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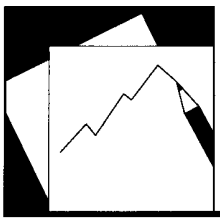

IMF Working Paper

Measuring Sovereign Risk in Turkey: An Application of the Contingent Claims Approach

Christian Keller, Peter Kunzel, and Marcos Souto

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Monetary and Capital Markets Department

Measuring Sovereign Risk in Turkey: An Application of the Contingent Claims Approach[1]

Prepared by Christian Keller, Peter Kunzel, and Marcos Souto

Authorized for distribution by Carlos Medeiros and Udaibir S. Das

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Abstract

Improved macroeconomic conditions and changes to the asset-liability structure on Turkish balance sheets since the 2001 crisis have improved Turkey's overall sovereign risk profile. Nonetheless, the country remains subject to bouts of volatility, as evidenced most recently in the May/June 2006 market turbulence. This paper examines these changes in Turkey's risk profile using the Contingent Claims Approach (CCA), to quantify the evolution of Turkey's sovereign risk, relate risk indicators to market prices of risk, and conduct scenario analyses to assess the effects of potential market volatility and policy adjustments on key risk indicators.

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Author's E-Mail Address: ckeller@imf.org, pkunzel@imf.org, msouto@imf.org

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[1] When this paper was done, Christian Keller was an IMF Resident Representative in Turkey. He currently works at Barclays Bank. Peter Kunzel and Marcos Souto work in the IMF Monetary and Capital Markets Department. We are grateful for contributions and useful suggestions from Dale Gray, Kevin Fletcher, Lorenzo Giorgianni, Carlos Medeiros, and Andre Meier. The usual disclaimer applies.

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I. Introduction

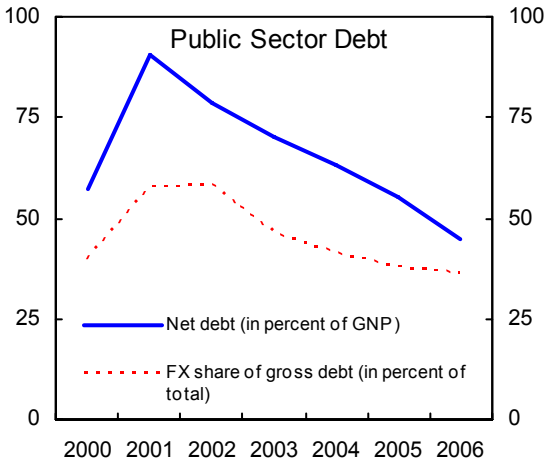
Turkey's exposure to risk has evolved considerably in recent years. The improvements achieved on the macroeconomic front since the 2001 crisis, and the associated gains in the market value of Turkish assets, are impressive. Furthermore, the asset-liability structure on Turkish balance sheets has changed considerably, as have interlinkages between various sectors—notably the sovereign, banking and corporate sectors. These developments have improved Turkey's overall sovereign risk profile, although the country remains subject to bouts of volatility, as evidenced most recently in the May/June 2006 market turbulence.

This paper examines these changes in Turkey's risk profile using the Contingent Claims Approach (CCA). The CCA is used to quantify the evolution of Turkey's sovereign risk, relate risk indicators to market prices of risk, and conduct scenario analyses to assess the effects of potential market volatility and policy adjustments on key risk indicators. The paper is structured as follows: as background, Section II reviews balance sheet developments since the 2001 crisis. Section III explains the CCA methodology, including a description of the underlying interlinkages. Section IV uses the CCA to develop default risk indicators for Turkey and relates them to market prices for default risk and sovereign ratings. Section V describes and quantifies the effects of capital market turbulence and policy adjustments on key risk indicators. Section VI concludes.

II. Overview of key balance sheet developments since the 2001 crisis

The 2001 crisis severely affected Turkey's overall risk profile. The crisis initially hit the banking sector the hardest. The sharp depreciation of the lira and the related hike in real interest rates fully exposed banks' large currency and maturity mismatches, causing a severe banking crisis. As part of the crisis resolution, the government issued bonds (many of them foreign exchange-indexed) to recapitalize salvageable banks and provided foreign exchange liquidity to the market to help banks and corporations meet their foreign exchange liabilities. This implied a massive re-allocation of risks onto the sovereign balance sheet. Net public debt surged, and its structure worsened with the share of foreign exchange debt growing, maturities shortening, and reserve holdings declining.

However, the sovereign balance sheet has strengthened considerably since. Tight fiscal policy, falling interest rates, lira appreciation, and strong economic growth helped reduce gross public debt ratios. Together with robust asset accumulation, in particular foreign exchange reserves, this brought down net debt to less than 45 percent of GNP in 2006 (from over 90 percent in 2001), with about one third of total debt denominated in foreign exchange (from 58 percent in 2001). While the still short maturity of domestic debt (averaging about 3 years since 2004) remains a challenge, the sovereign's balance sheet has improved markedly overall.



Source: Ministry of Finance.

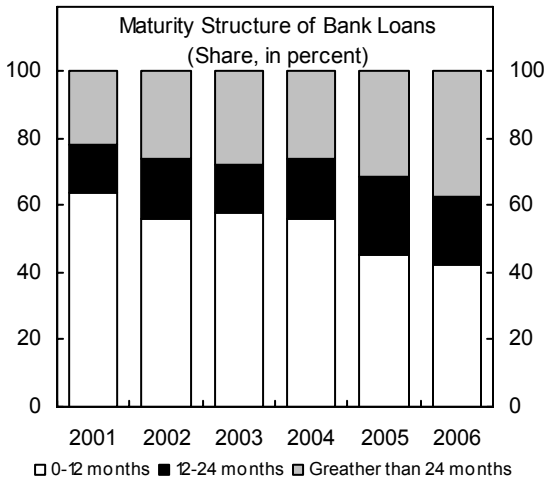
Aided by a strong economic recovery and ample global liquidity, banks and the corporate sector also strengthened their balance sheets, though risks remain.

- **Banking sector**. The favorable economic environment since 2002 led to a sharp improvement in banks' profitability ratios and a parallel surge in banks' market valuations. In search of new growth areas, banks expanded lending to the corporate and household sectors. While the maturity for such loans increased, deposit maturities remained short however, thereby worsening banks' maturity mismatch. Also, given a still high share of domestic foreign exchange deposits and increased foreign funding (syndicated loans), the banking sector has large negative on-balance sheet foreign exchange positions. While this seems well-hedged through derivative transactions, mostly cross-currency swaps, banks' domestic lira loans linked to the exchange rate (which regulators allow to be counted as foreign exchange assets for the purpose of computing banks' net foreign exchange position) may carry indirect foreign exchange risk (i.e. in the event a lira depreciation causes a decline in the quality of the FX and FX-indexed loan portfolio). Overall, however, banks' high loan provisioning and robust capitalization (on average well above the legal requirement) provide a buffer to balance sheet risks.

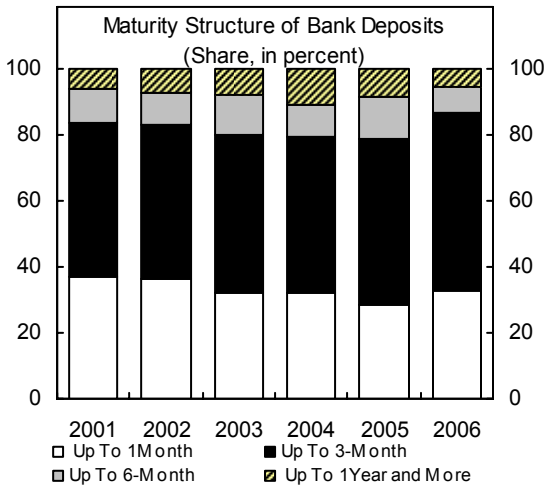
- **Corporate sector**. Nonfinancial corporations also benefited from the strong post-crisis recovery as profitability ratios and equity valuations improved. Though Turkish firms have high concentrations of short-term debt and foreign exchange liabilities, which exposes them to interest rate and foreign exchange risk, coverage ratios derived from the balance sheets of a representative sample of companies listed on the Istanbul Stock Exchange (ISE) are quite high by international standards, suggesting that larger Turkish firms may be in a good position to withstand shocks.[1] Nonetheless, loans denominated in lira but linked to a foreign exchange index have been growing rapidly in recent years and, as noted above, may be a source of rising foreign exchange risk, particularly among SMEs.[2]

[1] Total liabilities to assets among these companies—representing 37 percent of market capitalization of all nonfinancial sector companies listed on the ISE—averaged 0.44 at end-June 2006, while the current ratio and interest coverage ratio averaged 1.28 and 2.81, respectively (a current ratio of about 1 is fairly standard among European corporates). Furthermore, current assets among these companies was 2.5 times as large as the net open foreign exchange position at end-June 2006.

