net foreign assets with domestic assets with a view to reducing the stock and cost of domestic debt.

A number of studies have addressed reserve optimality in LICs following the large literature on reserve adequacy and sudden stops in emerging economies.[6] For example, Drummond and Dhasmana (2008), Barnichon (2009) and Valencia (2010) present variations of representative agent models of intertemporal consumption smoothing that embed a precautionary savings motive in the face of shocks to the terms of trade, foreign demand for exports, and foreign transfers (official aid and remittances).[7]

We apply the models of Barnichon (2009) and Valencia (2010) to complement a traditional analysis of reserve adequacy using rule-of-thumb thresholds for reserve coverage in months of imports. Our results suggest that international reserves holdings in The Gambia are broadly aligned with macroeconomic risks, with import coverage indicators generally varying between 4.5 months and 7 months of imports. The robustness analysis indicates that results should be interpreted with caution, as parameter sensitivity is an important caveat of the models considered. However, taken together with other rule-of-thumb indicators of reserve coverage, our simulations allow for more informed policy decisions that balance flexibility with a prudent approach to reserve use.

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[3] For a discussion of precautionary saving behavior, see Carroll (2004), and Carroll and Kimball (2007).

[4] For a more comprehensive discussion of motives, including transaction demand and reserve accumulation as a result of active exchange rate intervention, see the discussion in Drummond et al. (2009).

[5] Jeanne (2007).

[6] Jeanne and Ranciere (2006), Kim (2008), Durdu, Mendoza, and Terrones (2009), Aizenman and Lee (2007), Alfaro and Kanczuk (2009), Caballero and Panageas (2008).

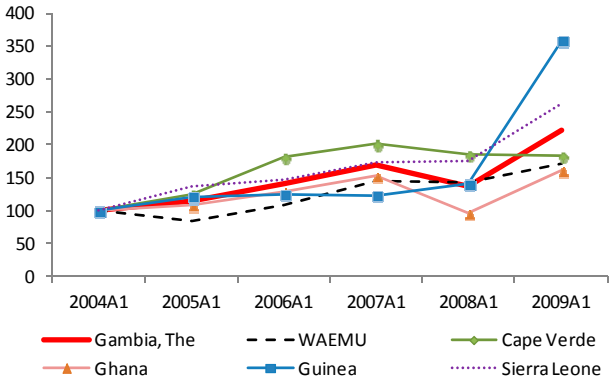
[7] For a discussion of precautionary savings and aid volatility, see Aslam and Kim (2009). Additional regional applications of reserve optimality models include Dehesa, Pineda and Samuel (2009).

The remainder of the paper is organized as follows. Section II discusses external developments and the recent evolution of international reserves in The Gambia. Section III analyzes a set of static benchmarks of reserve adequacy from a cross-country perspective. Sections IV and V present the models and the results, respectively. Section VI includes a sensitivity analysis and conclusions are deferred to Section VII.

II. The Recent Evolution of International Reserves in the Gambia

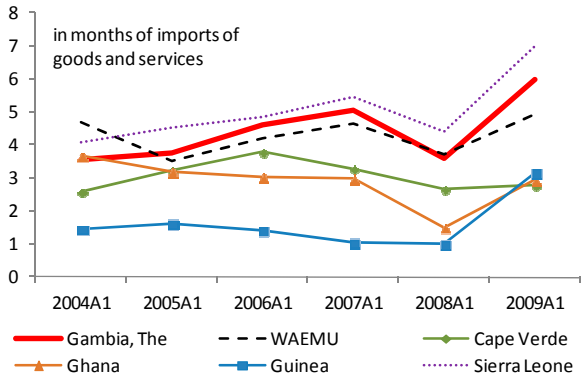
Between 2004 and 2007, increased macroeconomic stability, a strengthening of foreign inflows (mainly private and official transfers but also FDI and tourism receipts), and a relatively stable currency, have enabled The Gambia to accumulate foreign exchange reserves in line with regional trends as well as the West Africa Monetary Zone (WAMZ) convergence criteria (Figures 2 and 3).[8]

