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Debt Management Analysis of Nepal’s Public Debt

Sungsup Ra, Changyong Rhee, and Joon-Ho Hahm
DEBT MANAGEMENT ANALYSIS
OF NEPAL’S PUBLIC DEBT

Sungsup Ra, Changyong Rhee, and Joon-Ho Hahm

December 2005

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This paper estimates an optimal target portfolio of sovereign debt for Nepal that minimizes long-term financing cost. In the analysis, a practical framework is applied, which is built upon the traditional mean–variance efficient frontier approach and simultaneously employs a relatively new concept of cost-at-risk (CaR). The framework is flexible enough to incorporate other factors such as liquidity risk. Simulation results show that the Nepali economy needs to increase longer-term domestic borrowing instruments, and that the maturity structure of domestic bonds should be simplified. The simulation also suggests an optimal currency composition of external debts in Nepal.
I. INTRODUCTION

High levels of sovereign debt are a common feature of modern economies. With the increased sophistication and liberalization of financial markets, this has made the problem of debt management one of the most important issues in economic policy. In this paper, we take up the question of what is a desirable scheme for Nepal’s sovereign debt management.

The optimal volume and sustainability of sovereign debt are important issues with regard to sovereign debt management. However, sustainability of sovereign debt may be more important than its management, particularly for an underdeveloped economy with a relatively large burden of sovereign debt such as Nepal. It should be also noted that effective sovereign debt management increases sustainability.

The Nepali economy relies heavily on short-term domestic debt and highly concessional foreign aid loans of long maturity. More than 60% of domestic debt has maturities of one year or shorter, and less than 9% of domestic debt has maturities of 10 years or longer. The bulk of the cheap foreign loans have maturities longer than 30 years and account for more than 57% of the financing of the budget deficits in Nepal. Concessional foreign loans have been the best source of financing, but will not be available forever. Therefore, the problem of debt management is increasingly important for the Nepali economy.

Beyond the problem of debt sustainability, why does sovereign debt management matter? First, sovereign debt management has important effects on the real economy. The financial decisions of a sovereign borrower may have an impact on the expected returns not only on government securities but also on private assets, especially if the economy is large and/or restrictions exist on capital mobility. Changes in the relative supply of debt instruments may affect risk premia and, in particular, the expected return that private investors require to hold equities and private debt. Through the financial market, government debt decisions may influence the cost of funds and, thus, total real investment. Second, debt management may redistribute risks. With incomplete markets for private financial assets, the introduction of a new government security instrument would lead to a reallocation of risks and would possibly open up new opportunities for individuals to share risk. Finally, debt management matters because it affects taxation and changes the distribution of taxes across future contingencies. Taxes distort the investment and labor choices of private agents. High and variable tax rates reduce people’s incentives to work and produce.

1 For sustainability issues, see Cohen (1991) and Eaton (1992), among others.
2 Only under restrictive assumptions about private agents’ altruism and rationality, completeness and efficiency of financial markets, and type of taxes, does the sovereign debt management not matter. See Missale (1999, chapter 2).
The ultimate objective of sovereign debt management is to minimize the long-term cost of debt given the trade-off between expected debt service costs and risks associated with various borrowing strategies to finance the borrowing requirements of the government. The problem of debt management interpreted in this way is a common issue for most economies. In this study, the problem is to find an optimal target debt portfolio that minimizes the long-term cost of debt given the trade-off between expected debt service costs.

In the analysis, we apply a practical analytical framework studied in Hahm and Kim (2003) to Nepali data and identify the target portfolio structure for managing sovereign debt. The analytical framework is built upon the traditional mean–variance efficient frontier approach and employs a relatively new concept of cost-at-risk (CaR) to identify a target benchmark portfolio. While the efficient frontier and CaR measures are estimated from the perspective of debt service cost risk, the benchmarking framework is flexible enough to incorporate other factors such as liquidity risks and counter-party asset structures as additional criteria in identifying the benchmark portfolio.

Sovereign debt generally consists of domestic and foreign debts. Thus, one has to consider domestic and foreign debts together in analyzing issues of sovereign debt. In the case of Nepal, however, we analyze portfolios of domestic and foreign debts separately due to the limited availability of data.

In analyzing portfolios of domestic debt, we focus on the maturity structure of the debt and seek answers to the following questions: First, how can we characterize the trade-off between expected debt service cost and risk given the current structure of the debt and borrowing requirements in the future? Second, what is the optimal debt maturity structure given the cost and risk trade-off identified in the first step? Finally, what is the best policy for debt issuance to obtain the benchmark portfolio structure?

Reviewing the basic profiles of the Nepali central government domestic debts, we see two noticeable features: First, short-term bonds with maturities of less than 5 years constitute about 87% of the whole portfolio. Longer-term debt is usually associated with lower risk (volatility) but has a higher average cost of borrowing. A shorter-term debt is associated with a lower average cost of borrowing but with higher risk. The government needs to balance the cost and risk of borrowing by choosing an appropriate portfolio of borrowing. Second, there are various durations/maturities of bonds and the amount of bonds in each duration is small, implying that the market is fragmented, thus liquidity problems may arise. Our simulation analysis shows that the Nepali economy needs to move to longer-term domestic borrowing and that the issue profile of domestic bonds should be simplified.