[2] Current regulations governing foreign exchange lending only allow banks to lend in foreign exchange for trade related purposes. However, companies can receive bank credit in lira linked to foreign currencies, which similarly exposes them to foreign exchange risk. Most of these credits appear to be going to SMEs who are least likely to be in a position to manage foreign exchange risks.



Source: Central Bank of Turkey.

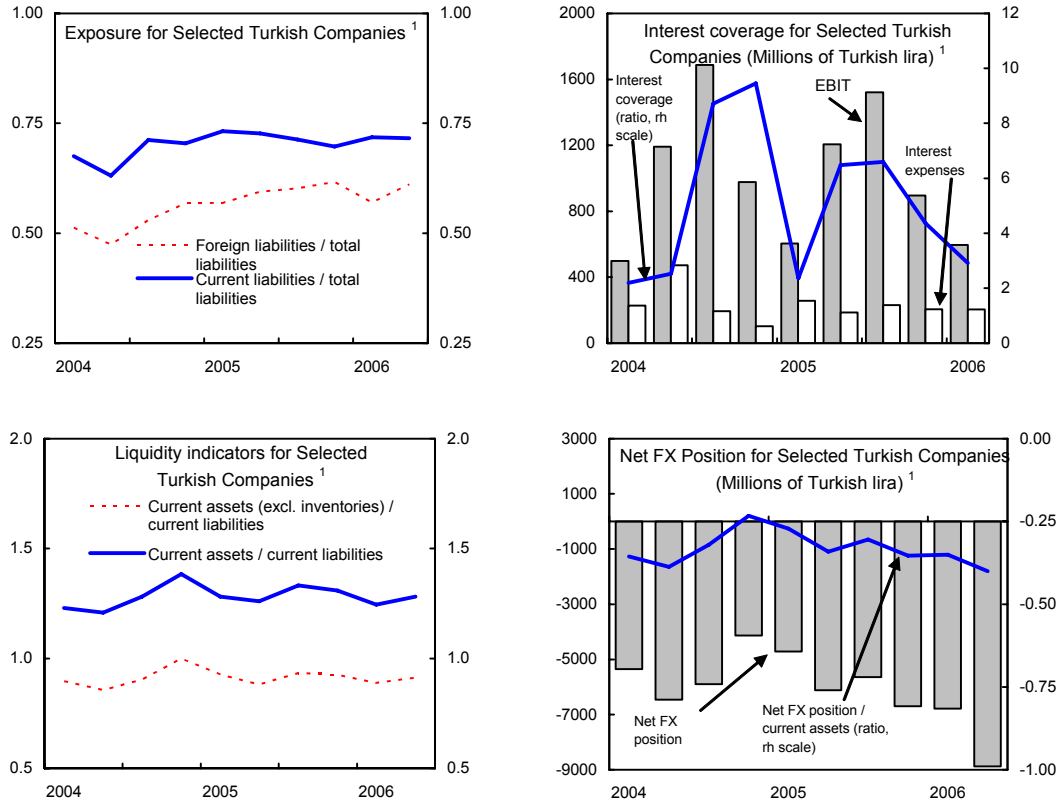


Central Bank of Turkey.

Banking sector indicators (in billion US$, unless otherwise noted)

	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Dec-05	Dec-06
FX position:							
1. Net FX position (excl. FX-indexed assets and liabilities)	-18.0	-10.2	-9.7	-9.3	-9.1	-11.7	-13.9
2. FX-indexed assets (net)	3.4	8.6	9.1	9.3	7.7	9.8	8.4
of which , FX-indexed loans to the private sector	…	…	1.5	1.7	2.9	5.3	6.6
3. On-balance sheet Net FX position (1+2)	-14.6	-1.6	-0.6	0.0	-1.4	-1.9	-5.6
4. Off-balance sheet hedge	9.1	1.5	0.1	0.3	1.3	1.8	5.6
5. Overal Net FX position for regulatory requirement (3+4)	-5.5	-0.1	-0.5	0.3	-0.1	-0.1	0.1
Memorandum items:							
Capitalization:							
Banking sector core capital (at end-period exchange rate)	…	…	14.9	24.0	31.5	36.5	41.7
Capital adequacy ratio (in percent)	…	15.3	25.3	30.9	28.8	24.2	22.2
Asset quality:							
Non performing loans (in percent of total loans)	…	29.3	17.6	11.5	6.0	4.8	3.8
Provisions (in percent of non performing loans)	…	47.1	64.2	88.5	88.1	89.8	90.8
Profitability:							
Return on assets (in percent)	…	-5.5	1.1	2.3	2.3	1.7	3.3
Return on equity (in percent)	…	-69.4	9.3	16.0	16.4	11.8	21.0

Source: BRSA



Source: Istanbul Stock Exchange.

[1] Based on 20 selected companies listed on the ISE.

Developments in the banking and corporate sectors clearly have implications for sovereign risk, and a comprehensive risk assessment therefore needs to take sectoral interlinkages into account. Shocks to interest rates, exchange rates, or market sentiment that deteriorate the asset-liability position in one sector can be transferred across balance sheets, triggering widespread distress. Such a risk transfer can be "top down"–from the sovereign to other sectors–or "bottom-up"–from the corporate sector to the banking system and ultimately to the sovereign balance sheet. In fact, the transfer of risks from the banking sector to the sovereign was well demonstrated during Turkey's 2001 crisis.

The CCA provides a framework for taking various sectoral balance sheet exposures into account, incorporating interlinkages between them, and deriving quantitative measures of default risk. This paper applies the CCA to Turkey to this end.

III. CCA Methodology

The CCA is a framework combining balance sheet information with commonly used risk measurement tools to construct marked-to-market balance sheets with a view to

identifying and quantifying risks.[3] The basic idea of the CCA is to model the sovereign's balance sheet similarly to a firm's balance sheet by grouping the main accounts into assets, liabilities, and 'equity'. Merton (1974) shows how a firm's equity can be modeled as a (junior) contingent claim on the residual value of its assets. In the event of default, equity holders receive nothing if the firm's assets are all consumed to pay the senior stakeholders (e.g. debt holders); otherwise, equity holders receive the difference between the value of assets and debt. Under this framework, the equity of the firm can be seen as a call option on the residual value of the firm's assets. This framework enables a rich characterization of a firm's (or sovereign's) balance sheet and the derivation of a series of credit risk indicators, in particular the distance-to-distress, the default probability, and credit spreads.

The application of the CCA to the sovereign requires the construction of a sovereign balance sheet (see Gray, Merton, and Bodie (2006) for details). In order to derive default probabilities, assumptions must be made about the seniority structure of the sovereign's liabilities. To derive external default probabilities, external debt is assumed to be the more senior liability, whereas domestic debt and base money are assumed to represent the equity portion of the sovereign balance sheet and thus can be viewed as a contingent claim on the residual value of sovereign assets (see table below).[4] The sovereign is assumed to default whenever the value of its implied assets—derived from market information on the liabilities and the Black and Scholes option pricing formula—falls below a distress barrier (see figure below).[5] The difference between the asset value and the distress barrier, scaled by the asset volatility, is referred to as the distance-to-distress, while the area of the distribution that falls below the distress barrier represents the sovereign's default probability.

Stylized Sovereign Balance Sheet

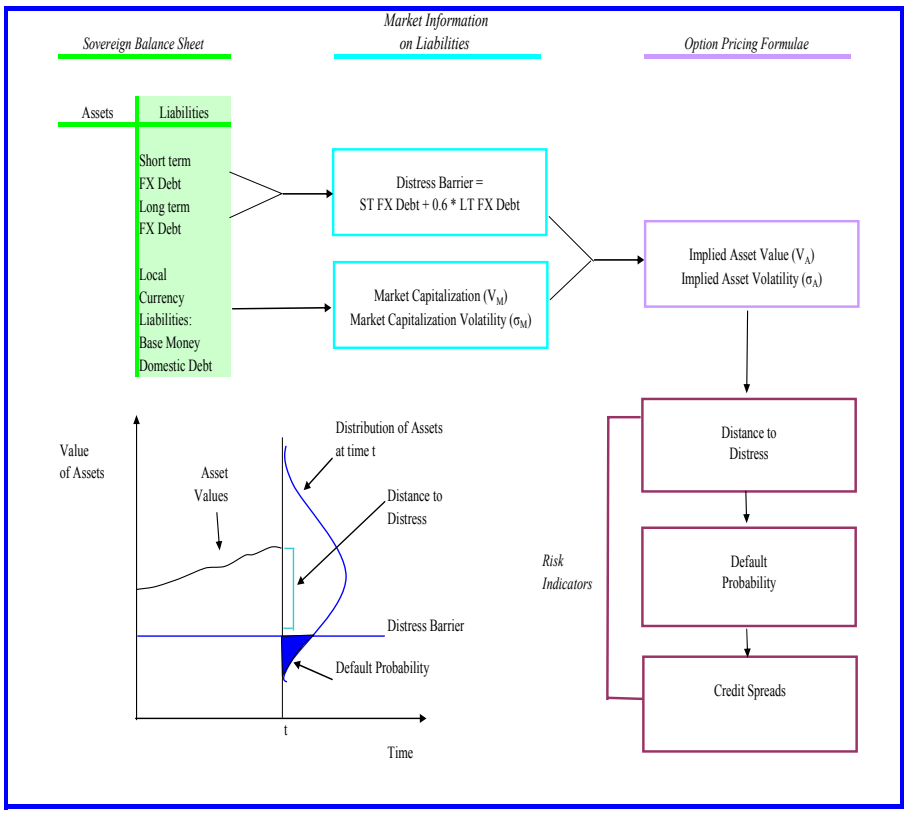
Assets	**Liabilities**
▫ International Reserves.	▫ External Debt.
▫ Net Fiscal Assets (Discounted Value of Primary Fiscal Surpluses).	**Equity**
▫ Value of Monopoly over Issue of Money.	▫ Domestic Debt.
▫ Other Assets less Guarantees.	▫ Base Money.