Figure 2. Gross International Reserves
2004=100



Source: World Economic Outlook

Figure 3. Import Coverage
of Gross International Reserves



Source: World Economic Outlook

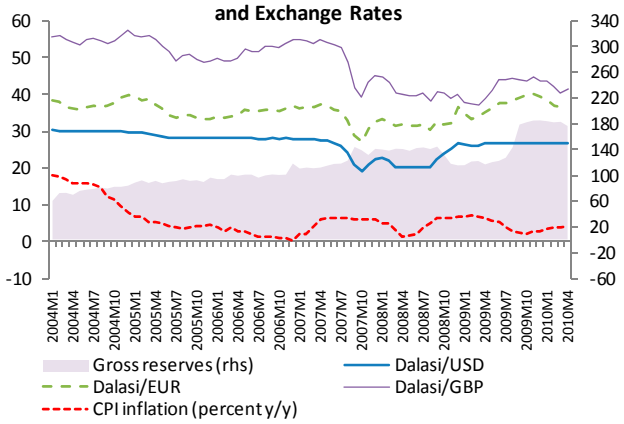
The commodity price shock of 2008 put significant pressure on the Gambian currency, the dalasi, resulting in a nominal depreciation of the average exchange rate against the U.S. dollar of 21 percent, coupled with a fall in the real effective exchange rate of 7 percent during the year (Figure 4). A measure of stress on the currency, the Exchange Market Pressure Index shows a sharp decline in the last quarter of 2008 (Figure 5).[9] The decline in world oil and food prices in the second half of the year was counterbalanced by a slowdown in remittances, travel income and re-exports. The central bank intervened promptly and significantly in the foreign exchange market in the last quarter of 2008 by selling about one fifth of its reserve stock to support the dalasi. As a result, gross international reserves coverage fell from 5.0 months to 3.6 months of imports of goods and services between end-2007 and end-2008.

[8] The WAMZ was established in 2000 and includes The Gambia, Ghana, Guinea, Nigeria, and Sierra Leone. A reserve coverage of 3 months of imports of goods and services is a convergence criteria for membership.

[9] The Exchange Market Pressure Index is a weighted average index of nominal exchange rate and reserve changes with an increase (decrease) indicating upward (downward) pressure on the currency (Cardarelli, et al., 2009).

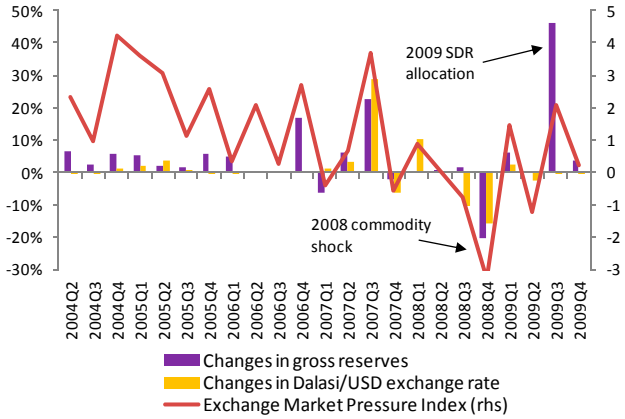
During 2009, increased budget support and high FDI inflows into the banking system supported a gradual rebuilding of foreign reserves. The most substantial boost to reserves (at 6 months of imports of goods and services at end-2009) resulted from the SDR allocation,[10] which together with the Extended Credit Facility (ECF) disbursement,[11] represented about one third of the stock of gross international reserves at end-2009.

Figure 4. Gross International Reserves and Exchange Rates



Source: IMF International Financial Statistics and authorities' data

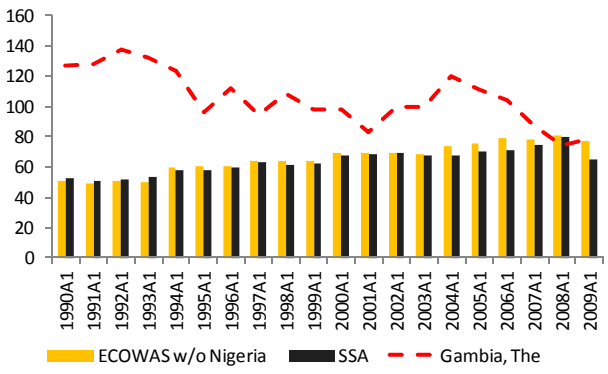
Figure 5. Exchange Market Pressure Index



