A NEW FRAMEWORK FOR MANAGING MACRO-FINANCIAL RISKS IN TRINIDAD & TOBAGO: AN APPLICATION OF CONTINGENT CLAIMS ANALYSIS TO THE BANKING SYSTEM

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ABSTRACT

Contingent claims analysis (CCA) brings together economics, finance and risk management to produce forward-looking indicators of risk for firms, the financial sector, and a sovereign. This paper applies CCA to Trinidad and Tobago's banking system. The results suggest that the four largest banks displayed extremely low default probabilities over the period 2006-2009; the 1-year ahead probability of default in 2009 was close to zero for three banks and just one per cent for the remaining bank. Further promising areas of research include extending the CCA model to other systemically important institutions, such as insurance companies, and incorporating its risk indicators into traditional monetary policy models.

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1.0 Introduction

The eruption and severity of the global financial crisis demonstrated how vulnerable economies are to undue volatility in the markets for credit, currencies, commodities and other assets. Yet traditional models are unable to sufficiently explain how economy-wide financial ("macro-financial") risks accumulate, much less how they can suddenly generate a full-blown crisis. This is mainly because the model assumptions usually exclude the possibility of default, which is very closely linked to financial fragility. In a crisis, shocks to prices or liquidity frequently end up being converted into credit risk. In addition, flow-of-funds and accounting balance sheets cannot provide measures of risk exposures, which are forward-looking estimates of losses.

Gray, Merton and Bodie (2002) proposed a new framework to improve the way central banks can analyze and minimize macro-financial risks, thereby protecting the stability of the financial system and overall economy. The framework, which is based on Contingent Claims Analysis (CCA), views the balance sheets of key economic sectors (sovereign, financial, corporate, and household) as interconnected portfolios of assets, liabilities and guarantees. The CCA combines this balance sheet information with the Black-Scholes-Merton option-pricing model to estimate the probability that an entity will default on its obligations. Additional measures include the expected loss to the holder of the entity's debt and financial fragility based on the distance to default. These forward-looking, market-based risk indicators better capture "non-linearities" and serve as barometers of risk for firms, financial sector vulnerability, and sovereign risk.

Perhaps the most widespread application of CCA comes from Moody's KMV, which has successfully applied its version of the framework to estimate creditworthiness for over 50,000 firms and financial institutions in 55 countries (KMV, 2001). Outside of the private sector, much of the applied work on the CCA has been carried out by the International Monetary Fund, as part of its surveillance oversight on emerging market economies. Gapen et al. (2004, 2005) extended the use

of the CCA to sovereign and industry-wide balance sheets. Jones and Gray (2006) used contingent claims to examine the evolution of sovereign and banking sector risk in Indonesia. Gray and Walsh (2008) stress tested major Chilean banks with a contingent claims model. Blavy and Souto (2009) used the CCA to estimate default probabilities and macro-financial linkages in the Mexican banking sector.

Given the dynamic interplay amongst economics, finance and risk management, contingent claims may prove to be a useful addition to a central bank's macro-financial policy toolkit. As such, this paper applies the CCA model to Trinidad and Tobago's banking system, which has grown in both size and complexity over the past decade, helping to make the country a Pan-Caribbean financial centre. The research focuses on the four largest commercial banks which have a long history of operating in Trinidad and Tobago and collectively account for well over 75 per cent of total assets in the banking system. In addition, each of the four banks is large enough to threaten the stability of the financial system so their inclusion in the paper is sufficiently justified. Section 2 presents the theoretical underpinnings of the CCA methodology. Section 3 provides background on macro-financial risks in the Trinidad and Tobago banking system. Section 4 discusses the data used in the analysis and presents the range of risk indicators including the distance to distress and the probability of default. Section 5 summarizes and concludes the study.

