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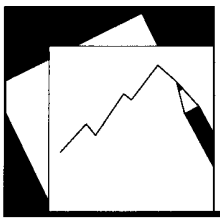

# IMF Working Paper

# International Reserve Trends in the South Caucasus and Central Asia Region

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**IMF Working Paper**

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# International Reserve Trends in the South Caucasus and Central Asia Region

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## Abstract



In recent years, the South Caucasus and Central Asia countries (CCA-6) have received significant foreign exchange inflows. While a healthy reserve buffer is desirable to self-insure against external crises, holding international reserves also involves costs. We analyze the adequacy of CCA-6 reserves using widely recognized rules of thumb, and simulate optimal reserve levels applying the Jeanne (2007) model. Both the adequacy measures and the model-based simulations indicate that, with the exception of Tajikistan, CCA-6 reserves had increased to broadly comfortable levels by 2006. More recently, reserve adequacy has been tested in Kazakhstan, which has been affected by the 2007 global liquidity crunch.

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Contents

## I. INTRODUCTION

The economies of the Caucasus and Central Asia[2] (CCA-6) have strengthened significantly after a decade of uncertainty that followed their emergence from the Soviet Union and the turbulence that engulfed them in the aftermath of the Russian crisis of 1998. Growth rates have averaged nearly 10 percent in the last six years. Inflation was in the single digits until recently,[3] debt burdens fell across the board, and international reserves increased from on average 8 percent of GDP at end-1998 to 16 percent of GDP at the end of 2006. International assets are even higher in countries endowed with oil and gas. In Azerbaijan and Kazakhstan, rising oil and commodity prices have lead to surging export revenues and stimulated private capital inflows (FDI in oil and gas, mining, construction) that helped to build up international reserve stocks. In addition, these countries have set up oil funds. In this paper, the balances accumulated in oil funds are not included in the assessment of reserves adequacy, but in Kazakhstan they could be used to complement reserve assets in case of a current or financial account shock.[4] In Armenia, Kyrgyz Republic, and Tajikistan, private transfers (mainly workers' remittances) have been the main sources of foreign exchange, together with rising commodity export prices, and emerging cash dedollarization. Georgia has benefited from both private transfers and high foreign direct investment (FDI) inflows, not least related to the construction of the Baku-Tbilisi-Ceyhan pipeline.

Nevertheless, the CCA-6 continue to face medium-term challenges, some of which are country-specific while others are common to all. The oil and gas exporters (Azerbaijan and Kazakhstan) face the risk of a sudden fall of oil prices and associated balance of payments pressures. Also, these countries have to address recurring pressures on their exchange rates brought on by the so-called "resource curse." Other economies (Armenia, Georgia, Kyrgyz Republic, and Tajikistan) depend to a significant extent on sizeable private transfers from their migrants working abroad, mainly in Russia. Here, potential balance of payments pressures could stem from a reversal of oil and gas prices (the Russian economy is largely hydrocarbon-based), but also from other factors (international commodity prices, regional political tensions, and social turbulence) that could result in a deterioration of their external positions. Finally, all of the CCA-6 are dollarized, albeit to a varying degree.[5] The provision of adequate foreign exchange liquidity is thus necessary to assure smooth functioning of their financial systems.

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[2]Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, and Tajikistan. Turkmenistan and Uzbekistan are not considered because of data limitations. International reserves data are taken from IFS and country desk projections as of November 2007.

[3] In 2007, inflation increased owing to international food and energy price hikes, and domestic demand pressures.

[4]In contrast, Azerbaijan's oil fund, which has a clear mandate to ensure intergenerational equality, cannot be used to temporarily complement international reserves.

[5] Deposit dollarization ranges from under 30 percent in Kazakhstan to about 70 percent in Tajikistan. and Georgia. Dedollarization trends have emerged in most CCA-6 countries during the past three years, being particularly pronounced in Armenia and Azerbaijan.

Dealing with the challenges identified above requires appropriate international reserve holdings. In addition, all of the CCA-6 hope to attract and benefit from FDI and external borrowing. Maintaining suitable levels of international reserves provides comfort to foreign investors and lenders alike, signaling that the country is able to service its external obligations. For developing countries, international reserves are an important instrument to mitigate and prevent external crises.[6]

This paper assesses the adequacy and optimality of the CCA-6 international reserves from the point of view of self-insurance against current and financial account crises. In addition, an assessment of reserve holdings is useful for formulating appropriate monetary policy advice, and to inform the discussion on reserve accumulation targets in monetary programs. Knowledge of an appropriate reserve level is also important as reserve accumulation may over time entail some risks and costs that the authorities have to manage through informed reserve management. Some of these risks and costs are inflationary pressure, over-investment, asset bubbles, sterilization costs, potentially sizeable central bank losses leading to the need for recapitalization, and segmentation of the public debt market.

The issues of reserve adequacy and the development of international reserve holdings have been investigated using methodologies ranging from heuristic analysis to more formal regression analysis (see Table A1).[8] The latter approach has resulted in a large and growing literature that focuses on a few core explanatory variables: size of economy, current and capital account vulnerability, and exchange rate volatility. This core set is at times supplemented by ad hoc controls for investment climate measure (for example: corruption index), crisis incidence, or regional effects. These models have matched long-term trends quite well, but have had trouble explaining the recent surge in reserves that took place in emerging market economies, mostly in Asia.

We discuss the adequacy of CCA-6 international reserves by relating them to a commonly used set of rules of thumb, and by applying the Jeanne (2007) model of optimal reserves, taking into account both country-specific characteristics and a set of uniformly calibrated parameters. We find that CCA-6 reserves in relation to imports have generally increased to comfortable levels, with the exceptions of Georgia and Tajikistan. Financial account-based ratios have been very high in most CCA-6 throughout the observation period, with the exception of Kazakhstan. The model simulations, on the other hand, show that actual reserves in most CCA-6 countries have been below, but relatively close to their optimal levels implied by the calibrated model over most of the past decade, with the exceptions of Kyrgyz Republic with much higher and both Georgia and Tajikistan with lower reserve holdings. More recently, however, actual reserve levels may have surpassed optimal levels in

[6] See Becker *et al.* (2007) p. 23. They add that this measure is especially relevant for dollarized economies. Other measures are: sound macroeconomic and financial policies, improving institutional quality, and innovative financial instruments.

[8] Table A1 presents a selected review of the recent literature. Other literature reviews can be found in Basmani-Oskooee and Brown (2002, 1985), Wijnholds and Kapteyn (2001), Williamson (1973), and Grubel (1971).

Azerbaijan and possibly Georgia. While the simulation results depend heavily on parameter calibrations, the sensitivity analysis shows that the qualitative results are generally robust.

The remainder of the paper proceeds as follows. Section II discusses the main vulnerabilities of the CCA-6 countries in the context of the insurance function of international reserves. Section III reports widely used measures of reserve adequacy and comparisons of CCA-6 reserves with peer countries. Section IV presents the model-based simulations, and Section V concludes.

## II. Reserves as Self-Insurance: Sources of External Vulnerability

Reserves are readily available external assets controlled by monetary authorities that can be used to finance external payments imbalances. Their main purpose is to provide self-insurance against external crises.[9] Changes in reserves $\Delta R_t$ can be used to balance temporary external shocks originating in the trade balance $TB_t$ (caused, for example, by a sudden fall in export prices), the income account $IT_t$ (such as from an interruption of remittance inflows) or the financial account $FA_t$ (sudden stop):

$$\Delta R_t = TB_t + IT_t + FA_t, \tag{1}$$

or to smooth the adjustment process in the case of permanent shocks. External shocks can also cause a fall in output, for example through a fall in export production or through a credit crunch caused by a sudden cut-off of external credit. Domestic absorption is the difference between domestic output and the trade balance:

$$A_t = Y_t - TB_t. \tag{2}$$

Combining (1) and (2) and rearranging terms shows that domestic absorption is the outcome of domestic output, income from abroad, the financial account, and changes of reserves:

$$A_t = Y_t + IT_t + FA_t - \Delta R_t. \tag{3}$$

Thus, the impact of external shocks on domestic absorption through drops in output, external income, or net financial flows can be mitigated by respective adjustments in reserves.

The main external vulnerabilities for the CCA-6 countries are a potential decline in international energy and commodity prices (directly for energy producers Azerbaijan and Kazakhstan, indirectly for the remittance-dependent economies), political risks, and—to a lesser extent—international financial turmoil. For most of the CCA-6, a current account

[9] Other uses of reserves, not discussed here, may be to provide liquidity to the foreign exchange market or to limit exchange rate volatility. Whether recent reserve accumulation in developing and emerging market economies has been for precautionary or for mercantilist purposes, has been a much discussed issue. See, for example, Aizenman and Lee (2005), Aizenman and Lee (2006), Aizenman (2007), Bird and Mandilaras (2005), and Dooley et al. (2003).

shock is likely to be of higher relevance than a sudden stop as (with the exception of Kazakhstan) their access to private international capital markets is still limited or just emerging. Their public sectors tend to rely on concessionary external financing from international financial institutions and bilateral donors, or on oil and gas export-related revenues. The private sectors of these countries—in particular banks—are just beginning to tap international capital markets. For oil and gas exporters (Kazakhstan and Azerbaijan), an abrupt fall in hydrocarbon prices would be most relevant, while Armenia and Georgia would be affected by a collapse in metals prices.[10] A fall in hydrocarbon prices would also have an impact on remittance-dependent countries, such as Armenia, Georgia, Kyrgyz Republic and Tajikistan, as private transfer growth has been driven by the oil and gas-related economic and construction boom in Russia. Political tensions prevalent in the region are another source of risk that could lead to border closures, loss of export markets, and disruptions of private transfers. Private transfer inflows could also be affected by changes in Russia's migration policy toward residents of CIS countries (Atoyan, 2007). Finally, those countries that are increasingly integrated into the international financial system, such as Kazakhstan, may be vulnerable to sudden stops and international financial contagion. The recent financial turmoil caused by the U.S. sub prime mortgage crisis, which caused massive temporary financial outflows from Kazakhstan, is a case in point.

## III. Traditional Measures of Reserve Adequacy

Various standard measures are commonly used to assess the adequacy of international reserve holdings from a precautionary viewpoint. Broadly, one can distinguish between (i) current account-based measures, which apply mainly to countries without or with only limited access to private international capital markets, and (ii) financial account-based measures—more relevant for countries with access to international capital markets. All of these measures are only broad indicators that should be interpreted with caution, taking into account macroeconomic fundamentals and institutional environments of individual countries.

The reserves-to-imports ratio is a useful measure for less developed countries, where potential reserve drains typically relate to the trade balance, rather than to capital flows. The ratio indicates how long a country facing an external shock can continue its current level of imports, when additional external financing is unavailable. A reserve cover of at least three months of prospective imports is commonly seen as broadly adequate. Whether a higher ratio is needed depends on the sensitivity of trade to changes in exchange rates, current account volatility, and the preference for smooth adjustment.