Source: IMF International Financial Statistics and authorities' data

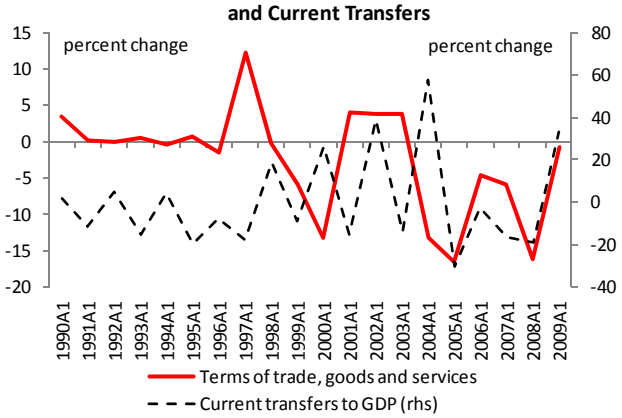
As a small open economy with significant import reliance and a relative lack of export diversification, the Gambian economy is vulnerable to terms of trade shocks. Volatility in aid and remittances can put additional pressure on the current account balance and reserves (Figures 6 and 7). While generally maintaining a flexible exchange rate with a minimum amount of intervention, The Gambia has a relatively shallow foreign exchange market with average foreign exchange transaction volumes of about US$ 130 million during 2007–08 and about US$ 150 million from September 2009 through April 2010.

Figure 6. Trade in Percent of GDP



Source: World Economic Outlook

Figure 7. Behavior of Terms of Trade and Current Transfers



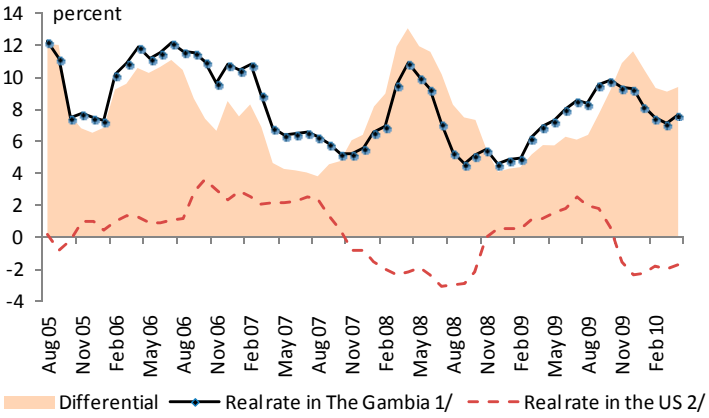
Source: World Economic Outlook

[10] The scope of the 2009 general SDR allocation of US$ 250 billion was to provide all IMF members with significant, one time unconditional financial resources to cope with liquidity constraints resulting from the global economic crisis.

[11] The latest financial arrangement between The Gambia and the IMF is in the form of an Extended Credit Facility (ECF, formerly PRGF) set to expire in February 2011.

Notably, The Gambia faces a significant opportunity cost of holding reserves (Figure 8). Given the high cost of domestic debt, one way of measuring the opportunity cost in real terms is the inflation normalized differential between the domestic treasury bill yield and relevant U.S. benchmarks. During August 2005–April 2010, this real differential averaged about 8 percent per annum. Generally, policy decisions conducive to a reduction in the cost of domestic debt or an increase in the return on foreign exchange reserve assets (for example, through asset management decisions that increase the yield while maintaining a maturity and risk profile in accordance with the balance of payments definition of a reserve asset) could have a positive impact on the optimal level of reserves.

Figure 8. Cost of Holding Reserves



1/ Difference between average treasury yield and CPI inflation
2/ Difference between the one year treasury bill and CPI inflation
Source: IMF International Financial Statistics and authorities' data