On the other hand, in analyzing portfolios of foreign debt, we focus on the currency composition of the debt and follow the same procedure as for analyzing portfolios of domestic debt. Due to limited availability of data we could not consider all the currencies. Also, for many currencies the loans are in the form of a multi-currency loan, for which we do not have enough data. In this report we consider only four currencies: Saudi riyal (SAR), Kuwaiti dinar (KWD), United States dollar (USD), and Special Drawing Rights (SDR) relative to Nepali rupee (NRS).
From our simulation study we obtained an optimal currency composition of 10% SAR, 10% KWD, 80% USD, and 0% SDR. This result is consistent with statistical features of each of the four currencies under study. That is, comparing the mean and variability of the borrowing costs, we found that USD dominates in both mean and variance of the cost; SAR is better than KWD in the mean cost, but KWD is better than SAR in variability; and SDR is inferior to all the other three in both mean and variance.

Our discussion proceeds as follows: In Section II, we explain the methodology of our analysis. Sections III and IV apply the method explained in Section II to Nepali sovereign debt portfolios. For both domestic and external sovereign debt portfolios we identify target debt structures and derive optimal borrowing mixes. Section V concludes our analysis.

**II. OUTLINE OF METHODOLOGY**

We adopt the approach of Hahm and Kim (2003) for our analysis, i.e., we consider the problem of determining the sovereign debt portfolio as a portfolio optimization problem. As noted by Claessens (1992), the problem can be represented as a variant of the following stochastic dynamic programming:

Minimize $E(f(s ; d))$, where $d$ is in $D$ \hspace{1cm} (1)

where $d$ stands for a sequence of decisions to be made, and $D$ is the set of all acceptable decisions; $E$ is an expectation operator and the function $f$ is an objective function that serves as decision criteria. $s$ provides a description of possible future environments when the consequences of the decisions $d$ are evaluated. In a dynamic discrete time setting, where time 0 and 1 represent today and next period and so on, the above problem can be restated as follows:

Find $d = (d^0, d^1(s^1), d^2(s^1,s^2), ...)$ \hspace{1cm} (2)

such that $d^0$ in $D^0$, $d^1(s^1)$ in $D^1(s^1; d^0)$, $d^2(s^1,s^2)$ in $D^2(s^1,s^2; d^0,d^1(s^1))$, ...........

which minimizes $E(f(s^1,s^2,...; d^0,d^1,......))$

In the context of sovereign debt management, $d$ may correspond to decisions on the maturity structure of the government debt portfolio or on the currency composition in the case of external sovereign debt. The vector of random variables $s$ may correspond to the term structure of interest rates, exchange rates, GDP growth rates, and so forth. The choice set $D$ represents the range of possible decisions and reflects policy constraints such as the minimum exposure to a specific currency or the maximum percentage of refinancing. The subsequent choice set $D$ in the future depends upon the realizations of random variables as well as previous decisions. For instance, the debt portfolio structure to be realized 5 years from now (2006–

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4 Hahm and Kim (2003) provide an excellent exposition of the method that we employ in this paper. This section is largely based on Hahm and Kim (2003).
2010) will depend upon realizations of term structures, fiscal requirements, refinancing policies of maturing debts, and interim borrowing mixes to finance borrowing requirements over the next 5 years. The control function $f$ can be specified in various forms and necessarily involves an attribute of the debt portfolio depending upon which risk is to be more actively managed. For instance, nominal values, market values, or debt service costs of the government debt can serve as arguments of the control function depending upon the detailed objectives of government debt management. The control function usually involves a target risk measure and is often represented in the form of a penalty function. For more details, see Hahm and Kim (2003).

The objective and horizon of government debt management differ from those of private institutions. For this reason, the types of risks actively managed at the sovereign level also differ from those of the private sector. Since most governments tend to hold debts up to maturity and do not frequently liquidate and reconstruct debt portfolios, sovereign debt managers are more concerned about debt service costs, which directly affect government budget expenses, rather than day-to-day fluctuations in the market value of debt portfolios. Hence, in the present paper, we assume that the debt service cost risk is a primary concern for the government in managing sovereign debts.

Also, as noted in Hahm and Kim (2003), the debt service cost of a debt portfolio in any given year depends upon the interest rates and debt issuance up to that year. Given the government borrowing requirements over the debt management horizon and the description of stochastic processes of random variables during the horizon, we can solve the above problem to identify an optimal debt strategy. More specifically, once the government's fiscal requirement over the debt management horizon is given, the first step in benchmarking is to identify the expected cost–risk trade-off over various borrowing strategies satisfying the government financing requirements. This step corresponds to identifying the decision choice sets $D_1, D_2...$ into the future. An efficient portfolio set at the end of the debt management horizon is derived as a summary of the expected cost-risk trade-off based upon full-blown term structure simulations over the horizon. In the next step, we employ a control function $f$, and based upon exogenously given control targets, an optimal benchmark portfolio is identified from the efficient portfolio set.