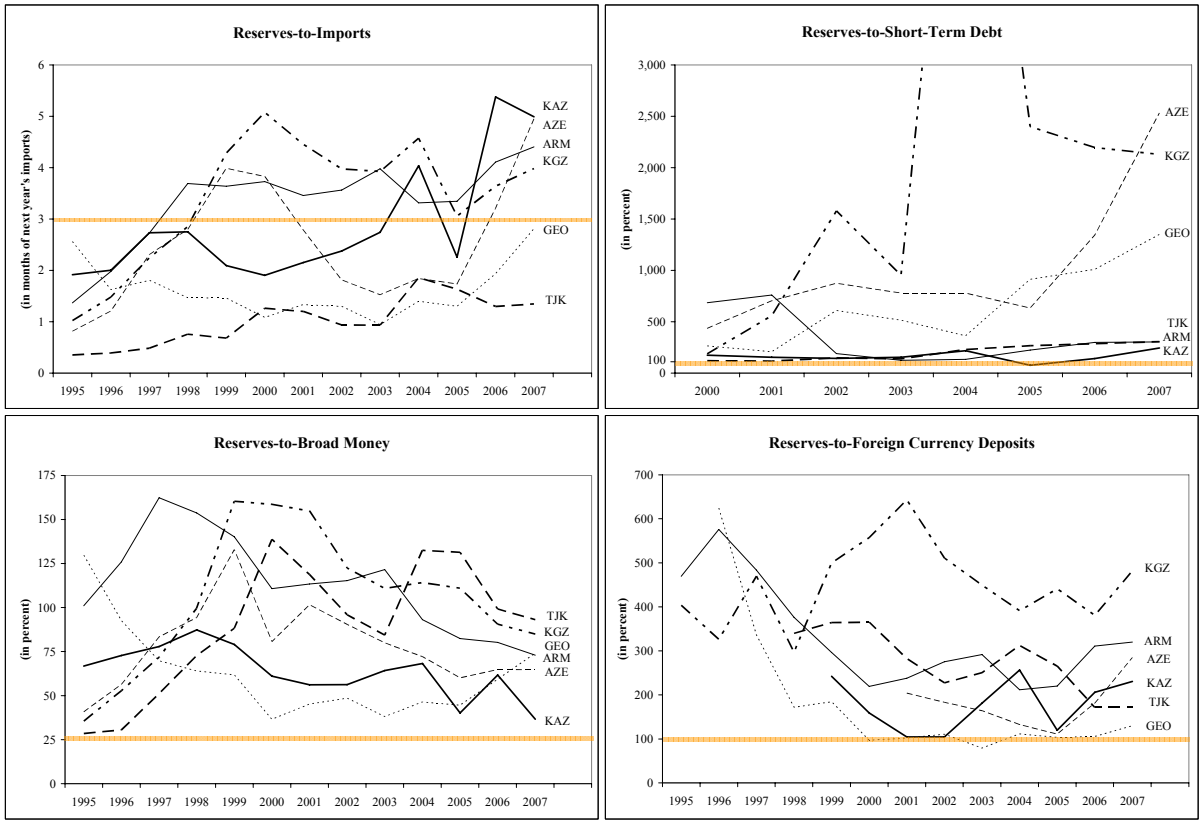
The ratio of reserves to total short-term external debt is a core measure of liquidity or rollover risk. The "Greenspan-Guidotti rule" calls for a cover of 100 percent of short-term debt, enabling a country to bridge one year without access to private international capital markets. A floating exchange rate regime and sound private sector debt management tend to reduce the needed reserve cover of short-term external debt, while a combination of fixed

[10] This could be triggered by a recession in the United States and/or an economic slowdown in China.

exchange rates, open financial account, and currency mismatches in bank balance sheets increases it.

Other financial account-based measures relate international reserves to monetary aggregates or foreign-currency deposits. The ratio of reserves to broad money is more appropriate in countries with fixed exchange rate regimes and weak banking systems. It is a measure of a country's ability to withstand a capital flight triggered by a loss of confidence in the domestic currency. Similarly, the ratio of reserves to foreign currency deposits indicates a country's ability to hold out a run on foreign currency deposits. However, in a currency crisis deposit holders would also tend to withdraw domestic currency deposits and exchange the proceeds into foreign currency, thus making the ratio of reserves to foreign currency deposits a less useful measure.

Figure 1. CCA-6. Measures of Reserve Adequacy, 1995—2007

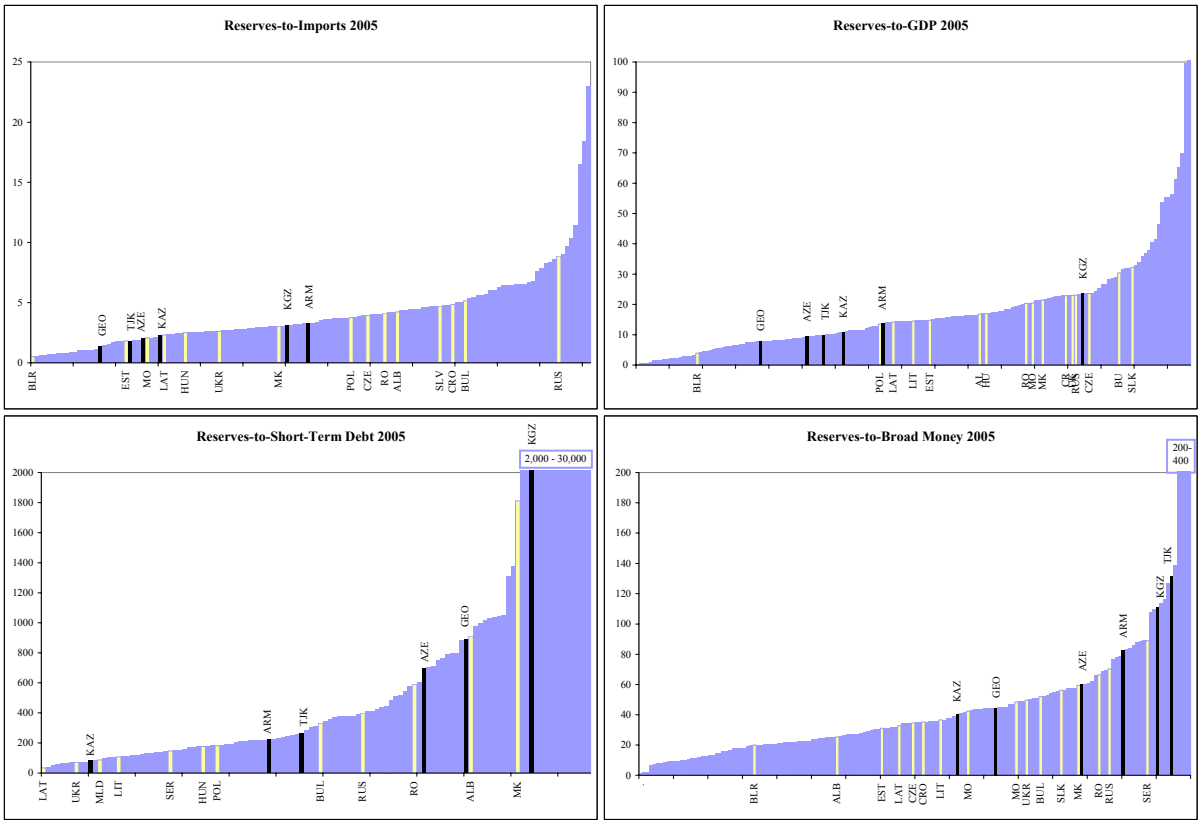



Sources: IFS, WBGDF, and staff estimates and projections.

Figure 1 shows the development of the above-mentioned reserve ratios in the CCA-6 over the past decade. Corresponding to these countries' status as low- to mid-income developing countries with low financial depth and limited access to international capital markets (the exception being Kazakhstan), all financial account-based measures indicate very high levels of reserves, and the reserves-to-imports ratio appears to be the most relevant measure of reserve adequacy. All CCA-6 countries' reserves significantly exceed the Greenspan-

Guidotti rule,[11] and likewise, reserves in all countries cover more than 100 percent of foreign currency deposits. The reserves-to-broad money ratio has generally trended downward since 2000, in line with the gradual remonetization and financial deepening trends in the CCA-6 economies. On the other hand, reserve coverage of imports has been historically weak, in particular in Tajikistan and Georgia. While prior to 1998, reserves fell short of the benchmark coverage of at least three months of imports, only Armenia and Kyrgyz Republic have consistently maintained reserves in excess of three months of projected imports since 1998. Since 2005, however, the reserves-to-imports ratios have increased markedly in all countries but Tajikistan, and are projected to remain at comfortable levels in the near future.

Figure 2. Measures of Reserve Adequacy 2005—International Comparison




Sources: IFS, WBGDF.

Figure 2 puts the reserve holdings of the CCA-6 in international perspective. The year 2005 was chosen due to data availability. In relation to prospective imports and to GDP, CCA-6 international reserves were not systematically different from those in other transition countries, and were generally in the mid-range of ratios found in the global sample. Reserves

[11] Kazakhstan fell short of 100 percent coverage of short-term debt at end-2005, when reserves fell by 21 percent in November/December. This, however, represented only a short-lived drop related to debt prepayment, stepped-up contributions to the oil fund, some foreign exchange outflows motivated by political uncertainty prior to the Presidential election, and delayed repatriation of earnings by exporters. Reserves had recovered fully by February 2006 and continued to grow strongly afterwards.

were generally higher in relation to the financial account-based measures—particularly in Kyrgyz Republic, Azerbaijan, and Georgia with respect to short-term debt; and Tajikistan, Kyrgyz Republic, and Armenia with respect to broad money.

In summary, international reserve holdings of the CCA-6 countries have been historically low in relation to imports—the most relevant measure of reserve adequacy for this country group— but have generally increased robustly since the mid-2000s in all CCA-6 but Tajikistan. With the exception of Kazakhstan, financial account-based measures have indicated very high levels of reserve adequacy, corresponding to the low domestic financial depth and limited access to international capital markets.

## IV. Optimal Reserves

### A. The model

Jeanne (2007) derives optimal international reserve holdings in the context of a small open economy in discrete time, populated by a representative consumer, where wealth can be held either in the form of liquid international reserves (*R*) or a higher yielding, but illiquid asset (*I*). The economy is vulnerable to external crises—a loss of access to external credit—that result in a fall in output. International reserves can be used to smooth absorption during a crisis (crisis mitigation), and possibly reserves also reduce the probability of a crisis (crisis prevention). At the same time, holding reserves entails cost in the form of the excess return δ of the illiquid asset. The optimal level of reserves minimizes the consumer's welfare loss function, which depends on the sum of the expected welfare cost of a crisis $f(R)$ that occurs with probability $\pi(R)$ and the opportunity cost of holding reserves $\delta R$.

$$Loss = \delta R + \pi(R) f(R). \tag{4}$$

The model has three periods. In period 0, the consumer decides what level of reserves to hold. This decision depends on the perceived risk and costs of a future crisis, which could occur in period 1, when an external liability comes due. The country repays its debt $L$ , issues new debt $L'$, and consumes $C_1$, facing the budget constraint:

$$Y_1 + L' + R = C_1 + L + R'. \tag{5}$$

Period 2 represents the long term, where the country's net foreign wealth is equal to the sum of output $Y_2$ and the net return on foreign assets:

$$W_2 = Y_2 + (1+r)^2 (1+\delta) I + (1+r)(R' - L'). \tag{6}$$

The consumer's welfare is defined as the sum of the expected utility of consumption $u(C_1)$ in period 1 plus the expected wealth $W_2$, discounted by the interest rate $r$:

$$U_i = E_i\left[u(C_i) + \frac{W_2}{1+r}\right]. \tag{7}$$

An external crisis can occur in period 1 with probability π. Its welfare cost $f(R)$ is increasing in the level of short-term debt $L$ coming due and the cost of the crisis in terms of lost output $\Delta Y$, and decreasing in the level of reserves $R$. A closed-form solution for the optimal level of reserves exists under the assumption that π is independent of the level of reserves and is given by the expression:

$$R = L + \Delta Y - \left[1 - \left(1 + \frac{\delta}{\pi}\right)^{-1/\sigma}\right], \tag{8}$$

where σ represents the constant parameter of relative risk aversion. Thus, the optimal level reserves is equal to the "full insurance" level $\overline{R} = L + \Delta Y$ (the minimum level sufficient to maintain consumption at the desired level in a crisis), minus a term reflecting the opportunity cost of holding reserves.