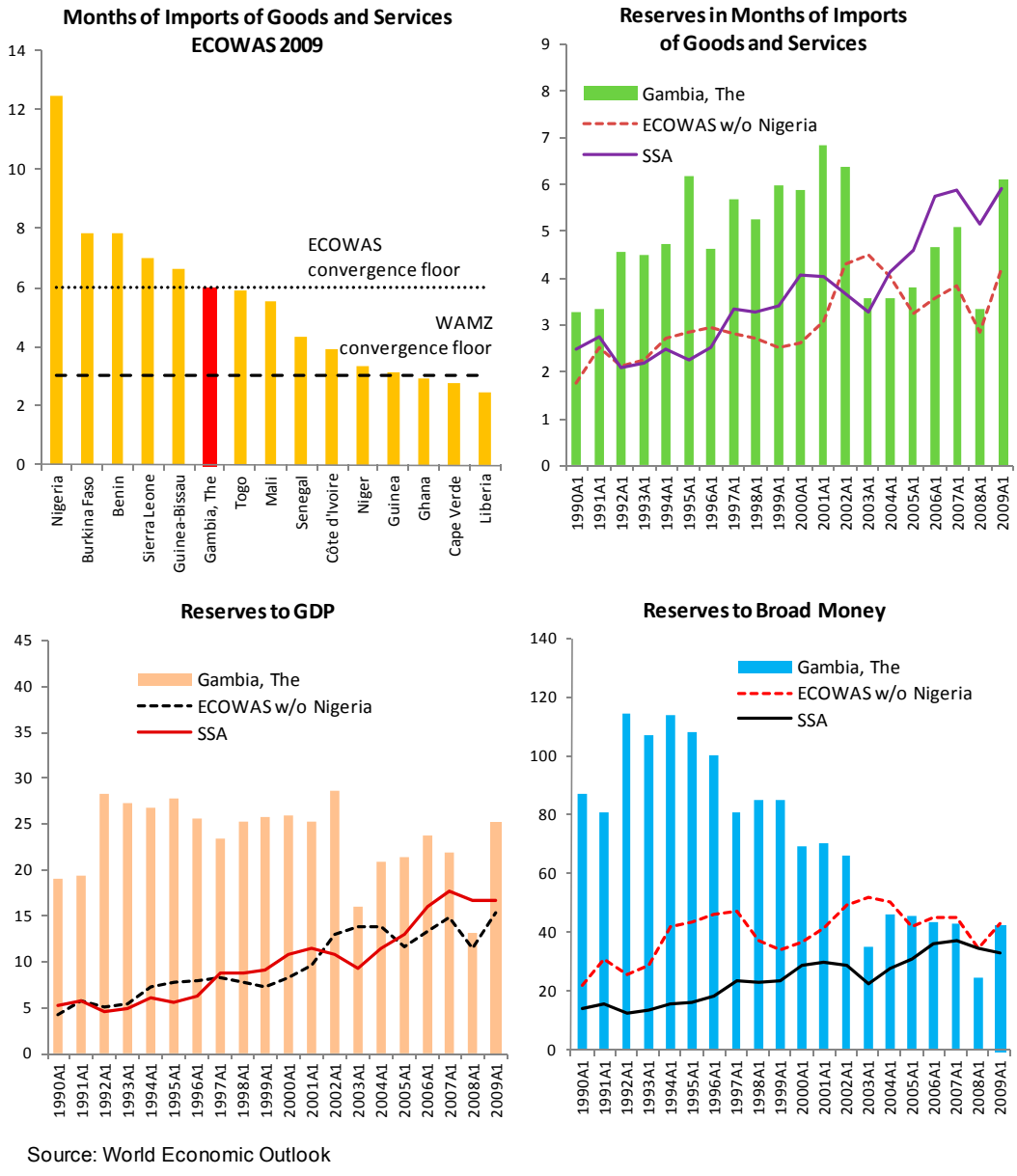
III. Static Benchmarks of Reserve Adequacy

Traditional metrics based on rules of thumb are helpful as a first step in gauging the adequacy of international reserves. The most popular indicators are reserve coverage of imports, reserves to short-term external debt, reserves to broad money and reserves to GDP. Of these indicators, reserve coverage of short term debt (operationalized by the Greenspan-Guidotti rule which suggests a full coverage of short term debt) is of lesser relevance in this analysis because short-term external debt of The Gambia is negligible.

Reserve coverage of imports is the key indicator for current account shocks which tend to be relatively more important in this context compared to other forms of external vulnerability. This indicator reflects the capacity of an economy to sustain its import (and consumption) demand in the face of disruptions in the normal inflow of foreign exchange. A widespread rule-of-thumb suggests a coverage of 3 months of imports as adequate. However, this masks a large degree of heterogeneity among countries and may be considered a lower bound for very open economies. By this standard, The Gambia's import coverage ratio at end-2009 was well within the cross-section of both the ECOWAS and WAMZ member countries (Figure 9). In addition, the increased reserve accumulation in recent years is aligned with regional and Sub-Saharan Africa trends. The ratio of foreign reserves to GDP

can also be of importance in countries where the contribution of trade to growth is significant. In addition, it is useful for purposes of calibration when cost-benefit models of optimal reserves are based on intertemporal consumption smoothing and where results are often presented in terms of ratios to output. Finally, measures of reserves to broad money potentially capture the coverage of banking system liabilities by international reserves, with a low ratio flagging the risk of capital flight induced by residents. On both measures, The Gambia's position appears robust, with the declining trend in terms of broad money coverage partly explained by the development of a somewhat broader financial sector in recent years.