[3] For an in-depth explanation of the CCA, see Gapen, Gray, Lim, and Xiao (2005). Annex I provides a technical description of the derivation of CCA risk indicators.

[4] The model is flexible enough to accommodate any seniority structure, as long as the distress barrier is estimated appropriately. However, domestic debt is typically considered a more junior liability since it is easier to restructure or inflate away. The separation between external debt and domestic debt in this way enables the computation of risk indicators, including CDS spreads, which can be compared to market prices of risk.

[5] We follow Moody's KMV and define the distress barrier (DB) for senior debt as short-term debt (maturity ≤ 1 year), plus interest payments due within a year and a fraction (usually a number between 0.5 and 0.8) of long-term debt (see Hull (1999) and Crouhy, Galai, and Mark (2001)).

Overview of CCA for the Sovereign[1]



[1] Adapted from Gray and Jones (2006).

To derive domestic default probabilities, an alternative approach, requiring the construction of a multiple-layer balance sheet, needs to be pursued. Here, external debt is still the more senior liability, FX-indexed and floating rate debt are now considered subordinated, while the equity-like portion of the sovereign balance sheet is represented by base money and fixed rate local currency debt.[6] [7] In this framework, the sovereign is assumed to default on its domestic debt when the value of its implied assets falls below an augmented distress barrier, which incorporates FX-indexed and floating rate domestic debt.

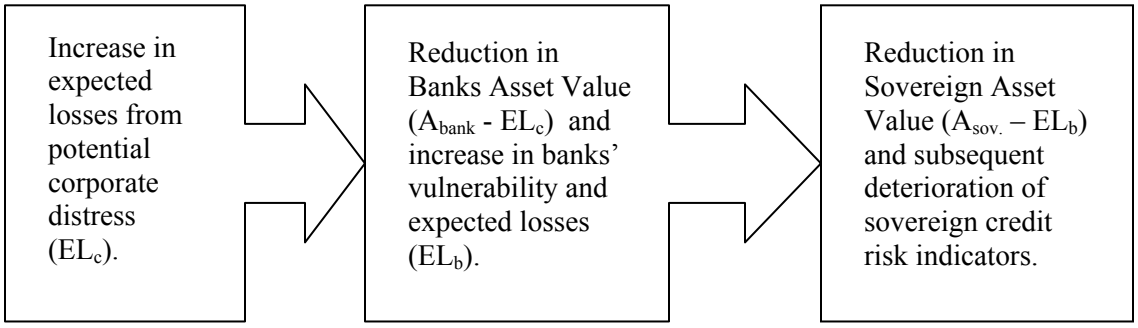
It is important to note that the CCA allows for interlinkages between the corporate, financial, and public sectors so that changes in the valuation of the balance sheet of one sector can transmit to another. For example, losses in the corporate sector may induce contingent liabilities on the financial sector, so that when corporates become unable to repay their loans to the banks, the asset values of banks decline correspondingly. Similarly, the sovereign can incur

[6] See Annex II and Gapen, Gray, Lim, and Xiao (2005) for additional details concerning the derivation of domestic debt risk indicators.

[7] For the purposes of this paper, "FX-indexed" debt refers to both FX-indexed and FX-denominated debt.

contingent liabilities stemming from potential defaults in the financial sector.[8] The interlinkages between the corporate, financial, and sovereign sectors within the CCA framework are depicted below.

CCA sector interlinkages.



Finally, it should be noted that, while the CCA primarily aims to measure credit risk, liquidity risk is also captured indirectly in the risk indicators. Since the model distinguishes between short-term and long-term debt, which in turn affects the distress barrier, the maturity structure of debt does have an impact on risk indicators.

The CCA offers some distinct advantages over other vulnerability analyses.[9] First, the CCA takes balance sheet information and combines it with current and forward-looking financial market prices to compute risk-adjusted marked-to-market balance sheets (i.e. asset values). Using financial market price information to derive forward-looking risk-adjusted balance sheets is a significant advantage compared to an analysis based on past balance sheet information. Second, the CCA distinguishes itself from other vulnerability analyses in that it incorporates market volatility when estimating credit risk. Volatility is crucial in capturing nonlinear changes in risk, especially during times of stress when small shocks can gain momentum and trigger systemic repercussions.

At the same time, the CCA is only a tool to help understand credit risk, and certain caveats need to be kept in mind. First, as with any model that uses market information, the output of the CCA sometimes reflects over- or under-reaction in the market. At the same time, the CCA does not account for off-balance sheet risks explicitly, though off-balance sheet risks are implicitly assumed to be captured in equity prices. Nonetheless, to the extent that financial markets do not fully price these risks, the CCA's ability to capture these off-balance sheet risks may be limited. Finally, the application of the CCA to the sovereign is still relatively new and

[8] Once implied sovereign assets and sovereign assets volatility have been estimated, with information on sovereign 'equity' and 'equity volatility', expected losses from the banking sector are subtracted and the corresponding risk indicators re-estimated using the new values for assets and assets volatility.

[9] See Gapen, Gray, Lim, and Xiao (2004) for a more in-depth discussion of advantages and hurdles relating to the CCA.

since occurrences of sovereign defaults are relatively few, it is sometimes difficult to benchmark the results. In the case of external risk indicators (i.e. external default probability), this is generally overcome by comparing the sovereign risk indicators with CDS spreads. In the case of domestic debt, benchmarking is made difficult by the lack of market credit spreads on domestic debt. In this case, external credit spreads or domestic interest rates may be used as an incomplete benchmark, along with knowledge of historical stylized factors and in comparison to the same indicators derived for countries with similar macroeconomic conditions.