Reserves help smooth consumption in a currency crisis or sudden stop, and may also reduce the probability of a crisis by increasing confidence in a country's currency and its ability to service external debt. Jeanne (2007) models the probability of a crisis as decreasing in the reserve cover of short-term foreign debt and increasing in a summary measure of vulnerability to a crisis $v$:

$$\pi(R) = F\left(v - a\frac{R}{L}\right), \tag{9}$$

where $a$ represents the strength of the crisis prevention effect. Other things equal, the optimal level of reserves increases when the benefits of crisis prevention are taken into account, and possibly exceeds the "full insurance" level. However, no closed-form expression for the optimal level of reserves exists for the case of endogenous crisis probability.

## B. Calibration

The level of optimal reserves is determined by 5 parameters: short-term debt $L$ and the output loss in a crisis $\Delta Y$, both measured as a ratio to GDP, the probability of a crisis $\pi$, the term premium $\delta$, and relative risk aversion $\sigma$. Data on short-term debt was taken from the World Bank's Global Development Finance (WBGDF) database, while the calibration of the remaining parameters is given in Table 1.

Table 1. Calibration Parameters

| Parameter | Baseline | Range of variation |
|---|---|---|
| Output costs, $\boldsymbol{\Delta Y}$ | 0.15 | [0.0, 0.3] |
| Probability of the shock, $\boldsymbol{\pi}$ | 0.10 | [0.0, 0.3] |
| Costs of holding reserves, $\boldsymbol{\delta}$ | 0.015 | [0.00, 0.05] |
| Risk aversion, $\boldsymbol{\sigma}$ | 2.5 | [1.0, 10.0] |

For the baseline simulations, it is assumed that the probability of a crisis $\pi$ is exogenous—that is higher reserve holdings have no benefits in terms of crisis prevention (equation 8). Following Jeanne and Rancière (2006) and Jeanne (2007), who estimate the crisis probability for an emerging market country based on a cross-country probit model, $\pi$ is calibrated at 10 percent. The cumulative output cost $\Delta Y$ of a crisis is assumed to be 15 percent of GDP. This is in the upper range of estimates found in the literature,[12] as output drops in developing countries tend to be significantly higher than in industrialized countries (Hakura, 2007). The term premium $\delta$ is set at 1.5 percent, which corresponds to the average differential between the yield on 10-year U.S. Treasury bonds and the federal fund rate during the past 20 years (Jeanne and Rancière, 2006).[13] Finally, the relative risk aversion parameter $\sigma$ is calibrated at 2.5, a value corresponding to medium risk aversion.[14] Alternative values of 1.5 and 5 expressing low and high risk aversion, respectively, are also used in alternative calibrations in order to create a corridor of "reasonable" reserve holdings.

[12] Bordo et al. (2001) estimate the average output cost of simultaneous currency and banking crises at between 13 and 16 percent of GDP, and Hutchison and Noy (2006) find cumulative output losses of twin crises of around 13-18 percent of GDP. Jeanne (2007) finds output costs of sudden stops between roughly 8 and 12 percent. See also Ahmed et al. (2001), Gupta, Mishra, and Sahay (2001), Hutchison and Noy (2002), and Milesi-Ferretti and Razin (2000).

[13] For a discussion of alternative concepts of measuring the opportunity cost of international reserves, see Hauner (2006) and Jeanne (2007).

[14] An individual is risk loving if $\sigma<0$, risk neutral if $\sigma=0$, and risk averse if $\sigma>0$. Most empirical studies find reasonable parameter values in the range of 2 to 4. See, for example, Dohmen et al. (2006) and Friend and Blume (1975). For corresponding calibrations, see Boersch-Supan et al (2003), Chari et al. (2000), Gollier et al. (2001), and Kocherlakota (1996).

## C. Baseline results

The baseline calibration for the CCA-6 countries implies optimal levels of reserves that average about 13 percent of GDP. This is 2 percentage points higher than the historic CCA-6 average between 1995 and 2006. Optimal values vary widely across countries and time—ranging from around 9 to 25 percent of GDP—corresponding to the developments in vulnerabilities over the past decade (Figure 3). Between 1995 and 2006, the actual international reserves of Armenia and Azerbaijan tracked the optimal values of the baseline calibration rather closely, while actual reserves of Georgia, Tajikistan, and—to a lesser extent—Kazakhstan fell short of the optimal values implied by the model. Kyrgyz reserves, on the other hand, have consistently exceeded optimal levels since 2001.

Recent international reserve holdings of most of the countries in the sample could be optimal under slightly modified assumptions about individual model parameters. Table 2 shows implicit parameter values, each of which would align actual 2006 reserve holdings with the optimal levels implied by the model, if all other parameters are unchanged. In line with the small discrepancies in the baseline model, relatively minor parameter modifications would suffice in the cases of Armenia, Georgia, and Kazakhstan to align the two reserve measures. Larger parameter adjustments would be needed to close the gaps between actual and optimal reserves of Azerbaijan and Tajikistan. In the case of Kyrgyz Republic, however, actual reserve holdings are so high that no reasonable individual parameter calibrations or combinations thereof exist to increase simulated optimal reserve holdings to the actual 2006 level. Recent international reserve accumulation in the Kyrgyz Republic clearly cannot be explained by the model of precautionary reserve holdings used in this paper.

Table 2. Implicit Parameter Values Yielding Optimality of End-2006 Reserves

| **Parameters** | | **Armenia** | **Azerbaijan** | **Georgia** | **Kazakhstan** | **Kyrgyz Rep.** | **Tajikistan** |
|---|---|---|---|---|---|---|---|
| | Baseline | Optimal | Optimal | Optimal | Optimal | Optimal | Optimal |
| Output costs, $\Delta Y$ | 0.15 | 0.17 | 0.17 | 0.14 | 0.12 | 0.31 | 0.11 |
| Probability of shock, $\pi$ | 0.10 | 0.11 | 0.13 | 0.07 | 0.05 | ... | 0.05 |
| Costs of holding reserves, $\delta$ | 0.015 | 0.013 | 0.011 | 0.020 | 0.028 | -0.021 | 0.031 |
| Risk aversion, $\sigma$ | 2.5 | 2.8 | 3.3 | 1.9 | 1.4 | ... | 1.3 |

Reserve growth has picked up markedly in all CCA-6 countries since at least 2006. A look at preliminary estimates for 2007 gives some interesting insights about emerging reserve trends (Figure 3). Estimated reserves-to-GDP ratios in Azerbaijan and Georgia surge and now exceed optimal levels indicated by the baseline model, while the gap between optimal and actual reserves in Kyrgyz Republic widens further. All three countries face large-scale foreign exchange inflows related to oil- and pipeline revenues and/or private transfers and exhibit only limited exchange rate flexibility. In Kazakhstan, on the other hand, the financial turmoil of 2007 has resulted in both a significant reduction of the level of short-term foreign debt (reflected in a lower optimal reserves level) and a lower level of actual international reserves, with the estimated actual reserves reasonably close to the model's optimal level in 2007 (Box 1).

Figure 3. Simulation Results

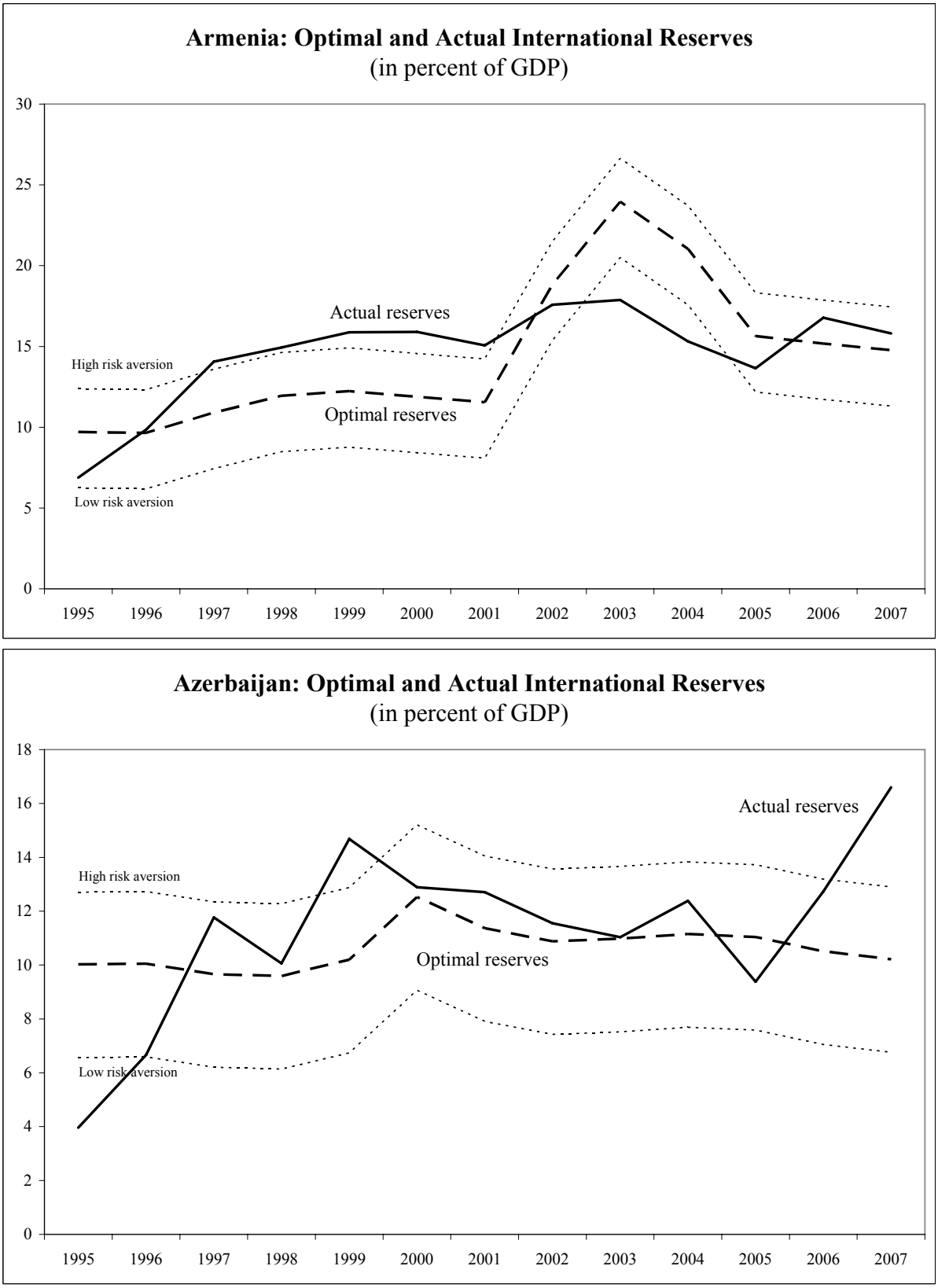
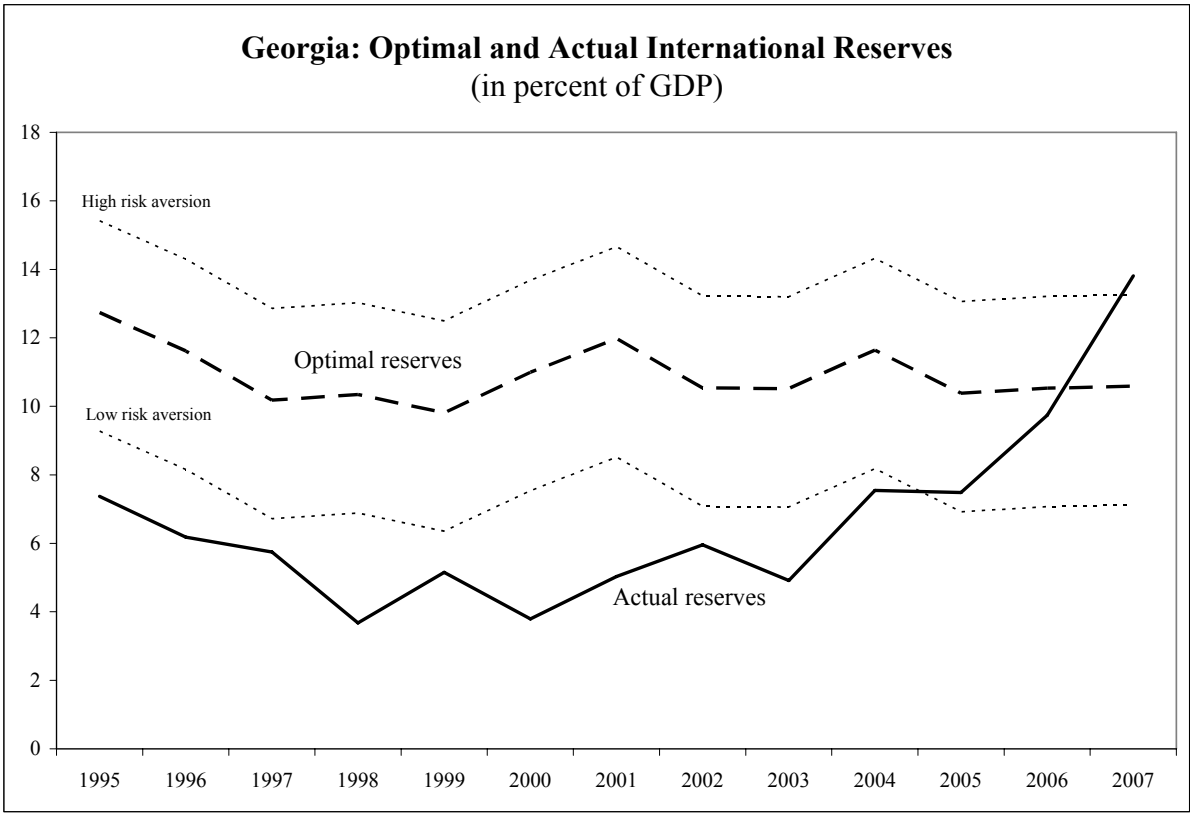