Figure 9. Standard metrics of reserve coverage



Source: World Economic Outlook

IV. Optimal Reserve Models for Low-Income Countries

We use the models of Barnichon (2009) and Valencia (2010) to characterize the level of optimal reserves in The Gambia. Wherever possible, the parameters are calibrated to values pertinent to The Gambia to better gauge shock distributions and steady state ratios.

Barnichon (2009) builds a small open economy model in which a representative agent maximizes the utility of consuming both Home and Foreign goods subject to a standard intertemporal resource constraint and balance of payment constraint.

$$\max_{\{c_{H,t},c_{F,t}\}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_{H,t}, c_{F,t})$$

s.t.

$$c_{H,t} + \frac{1}{\varepsilon} c_{F,t} = Y_t + \frac{1}{\varepsilon} Tr_t - \frac{1}{\varepsilon} r R_t - \frac{1}{\varepsilon}(R_{t+1} - R_t)$$

$$c_{F,t} \leq \varepsilon c^*_{H,t} + Tr_t + (R_{t+1} - R_t)$$

In each period, total consumption in the economy (with foreign good consumption expressed in terms of the home good via the real exchange rate ε) equals the endowment of home good Y_t plus any foreign transfers less the opportunity cost of reserves less the accumulation (alternatively, *plus* the decumulation) of foreign reserves. Here foreign transfers is a generic term that is meant to captures private remittances, official aid and foreign loans. Consumption of the foreign good (imports) can be financed via foreign exchange inflows from three sources: exports of home good (or foreign consumption of the Home good), foreign transfers as defined above, or foreign exchange reserves.

In the model, reserves are held as insurance against shocks (such as natural disasters or terms of trade) with an opportunity cost of holding insurance (reserves) calibrated on the interest rate differential between domestic investment opportunities and the return on riskless foreign reserve assets. Shocks are modeled via a two-state Markov process with time invariant probabilities. In the "normal" state, the economy receives an endowment of home good Y^n out of which it exports a fraction δY^n. Once the shock occurs, the economy transits, with probability π^{ns}, from the "normal" state into a "shock" state characterized by disrupted output, exports and a real depreciation (with $Y^s = \eta_y Y^n$,$c_H^{*n} = \eta_x c_H^{*s}$, $\varepsilon^s = \eta_\varepsilon \varepsilon^n$ where $\eta_y \eta_x \eta_\varepsilon < 1$). From the "shock" state the economy recovers with probability π^{sn}.

All variables are expressed relative to "normal" output. A higher probability of transiting into a "shock" state as well as higher losses in output, exports, and real exchange rate *increase* the benefits of holding reserves and implicitly the optimal reserves-to-imports

ratio. On the other hand, a higher opportunity cost of holding reserves and larger ratio of foreign transfers (aid or remittances) *decrease* the optimal reserves coverage. Finally, the share of exports to "normal" output has an ambiguous effect due to the concavity of the utility function: as the country exports more relative to GDP, reserve accumulation is easier and the reserve coverage ratio increases. However, as the country exports and imports ever higher shares of GDP, the equilibrium level of reserves becomes larger relative to GDP, making it costlier to hold reserves.

Valencia (2010) uses a variant of Carroll's (2004) standard precautionary savings model in which the representative household maximizes the utility of consumption subject to a resource constraint. The model complements the analysis of Barnichon (2009) by allowing for shocks to terms of trade and export volumes, as well as introducing investment (for ease of comparison, notations are kept broadly similar).

$$\max_{\{c_t,k_t\}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

s.t.

$$R_{t+1} = r(R_t - c_t - k_t) + \varsigma_{t+1}\gamma_{t+1}k_t^{\alpha} + (1-\delta)k_t + Tr_t$$

The stock of net foreign assets in the next period (reserves R_{t+1}) is a function of the consumption and investment choices of the representative consumer together with the (shock conditional) level of production, the rate of depreciation (δ), and foreign transfers (remittances, aid, foreign loans *Tr*). A version of the model also allows the option of modeling a lack of access to international capital markets through the borrowing constraint in which consumption and the stock of capital cannot exceed the current level of reserves. The productive capacity of this economy is affected by transitory shocks to both terms of trade (ς) and export volumes (γ) which for simplicity are assumed to be non-negative i.i.d. variables.