2.0 Framework for Contingent Claims Analysis

A contingent claim is any asset whose future payoff depends upon the value of other assets (Gray, Merton and Bodie, 2002). The typical contingent claim is an option - the right to buy or sell the underlying asset at a specified exercise price by a certain expiration date. A call is an option to buy; a put is an option to sell, and the value of each is contingent on the price of the underlying asset to be bought or sold. Contingent claims analysis is a generalization of option pricing theory pioneered by Black-Scholes (1973) and Merton (1974). According to Gapen et al. (2004), the contingent claims approach is based on three principles: (i) the value of

liabilities flows from assets; (ii) liabilities have different seniority; and (iii) asset values follow a stochastic process. Liabilities consist of senior claims (such as senior debt), subordinated claims (such as subordinated debt), and junior claims (equity or the most junior claim).

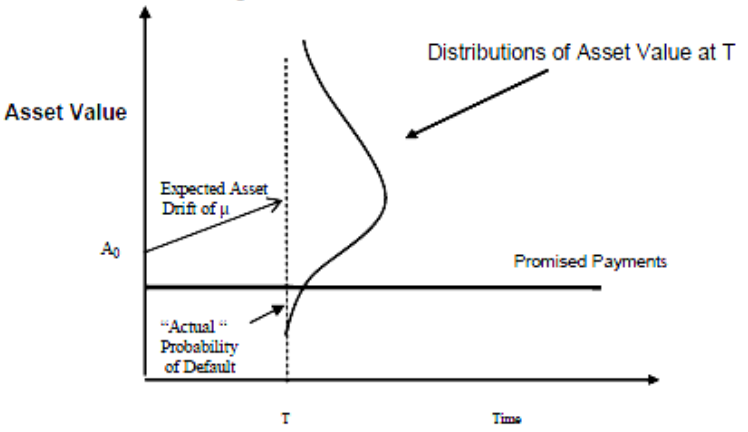
Balance sheet risk is the key to understanding credit risk and crisis probabilities. Debt is a senior claim on assets; equity has junior or residual claim on asset value. Debt is risky because asset value may not be sufficient to meet the promised debt payments. When assets exceed debt, there are sufficient resources to repay debt; debt holders will receive the full amount of the debt. Default happens when assets cannot service debt payments, that is, when assets fall below a distress barrier comprising the total value of liabilities. Uncertain changes in future asset value (price changes, shocks and other factors), relative to promised payments on debt, is the driver of default risk. Figure 1 illustrates the key relationships. The uncertainty in asset value is represented by a probability distribution at time horizon T. At the end of the period, the value of assets may be above the promised payments indicating that debt service can be made, or below the promised payments leading to default[2].

From the view of debt holders, debt can be modelled as being short a put option on the asset with a strike price equal to the debt. Similarly, it can also be modelled as a long position in the assets and a short call option on the asset with a strike price equal to the distress barrier. Equity is the owners' claim on assets and ranks junior to those of the debt holders. From the view of the equity holders, the debt will be

[2] The asset-return probability distribution used to value contingent claims is not the "actual" one but the "risk-adjusted" or "risk-neutral" probability distribution, which substitutes the risk-free interest rate for the actual expected return in the distribution. The calculation of the "actual" probability of default is outside the CCA/Merton Model but such a probability can be calculated by combining the CCA/Merton model with an equilibrium model of underlying asset expected returns to produce estimates that are consistent for expected returns on all derivatives, conditional on the expected return on the asset. One does not have to know expected returns to use the CCA/Merton models for the purpose of value or risk calculations, but for calibration into actual probabilities such data are necessary.

repaid when assets values are greater than the liabilities. When asset values fall below that of debt, assets will be put to the debt holders to satisfy the outstanding liabilities. Therefore, equity is a call option on the asset with a strike price equal to the distress barrier. As long as the value of assets exceeds the distress barrier, equity holders would maintain their positions. The higher asset values are relative to debt, the greater the value of the call option.