Figure 3. Simulation Results (continued).



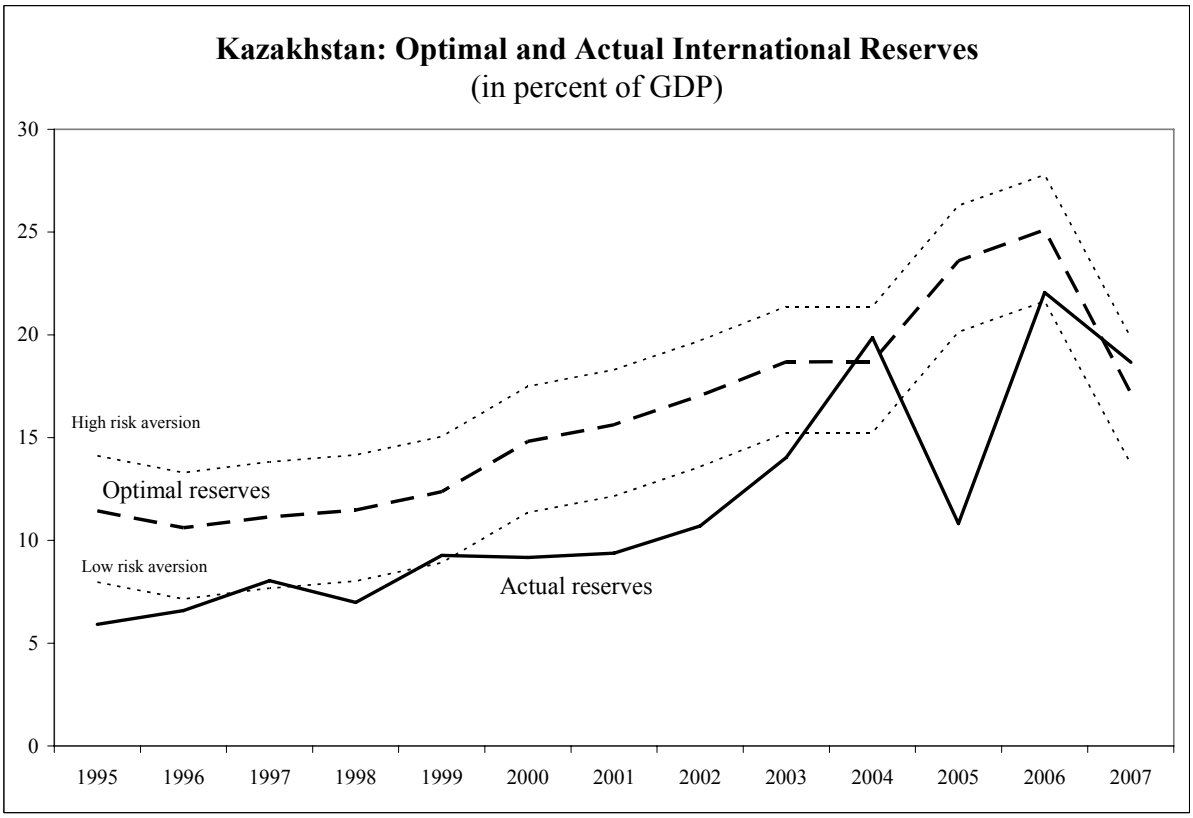
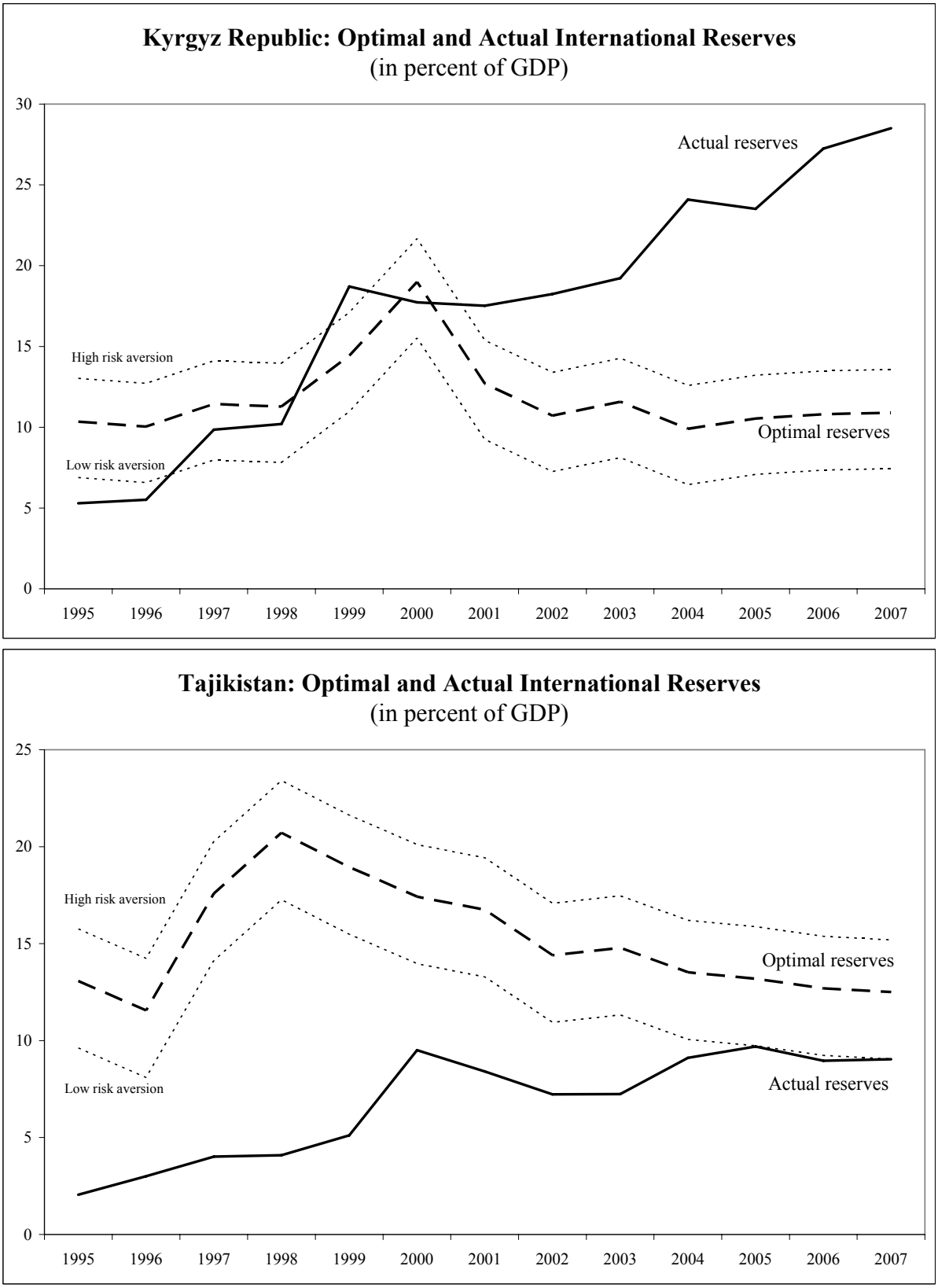



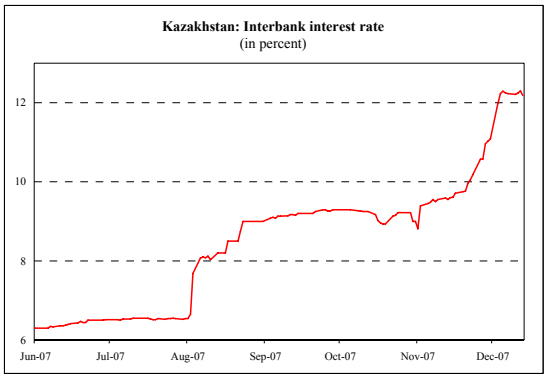
Figure 3. Simulation Results (concluded).

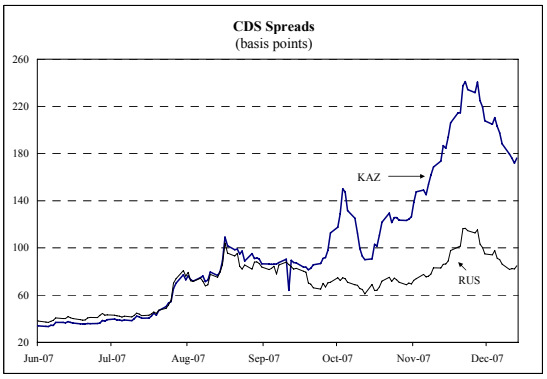



Sources: IFS, WBGDF, and staff estimates and projections.