V. SIMULATION RESULTS

We start with a baseline version closely following the calibration in Barnichon (2009). Specifically, while assuming values consistent with the literature for some of the standard parameters in the model (for example, the coefficient of relative risk aversion is set to 2), other key parameters such as the likelihood of a terms of trade shock or the ratio of current transfers to output are calibrated using data for The Gambia.

The baseline scenario assumes a 20 percent (annual) likelihood of a terms of trade shock (defined as an annual negative change in terms of trade for goods and services of at least –10 percent), in line with average negative annual changes in terms of trade for goods and services in The Gambia since 1980. The shock is assumed to last about a year and has no direct effect on output or exports beyond a real depreciation of 10 percent. In addition, current transfers (including both aid and remittances) are assumed to decline by 20 percent

relative to equilibrium. The simultaneous shock to foreign exchange inflows based on terms of trade and aid/remittances bears resemblance to developments during the 2008 commodity price shock to the Gambian economy, when worsening terms of trade and lackluster performance in remittances and re-exports prompted the CBG to intervene in the foreign exchange market, resulting in a loss of about one fifth of its gross stock of reserves. Finally, the opportunity cost is initially calibrated to a relatively low (yearly) value of 3.5 percent Barnichon, 2009).[12]

Taken together, the baseline parameters suggest a benchmark value for optimal reserves in months of imports of goods and services of 4.6 months, which is broadly in line with the actual import coverage at end-2007 (5 months of imports). This suggests that CBG's gradual reserve accumulation policy in preceding years was prudent in light of potential shocks.

As discussed in Section II, The Gambia likely faces a higher opportunity cost of holding reserves due to the high cost of its domestic debt. Inasmuch as domestic investment returns relate to government debt yields plus a risk premium, the average treasury yield in The Gambia can be used to compute a lower bound for the opportunity cost of holding reserves. Specifically, doubling the opportunity cost parameter to 7 percent is broadly in line with the average real interest rate differential between The Gambia and the United States since 2005. Given the reduced incentive to hold reserves relative to the baseline parameterization, the resulting optimal reserve coverage is only 4.2 months of imports.

In a different scenario, the higher opportunity cost is balanced against a higher likelihood of terms of trade shocks (of 30 percent), with the shock lasting a shorter period (about 8 months).This results in an import coverage ratio of 5.1 months. Finally, a baseline scenario where the real depreciation during the shock state is doubled to 20 percent results in an indicative coverage of about 7 months of imports.

Simulations using the Valencia (2010) model offer additional insights. In its original form, the model does not yield results directly comparable with previous simulations—for example, given the equivalence between consumption and imports in the model, imposing the borrowing constraint that consumption not exceed net foreign assets, implies that the ratio of reserves to consumption (imports) will always be greater than one. For comparability with standard indicators and Barnichon's (2009) model, we relax the borrowing constraint. Furthermore, since The Gambia has access to multilateral concessional debt, an assumption of complete lack of access to external debt would seem rather strong. Another difference is that the gross interest factor in the model does not reflect the opportunity cost directly, only the real interest benefit derived from holding the risk free asset (e.g., U.S. T-bills). The

[12] Barnichon (2009) calibrates the opportunity cost as the differential between the average annual real return on capital in LICs estimated by Caselli and Feyrer (2007) at 7 percent and the average real rate of return of 3.5 percent on the 10-year U.S. treasury bonds over 1967–2007. As discussed in the text, we also experiment with a calibration that considers real returns on The Gambia domestic debt.

opportunity cost is modeled through the degree of impatience (parameterized by the discount factor β). To build reserves, the consumer foregoes current consumption in favor of future consumption where the two periods are substitutable at the rate β (i.e., a lower β gives less weight to next period's utility and indicates more impatience or a higher cost of savings (reserves)).