IV. Baseline Results for the Sovereign

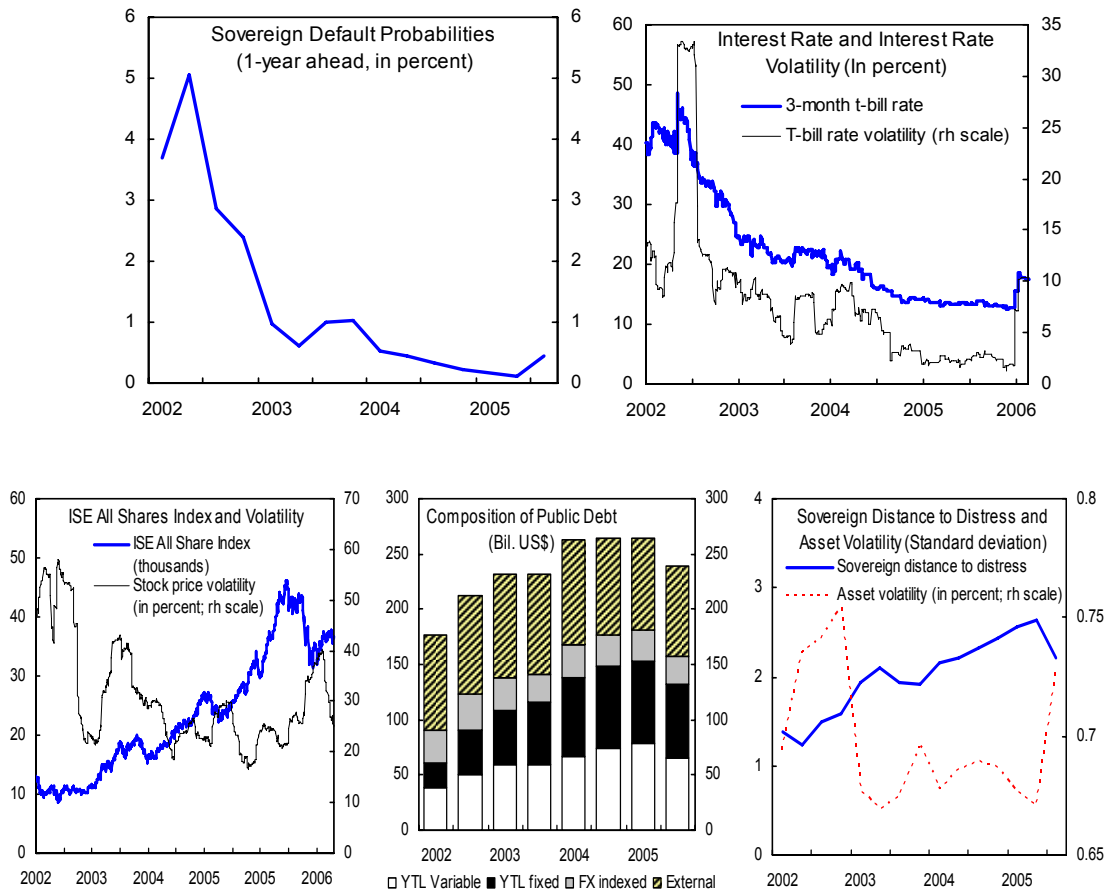
The CCA was applied to Turkey with a view to examining the risk profile for both sovereign external and domestic debt for the period Q4 2002-Q2 2006.[10] The structure of Turkish sovereign debt was used to derive distress barriers, which along with historical data on the liability side of the sovereign balance sheet was used to solve for implied asset values and volatilities plus a range of risk indicators. The same procedure was applied to five Turkish banks and 20 publicly traded non-financial companies, producing corresponding risk indicators for those sectors.[11] The baseline for calibrating the CCA was set at June 30, 2006.

A. External Risk Profile

The results of the CCA show a decline in external sovereign risk indicators in recent years. As can be seen in the figure below, external default probabilities have fallen considerably since the beginning of 2003, a period of significant financial market volatility in Turkey. The decline in the one year ahead external sovereign default probabilities over this time period (by 4.5 percentage points) corresponds to improved macroeconomic and financial market conditions, as reflected in reduced domestic interest rates and volatilities, more benign domestic and global market conditions, and a more stable lira. In this context, banking and corporate share prices performed strongly, with the ISE All Share Index rising 236 percent between 2003 and mid-2006, and expected losses arising from these sectors declined. Furthermore, as noted above, the sovereign's debt profile has improved considerably—reflecting a decline in the debt to GDP ratio, a lower share of foreign currency debt (with a concomitant decline in the distress barrier), and an increase in the share of fixed rate debt. As a result, the country's vulnerability to exchange rate or interest rate shocks has diminished considerably. Taken together, these factors have helped increase the value of implied sovereign assets, reduced its volatility, increased the sovereign's distance to distress, and strengthened the sovereign balance sheet overall.

[10] For this paper, external debt is defined as debt issued internationally (which is essentially all in foreign currency) while domestic debt is defined as debt issued domestically (which may be in foreign or domestic currency).

[11] Turkish banks used in the analysis represent 54 percent of total banking sector assets while the 20 firms represent 37 percent of all non-financial corporates listed on the ISE.

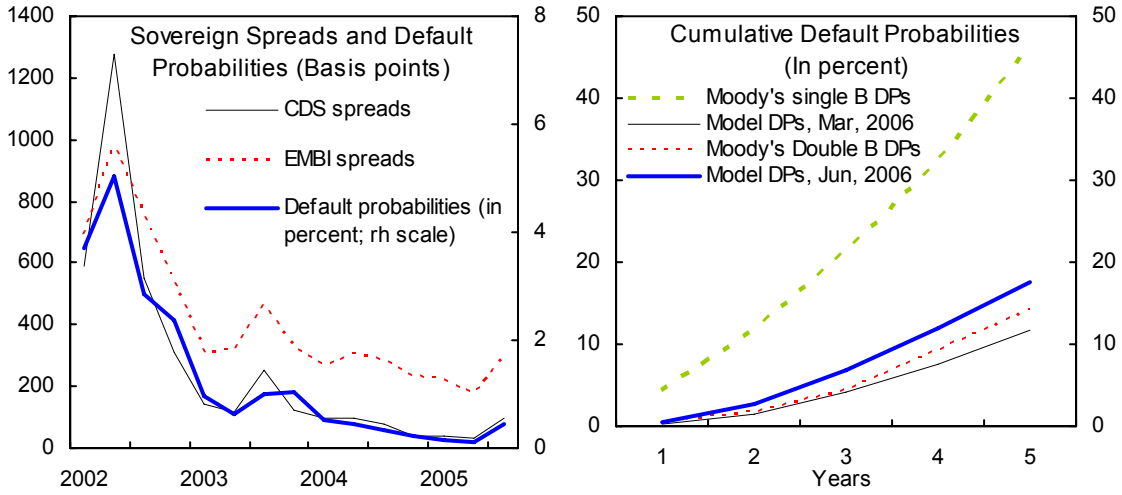


The CCA results pertaining to external debt closely match trends in market prices of risk. The figure below shows the strong correlation in sovereign external default probabilities obtained from the CCA with EMBI and CDS spreads.[12] Since the beginning of 2003, EMBI Turkey and 1 year CDS spreads have fallen by 750 and 1025 basis points, respectively. The results of the CCA show a similar improvement in Turkey's sovereign risk profile as noted above. While market turbulence in the second quarter of 2006—entailing roughly a 20 percent lira depreciation, a 20 percent rise in T-bill rates, and a 20 percent decline in stock prices—has resulted in widening spreads and an uptick in CCA risk indicators, these remain relatively low by historical standards: at end-June 2006, 1 year CDS spreads reached 100 bps, while the sovereign 1-year ahead default probability rose to 0.47 percent.

In addition, the CCA results for external debt are broadly consistent with sovereign ratings assigned by major rating agencies. The one-year ahead cumulative default

[12] Correlation between risk indicators obtained from the CCA for Turkey and CDS/EMBI spreads are approximately the same as those obtained for Turkey in Gapen, Gray, Lim, and Xiao (2005). For example, correlation between the distance-to-distress and CDS spreads in that paper is 0.83, the same as the correlation coefficient obtained here.

probabilities obtained from the CCA are similar to historical averages of sovereign default probabilities for BB rated sovereigns, which is the foreign currency rating currently assigned to Turkey by major rating agencies.[13]

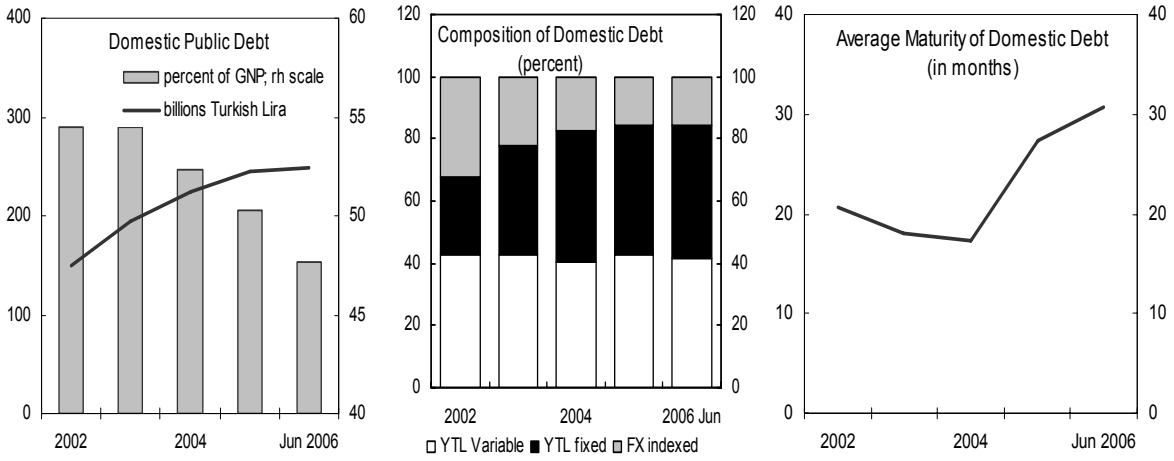


B. Domestic Risk Profile

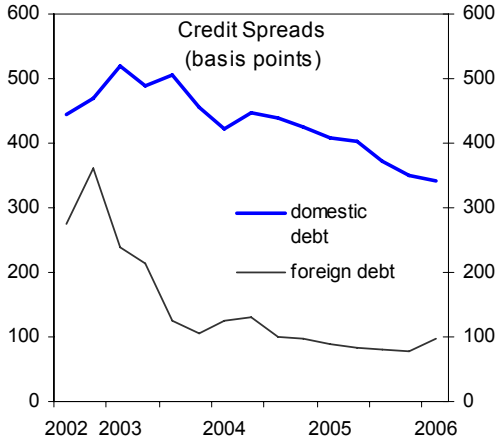
Turkey's domestic risk profile has also evolved considerably in recent years. As mentioned previously, the decline in external sovereign debt has resulted in a concomitant increase in domestic debt, reflecting inter-alia, the authorities' intention to reduce foreign exchange risk. As a result, domestic debt as a share of total public debt has increased from around 50 percent in 2002 to over 65 percent in mid-2006.