### III. EFFICIENT FRONTIER AND BENCHMARK PORTFOLIO FOR DOMESTIC GOVERNMENT DEBT

#### A. The Data: Basic Profiles of Government Debt Portfolios in Nepal

Table 1 summarizes the basic profiles of domestic debt of the central government in Nepal by category as of 16 July 2003. The domestic debt portfolio consists of treasury bills, development bonds, national saving certificates, special bonds, and citizen savings certificates. Treasury bills account for the largest share of the domestic debt portfolio, and development bonds and national savings certificates also represent relatively large shares.
SECTION III
Efficient Frontier and Benchmark Portfolio for Domestic Government Debt

Table 1
(in NRs. million)

<table>
<thead>
<tr>
<th>BONDS</th>
<th>AMOUNT</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Bonds</td>
<td>16,059.21</td>
<td>19.96</td>
</tr>
<tr>
<td>National Savings Certificates</td>
<td>9,629.84</td>
<td>11.97</td>
</tr>
<tr>
<td>Treasury Bills</td>
<td>48,860.70</td>
<td>60.72</td>
</tr>
<tr>
<td>Special Bonds</td>
<td>4,992.81</td>
<td>6.20</td>
</tr>
<tr>
<td>Citizen Savings Certificates</td>
<td>931.10</td>
<td>1.16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80,473.67</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

Note: As of 16 July 2003 except for Treasury Bills, which is as of 1 September 2003.

Table 2 shows the basic profiles of the Nepali central government domestic debts sorted according to duration. First, there are various durations and the amount of each bond is relatively small, implying that the market is fragmented. If this is indeed the case, a liquidity problem may arise. The issue profile of domestic bonds should, therefore, be simplified. Second, short-term bonds with maturities of less than 5 years constitute about 87 percent of the whole portfolio, while long-term bonds with maturities longer than 12 years account for only a meager proportion of the portfolio. Note that the average duration of the central government domestic debt is 3.04 years, which is relatively short compared to other countries. As shown in Table 3, the average duration of domestic sovereign debt portfolios in Europe is around 4.0 years. Shorter durations imply a higher debt service cost risk because more frequent refinancing is necessary and changes in market interest rates are reflected more quickly into the debt service costs. Short durations, however, imply lower market-value risks as market value fluctuations due to interest rate variations are relatively small for portfolios with short durations. Thus, the domestic debt portfolio of the Nepali government is characterized by a relatively high debt service cost risk, but with a relatively low market value risk.

Table 2
(in NRs. million)

<table>
<thead>
<tr>
<th>BOND</th>
<th>AMOUNT</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-month T-bill</td>
<td>10,451.00</td>
<td>12.99</td>
</tr>
<tr>
<td>1-Year T-bill (primary)</td>
<td>9,348.50</td>
<td>11.62</td>
</tr>
<tr>
<td>1-Year T-bill (secondary)</td>
<td>29,061.20</td>
<td>36.11</td>
</tr>
<tr>
<td>1-Year Bond</td>
<td>2,434.69</td>
<td>3.03</td>
</tr>
<tr>
<td>3-Year Bond</td>
<td>2,950.27</td>
<td>3.67</td>
</tr>
<tr>
<td>4-Year Bond</td>
<td>2,790.00</td>
<td>3.47</td>
</tr>
<tr>
<td>5-Year Bond</td>
<td>12,923.29</td>
<td>16.06</td>
</tr>
<tr>
<td>7-Year Bond</td>
<td>1,500.00</td>
<td>1.86</td>
</tr>
<tr>
<td>8-Year Bond</td>
<td>1,860.00</td>
<td>2.31</td>
</tr>
<tr>
<td>10-Year Bond</td>
<td>4,566.10</td>
<td>5.67</td>
</tr>
<tr>
<td>14-Year Bond</td>
<td>1,070.00</td>
<td>1.33</td>
</tr>
<tr>
<td>20-Year Bond</td>
<td>1,518.62</td>
<td>1.89</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80,473.67</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

Note: As of 16 July 2003 except for Treasury Bills, which is as of 1 September 2003.
Below, we conduct empirical analysis to obtain a set of efficient cost-risk trade-offs and to identify the optimal benchmark portfolio. The analysis is based on actual Nepali government debt data up to 16 July 2003. We suppose that we are at the end of period 4Q2003 (t=4Q2003), and the plan period or debt management horizon is assumed to be 9 years, 1Q2004–4Q2012 (N=36). The decision interval or time unit of the analysis is assumed to be one quarter because 3-month treasury bills are considered.

### B. Obtaining the Efficient Portfolio Set Conditional upon Existing Domestic Debt Structure

The set of efficient portfolios for domestic government debt at the end of 4Q2012 is obtained from the set of expected cost–risk trade-offs. We obtain the efficient frontier in two different cases. In Case 1, the instruments considered are the 3-month and 1-year treasury bills, and 3- and 5-year bonds. In Case 2, they are the 3-month and 1-year treasury bills; and 3-, 5-, and 10-year bonds. There are bonds of 11 different maturities in our data set, but to simplify our analysis, we assume that there are four and five different maturities, respectively, in Case 1 and in Case 2. To further simplify the analysis, we assume that both the principal amounts of maturing bonds and the interest payments on all existing bonds are refinanced by the same types of bonds.

We first need to get the values of the primary budget deficit in the period under consideration. They are obtained based on a large macro model of the Nepali economy and are presented in Table 4.