We first calibrate a baseline version of Valencia (2010) without investment or external borrowing constraints. The discount factor beta is set to 0.9, the volatility of the transitory shock to terms of trade is matched to the standard deviation (0.16) of The Gambia terms of trade for goods and services over 1980–2010 from the World Economic Outlook and the volatility of export volume shocks (0.027) is based on the elasticity of The Gambia exports to world import demand over the same period. This version yields a baseline optimal reserve to import coverage of about 6.2 months.

Introducing investment in the model adds another incentive for saving as economic agents need to maintain resources for consumption and accumulating capital. In a version where external borrowing is constrained, a negative realization of the shock leaves consumers with fewer resources from which to finance both consumption and the replacement value of the depreciated capital stock, compared to financing consumption only in the baseline model. For a given period stock of net foreign assets, resulting consumption is implicitly lower in an investment-augmented model, hence the optimal reserve coverage resulting from a precautionary motive is higher. Absent the borrowing constraint, agents have fewer restrictions in financing a higher level of consumption and would need a lower reserve coverage to withstand a negative shock. Specifically, if the baseline model without borrowing constraints is augmented with a simple Cobb-Douglas production function with the share of capital set at 0.2 and an associated (annual) depreciation of 10 percent, the import coverage decreases to 4.6 months compared with the baseline.

VI. Sensitivity Analysis

Optimization models are useful for policy-making due to their flexibility in capturing informative scenarios. Nevertheless, they are subject to a number of important caveats. For example, the results typically hinge on the chosen parameter values and are sensitive to alternative parameterizations. Such models may also fail to fully capture the structure of the economy and its heterogeneity. Modeling the opportunity cost of holding reserves is also not straightforward and some of the potential benefits of holding reserves such as fostering confidence in the government policy are difficult to quantify and are left outside the model. In addition, data quality issues may pose problems when choosing appropriate parameter values for calibration.[13] It follows that conclusions derived from such models can often be interpreted as indicative at best.

[13] For a more complete discussion of optimization model caveats in the context of LICs, see Drummond et al. (2009).

We present results from a broad sensitivity analysis for our key results (for both models considered) to changes in parameters (Tables 1 and 2 in the Appendix). Both models suggest the need for increased precautionary saving as risk aversion rises or the degree of impatience is reduced. Shock likelihood and volatility also require higher reserves while an increased opportunity cost reduces the incentive for reserve accumulation.

VII. Conclusions and Policy Implications

Improved macroeconomic stability and increasing foreign exchange inflows through 2007 have allowed The Gambia to accumulate international reserves which proved to be a supportive buffer for the commodity price shock of 2008. Following the boost in reserves resulting from the SDR allocation of 2009 and the increased policy debate about the role of international reserves in emerging and developing countries, this paper complements the discussion of standard reserve adequacy indicators with an application of cost-benefit precautionary saving models to gauge the stance of foreign exchange reserves as well as inform various policy options for reserve accumulation and use.

While simulations are highly sensitive to the choice of parameters, baseline scenarios indicate a central range somewhere between 4.5 months to 7 months of import coverage. The actual coverage of 6 months of imports of goods and services at end 2009 would therefore suggest that international reserve adequacy in The Gambia is broadly in line with optimal levels derived from theoretical models. However, model caveats point at caution when interpreting the results.

The analysis implies that, conditional on macroeconomic developments, the authorities could have an option to forego an accumulation of international reserves in the short run given the actual reserve coverage ratio. Similarly, simulations based in part on The Gambia specific data, which account to some degree for country specific balance of payments vulnerabilities, support the current cautionary policy stance of maintaining a reserve coverage well in excess of 3 months of imports of goods and services as would be suggested by a traditional rule-of-thumb.

Finally, the one off nature of the 2009 reserve increase resulting from the SDR allocation strengthens the case for a continued prudent approach to reserve policy.

REFERENCES

Aizenman, J. and J. Lee, 2007, "International reserves: Precautionary versus Mercantilist views, theory and evidence," *Open Economies Review*, Vol. 18, Issue 2, pp. 191–214.

Alfaro, L. and F. Kanczuk, 2009, "Optimal reserve management and sovereign debt," *Journal of International Economics*, Vol. 77, Issue 1, pp. 23–36.

Aslam, A. and J. Kim, 2009, "Aid volatility and precautionary saving," University of Cambridge Department of Economics, unpublished manuscript (Cambridge, UK: University of Cambridge).