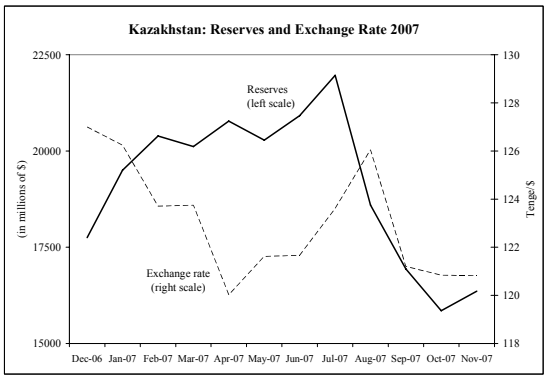
## Box 1. Kazakhstan: Impact of the 2007 Global Credit Squeeze

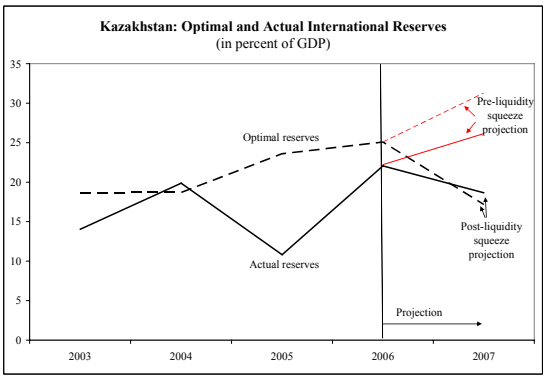
Financial turmoil has recently tested the adequacy of Kazakhstan's reserve holdings. In the summer of 2007, the world-wide credit crunch triggered by the sub-prime crisis in the U. S. mortgage market spilled into Kazakhstan. After borrowing $13 billion externally during the first half of 2007—accounting for 15 percent of emerging market corporate bond issuance in international capital markets—Kazakh banks faced a virtual closure of external markets in August. Interbank rates surged to above 9 percent in late August and more recently climbed to more than 12 percent. Five year credit default swaps (CDS) widened to more than 220 bps by end-November, but have come down since to below 180 bps.




The National Bank of Kazakhstan (NBK) responded by injecting liquidity and affirming that it was ready to provide additional funds to stabilize the financial sector. Since end-July, NBK sold more than $6 billion of its reserves (about 6 percent of GDP) in response to increased demand for foreign exchange. Pressures on the domestic currency were significant, but short-lived. The tenge depreciated by about 3.6 percent against the dollar between June and August, but is now back at its pre-liquidity squeeze exchange rate.




Capital outflows were finally brought to a halt, and the NBK was able to add about $500 million to its reserves in November. Nevertheless, projections of reserve growth in Kazakhstan have been revised downward significantly due to the recent developments. At the same time, the optimal reserve levels implied by the simulation model are also reduced, because external short-term debt has been brought down, and is projected to remain much lower than previously projected through 2008.

## D. Sensitivity analysis

As indicated in the previous discussion, simulation results depend on the chosen parameter calibrations. The Figures A1 to A6 in Appendix 2 show the impact of alternative calibration choices on the model's outcomes. The optimal level of reserves in the CCA-6 countries is particularly sensitive to the assumed output loss in a crisis (Table 3). A one-percent increase (reduction) of the baseline output loss, $\Delta Y$, results, on average, in a one and a quarter-percent increase (reduction) in the level of optimal reserves in percent of GDP. one-percent changes from the baseline in the other parameters result in weaker responses of optimal reserves, slightly over 0.4 percent. Due to the nonlinearity of the model, the impact of parameter changes becomes progressively more asymmetric with increasing magnitudes of parameter variations. Larger reductions in the assumed crisis probability and relative risk aversion parameters decrease the simulated levels of optimal reserves by more than respective higher parameter values would increase them.

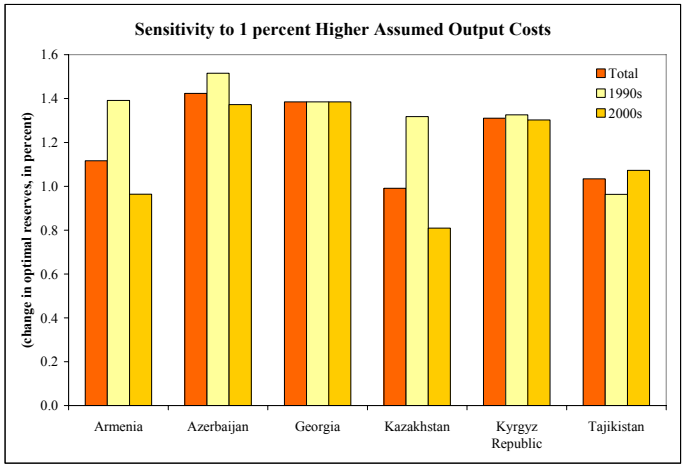
Table 3. Sensitivity of Simulation Results: Average Impact of Parameter Changes

(in percent)

| | (1% change) | | (10% change) | | (25% change) | |
|---|---|---|---|---|---|---|
| | reduction | increase | reduction | increase | reduction | increase |
| Output costs, **ΔY** | -1.25 | 1.25 | -12.5 | 12.5 | -31.1 | 31.1 |
| Probability of shock, **π** | -0.41 | 0.41 | -4.5 | 3.8 | -13.3 | 8.3 |
| Costs of holding reserves, **δ** | 0.41 | -0.41 | 4.1 | -4.1 | 10.5 | -10.0 |
| Risk aversion, **σ** | -0.44 | 0.43 | -4.9 | 4.0 | -14.5 | 8.8 |

The sensitivity of results to parameter changes is generally decreasing over time (higher in the 1990s than in the 2000s) and is lowest in the case of Kazakhstan and highest in Azerbaijan. Moreover, results for Armenia and Tajikistan are somewhat less affected by parameter variations than those for Georgia and the Kyrgyz Republic (Figure 4).

Figure 4. Sensitivity of Simulation Results: Country- and Time Effects



## E. Model extensions and qualifications

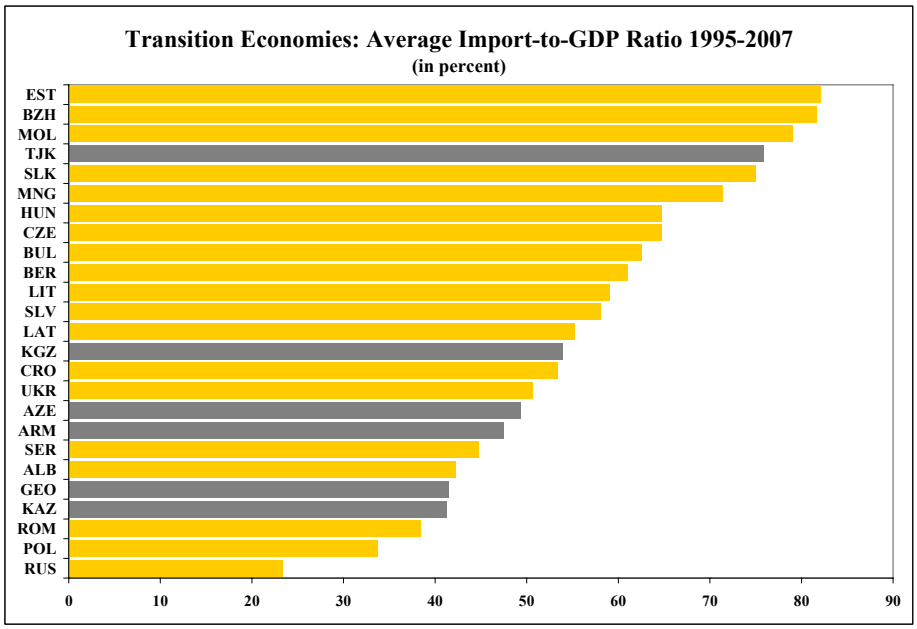
Several factors that affect the optimal level of precautionary reserves are not captured in the baseline model. Specifically, Jeanne (2007) and Chami *et al.* (2007) show that optimal reserves are substantially higher if reserve holdings influence the probability of a crisis (crisis prevention). However, the empirical evidence on the crisis prevention benefit of reserves is not clear, as it may be possible that spending reserves merely postpones a crisis.

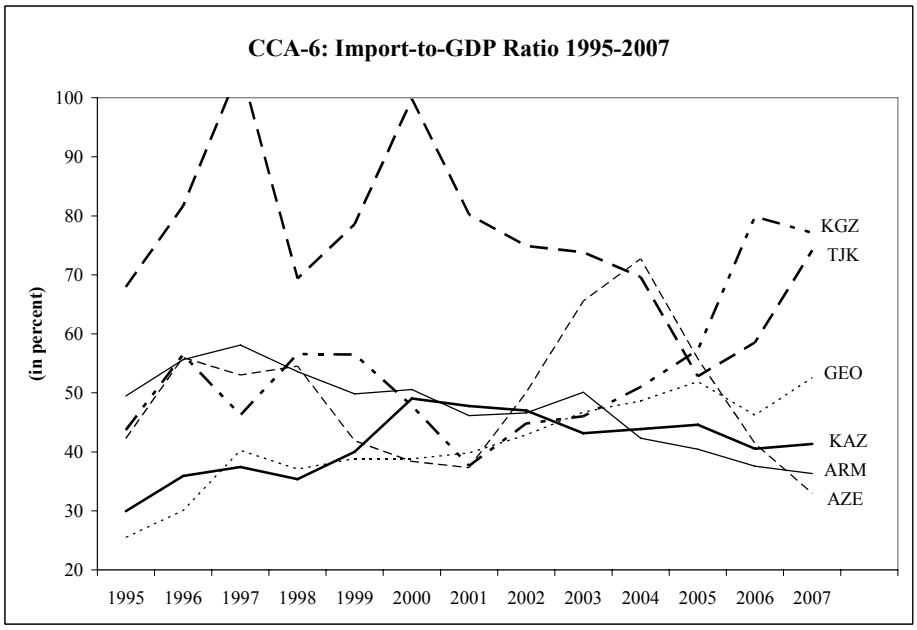
In dollarized economies, the adverse impact of sudden stops and currency crises can be compounded by large-scale withdrawals of foreign currency deposits, which reduce funds available for lending, resulting in larger output drops. Gonçalves (2007) finds that incorporating dollarization of bank deposits in the Jeanne and Rancière (2006) model increases the amount of international reserves held for self insurance. All CCA-6 countries exhibit a significant degree of deposit dollarization, suggesting that optimal reserves for these countries might be higher than in the baseline model. Nevertheless, the impact of dollarization is likely to be limited, as the degree of financial intermediation in most CCA-6 countries is still modest compared to other developing and emerging market countries.

Real exchange rate depreciation in a crisis may have an ambiguous effect on optimal reserve levels. On the one hand, it has a contractionary effect by increasing the burden of foreign currency-denominated liabilities, thus increasing the need to hold reserves for self-insurance. On the other hand, the value of reserves in terms of domestic consumption increases due to the depreciation, so that the same amount of reserves now provides more insurance than in the baseline model. Jeanne and Rancière (2006) find that, due to this ambiguity, real exchange rate depreciation does not have a substantial impact on the optimal level of reserves.

Finally, the model presented above focuses mainly on the vulnerability to and the effect of sudden stops, i.e. the loss of access to external credit. In some of the CCA-6, however, external vulnerabilities are more likely to emanate from the current account, in particular from high and volatile imports and the remittance flows that finance them. Such current account shocks are only indirectly covered by the model through their effect on GDP. Therefore, the model's findings should be supplemented by an assessment of the reserves-to-imports ratio. For example, the model simulations suggested that Kyrgyz reserves exceeded simulated levels by a large margin. However, Kyrgyz Republic is a country with only limited access to international capital markets, and its short-term external debt has been comparatively low in most periods: it amounted to 5 percent of GDP in 1999 and 9.4 percent of GDP in 2000, but fell below 2 percent of GDP thereafter. On the other hand, imports have grown rapidly in recent years, and the import-to-GDP ratio has roughly doubled between 2001 and 2007 (Figure 5), resulting in a modest decline in the reserves-to-imports ratio, which has remained close to the benchmark level of three months of projected imports (Figure 1).