---

**Table 3**

Duration of Sovereign Debt Portfolios, 1999–2000

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>DOMESTIC DEBT PORTFOLIO</th>
<th>EXTERNAL DEBT PORTFOLIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>4.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Denmark</td>
<td>4.1</td>
<td>2</td>
</tr>
<tr>
<td>Finland</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>3.0</td>
<td>3.1</td>
</tr>
<tr>
<td>Spain</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6.8</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>4.0</td>
<td>2.4</td>
</tr>
</tbody>
</table>


---

5 This is just for convenience of indexation in the analysis. As the analysis is based on the accrual data up to 16 July 2003, we are in the early part of 3Q2003. Therefore, for readers who are keen at counting dates, the actual periods in the following analysis should be half a year back.
We obtain values for the quarterly primary budget deficits over the debt management horizon \((N=36)\) by dividing each annual value by four. We multiply a certain fraction \(\theta=0.4218\) to the amount of the budget deficit in a period to get the amount of domestic financing in the period. The fraction \(\theta=0.4218\) is the average ratio of the amount of domestic financing to the total budget deficit in each year in the period 1975–2002. We denote the values of quarterly primary budget deficits by \(\{P_{t+1}, P_{t+2}, \ldots, P_{t+36}\}\).

We consider Case 1 below. The same analysis applies to Case 2. In Case 1, the borrowing strategy of the government is a combination of borrowings of four maturities: 3-month and 1-year treasury bills, and 3- and 5-year bonds. We denote it by a vector of weights, \(w=(w_{3/4}, w_1, w_3, w_5)\), which sum to unity, where \(w_j\) is the weight of the \(j\)-year bond. We assume that each borrowing strategy is time-invariant, implying that the same weights are maintained throughout the debt management horizon.

We denote the existing government debt portfolio at the end of period \(t\) by a vector

\[
Z_t = (z^{1/4}_t, z^1_t, z^{3/4}_t, z^1_{t-1}, z^3_t, z^5_{t-1}, \ldots, z^3_{t-2}, z^5_{t-3}, \ldots, z^5_{t-36}),
\]

where a typical element \(z^j_{t-i}\) is the balance of the \(j\)-year bond issued in the period \(t-i\). The elements in \(Z_t\) are determined by the Nepali central government’s domestic debt portfolio as of July 2003. Now, for a given borrowing strategy \(w\), the government’s total financing requirement for the next year, \(B_{t+1}\), can be represented as the sum of primary budget deficit \(P_{t+1}\) and the refinancing amount \(\alpha Y_{t+1}\), where \(\alpha \in [0,1]\) is the fraction of refinancing and \(Y_{t+1}\) is the sum of principals of maturing debt and interest costs to be paid in period \(t+1\). In the simulation, we assume that \(\alpha=1\), which means 100% of maturing debt principals and interest expenses are refinanced.

### Table 4

**Primary Budget Deficit under Basic Scenario**

(\textit{in NRs million})

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>23,181</td>
<td>26,195</td>
<td>30,079</td>
<td>34,757</td>
<td>40,314</td>
<td>46,810</td>
<td>54,764</td>
<td>64,548</td>
<td>76,646</td>
</tr>
</tbody>
</table>
\[ B_{t+1} = P_{t+1} + \alpha Y_{t+1} \]
where \( Y_{t+1} = (z_{t+1}^{1/4} + i_{t+1}^{1/4} z_{t+1}^{1/4}) \)
\[ + (z_{t+3}^{1} + i_{t+3} z_{t+3}^{1} + i_{t+3} z_{t+3}^{1} + i_{t+3} z_{t+3}^{1}) \]
\[ + (z_{t+11}^{3} + i_{t+11}^{3} z_{t+11}^{3} + i_{t+11}^{3} z_{t+11}^{3} + \ldots + i_{t+11}^{3} z_{t+11}^{3}) \]
\[ + (z_{t+19}^{5} + i_{t+19}^{5} z_{t+19}^{5} + z_{t+19}^{5} z_{t+19}^{5} + \ldots + i_{t+19}^{5} z_{t+19}^{5} + i_{t+19}^{5} z_{t+19}^{5}) \]

Note that \( i_t^{j} \) is the interest rate on the \( j \)-year bond issued in period \( t \). Under the borrowing strategy \( w \), the actual issue amount for \( J \) respective maturity bonds in the year \( t+1 \) can be computed as follows:

\[ (z_{t+1}^{1/4}, z_{t+1}^{1}, z_{t+1}^{3}, z_{t+1}^{5}) = B_{t+1}(w_1, w_1, w_3, w_5) \]

Now by the same logic, the total financing requirement for period \( t+2 \) and the actual issuance amount for each bond in period \( t+2 \) under the time-invariant borrowing strategy \( w \) can be represented as follows.

\[ B_{t+2} = P_{t+2} + \alpha Y_{t+2} \]
where \( Y_{t+2} = (z_{t+2}^{1/4} + i_{t+2}^{1/4} z_{t+2}^{1/4}) \)
\[ + (z_{t+2}^{1} + i_{t+2} z_{t+2}^{1} + i_{t+2} z_{t+2}^{1} + i_{t+2} z_{t+2}^{1}) \]
\[ + (z_{t+10}^{3} + i_{t+10}^{3} z_{t+10}^{3} + i_{t+10}^{3} z_{t+10}^{3} + \ldots + i_{t+10}^{3} z_{t+10}^{3}) \]
\[ + (z_{t+18}^{5} + i_{t+18}^{5} z_{t+18}^{5} + z_{t+18}^{5} z_{t+18}^{5} + \ldots + i_{t+18}^{5} z_{t+18}^{5} + i_{t+18}^{5} z_{t+18}^{5}) \]

and
\[ (z_{t+2}^{1/4}, z_{t+2}^{1}, z_{t+2}^{3}, z_{t+2}^{5}) = B_{t+2}(w_1, w_1, w_3, w_5) \]