Barnichon, R., 2009, "The optimal level of reserves for low-income countries: Self-insurance against external shocks," *IMF Staff Papers*, Vol. 56, Issue 4, pp.852–875.

Caballero, R. and S. Panageas, 2008, "Hedging sudden stops and precautionary contractions," *Journal of Development Economics*, Vol. 85, Issue 1–2, pp. 28–57.

Cardarelli, R., S. Elekdag and A. M. Kose, 2009, "Capital inflows: Macroeconomic implications and policy responses," IMF Working Paper No. 09/40 (Washington, DC: International Monetary Fund).

Carroll, C., 2004, "Theoretical foundations of buffer stock saving", NBER Working Paper No. 10867 (Cambridge, MA: The National Bureau for Economic Research).

Carroll, C. and M. Kimball, 2007, "Precautionary saving and precautionary wealth," Palgrave Dictionary of Economics and Finance, 2nd Ed.

Caselli, F. and J. Feyrer, 2007, "The marginal product of capital," *Quarterly Journal of Economics*, Vol. 122, Issue 2, pp. 535–568.

Dehesa, M., E. Pineda and W. Samuel, 2009, "Optimal reserves in the Eastern Caribbean Currency Union", IMF Working Paper No. 09/77 (Washington, DC: International Monetary Fund).

Drummond, P. and A. Dhasmana, 2008, "Foreign reserve adequacy in Sub-Saharan Africa," IMF Working Paper No. 08/150 (Washington, DC: International Monetary Fund).

Drummond, P., A. Mrema, S. Roudet and M. Saito, 2009, "Foreign exchange reserve adequacy in East African Community Countries," IMF African Department Working Paper 9/01 (Washington, DC: International Monetary Fund).

Durdu, C., E. Mendoza, and M. Terrones, 2009, "Precautionary Demand for Foreign Assets in Sudden Stop Economies: An Assessment of the New Mercantilism," *Journal of Development Economics*, Vol. 89, pp. 194–209.

International Monetary Fund, 2010, "Reserve accumulation and International Monetary Stability: Supplementary Information", April 13. Available on: http://www.imf.org/external/np/pp/eng/2010/041310a.pdf

Jeanne, O., 2007, "International reserves in emerging market countries: Too much of a good thing?" *Brookings Papers on Economic Activity*, Volume 1, pp. 1–55.

Jeanne, O. and R. Ranciere, 2006, "The optimal level of international reserves for emerging market countries: Formulas and applications", IMF Working Paper No. 06/229 (Washington, DC: International Monetary Fund).

Kim, J., 2008, "Sudden stops and optimal self-insurance", IMF Working Paper No. 08/144 (Washington, DC: International Monetary Fund).

Valencia, F., 2010, "Precautionary reserves: An application to Bolivia", IMF Working Paper No. 10/54 (Washington, DC: International Monetary Fund).

APPENDIX

Table 1. Sensitivity analysis using Barnichon (2009) 1/

Coefficient of relative risk aversion	1	0.0
	2	**4.6**
	3	9.9
Discount factor	0.97	0.0
	0.98	0.3
	0.99	**4.6**
Transition probability of terms of trade shock	10%	1.4
	20%	**4.6**
	30%	8.7
Opportunity cost of reserves	3.5%	**4.6**
	7.0%	4.2
	9.0%	3.3
Export loss	0%	**4.6**
	10%	7.5
	20%	11.6
Real exchange rate depreciation	10%	**4.6**
	20%	7.0
	30%	9.5
Aid/remittances loss	20%	**4.6**
	30%	5.3
	50%	6.7

Note:
1/ Simulations using the model baseline and individual parameter changes

Table 2. Sensitivity analysis using Valencia (2010) 1/

Coefficient of relative risk aversion	1	5.1
	2	**6.2**
	3	7.0
Discount factor 2/	0.90	**6.2**
	0.94	8.0
	0.96	15.0
Volatility of terms of trade shock	8%	4.1
	16%	**6.2**
	32%	10.6
Volatility of export volume shock	1.4%	6.0
	2.7%	**6.2**
	5.4%	6.7

Note:
1/ Simulations using the model baseline (w/o investment) and individual parameter changes
2/ In Valencia (2010), the opportunity cost of reserves in modeled through the discount factor, reflecting the impatience motive.