Figure 5: Imports-to-GDP Ratios in Transition Countries




Sources: IFS, WBGDF, and staff estimates and projections.

## V. Summary and Concluding Remarks

This paper analyzed the development of international reserve holdings in the CCA-6 over the past decade, and assessed their appropriateness for self-insurance against external crises. The main external vulnerabilities facing the CCA-6 economies were found to be related to interruptions in private transfer flows, changes in international energy and commodity prices, as well as regional political tensions.

Conventional measures of reserve adequacy suggest that CCA-6 reserves have been adequate to mitigate crises originating in the financial account. This is as expected, since with the exception of Kazakhstan, CCA-6 countries have limited access to international capital markets and low financial depth. Hence, a current account-based measure, such as the reserves-to-imports ratio, is more relevant in the case of most CCA-6 economies. The latter was historically weak, but has improved significantly since 2005 in all CCA-6 but Tajikistan.

This view is broadly confirmed by simulations based on the Jeanne (2007) model of optimal reserves. Compared to the optimal levels implied by the baseline calibration, actual reserves were comparatively low in Georgia and Kazakhstan until 2005, and they continue to fall short of optimal values in Tajikistan. In Kyrgyz Republic, on the other hand, since 2001, actual reserves significantly exceeded levels that can be explained by the model. Reserve holdings have improved in all CCA-6 economies since the mid-2000s, and higher-than-optimal reserve accumulation was estimated for Azerbaijan and Georgia in 2007.[15]

The adequacy of international reserves was recently tested in Kazakhstan. The country experienced significant capital outflows related to a global credit squeeze originating in the U.S. sub prime mortgage market. The National Bank of Kazakhstan used part of its international reserves to provide the market with demanded liquidity and foreign exchange, and so far it appears that it successfully counteracted both capital outflows and pressures on the exchange rate.

An assessment of precautionary reserve holdings needs to be based on a broad spectrum of measures. It must also take into account individual countries' macroeconomic environment and structural characteristics. Both conventional reserve adequacy measures and model-based simulations have limitations: reserve adequacy ratios capture only selected vulnerabilities and ignore welfare considerations and country characteristics; model-based estimates take into account the trade-off between the benefits of reserves in crisis mitigation and the cost of holding reserves, but simulation results are sensitive to parameter calibrations. Possible model extensions, including crisis prevention benefits and dollarization, suggest higher optimal reserves than in the baseline simulations.

In conclusion, measures of reserve adequacy and optimality provide valuable insights for policymakers and can help guiding monetary and reserve policies. They are easily applicable, and the model of optimal reserves can be calibrated so as to realistically reflect individual countries' characteristics and vulnerabilities. Such analysis can inform policy discussions on reserve accumulation targets, intervention policies, and the scope for diversification of "excess" reserves into less liquid, but higher-yielding asset classes, such as in the context of sovereign wealth funds.

[15] In addition, Kazakhstan and Azerbaijan have established oil funds. These funds were excluded from the above analysis, but in Kazakhstan, the authorities could, in principle, use them to complement international reserves, if needed.

# APPENDIX 1: RECENT EMPIRICAL WORK ON INTERNATIONAL RESERVE HOLDINGS

| Author | Year | Coverage | Focus | Time period | Estimation method | Explanatory | Main conclusions |
|---|---|---|---|---|---|---|---|
| | | | | | **Heuristic analysis** | | |
| Feldstein | 1999 | East Asia, China | How to avoid a crisis? | 1990s | Heuristic analysis | Precautionary motive | To avoid crisis: avoid ST debt, accumulate reserves, create collateralized loan facility, but sound economic policies best. |
| Wijnholds & Kapteyn | 2001 | 21 emerging market economies | Assessment of reserve adequacy | 1990s | Adequacy ratio analysis | Reserves to STD, imports, M2. | Maintain reserve at adequate levels suggested by benchmarks. Avoid excessive reserves-they are costly and might have detrimental macroeconomic impacts. |
| Bird & Rajan | 2003 | Developing | How to think of adequacy of reserves | 1999 | Descriptive indicators and heuristic analysis | Reserves to STD, imports. | Many hold substantial "excess" reserves. Adequate reserve levels are needed but should not be treated as a substitute for policy changes; pooling arrangements (i.e. IMF) should be considered as alternative ways of assuring adequacy of reserves. |
| Kim, Li, Rajan, Sula, and Willet | 2005 | Developing Asia | How to assess adequacy in an era of high capital mobility | 1996-04 | Adequacy ratio analysis | Reserves to various measures of "mobile" capital inflows | Augmented benchmarks explain possible outflows of "mobile" capital when determining adequacy of reserves. Reserves seem excessive even against new benchmarks. |
| ECB Int. Relations Comm. Task Force | 2006 | Developed and developing | 2002-04; countries with rapid reserve growth | 1945-04 | Review of various methods | Self-insurance against crisis, exchange rate anchoring against $US, underdeveloped local financial systems, dollarization of cross-border assets, excess of domestic savings vs. investment. | Reserve accumulation is in excess of levels warranted by conventional indicators and will entail risks and costs if it continues. |
| | | | | | **Regression analysis** | | |
| Flood & Marion | 2002 | 36 developed and developing | Buffer stock model | 1988-97 | GMM panel regression | Scale variable (none, real GNP, imports, M2), country fixed effects, reserve volatility measure, domestic and US interest rates. | Buffer stock model works well but explains only about 10-15% of variation in reserve holdings. Fixed effects explain about 75% of variation. |
| Aizenman & Marion | 2002 | 122 countries plus Asian countries analysis | What factors predict reserve levels? | 1980-00 | Panel regression; Buffer stock model | Population, real GDP per capita, volatility of real export receipts, MGS share in GDP, volatility of NEER plus political uncertainty and corruption. | Model predicts well (over predicts) pre-1997 reserve levels, but under predicts Far East reserve holdings afterwards. Lucas critique might be an explanation. Size of fiscal commitment, loss aversion, shock variability can account for excessive accumulation. |
| IMF | 2003 | 24 developing | Asia | 1997-02 | Step-wise multivariate regression with 122 country fixed effects 1980-1996 | Real GDP per capita, population, imports to GDP, export volatility, exchange rate volatility. | Reserve build-up for 1997-01 broadly in line with the model forecast; 2002 reserves in Asia, Russia, Mexico appear excessive; slowdown of accumulation might be desirable. |
| Ozyildirim & Yaman | 2005 | Turkey | Analysis of Turkey's international reserves. | 1988-04 | Rules of thumb for adequacy; model minimizing expected cost of reserves a la Ben-Bassat &Gottlieb (1992) for optimality analysis | Loss of output, probability of a crisis, opportunity cost of reserves. | Through most of the period reserves were below their estimated optimal and adequate levels determined by the accepted rules of thumb. |
| Aizenman & Lee | 2005 | 53 countries: developed, developing, emerging | Evaluate merits of mercantilist approach to reserve accumulation | 1980-00 | Cross sectional regressions with country fixed effects; a minimal model to explain self-insurance | Population, real GDP per capita, volatility of real export receipts, MGS share in GDP, MA(3) of real export growth; exchange rate volatility; PPP measure; crisis dummies, regional dummies. | Sound economic policies did not stave-off crisis. Mercantilist motive not supported by evidence. Precautionary demand and its benefits outweigh opportunity costs of "excessive" reserves; better data might alter the results. To assess efficiency of reserves requires detailed model, information on probability and output costs of sudden stops and opportunity costs of reserves. |
| | | | | | **Optimization** | | |
| Jeanne & Ranciere | 2006 | 34 middle income countries, excluding oil producers | Determination of optimal reserve level | 1975-03 | Representative consumer welfare maximizing model | Capital flight, loss of output, opportunity cost of reserves, relative risk aversion of a domestic consumer, probability of a crisis. | Model calibrates well on 2000 reserve levels but can not explain rapid build-up of reserves post 2000. The build up appears excessive. |
| Jeanne | 2007 | Emerging markets | Determination of optimal reserve level | 2000-05 | Representative consumer welfare maximizing model | Capital flight, loss of output, opportunity cost of reserves, relative risk aversion of a domestic consumer, probability of a crisis. | Model calibrates well on 2000 reserve levels but can not explain rapid build-up of reserves post 2000. The build up appears excessive. |