Figure 1. Distribution of Asset Value



Using the Black-Scholes-Merton differential equations for pricing contingent claims, the value of risky debt is a function of the default-free value of debt (i.e. distress barrier) at time 0, asset level at time 0, volatility of the asset, the time horizon until the expiration date of the claim, and the risk-free interest rate. The total market value of assets at any time, t, is equal to the market value of the claims on the assets, equity and risky debt maturing at time T:

$$A(t) = E(t) + D(t) \quad (1)$$

where A is assets, E is equity and D represents risky debt. Asset value is stochastic and in the future may decline below the point where debt payments on scheduled dates cannot be made. The equity can be

modelled and calculated as an implicit call option on the assets, with an exercise price equal to the promised payments, B, maturing in T-t periods. The risky debt is equivalent in value to default-free debt minus a guarantee against default. This guarantee can be calculated as the value of a put on the assets with an exercise price equal to B.

$$D(t) = Be^{-r(T-t)} - P(t) \tag{2}$$

where B is default-free debt and P represents the debt guarantee. We omit the time subscript at t = 0.

The value of the equity is computed using the Black-Scholes-Merton formula for the value of a call:

$$E = AN(d_1) - Be^{-rT} N(d_2) \tag{3}$$

$$d_1 = [\ln(A/B) + (r + \sigma^2/2)T] / \sigma\sqrt{T}, \text{ and } d_2 = d_1 - \sigma\sqrt{T} \tag{4}$$

where r is the risk-free rate; σ is the asset return volatility; $N(d)$ is the cumulative probability of the standard normal density function below d. The formula for the "delta" of the put option is $N(d_1) - 1$. The yield to maturity on the risky debt, y, is defined by: $D = Be^{-yT}$ or $y = \ln(B / D)/T$; and the credit spread is $s = y - r$. The "risk-neutral" or "risk-adjusted" default probability is $N(-d_2)$. The simplest method solves two equations for two unknowns, asset value and asset volatility. Details are shown in Merton (1974).

3.0 Macrofinancial Risk and the Banking System in Trinidad & Tobago

Over the past decade, prudent regulatory practices, an open market and good macroeconomic management have all helped Trinidad and Tobago's financial sector to grow in both size and complexity and to emerge as the Pan-Caribbean financial centre. At the end of 2008,

financial services accounted for over 20 per cent of non-energy GDP, nearly 9 per cent of total employment, and around half of the country's stock market capitalization. Banks remain the titans of the financial system, although they have lost significant market share to the contractual savings sector. The combined assets of the eight commercial banks accounted for nearly 40 per cent of total assets of the financial system at the end of 2008, down from 55 per cent at the end of 1995. Foreign bank entry has dramatically changed the face of ownership. In 2008, six of the eight banks were completely foreign-owned; four of these banks are owned by Canadian and U.S. banks. Of the remaining two banks with local ownership, one is state-owned and the other is partly locally-owned. By contrast, most the banking sector was indigenous in 2002.

While not immune to contagion arising from the global financial crisis, disruptions to Trinidad and Tobago's banking system have been fairly limited for several reasons. First, despite dominant foreign ownership, banks had little exposure to the sub-prime mortgage market where the crisis originated, and even where there was direct exposure to Lehman Bros or Merrill Lynch this was minimal in relation to total assets. Second, most banks depend almost wholly on deposits, which are the least volatile sources of funding, to engage in credit expansion. There is marginal dependence on foreign loans. Bank deposits accounted for almost three-quarters of total bank resources at the end of 2008, while foreign liabilities were less than 1 per cent of total funding (Central Bank of Trinidad & Tobago, 2009). Third, banks entered the global financial crisis from a position of relative strength. Banks' regulatory capital have averaged more than 18 per cent of risk-weighted assets in 2006-2008, well above the minimum 8 per cent regulatory requirement (see Table 1). Regulatory Tier 1 capital is also robust, averaging 16 per cent of total risk-weighted assets in the same period. The statutory minimum requirement for Tier 1 capital is 4 per cent. Non-performing loans have also been low, accounting for 1 per cent of gross loans over 2006-2008, and liquidity quite comfortable, with liquid assets covering 20 per cent of total assets in the three years to 2008.

Notwithstanding the improvement in financial soundness, there are areas where structural and institutional vulnerabilities exist, some of which were masked by the favourable global and domestic economic environment. An IMF Financial System Assessment Program (FSAP) conducted in 2005 found that the dominance of large financial conglomerates, with engagements in commercial banking, investment banking, insurance business, as well as non-financial activities, tended to increase risks for the financial institutions of these mixed groups. The Central Bank's intervention in January 2009 in two subsidiaries of the CL Financial Group to avert a systemic crisis is illustrative. The CL Financial Group's interests cover banking and financial services, energy, real estate and manufacturing and distribution. The four largest financial institutions in the Group managed assets equivalent to over 25 per cent of the country's GDP, holding substantial deposits, insurance and pension funds for a significant portion of the population.