Note that we are at the end of period \( t \), and that \( B_{t+1} \) is a random variable as interest rates in the period \( t+1 \), \( (i_{t+1}^{1/4}, i_{t+1}^{1}, i_{t+1}^{3}, i_{t+1}^{5}) \), are not observed at \( t \). Note also that the actual amount of bond issuance in period \( t+2 \) is determined by the amount borrowed in period \( t+1 \). Hence, the issuance amount of each bond in any given period is a function of the borrowing strategy itself as well as the actual term structure of interest rates up to that period. The process can be repeated until period \( t+N \). A specific debt portfolio will emerge depending on the path of term structures during the \( N \) periods.

For yield curve simulations, we assume that the yields of government bonds are random variables that have a multivariate normal distribution. Thus, letting \( i_{t+1} = (i_{t+1}^{1/4}, i_{t+1}^{1}, i_{t+1}^{3}, i_{t+1}^{5}) \), we have \( i_{t+1} \sim N(\mu, \Sigma) \). We estimate \( \mu \) by the average yield to maturities of Nepali government bonds. Due to the lack of data in Nepal, the variance–covariance matrix \( \Sigma \) is estimated using the daily yield curve data on Korean bonds from 30 October 2000 to 28 November 2003.

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6 We need much richer data in our analysis to allow possible non-normality, in which case we need to employ a more or less sophisticated method such as bootstrapping.
Given a stochastic process of the term structure of interest rates and given a borrowing strategy \( \mathbf{w} \), we can obtain a conditional distribution of the debt service costs on the debt portfolio that emerges at the end of the horizon by conducting simulations on the term structure of interest rates. Each borrowing strategy is characterized by the mean and standard deviation of debt service costs and/or by the cost at the 95th percentile associated with the resulting debt portfolio. By conducting 1,000 iterations of the simulation for each of the borrowing strategies, in Figure 1(a), we can obtain all period-end portfolios in the space of the mean and standard deviation, from which we can identify the efficient portfolio set conditional upon the existing debt portfolio (Case 1). Figure 1(b) plots the mean and the standard deviation of period-end debt portfolios with the emphasis on those at the lower left corner of Figure 1(a). The efficient frontier is then constructed in Figure 2 along with the choice of a benchmark portfolio for domestic debt following the procedure in the next section. The same analysis applies to Case 2, and the results are in Figures 3 and 4.

The figures show negative trade-offs between expected cost and risk. With the usual upward sloping yield curves, shorter-term financing implies lower expected debt service cost but higher volatility than longer-term financing. There are two reasons for this. First, short-term interest rates are more volatile than long-term interest rates, and short-term financing requires more frequent refinancing in a debt management horizon. Second, under the liquidity preference theory of term structures, longer-term financing tends to be associated with higher expected average annual debt service cost but with lower conditional variance of the average annual cost. We can obtain the efficient portfolio set by selecting portfolios that yield the lowest expected cost at each level of standard deviation.

**Figure 1**

**Case 1: Whole Portfolios for Domestic Debt (in Rs. Million)**
null
FIGURE 3

CASE 2: WHOLE PORTFOLIOS FOR DOMESTIC DEBT (IN RS. MILLION)
FIGURE 4
CASE 2: EFFICIENT FRONTIER AND BENCHMARK PORTFOLIO
FOR DOMESTIC DEBT (IN RS. MILLION)
C. Benchmark Portfolios and Optimal Borrowing Strategies

Given the efficient frontier, the next step is to identify a benchmark (or optimal) portfolio from the feasible choice set. Given the feasible efficient portfolio set and exogenous risk targets, a portfolio that minimizes deviations from the exogenous targets can be selected as the benchmark portfolio. That is, the benchmark portfolio is identified by minimizing a penalty function defined as a weighted average of deviations from the respective risk targets. An example of exogenous targets is the cost at risk (CaR) of a portfolio. A simple penalty function is one that only considers CaR for the target. Thus, letting CaR (95%) be the 95% CaR from a portfolio, we have a penalty function: \( f = \text{CaR} (95\%) \).\(^7\) The value of 95% CaR for a borrowing strategy or portfolio is the 95\(^{th}\) percentile in the distribution of debt service costs from the strategy. In our simulation study, we obtain the distribution for each borrowing strategy from a set of 1,000 iterations. A portfolio that has the minimum value of CaR (95%) is selected as the benchmark portfolio. The circled one in Figure 2 is the benchmark portfolio for domestic debt in Case 1. The same analysis applies to Case 2, and the benchmark portfolio is circled in Figure 4.

Optimal borrowing strategies for Case 1 and Case 2 are summarized in Table 5. For Case 1, the optimal debt issuance mix is 40% 3-month treasury bills, 0% 1-year treasury bills, 0% 3-year bonds, and 60% five-year bonds. For Case 2, the optimal debt issuance mix is 30% 3-month treasury bills, 10% 1-year treasury bills, 0% 3-year bonds, 0% 5-year bonds, and 60% 10-year bonds. These results imply that it would be better for the Nepali economy to choose a portfolio with longer-term debts to reduce the debt service cost risk and to simplify the issue profile of domestic bonds.