## APPENDIX 2: SENSITITVITY OF SIMULATION RESULTS

Figure A1: Armenia

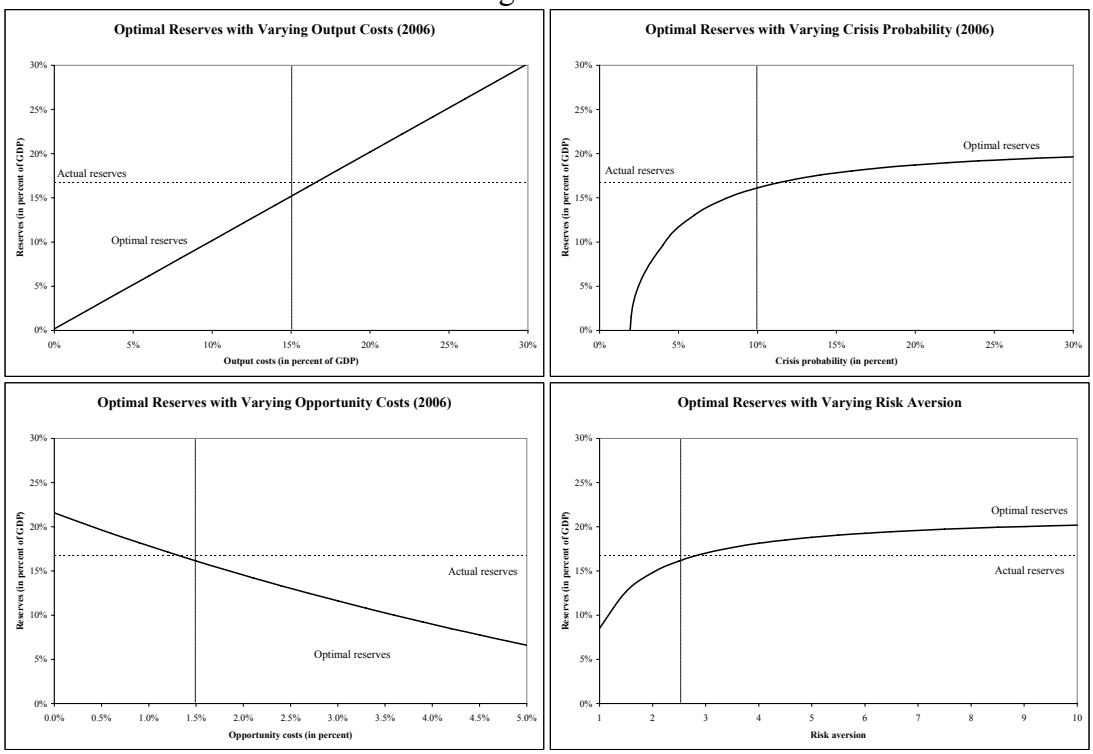



Figure A2: Azerbaijan

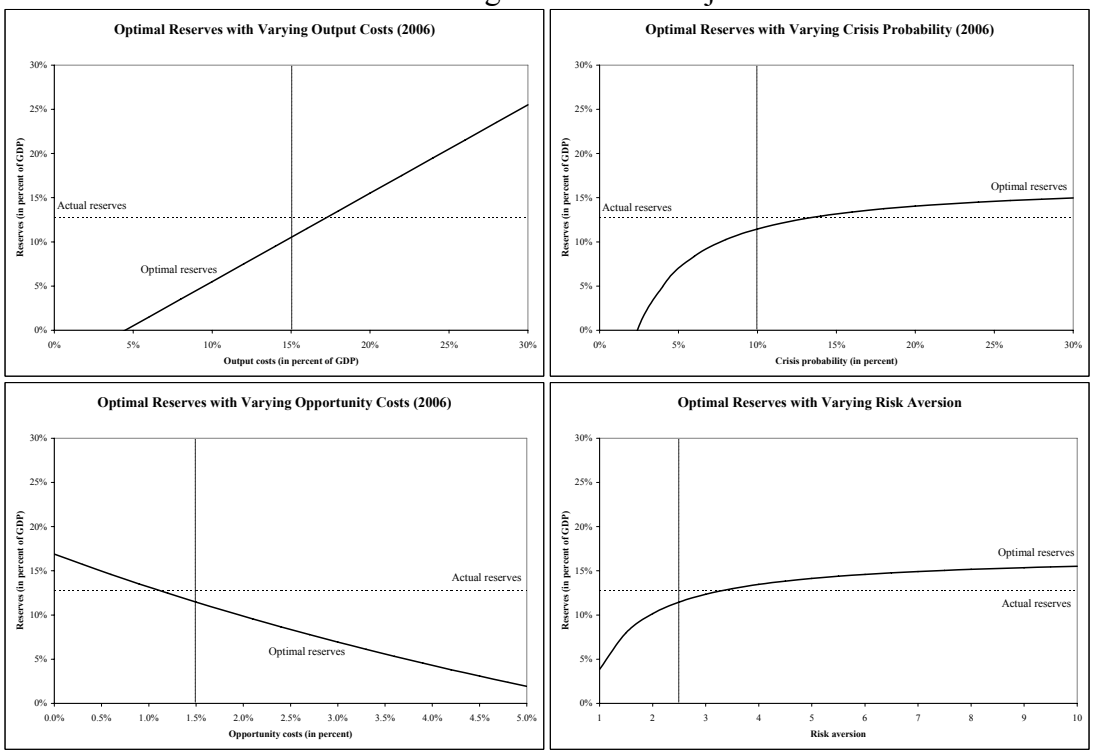


Figure A3: Georgia

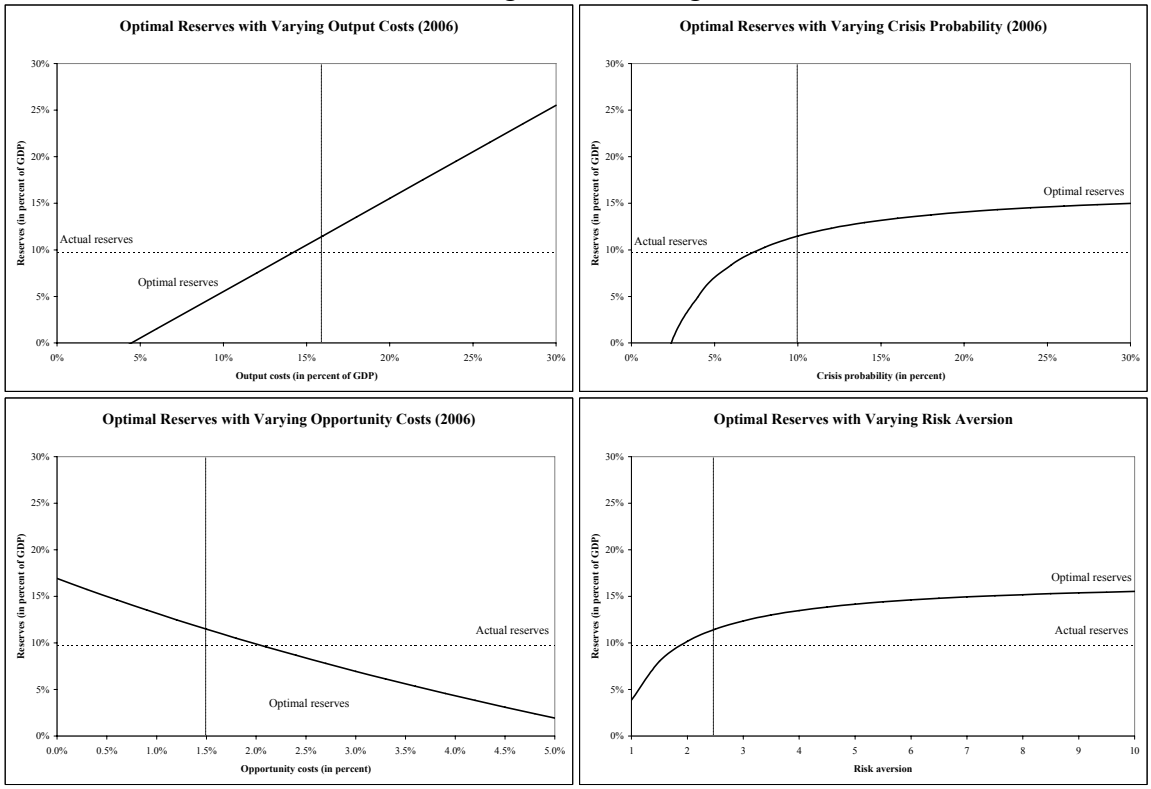



Figure A4: Kazakhstan

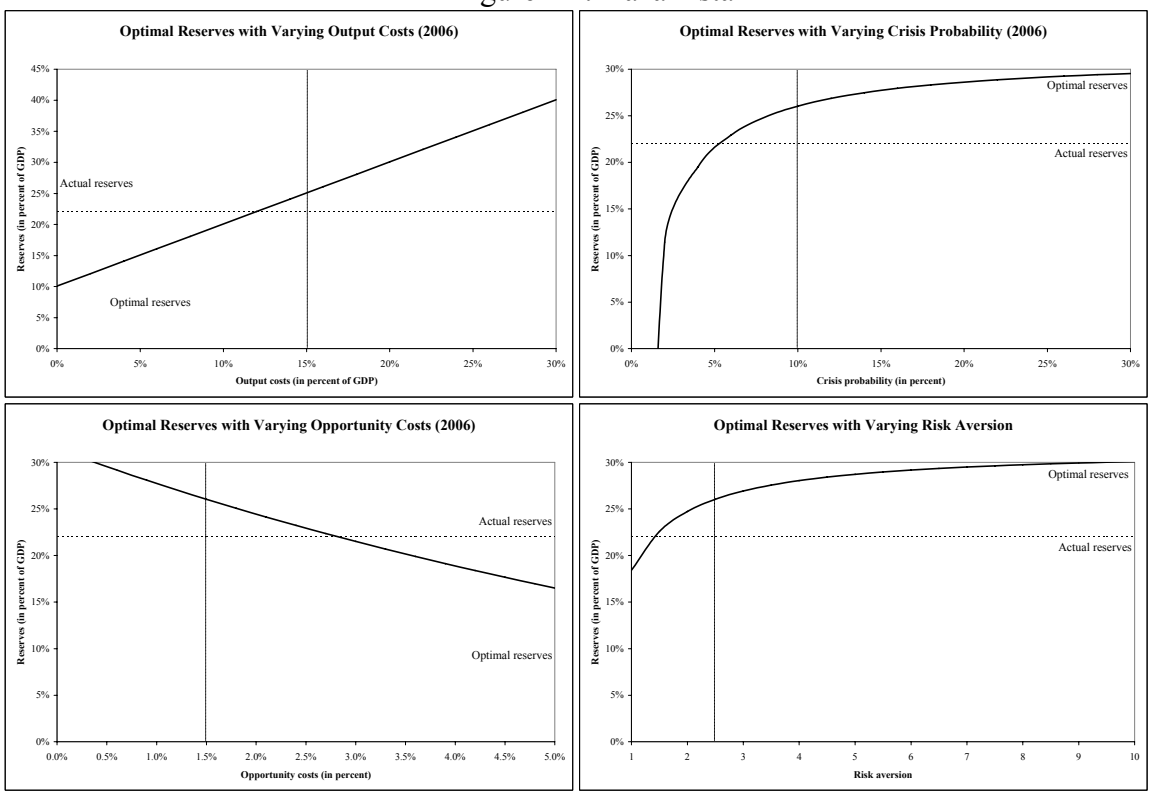


Figure A5: Kyrgyz Republic

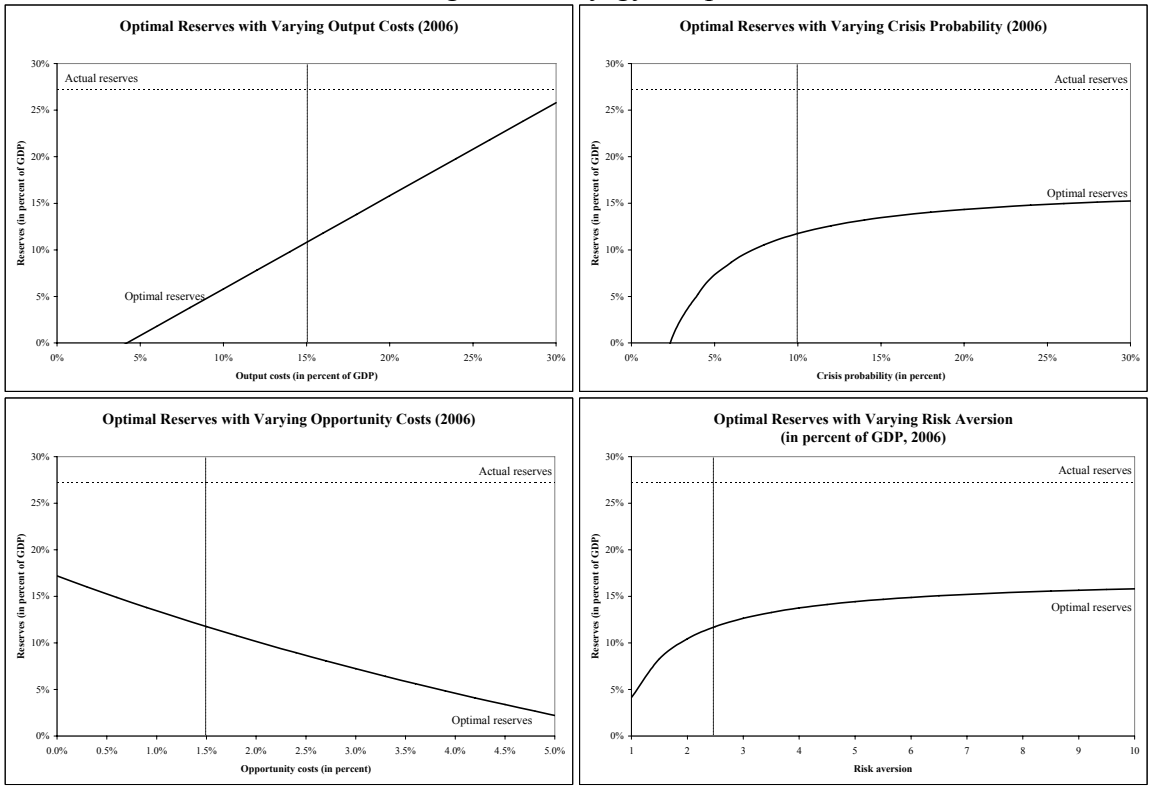
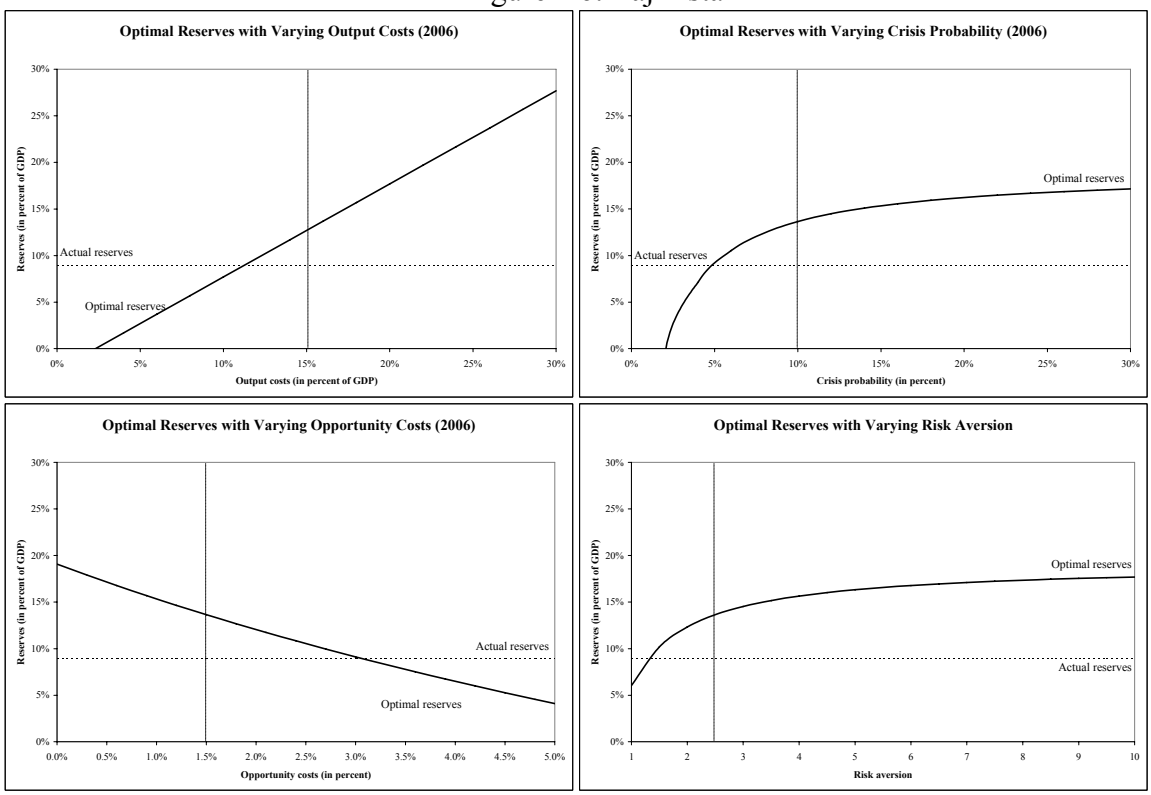