Exposure to energy prices is another source of vulnerability. Stress tests indicated that the banking system should be able to withstand a sharp deterioration in energy prices, but banks with large exposures to real estate and construction could be severely affected. The FSAP also found that the local financial system faces contagion risk associated with the Caribbean region. Some one-fifth of the total banking system assets are held in the Caribbean. This exposure is even higher if one includes the cross-border investments of domestic insurance companies, pension funds and mutual funds (IMF, 2006). All the economies in the Caribbean have been severely affected by the second round effects of the global crisis, mainly through declines in trade (including tourism) and financial flows and especially the contraction in remittances. Thus, a shock originating in one country could be rapidly transmitted throughout the region.

The global financial crisis has underscored the urgency to upgrade the legislative framework, which has not kept pace with innovation and expansion in the financial system. In November 2008, the Parliament approved a new Financial Institutions Act (FIA, 2008). The previous FIA dated back to 1993 with some amendments made in 2006 to address

specific issues. The new FIA formalizes consolidated supervision of the entire conglomerate group, in order to reduce regulatory arbitrage and to take corrective action to prevent deterioration in one entity from affecting operations of related entities. FIA (2008) requires the restructuring of mixed groups to include a financial holding company that will be regulated. The new FIA upgrades governance structures requiring more independent Board directors and its audit committee chaired by an independent director. It also gives more authority to the external auditors.

Table 1: Trinidad & Tobago Banking System: Financial Soundness Indicators, 2004-2008

(per cent)	2004	2005	2006	2007	2008
Regulatory capital to risk-weighted assets	19.3	18.2	18.0	19.1	18.8
Regulatory Tier 1 capital to risk-weighted assets	17.4	16.4	16.2	17.0	15.5
Non-performing loans/ total gross loans	3.9	1.7	1.4	0.7	1.0
Return on equity	32.5	25.2	27.2	27.3	25.9
Return on assets	4.3	3.2	3.4	3.4	3.5
Liquid assets/total assets	14.8	15.0	20.1	17.0	22.1
Net open position in FX/capital	-0.9	-13.9	-3.5	-12.1	0.5

Source: Central Bank of Trinidad and Tobago Financial Stability Report, October 2009

Very importantly, the new FIA gives more authority to the Central Bank to issue compliance directions such as "cease and desist" or "to perform" so as to protect depositors.

Another lesson from the current crisis is the need to identify risks to the financial system at the earliest possible opportunity. Accordingly, the Central Bank is working on establishing an early warning system. The system will require more and better information from the financial

institutions, closer collaboration between regulators and more detailed macro-economic analysis of the local and the international economy. To this end, the Central Bank recently published a Financial Stability Report (FSR) to provide an assessment of the financial system and its capacity to withstand potential risks. The intention is to publish an annual FSR supplemented by mid-year reviews.

4.0 Estimation of Credit Risk Indicators for the Banking System

Following Jones and Gray (2006), an estimate of the market value of bank assets in Trinidad and Tobago and their volatility is needed to understand changes in the overall level of balance sheet risk. Many of the assets on the bank's balance sheet are not traded, and are observed infrequently, making it difficult to derive marked-to-market balance sheets. In contrast, many of the liabilities on the balance sheet are traded and can be valued more readily using financial valuation models. Short-term liabilities include savings and interbank deposits. Long-term liabilities include time deposits, CD deposits, promissory notes, other long-term loans, and other liabilities. The book value of short- and long-term obligations is used to calculate the distress barrier for each bank.[3] Debt prices can be obtained for traded securities and financial models employed for non-traded debt. Equity prices are directly observed from stock market transactions. The market capitalization based on traded stock prices is used to calculate the volatility of bank equity. Contingent claims then uses option pricing theory to impute the value and volatility of assets using the funding side of the balance sheet.