<table>
<thead>
<tr>
<th>TABLE 5</th>
<th>OPTIMAL BORROWING STRATEGIES FOR DOMESTIC GOVERNMENT DEBT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BOND MATURITY (PERCENT)</strong></td>
<td>3-MONTH</td>
</tr>
<tr>
<td>Case 1</td>
<td>40</td>
</tr>
<tr>
<td>Case 2</td>
<td>30</td>
</tr>
</tbody>
</table>

IV. EFFICIENT FRONTIER AND BENCHMARK PORTFOLIO FOR EXTERNAL GOVERNMENT DEBT

What financial instruments are available to manage external risks? An important one for hedging is the currency mix of foreign debt. This is particularly true for developing countries. Many developing countries lack access to futures and options markets to hedge the enormous risks arising from the currency exposure of their foreign debt. Even if these markets are accessible, the maturities are often too short compared to the maturities of long-term debts. In this section, we study the optimal currency mix of Nepali external debt based on the approach used in the previous section.

\(^7\) Alternatively, as in Hahm and Kim (2003), we can add duration targets in an attempt to control medium-term market risks as well as liquidity risks. In this case, the penalty function is a weighted average of deviations from an exogenous duration target and CaR.
A. The Data: Basic Profiles of External Debt Portfolios in Nepal

Table 6 shows the basic profiles of the government external debt by currency as of 30 September 2002. The borrowing currencies are Nepali rupee, Saudi riyal, Kuwaiti dinar, US dollar, and Special Drawing Rights.8

<table>
<thead>
<tr>
<th>CURRENCY</th>
<th>AMOUNT IN EACH NATIONAL CURRENCY</th>
<th>AMOUNT IN NEPALI RUPEES</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepal rupees (NRs)</td>
<td>19,073,535</td>
<td>19,073,535</td>
<td>0.01</td>
</tr>
<tr>
<td>Saudi riyals (SAR)</td>
<td>184,399,830</td>
<td>3,857,867,974</td>
<td>2.58</td>
</tr>
<tr>
<td>Kuwaiti dinars (KWD)</td>
<td>14,550,000</td>
<td>3,766,995,000</td>
<td>2.52</td>
</tr>
<tr>
<td>US dollars (USD)</td>
<td>293,062,000</td>
<td>22,992,046,000</td>
<td>15.37</td>
</tr>
<tr>
<td>Special Drawing Rights (SDR)</td>
<td>1,148,450,000</td>
<td>118,933,482,000</td>
<td>79.52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>149,569,464,509</strong></td>
<td><strong>100.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

Note: Amounts in NRs are calculated using the exchange rates of 30 September 2002.

In this section, we use the same methodology as in the previous section to identify the efficient cost–risk trade-offs and optimal benchmark portfolios for external debt. Note, however, that this time we use the currency composition (instead of the maturity structure of the debt portfolio) as the decision variable. The analysis is conducted based upon the actual Nepali government external debt data as of 30 September 2002. Suppose that we are at the end of period 4Q2002 (t=4Q2002). The plan period or debt management horizon is 10 years 1Q2003 to 4Q2012 (N=40). The decision interval or time unit of the analysis is a quarter.

B. Derivation of Efficient Portfolio Set Conditional upon Existing External Debt Structure

The efficient frontier set for external government debt as of the end of 4Q2012 is derived as a summary of the expected cost–risk trade-off. The currencies available for borrowing are the Saudi riyal, Kuwaiti dinar, US dollar, and Special Drawing Rights. We assume that the payments of principal and interest on all outstanding bonds are refinanced by borrowing in any of these four currencies. We also assume that the maturities of loans are all 40 years and that interest payments are made semiannually.

The primary budget deficit under the basic scenario is shown in Table 7.

---

8 We do not consider multicurrency loans here due to insufficiency of data. Examples are loans in Euro and Japanese yen.
### TABLE 7
FOREIGN FINANCING OF PRIMARY BUDGET DEFICIT UNDER BASIC SCENARIO
(IN NRs. MILLION)

<table>
<thead>
<tr>
<th>Year</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11,594</td>
<td>13,403</td>
<td>15,146</td>
<td>17,392</td>
<td>20,097</td>
<td>23,310</td>
<td>27,066</td>
<td>31,664</td>
<td>37,322</td>
<td>44,317</td>
</tr>
</tbody>
</table>

From the annual budget deficit series above, the forecast of quarterly primary budget deficits over the debt management horizon from 1Q2003 to 4Q2012 (N=40) is obtained by dividing the annual data by four. These quarterly primary budget deficit series are exogenous variables and are denoted by \{P_{t+1}, P_{t+2}, \ldots, P_{t+40}\}.

The government is considering a combination of SAR, KWD, USD, and SDR loans to finance the primary budget deficits and to rollover maturing debts given the existing debt portfolio at the end of period 4Q2002. A borrowing strategy is denoted by a composition of loans in these four currencies represented as a vector of weights, \(w = (w_{\text{SAR}}, w_{\text{KWD}}, w_{\text{USD}}, w_{\text{SDR}})\), which sum to unity. \(w_j\) is the weight of the \(j\)-th currency. We assume that each borrowing strategy is time-invariant, implying that under the borrowing strategy, the same weights of respective currencies are maintained throughout the debt management horizon.