While domestic debt has been increasing, it has declined in relation to the size of the Turkish economy, and its structure has generally improved. The domestic debt to GNP ratio has declined from 54 percent of GNP at end-2002 to under 50 percent of GNP in mid-2006. As regards its structure, the FX-indexed component of domestic debt has been halved over the past four years, dropping from 32 percent in 2002 to 16 percent in mid-2006. This has contributed to further reducing the sovereign's exposure to FX risk. The fixed rate share of domestic debt over that time period has increased from 25 percent to over 40 percent, while the floating rate share has remained relatively steady, averaging about 40 percent over the past few years. The maturity structure of domestic debt has also improved somewhat, with the share of short-term debt declining to under 5 percent of total in mid-2006 (from over 20 percent at end-2002), but the average maturity of domestic debt—while lengthening somewhat (to 30 months in mid-2006)—remains short.

[13] Turkey is currently rated Ba1 by Moody's, and BB (positive outlook) by S&P and Fitch.



The application of the CCA confirms an overall improvement in the sovereign domestic debt risk profile.[14] The figure to the right shows the evolution of the estimated credit spreads derived from the application of the CCA to domestic debt.[15] At the outset it should be noted that the model predicts a decline in credit spreads in recent years, consistent with the improvements in the structure of domestic debt described above. As noted in section III, there are no domestic credit spreads available on domestic debt, making it difficult to benchmark these results. However, a comparison of estimated credit spreads on domestic debt with those obtained on external debt can help provide some insights. First, estimated credit spreads on domestic debt are significantly higher than those on external debt. The average credit spread on domestic debt is 433 bps over the period investigated, compared with 147 bps in the case of external debt. This is not surprising since domestic debt accounts for roughly two-thirds of total public debt and given that the CCA assumes the government would—in the event of payment difficulties—default on, or restructure, domestic debt before external debt. Second, credit spreads on external debt have declined faster than those on domestic debt. This likely reflects the authorities' progressive shift away from external debt in favor of domestic debt, and the associated relative decline in the share of external debt. Finally, it should be noted that both credit spreads on domestic and external debt follow similar trends, indicating that in recent years Turkey's sovereign risk profile has improved overall.



[14] The domestic debt risk profile and indicators pertain to domestic FX-indexed and floating rate debt.

[15] The credit spread on domestic debt is over the foreign risk-free rate. It refers to the risk that the government will not make payments on its domestic obligations or that it can impose some losses on the market value of domestic debt by forcing a restructuring.

V. Capital Market Turbulence and Policy Adjustments

A. Effects of changes in key variables on risk indicators

Scenario analysis can be conducted within the CCA framework to estimate the impact of volatility and policy adjustment on risk indicators. Several scenarios are considered: (i) price and volatility changes; and (ii) adjustments to the government's fiscal stance. Price and volatility changes are possible for the following variables: (i) the spot exchange rate (YTL/US$); (ii) the 1-year forward exchange rate (YTL/US$); (iii) the domestic interest rate; (iv) the foreign interest rate; and (v) the stock market index. Volatilities are adjusted through the historical relation between price levels and associated volatility.[16] The effect of changes in various variables within the CCA framework that are considered in this paper is briefly discussed below.

Impact on external risk indicators

(i) Changes in the spot exchange rate

At the outset it should be noted that all values in the CCA are converted into a single currency (in this case the U.S. Dollar) to compile debt statistics and to enable the build up of the balance sheet. Changes to the spot rate impact all current values that are reported in local currency and that are converted into foreign currency. Thus, for the corporate and banking sectors, a depreciation in the lira causes the dollar value of equity to fall whereas equity volatility is adjusted upward through the historical relation between price levels and associated volatility. As a consequence, the implied value of assets falls, the implied volatility of assets rises, resulting in a deterioration in risk indicators. For the sovereign sector, changes in spot exchange rate impacts the foreign currency value of the stock of debt and base money denominated in local currency. Since these two factors form the sovereign's 'equity', the impact on sovereign implied assets and assets volatility and on risk indicators is the same as for the firms. The impact of changes in the spot exchange rate can be summarized as follows:

The impact of changes on the spot exchange rate[1]

$$\text{er} \uparrow \Rightarrow V_{eq\text{-}like} \downarrow \Rightarrow \sigma_{eq-like} \uparrow \Rightarrow V_A \downarrow \Rightarrow \sigma_A \uparrow \Rightarrow$$

$$\Rightarrow D2D \downarrow \Rightarrow DP \uparrow \Rightarrow EL \uparrow \Rightarrow spread \uparrow$$

[1] Where er is the spot exchange rate (local currency/foreign currency, an increase in er represents a depreciation of the local currency), $V_{eq\text{-}like}$ is the value of the equity-like portion of the sovereign balance sheet, $\sigma_{eq\text{-}like}$ is the volatility of the equity-like portion of the sovereign balance sheet, V_A is the implied value of assets, σ_A is the implied value of assets volatility, D2D is the distance to distress, DP is the default probability, EL is the expected loss on the risky debt (foreign currency debt), and *spread* is the credit spread (premium demanded by debt holders to bear the risk that the government may default on its debt obligations).

[16] Historical data on assets and asset volatilities show a decreasing monotonic relationship: as assets increase, volatilities decrease, and vice-versa.

(ii) Changes in the forward exchange rate

The forward exchange rate impacts primarily domestic debt (for the sovereign) and the distress barrier (for banks and corporates). If the forward exchange rate depreciates, the foreign currency value of debt denominated in local currency will fall, which will adjust the sovereign's implied asset value down, propagating through the risk indicators in the same fashion as for the depreciation in the spot exchange rate.

The impact of changes on the 1-year forward exchange rate[1]

$$\text{fer}\uparrow \Rightarrow V_{eq\text{-}like}\downarrow \Rightarrow \sigma_{eq-like}\uparrow \Rightarrow V_A\downarrow \Rightarrow \sigma_A\uparrow \Rightarrow$$
$$\Rightarrow D2D\downarrow \Rightarrow DP\uparrow \Rightarrow EL\uparrow \Rightarrow spread\uparrow$$

[1] Where fer is the forward exchange rate.

(iii) Changes to the domestic interest rate

Changes in the spot interest rate affects the term structure of interest rates. An increase in the spot interest rate will increase the 1-year ahead interest rate assuming the term structure of interest rates is unchanged. This will increase interest rate payments on sovereign domestic floating rate debt,[17] which increases the value of domestic debt and the "equity" portion of the sovereign balance sheet. In this case the sovereign external risk indicators may improve.[18]

The impact of changes on the domestic interest rate[1]

$$r_d\uparrow \Rightarrow ip_d\uparrow \Rightarrow V_{eq-like}\uparrow \Rightarrow \sigma_{eq-like}\downarrow \Rightarrow V_A\uparrow \Rightarrow \sigma_A\downarrow \Rightarrow$$
$$\Rightarrow D2D\uparrow \Rightarrow DP\downarrow \Rightarrow EL\downarrow \Rightarrow spread\downarrow$$

[1] Where r_d is the domestic interest rate and ip_d is the 1-year ahead interest payment on local currency denominated sovereign debt.

(iv) Changes to the foreign interest rate

For an increase in the foreign interest rate, the impact will propagate through two different channels: (i) it increases floating rate interest payments on foreign-currency denominated debt, which increases the distress barrier, entailing a deterioration of risk indicators; and (ii) it

[17] The model only takes into account the effect of changes in interest payments on the existing stock of debt, without consideration to new borrowings.

[18] In a multi-layer framework, such as the one applied for calculating domestic debt default probabilities, an increase in the domestic interest rate could lead to a deterioration in the risk indicators for domestic debt, as the associated distress barrier would increase as well.

increases the discount rate used to calculate the present value of domestic debt (the sovereign's equity), which decreases the present value of equity, with a similar impact on risk indicators.