The implied asset values and volatilities are then used to determine the probability of default and the distance to distress as well as the expected losses of the individual banks. The distance to distress is the

[3] KMV (2001) provides empirical evidence that the fraction of long-term debt averages around 0.6 to 0.8 for banks. In this study, we reduce the weight of long-term debt in the distress barrier to 0.6 because assets can fall below total debt for long periods without default if most of the debt is long term.

value by which assets must decline before default occurs. Due to variations in asset size and volatility, this measure is normalized by dividing by the standard deviation of the firm assets over time T. A distance to distress of 2.5 over one year means that the asset exceeds the distress barrier by 2.5 times the asset standard deviation. The distance to distress can be converted to a probability of default using the cumulative normal distribution function. Expected losses can be used as a proxy for the value of the "implicit" government guarantee of the banking system. Aggregated figures for the banking system are then derived by summing the respective balance sheets and calculating the risk indicators.

Using the Black - Scholes - Merton option pricing model, asset values and asset volatilities were estimated for each bank and for the commercial banking system in Trinidad and Tobago over 2006-2009. Default probabilities were determined over one year. Tables 2 and 3 show that all of the four banks analyzed in Trinidad and Tobago maintained healthy financial positions over the review period. Default probabilities ranged from 0.1 per cent to 2.5 per cent over the period 2006-2009. The trend reveals improvements for all four banks over the period 2006 – 2009. The 1-year ahead probability of default in 2009 shows that the likelihood of default is close to zero for three banks and just 1 per cent for the remaining bank. In addition, the 1-year ahead probability of default for the banking system has declined from a high of 0.34 per cent in 2007 to under 0.02 per cent in 2009. Based on this analysis, there is a 0.18 probability that the commercial banks in Trinidad and Tobago would default on their obligations to meet their debt payments over the next year.

Research conducted in other jurisdictions shows that actual default is often less than that predicted by the CCA model. If similar considerations are applicable to Trinidad and Tobago banks, then the banking sector is indeed strong.

Table 2: Probability of Default for Banks in Trinidad & Tobago (%)

	2006	2007	2008	2009
Bank 1	0.4	0.5	0.2	0.2
Bank 2	0.9	2.5	1.4	1.0
Bank 3	0.3	0.3	0.3	0.1
Bank 4	0.4	0.2	0.2	0.1
Industry	**0.3**	**0.1**	**0.2**	**0.1**

Table 3: Distance to Default for Banks in Trinidad & Tobago (std. deviation)

	2006	2007	2008	2009
Bank 1	2.65	2.56	2.85	2.95
Bank 2	2.35	1.96	2.19	2.31
Bank 3	2.78	2.76	2.78	2.97
Bank 4	2.68	2.77	2.92	3.01

5.0 Summary and Conclusions

Contingent claims analysis, which brings together the disciplines of economics, finance and risk management, appears to be a useful supplement to a central bank's macro-financial policy toolkit. This paper applies the CCA to Trinidad and Tobago's banking system, which has grown in size and complexity over the past decade. Using data from the liabilities side of the balance sheets of the banking sector, it has been possible to impute the value and volatility of assets to produce a range of forward-looking risk indicators such as probability of default, distance to distress, and expected losses for the banking system. In general, the analysis confirms the view that banks in Trinidad and Tobago entered the global financial crisis from a position of relative strength. All of the four banks analyzed displayed extremely low default probabilities ranging from 0.1 per cent to 2.5 per cent over the period 2006-2009. Of these four banks, the 1-year ahead probability of default in 2009 shows that the

likelihood of default is close to zero for three banks and just 1 per cent for the remaining bank.

Notwithstanding the low probability of financial distress for banks, there are promising areas for further research. One is extending the CCA to systemically important players in other parts of the financial system, such as insurance companies where the crisis in the CL Financial Group originated. Similarly, credit unions are emerging as a collective force in the financial system where structural and institutional vulnerabilities exist and which could eventually manifest into financial problems, if left unchecked. Finally, the Central Bank could consider incorporating financial system risk indicators in the tradition of the CCA into its monetary policy models.

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