In the case of external debts, it would be desirable to conduct a full-blown simulation with respect to yield curves, exchange rates, and sovereign risk premia for Nepali government debt. Such multivariate simulations covering all those factors, however, are not feasible and extremely costly. Our simulation study focuses on the exchange rate since our objective is to find the currency composition of liabilities that minimizes risk stemming from the variability in values of foreign liability debt service. For this purpose, we assume that there is no sovereign risk premium and that the semiannual interest rate for each currency loan is 3%. Then, the effective interest rate on the loan from the \(j\)-th country can be written as follows:

\[
(1 + i_t^j) = (1 + i^*) \frac{E(e_{t+4}^j)}{e_t^j}
\]  

(5)

where \(i_t^j\) is the interest rate on the \(j\)-th currency issued in period \(t\); \(i^*\) and \(\frac{E(e_{t+4}^j)}{e_t^j}\) are, respectively, the foreign interest rate and rate of depreciation of the domestic currency relative to currency \(j\).

Note that the existing government external debt portfolio at the end of period \(t\) is summarized as a vector

\[
Z_t = (z_t^\text{SAR}, z_{t-1}^\text{SAR}, \ldots, z_{t-159}^\text{SAR}, z_t^\text{KWD}, z_{t-1}^\text{KWD}, \ldots, z_{t-159}^\text{KWD}, z_t^\text{USD}, z_{t-1}^\text{USD}, \ldots, z_{t-159}^\text{USD}, z_t^\text{SDR}, z_{t-1}^\text{SDR}, \ldots, z_{t-159}^\text{SDR})
\]

where \(z_{t-i}^j\) is the balance of \(j\)-th currency loans borrowed in period \(t-i\); the number 159 indicates...
the last quarter at the end of 40 years. As in the case of domestic debt, the elements in $Z_t$ are determined by the Nepali central government’s external debt portfolio as of July 2003. Now, for a given borrowing strategy $w$, the government’s total financing requirement for the next year, $B_{t+1}$, can be represented as the sum of the primary budget deficit $P_{t+1}$ and the refinancing amount $\alpha Y_{t+1}$, where $\alpha \in [0,1]$ is the fraction of refinancing and $Y_{t+1}$ is the sum of principal and interest to be paid in period $t+1$. In simulation, we assume that 50% of principal payments and interest expenses are refinanced every quarter ($\alpha = 0.5$).

$$B_{t+1} = P_{t+1} + \alpha Y_{t+1} \tag{6}$$

where $Y_{t+1} = \sum_{j=1}^{4} \sum_{k=1}^{80} \left( \frac{1}{80} + i_{t+1-2k} \right) z_{t+1-2k}$

where $k$ runs through 80, the number of half-year periods in 40 years.

We assume that a constant fraction of the principal of maturing bonds as well as interest payments on all existing bonds is refinanced every quarter, and the remaining fraction is repaid from the government budget. The actual issuance amount in year $t+1$ is a function of the borrowing strategy $w$:

$$(z_{t+1}^{SAR}, z_{t+1}^{KWD}, z_{t+1}^{USD}, z_{t+1}^{SDR}) = B_{t+1}(w_{SAR}, w_{KWD}, w_{USD}, w_{SDR}) \tag{7}$$

Now, by the same logic, the total financing requirement for period $t+2$ and the actual issuance amount for each bond in period $t+2$ under the time-invariant borrowing strategy $w$ can be represented as follows:

$$B_{t+2} = P_{t+2} + \alpha Y_{t+2} \tag{8}$$

where $Y_{t+2} = \sum_{j=1}^{4} \sum_{k=1}^{80} \left( \frac{1}{80} + i_{t+2-2k} \right) z_{t+2-2k}$

and $$(z_{t+2}^{SAR}, z_{t+2}^{KWD}, z_{t+2}^{USD}, z_{t+2}^{SDR}) = B_{t+2}(w_{SAR}, w_{KWD}, w_{USD}, w_{SDR})$$

Note that we are at the end of period $t$, so that $B_{t+2}$ is a random variable as exchange rates and effective interest rates in period $t+1$, $(i_{t+1}^{SAR}, i_{t+1}^{KWD}, i_{t+1}^{USD}, i_{t+1}^{SDR})$, are not observed at $t$. Note also that the actual amount of bond issuance in period $t+2$ is determined by the borrowing amount in period $t+1$. Hence, the issuance amount of each bond in any given period is a function of the borrowing strategy itself as well as the actual exchange rates up to that period. The process can be repeated until period $t+N$. A specific debt portfolio will emerge depending on the path of exchange rates during the $N$ periods and the given specific borrowing strategy.