Figure A6: Tajikistan



## REFERENCES


Ahmed, Shaghil, Christopher J. Gust, Steven B. Kamin, and Jonathan Huntley, 2002, "Are Depreciations as Contractionary as Devaluations? A Comparison of Selected Emerging and Industrial Economies," Board of Governors of the Federal Reserve System, International Finance Division Working Paper No. 737.

Aizenman, Joshua, 2007, "Large Hoarding of International Reserves and the Emerging Global Economic Architecture," NBER Working Paper 13277 (Cambridge, Massachusetts: National Bureau of Economic Research).

Aizenman, Joshua, and Jaewoo Lee, 2005, "International Reserves: Precautionary vs. Mercantilist Views, Theory and Evidence," IMF Working Paper 05/198 (Washington: International Monetary Fund).

Aizenman, Joshua, and Jaewoo Lee, 2006, "Financial Versus Monetary Mercantilism—Long-Run View of Large International Reserve Hoarding," NBER Working Paper 12718 (Cambridge, Massachusetts: National Bureau of Economic Research).

Aizenman, Joshua, and Nancy Marion, (2003), "The High Demand for International Reserves in the Far East: What's Going On?, " *Journal of the Japanese and International Economies*", Volume 17, (September), pp. 370—400.

Atoyan, Ruben, 2007, "Armenia: Assessing Reserve Adequacy and Optimal Level of Reserves," mimeo, (Washington: International Monetary Fund).

Bahmani-Oskooee, M., and F. Brown, (2002), "Demand for International Reserves: A Review Article", *Applied Economics*, Volume 34 (July), pp. 1209–26.

Bahmani-Oskooee, Mohsen, (1985), "Demand for International Reserves: Survey of Recent Empirical Studies," Applied Economics, No. 17, pp. 359-75.

Becker Tőrbjőrn, Olivier Jeanne, Paolo Mauro, Jonathan D. Ostry, and Roman Rancière, (2007) "Country Insurance The Role of Domestic Policies", *Occasional Paper* 254, IMF, Washington DC.

Ben-Bassat, A. and David Gottlieb, (1992), "On the effect of opportunity cost on international reserves holdings", *Review of Economics and Statistics*, Volume 74, pp. 329–32.

Bird, Graham, and Alex Mandilaras, 2005, "Reserve Accumulation in Asia," World Economics, Vol. 6, No. 1, 85—99.

Bird, Graham, and Ramkishen Rajan, (2003), "Too Much of a Good Thing? The Adequacy of International Reserves in the Aftermath of Crises", *World Economy*, Volume 26 (June), pp. 873–91.

Boersch-Supan, Axel, Florian Heiss, Alexander Ludwig, and Joachim Winter, 2003, "Pension Reform, Capital Markets and the Rate of Return," *German Economic Review* 4(2):151—181.

Bordo, Michael, Barry Eichengreen, Daniela Klingebiel, and Maria Soledad Martinez-Peria, 2001, "Is the Crisis Problem Growing More Severe?" *Economic Policy* 16, 53—82.

Chami, Saade, Donal Mc Gettigan, and Stanley Watt, 2007, "Jordan's International Reserve Position: Justifiably Strong," IMF Working Paper 07/103 (Washington: International Monetary Fund).

Chari, V. V., Patrick J. Kehoe, and Ellen R. McGrattan, 2000, "Sticky Price Models of the Business Cycle: Can the Contract Multiplier Solve the Persistence Problem?" *Econometrica*, Vol. 68, No. 5 (September), 1151—1179.

De Beaufort Wijnholds, J. Onno, and Arend Kapteyn, (2001), "Reserve Adequacy in Emerging Market Economies", IMF Working Paper WP/01/143, International Monetary Fund, September 2001.

Dohmen, Thomas J., Armin Falk, David Huffman, Juergen Schupp, Uwe Suende, and Gert Georg Wagner, 2006, "Individual Risk Attitudes: New Evidence from a Large, Representative, Experimentally-Validated Survey," CEPR Discussion Paper No. 5517 (London: Centre for Economic Policy Research).

Dooley, Michael., David Folkerts-Landau, and Peter M. Garber, 2003, "An Essay on the Revived Bretton Woods System," NBER Working Paper No. 9971, (Cambridge, Massachusetts: National Bureau of Economic Research).

European Central Bank, (2006), "The Accumulation of Foreign Reserves", *Occasional Paper Series*, no. 43.

Feldstein, Martin (1999), "A Self –Help Guide for Emerging Markets", Foreign Affairs, Volume 78, No. 2, March/April 1999, pp. 93-109.

Friend, Irwin, and Marshall E. Blume, 1975, "The Demand for Risky Assets." *The American Economic Review*, Vol. 65, No. 5 (December), 900—922.

Gollier, Christian, Benny Moldovanu, and Tore Ellingsen, 2001), "Should We Beware of the Precautionary Principle?" *Economic Policy*, Vol. 16, No. 33. (Oct., 2001), 301—327.

Gonçalves, Fernando M., 2007, "The Optimal Level of Foreign Reserves in Financially Dollarized Economies: The Case of Uruguay." IMF Working Paper 07/265 (Washington, International Monetary Fund).

Grubel, Herbert, (1971), 'The Demand for International Reserves: A Critical Review of the Literature," Journal of Economic Literature Volume. IX, No. 4, (December), pp. 1148-66.

Gupta, Poonam, Deepak Mishra, and Ratna Sahay, 2000, "Output Response during Currency Crises." IMF Working Paper 03/230 (Washington, International Monetary Fund).

Hakura, Dalia S., 2007, "Output Volatility and Large Output Drops in Emerging Market and Developing Countries." IMF Working Paper 07/114 (Washington: International Monetary Fund).

Hauner, David, 2007, "A Fiscal Price Tag for International Reserves." *International Finance* 9:2, 2006:169—195.

Heller, H. Robert, (1966), "Optimal International Reserves", *Economic Journal*, Volume 76 (June), pp. 296–311.

Hutchison, Michael, and Ilan Noy, 2005, "How Bad Are Twins? Output Costs of Currency and Banking Crises." *Journal of Money, Credit, and Banking*, Vol. 37, No. 4 (August 2005).

Hutchison, Michael, and Ilan Noy, 2002, "Output Costs of Currency and Balance of Payments Crises in Emerging Markets." *Comparative Economic Studies* XLIV, 27—44.

International Monetary Fund, (2003), "World Economic Outlook", Washington D.C.: International Monetary Fund.

International Monetary Fund, (2004), "Liquidity Management", *IMF Policy Paper*, SM/04/149, April, Washington D.C.: International Monetary Fund.

International Monetary Fund (2007), "Regional Economic Outlook—Middle East and Central Asia", October. Washington D.C.: International Monetary Fund.

Jadresic, Esteban, (2007), "The Cost-Benefit Approach to Reserve Adequacy: the Case of Chile", *Mimeo*.

Jeanne, Olivier, 2007, "International Reserves in Emerging Market Countries: Too Much of a Good Thing?" *Brookings Papers on Economic Activity*, 1:2007, 1—79.

Jeanne, Olivier, and Romain Rancière, 2006, "The Optimal Level of International Reserves For Emerging Market Countries: Formulas and Applications." IMF Working Paper 06/229 (Washington: International Monetary Fund).

Kim, Jung Sik, J. Li, R. Rajan, O. Sula, and Thomas D. Willett, (2004), "Reserve Adequacy in Asia Revisited: New Benchmarks Based on the Size and Composition of Capital Flows", *mimeo*.

Kocherlakota, Narayana R., 1996, "The Equity Premium: It's Still a Puzzle." *Journal of Economic Literature*, Vol. 34, No. 1 (March), 42—71.

Milesi-Ferretti, Gian Maria, and Assaf Razin, 2000, "Current Account Reversals and Currency Crises: Empirical Regularities." In *Currency Crises*, edited by P. Krugman. (Chicago, IL: The University of Chicago Press).

Obstfeld Maurice, Jay C. Shambaugh, and Alan M. Taylor, (2007), "Financial Stability, the Trilemma, and International Reserves", *Mimeo.*

Ozyildirim, Suheyla, and Bűlent Yaman, (2005), "Optimal Versus Adequate Level of International Reserves: Evidence for Turkey", *Applied Economics*, Volume 37, pp. 1557-1569.

Summers, Lawrence H., (2006),"Reflections on Global Account Imbalances and Emerging Markets Reserve Accumulation.", *L. K. Jha Memorial Lecture*, Reserve Bank of India (March), http://www.president.harvard.edu/speeches/2006/0324_rbi.html.

Williamson, John, (1973), "Surveys in Applied Economics: International Liquidity", *Economic Journal*, Volume 83 (September), pp. 685–746.