The impact of changes on the foreign interest rate[1]

Channel 1:

$$r_f \uparrow \Rightarrow ip_f \uparrow \Rightarrow DB \uparrow \Rightarrow V_A \downarrow \Rightarrow \sigma_A \uparrow \Rightarrow$$

$$\Rightarrow D2D \downarrow \Rightarrow DP \uparrow \Rightarrow EL \uparrow \Rightarrow spread \uparrow$$

Channel 2:

$$r_f \uparrow \Rightarrow \text{PV of } V_{eq-like} \downarrow \Rightarrow \sigma_{eq-like} \uparrow \Rightarrow V_A \downarrow \Rightarrow \sigma_A \uparrow \Rightarrow$$

$$\Rightarrow D2D \downarrow \Rightarrow DP \uparrow \Rightarrow EL \uparrow \Rightarrow spread \uparrow$$

[1] Where r_f is the foreign interest rate and ip_f is the 1-year ahead interest payment of the foreign currency denominated sovereign debt.

(v) Changes to the stock market index

The stock market index impacts the corporates' and banks' equity values proportionally to the firms' beta. A decrease in the market index will be followed by a drop in the firms' equity value, an increase in the equity volatility and a deterioration of risk indicators. Losses from the corporate sector cause a deterioration of banks' risk indicators which transmit to the sovereign as well.

The impact of changes on the domestic equity market[1]

$$EMI \downarrow \Rightarrow V_{eq-like} \downarrow \Rightarrow \sigma_{eq-like} \uparrow \Rightarrow V_A \downarrow \Rightarrow \sigma_A \uparrow \Rightarrow$$

$$\Rightarrow D2D \downarrow \Rightarrow DP \uparrow \Rightarrow EL \uparrow \Rightarrow spread \uparrow$$

[1] Where EMI is the domestic broad equity market index.

(vi) Changes in fiscal savings on external risk

Fiscal savings can impact the sovereign balance sheet in different ways, depending on how fiscal savings are used. If, as is considered here, it is used to pay off external debt, the decline in

external debt reduces the distress barrier. This would improve the sovereign balance sheet position and reduce risk.

The impact of changes in fiscal savings on external risk[1]

$$\text{FS}\uparrow \Rightarrow DB\downarrow \Rightarrow D2D\uparrow \Rightarrow DP\downarrow \Rightarrow EL\downarrow \Rightarrow spread\downarrow$$

[1] Where FS represents fiscal savings.

Impact on domestic risk indicators

(i) Changes in fiscal savings on domestic risk

Changes in fiscal savings within the CCA framework have a similar impact on risk indicators relating to domestic debt as they do for external debt. If, as is assumed here, the authorities use fiscal savings to reduce the FX-indexed and floating rate components of domestic debt, this reduction will result in a lower distress barrier.[19] This will cause a decline in risk indicators associated with domestic debt.

The impact of changes in fiscal savings on domestic risk[1]

$$\text{FS}\uparrow \Rightarrow DB\downarrow \Rightarrow D2D\uparrow \Rightarrow DP\downarrow \Rightarrow EL\downarrow \Rightarrow spread\downarrow$$

B. Scenario Analysis

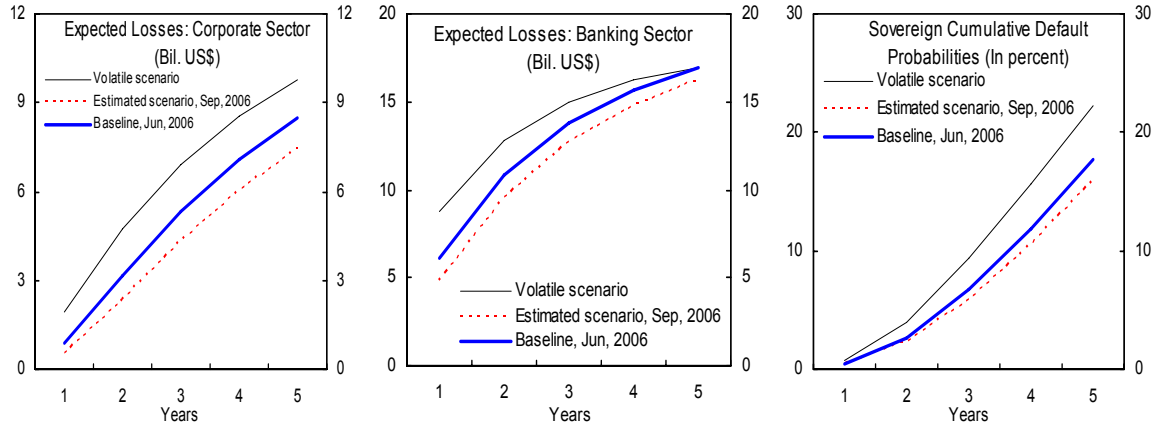
While the findings of the CCA in the preceding section point to fairly benign risks, the turbulence of Turkish markets in recent years suggests that these risks can change fairly suddenly. Several scenarios are therefore conducted to illustrate the effect of a change in key economic and financial indicators and policy adjustments on external and domestic risk indicators.

Impact of Market Volatility and Policy Adjustments on External Risk Indicators

The first scenario examines the effect of a shock of the same order of magnitude as that which occurred in Q2 2006 and compares the results with risk estimates based on actual

[19] The assumption concerning the reduction in FX-indexed and floating rate debt is broadly consistent with the authorities' debt management strategy and the evolution of domestic debt in recent years.

market developments through end-September 2006. This "volatile" scenario—entailing a 20 percent lira depreciation, a 20 percent rise in T-bill rates, and a 20 percent decline in asset prices—is depicted in the figures below. Such a shock reduces implied assets and increases its volatility for the corporate and banking sectors as well as for the sovereign, leading to a decline in the distance to distress measures and increases in expected losses. Expected losses for the corporate and banking sector are estimated to rise by $1.3 billion (0.4 percent of GDP) over a five year horizon relative to the baseline scenario, equivalent to about 1 percent of total market capitalization at end-June 2006 (or about 50 percent of total estimated profits for the banking and corporate sectors in Q2 2006).[20]

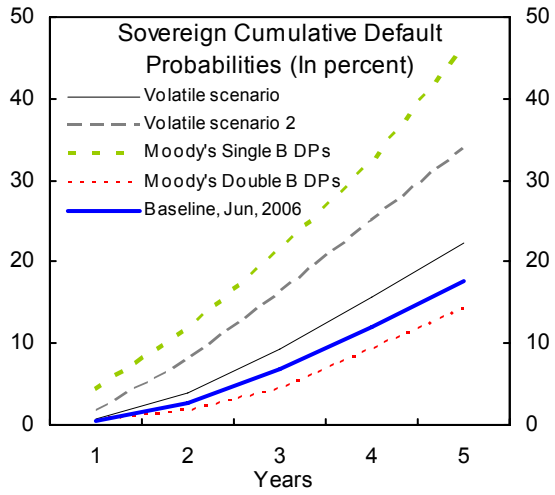


Under the volatile scenario, default probabilities for the sovereign increase, although the magnitude of the impact is relatively modest: over a five year horizon the sovereign's default probability is estimated to rise by about 3 percent. This reflects a number of factors. First, the expected losses of firms and banks are relatively low in relation to the implied asset values of the sovereign and, thus, have a limited effect on the sovereign's risk indicators. In addition, the general improvement of the sovereign's balance sheet in recent years has strengthened Turkey's resilience to shocks, while Turkey's improved debt profile has reduced the impact that shocks—such as that arising from an exchange rate depreciation—have on the sovereign's ability to service its foreign exchange liabilities.

By contrast, actual market developments in the third quarter of 2006 point to an overall improvement in risk indicators for Turkey. Based on actual market developments, expected losses for the corporate and banking sector declined and the sovereign's cumulative default probability fell by 1.5 percent over five years compared with end-June 2006. This reflects a general improvement in market conditions as the exchange rate and the stock market strengthened. Between Q2 2006 and Q3 2006 the Turkish lira appreciated by 10 percent, and the stock market index recovered by over 8 percent, although T-Bill rates continued to rise by

[20] These expected losses represent an approximate estimate of total losses for all companies listed on the ISE. The estimation of expected losses is based on the relative asset share of the subsample of companies used in the CCA and for banks assumes a full write-off of losses stemming from the corporate sector. The estimated losses should be viewed as a lower bound of potential losses, particularly for the corporate sector since the representative sample consists of larger publicly traded companies, which are more likely to be able to withstand shocks and hedge risks.