For simulating out of sample exchange rates, we employ the bootstrap method based on quarterly exchange rate data from 1Q1957 to 2Q2003. The idea behind bootstrapping is to obtain an estimate of the small sample distribution of parameters without assuming that the innovation terms are Gaussian. We use a vector autoregression of order one in our bootstrap procedure. A VAR(1) is estimated for each series of exchange rates; NRs/SAR, NRs/KWD, NRs/USD, and NRs/SDR. We take a random draw from the fitted residuals for the exchange rates NRs/SAR,
NRs/KWD, NRs/USD, and NRs/SDR and use it to construct the first year innovation in an artificial sample. The draw is continued with replacement to obtain a full sample exchange rate series for the next 10 years, i.e., 40 quarters. Given a series of simulated exchange rates, actual portfolio evolution is traced for a given specific borrowing strategy. The debt service cost is calculated for the resulting portfolio at the end of 40 quarters, i.e., 4Q2012. Next, we generate a second set of draws from the fitted residuals and calculate another debt service cost for the resulting portfolio for the same borrowing strategy. As in the case of government domestic debt, a set of 1,000 iterations of such a simulation was undertaken for each borrowing strategy. The mean, standard deviation, and 95% CaR value are obtained from the distribution of the 1,000 debt service costs for each borrowing strategy.

By conducting 1,000 iterations of the simulation for each of the borrowing strategies, we can represent all period-end portfolios in the space of the mean and standard deviation. In turn, we can identify the efficient portfolio set conditional upon the existing debt portfolio. The simulation results are summarized in Figure 5, which shows a clear negative trade-off between expected cost and risk. In Figure 6, we have an efficient portfolio frontier obtained by selecting portfolios that yield the lowest expected costs at each level of the standard deviation in Figure 5.

**C. Benchmark Portfolios and Optimal Borrowing Strategies**

The benchmark portfolio for external debt is identified from the set of efficient portfolios based on the same penalty function as in Section III. Therefore, an optimal benchmark portfolio is identified from the efficient set by minimizing the 95% CaR. The circled one in Figure 6 is the benchmark portfolio for external debt. The optimal borrowing strategy is summarized in Table 8. The optimal currency composition is 10% SAR, 10% KWD, 80% USD, and 0% SDR.

<table>
<thead>
<tr>
<th>TABLE 8</th>
<th>OPTIMAL BORROWING STRATEGIES FOR EXTERNAL GOVERNMENT DEBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURRENCY</td>
<td>SAR</td>
</tr>
<tr>
<td>Percent</td>
<td>10</td>
</tr>
</tbody>
</table>

Why do we have the above results of optimal borrowing mixes for foreign debt portfolio? The above result has much to do with the statistical characteristics of each currency, in particular the mean cost and risks contained in each currency. In Table 9 below we report mean and variability of \( \frac{\Delta e_t}{e_t} \). Notice that \( \frac{\Delta e_t}{e_t} \) is main determinant of the cost of borrowing in our study as expressed in the interest rate parity equation (5). We can see that USD dominates in both mean and variance of the cost; SAR is better than KWD in the mean cost, but KWD is better than SAR in variability; and SDR is inferior to all the other three currencies in both mean and variance. The statistics in Table 9, therefore, are consistent with the chosen benchmark portfolio in Table 8.
### Table 9

**Mean and Variability of \( \frac{\Delta e}{e} \)**

<table>
<thead>
<tr>
<th>EXCHANGE RATE (e)</th>
<th>NRs/SAR</th>
<th>NRs/KWD</th>
<th>NRs/USD</th>
<th>NRs/SDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of ( \frac{\Delta e}{e} )</td>
<td>0.0296</td>
<td>0.0316</td>
<td>0.0294</td>
<td>0.0336</td>
</tr>
<tr>
<td>Variance of ( \frac{\Delta e}{e} )</td>
<td>0.0042</td>
<td>0.0041</td>
<td>0.0037</td>
<td>0.0048</td>
</tr>
<tr>
<td>Standard Deviation of ( \frac{\Delta e}{e} )</td>
<td>0.0647</td>
<td>0.0641</td>
<td>0.0611</td>
<td>0.0695</td>
</tr>
</tbody>
</table>

By the results summarized in Tables 8 and 9 we can conclude that it is desirable to have a larger portion of the currency whose exchange rate relative to the Nepali rupee has lower average rate of change, \( \frac{\Delta e_t}{e_t} \), and smaller variability of rate of change than the other currencies.

In the above study we are confined to the situation where the mean and volatility of the borrowing cost are the only factors considered in portfolio selection. In such a case the optimal portfolio is the one that has the lowest mean cost and the smallest variance of the cost. If we have other factors such as the interest rates on loans, term structure of loans, and the sovereign risk premium in our simulation, we can perform richer analysis.

### Figure 5

**Whole Portfolios for External Debt**

![Graph showing whole portfolios for external debt](image-url)
V. CONCLUDING REMARKS

We have studied the problem of debt management for the Nepali economy by applying the framework studied in Hahm and Kim (2003). Some important conclusions from the analysis of the Nepali debt data are drawn. The analysis of domestic debt suggests that the Nepali economy needs to move to longer-term domestic borrowing, and that the issue profile of domestic bonds of Nepal should be simplified. From the analysis of foreign debt we have found that it is desirable to have a larger portion of the currency whose exchange rate relative to the Nepali rupee has a lower average rate of change and smaller variability of rate of change than the other currencies.

The analytical approach used in the study can be easily applied for other countries to identify their benchmark government debt portfolios. The empirical exercise for the Nepali data is only an example. As is noted in the previous sections, the empirical analysis for the Nepali data is constrained due to limited availability of data. A richer and more informative data set has to be accumulated to analyze more interesting issues and perform detailed analysis of debt management in Nepal in the future.
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