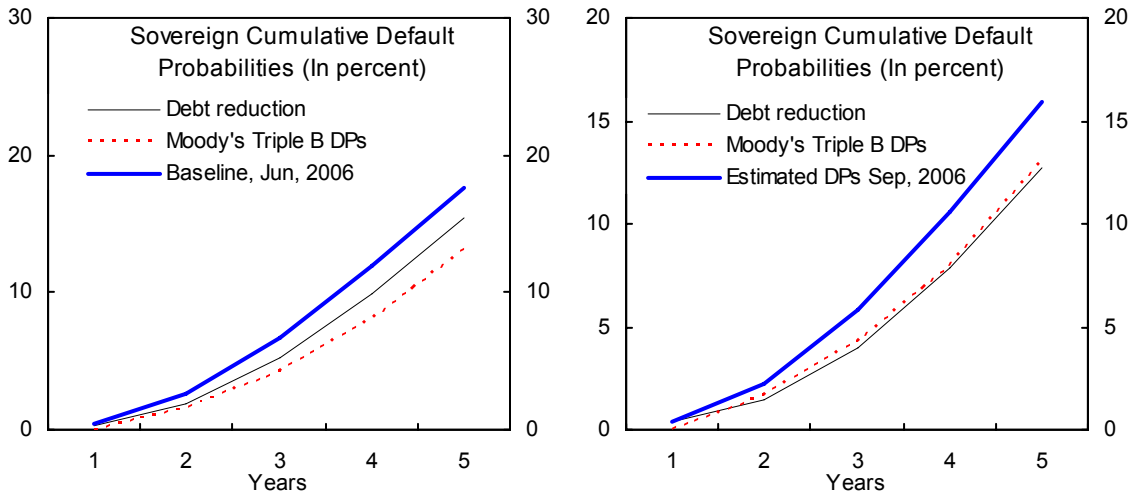
roughly 16 percent. Reduced volatility in the market also contributed to a reduction in expected losses of the corporate and banking sectors, with a concomitant improvement in the sovereign risk profile.



Another scenario was conducted to examine the effect of additional volatility on Turkey's external sovereign risk profile. This scenario (volatile scenario 2) considers the effect of market turbulence of a magnitude last observed in early 2003. Assuming an increase in the forward volatility to over 30 percent (which occurred at the time), a depreciation in the forward exchange rate of about 45 percent compared to Q2 2006, and corresponding declines of about 30 percent in the spot exchange rate and stock exchange, as well as a domestic interest rate hike of 30 percent, the cumulative default probability of the sovereign increases to 34 percent over five years (compared to 17 percent at Q2 2006). The cumulative default probability curve under the more volatile scenario (volatile scenario 2) would be more in line with that of a single B rating, based on historical default probabilities.[21]

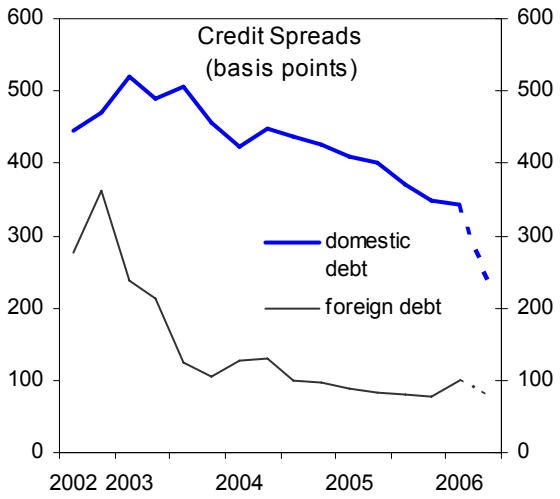
The effect of a policy adjustment alone—in this instance a change in the government's fiscal stance and debt management policy—is considered as well. The scenario that is investigated is the scope that fiscal savings could have for reducing the sovereign's external default probabilities. Specifically, it is assumed that the equivalent of additional annual fiscal savings of 2 percent of GNP per year over the next five years is used towards reducing Turkey's external debt. In present value terms, the external debt reduction would amount to roughly $30 billion (or about 5 percent of current GNP). According to the CCA, a reduction in external debt of this amount applied to the end-June 2006 baseline scenario would reduce the cumulative default probabilities to 15 percent over the five-year horizon (compared to 17 percent for the baseline scenario). However, applying the same fiscal savings to debt reduction in Q3 2006 (by which time Turkey's sovereign risk profile had already improved), would help reduce the cumulative sovereign default probability to about 13 percent over five years. Such a default probability curve would be in line with an investment grade sovereign rating (BBB), based on historical default probabilities.

[21] Turkey was rated B1 by Moody's in March 2003.



Impact of Policy Adjustments on Domestic Risk Indicators

A fiscal scenario analysis similar to the previous one is conducted for Turkey's domestic debt risk profile. Specifically, the scenario that is investigated is the effect that additional annual fiscal savings of 2 percent of GNP over the next five years used towards reducing Turkey's FX-indexed and floating rate domestic debt would have on Turkey's domestic risk profile. According to the CCA, a reduction in domestic debt of this amount applied to the end-June 2006 baseline scenario would reduce credit spreads on domestic debt by just over 100 basis points to 235 basis points, representing a significant reduction in the cost of borrowing for the sovereign.



VI. Conclusion

The application of the CCA to Turkey provides a number of interesting insights into the sovereign risk profile. First, Turkey's external and domestic risk profile has improved considerably in recent years reflecting improved macroeconomic and financial market conditions: interest rates and interest rate volatility have declined, the lira has become more stable, domestic and foreign equity markets have performed well and have been associated with reduced volatility, while Turkey's debt profile has improved considerably. As a result, estimated default probabilities and credit spreads for the sovereign—both for domestic and external debt—have been on a declining trend.

Turkish EMBI and CDS spreads, which have fallen considerably in recent years, are closely correlated with CCA external risk indicators. Despite some market volatility in the second quarter of 2006—entailing roughly a 20 percent lira depreciation, a 20 percent rise in T-bill rates, and a 20 percent decline in stock prices—which has resulted in widening spreads and an uptick in CCA risk indicators, these risk indicators remain relatively low by historical standards and appear to have anchored Turkey in the BB sovereign rating category.

Turkey appears fairly resilient to shocks, though bouts of market volatility as seen in early 2003 could adversely affect Turkey's sovereign rating. A shock of the same order of magnitude as that which occurred in Q2 2006 is estimated to increase the sovereign's default probabilities only modestly and based on historical sovereign default probabilities would maintain Turkey within the BB rating category. At the same time, a more extreme shock, such as that which occurred in early 2003 would, according to the CCA, bring Turkey's risk profile more in line with a single B rating according to historical data on default probabilities.

At the same time, there appears to be scope for further improvements in Turkey's risk profile. This could be achieved, for example, through additional fiscal savings aimed at reducing Turkey's debt. The CCA would suggest that a reduction in external debt induced by fiscal savings equivalent to 2 percent of GNP per year over a five year period, could provide a sufficient improvement in Turkey's debt profile to warrant an upgrading to the BBB rating category. At the same time, a reduction in FX-indexed or floating rate domestic debt of the same order of magnitude would result in a significant decline in credit spreads on domestic debt, and could result in a substantial reduction in the sovereign's debt servicing costs.

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Annex I

Technical Derivation of CCA Risk Indicators

The first step is to define a foreign debt distress barrier, in foreign currency terms ($D_{f,\$}$). Following KMV, we define the distress barrier to be:

$$D_{f,\$} = \text{short-term foreign debt} + \alpha_{FD} \cdot \text{long-term foreign debt} + \\ + 1 \text{ year of interest payments on the foreign debt}, \quad \text{(II.1)}$$

where α_{FD} = 0.60. The sovereign is assumed to default if its assets value goes below this barrier.

Likewise, we can define a second distress barrier for a portion of the domestic debt, in local currency terms ($D_{d,LC}$):

$$D_{d,LC} = \text{short-term domestic floating and FX-linked debt} + \\ + \alpha_{DD} \cdot \text{long-term domestic floating and FX-linked debt} + \\ + 1 \text{ year of interest pmts on the dom. float. and FX-linked debt}. \quad \text{(II.2)}$$

The 'equity portion' of sovereign balance sheet is assumed to be:

$$\text{Base money } (M_{\$}) + \text{Domestic debt } (D_{d,\$}) \quad \text{(II.3)}$$

To estimate sovereign 'equity' volatility, we first estimate domestic debt volatility, in foreign currency terms ($\sigma_{D_{d,\$}}$) as:

$$\sigma_{D_{d,\$}} = \sqrt{\sigma^2_{Dd,LC} + \sigma^2_{X_F} - 2\rho_{D_d,X_F}\sigma_{X_F}\sigma_{Dd,LC}}, \quad \text{(II.4)}$$

where $\sigma_{Dd,LC}$ is the volatility of domestic debt in local currency terms, σ_{X_F} is the volatility of the 1-year forward exchange rate, and ρ_{D_d,X_F} is the correlation between domestic debt in local currency terms and the 1-year forward exchange rate.

We also need to estimate the base money volatility (annualized), in foreign currency terms (σ_M):

$$\sigma_M = \sqrt{\sigma^2_{M,LC} + \sigma^2_{X_F} - 2\rho_{M_{LC},X_F}\sigma_{X_F}\sigma_{M,LC}}, \quad \text{(II.5)}$$

where $\sigma_{M,LC}$ is the volatility of domestic debt in local currency terms, σ_{X_F} is the volatility of the 1-year forward exchange rate, and ρ_{M_{LC},X_F} is the correlation between domestic debt in local currency terms and the 1-year forward exchange rate.

Finally we can estimate the sovereign 'equity' volatility, in foreign currency trems ($\sigma_{LCL,\$}$):

$$\sigma_{LCL,\$} = \sqrt{\left(\frac{M_\$}{M_\$ + D_{d,\$}}\right)^2 \sigma_M^2 + \left(\frac{D_{d\$}}{M_\$ + D_{d\$}}\right)^2 \sigma_{D_{d,\$}}^2 + 2\rho_{M,D_{d,\$}} \left(\frac{M_\$}{M_\$ + D_{d,\$}}\right)\sigma_M \left(\frac{D_{d,\$}}{M_\$ + D_{d,\$}}\right)\sigma_{D_{d,\$}}}, \tag{II.6}$$

With information on equity, equity volatility, the distress barrier and the risk-free interest rate, it is possible to estimate the implied sovereign asset and sovereign asset volatility from the system of equations below:

$$V_{Sov\$}\sigma_{Sov\$} = LCL_\$\sigma_{LCL\$}N(d_1), \text{ and} \tag{II.7}$$

$$LCL_\$ = V_{Sov\$}\mathrm{N}(d_1) - D_{f,\$}e^{-r_f T}\mathrm{N}(d_2), \tag{II.8}$$

where d_1 and d_2 are the known terms in the Black and Scholes option formula as defined below:

$$d_1 = \frac{\ln\left(\frac{V_{Sov\$}}{D_{f,\$}}\right) + \left(r_f + \frac{1}{2}\sigma_{Sov\$}^2\right)T}{\sigma_{Sov\$}\sqrt{T}} = \frac{\ln\left(V_{Sov\$} * \exp\left(\left(r_f + \frac{1}{2}\sigma_{Sov\$}^2\right)T\right)\right) - \ln(D_{f,\$})}{\sigma_{Sov\$}\sqrt{T}}, \text{ and} \tag{II.9}$$

$$d_2 = \frac{\ln\left(\frac{V_{Sov\$}}{D_{f,\$}}\right) + \left(r_f - \frac{1}{2}\sigma_{Sov\$}^2\right)T}{\sigma_{Sov\$}\sqrt{T}} = \frac{\ln\left(V_{Sov\$} * \exp\left(\left(r_f - \frac{1}{2}\sigma_{Sov\$}^2\right)T\right)\right) - \ln(D_{f,\$})}{\sigma_{Sov\$}\sqrt{T}}. \tag{II.10}$$

Once sovereign asset and sovereign asset volatility have been determined, it becomes straightforward to estimate the credit risk indicators:

(1) Distance to distress ($D2D_t$): The distance to distress, which gives the number of standard deviations of sovereign asset value is away from the foreign debt distress barrier ($D_{f,\$}$):

$$D2D_t = \frac{\ln(V_{Sov\$}) + (r_f - \frac{\sigma_{Sov\$}^2}{2})T - \ln(D_{f,\$})}{\sigma_{Sov\$}\sqrt{T}}. \tag{II.11}$$

(2) Risk neutral default probability ($RNDP_t$):

$$RNDP_t = N(-\mathrm{d\_2}). \tag{II.12}$$

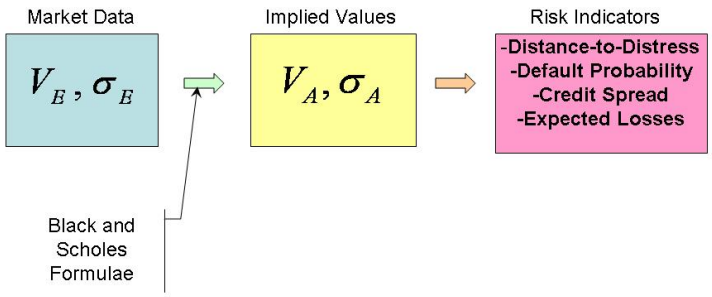
(3) Credit default spread ($spread_t$):

$$spread_t = \frac{-1}{t}\ln\left(\frac{V_{Sov\$}}{D_{f,\$}e^{-r_f t}}N(-d_1) + N(d_2)\right). \quad \text{(II.13)}$$

(4) Actual default probability[22] ($MIDP_t$):

$$MIDP_t = N(-d\_2 - 0.40). \quad \text{(II.14)}$$

In a nutshell, the CCA framework could be summarized as in the figure below:



Once implied sovereign assets and sovereign assets volatility have been estimated, it is possible to conduct scenario analysis and change V_A and σ_A (through the relation between price levels and associated volatility), according to a particular shock, and then reestimate the corresponding risk indicators.

[22] Empirical studies by KMV show that adding a constant factor of 0.40 to $D2D_t$ brings the default probability close to what is implied by the market.

Annex II

Measuring External and Domestic Risk in the CCA Framework

Several considerations need to be taken into account when quantifying sovereign risk in the CCA framework, particularly when considering risk indicators on subordinated debt. As noted in the text, the estimation of sovereign risk indicators—including spreads and sovereign default probabilities—requires a determination to be made concerning debt seniority and the corresponding distress barrier. While, in principle, the model is flexible enough to handle any specification for debt seniority, the application of the CCA to Turkey for deriving external risk indicators has assumed that governments find it easier to inflate away or forcibly restructure local currency debt before defaulting on foreign currency debt. Similarly, a multiple-layer balance sheet with multiple distress barriers and various degrees of debt seniority was constructed for deriving risk indicators on sovereign domestic debt.

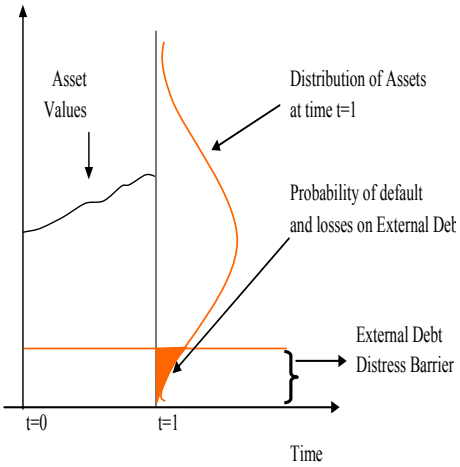
While the determination of the seniority structure of debt allows for the estimation of risk indicators for the respective layers of debt, one final technical difficulty needs to be overcome. For tractability purposes, the Merton (1974) framework assumes that sovereign asset values are lognormally distributed, while empirical evidence points to statistical distributions for assets that have fatter tails. Failure to account for fat tails implies that risk indicators may be underestimated.

One way of correcting the model results is to adjust the equity volatility parameter so as to achieve a bigger mass in the tails. This approach, which is used in this paper for senior debt, uses historical information on the relation between sovereign asset values and volatilities and empirically provides a good fit for senior debt risk indicators. However, for the subordinated debt this approach may distort risk indicators, as the volatility adjustment may excessively magnify the mass above the senior distress barrier.

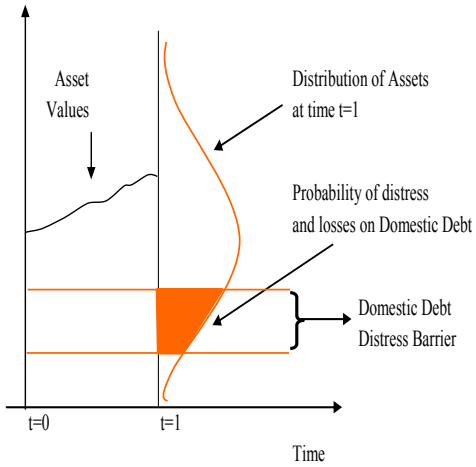
An alternative is to fit a mixture of two lognormal distributions, which combined form another distribution with fatter tails. It is possible to show that a linear combination of lognormals leads to an aggregate option price that is a linear combination of the option prices for each individual lognormal distribution.[23] Thus, the proper mix of lognormals yields risk indicators for subordinated debt while refraining from making any adjustments to volatility. Such an approach—which is illustrated in the figure below—is used in this paper to extend the analysis on Turkey to encompass risk measures pertaining to subordinated debt.

[23] See Alexander (2001) and Rebonato (2004) for details.

Asset Distribution at One Horizon and the Probability of Default/Losses on External Debt



Asset Distribution at One Horizon and the Probability of Distress/Losses on Domestic Debt



Source: MfRisk