

A CONTINGENT CLAIMS APPROACH TO MEASURING INSOLVENCY RISK: AN EMPIRICAL ASSESSMENT OF THE IMPACT OF THE GLOBAL FINANCIAL CRISIS ON JAMAICA AND ITS FINANCIAL SECTOR

JIDE LEWIS¹

ABSTRACT

This paper proposes to compute a probability of default measure for Jamaica and its financial system using the contingent claims approach (CCA) which has its foundations in the Black-Scholes-Merton's option pricing theory. Estimates for the distance-to-default and the probability of default for the sovereign and publicly listed financial institutions in the bank and non-bank sector in Jamaica are presented between 2005 and 2010. The resulting vulnerability indicators are then used retroactively to assess the impact of the global financial crisis on the sustainability of Jamaica's debt profile and the viability of its financial sector. The results underscore the framework's ability to act as an early warning indicator of macro-financial vulnerabilities and highlight possibility of contagion between various sectors of the Jamaican economy.

Keywords:Contingent claims approach, Credit risk, Financial stability, Early Warning Model.

JEL Classification:G13, G32, E4, G2.

¹ The views expressed in this paper are those of the author and do not necessarily reflect the view of the Bank of Jamaica. Author E-Mail Address: jidelewis@gmail.com/jide.lewis@boj.org.jm

1.0 Introduction

The use of option-pricing models in bankruptcy prediction provides a theoretically grounded structural model of default by assessing the likelihood that the market value of an entity or a sovereign nation is likely to fall below the value of its liabilities at some point in the future. Further, the framework allows for the extraction of such bankruptcy-related information from prices derived from the equity, foreign exchange and bond markets. These markets provide a potentially superior source of information regarding the risk of insolvency because it aggregates high frequency information from several markets simultaneously about the collective views of many investors. Valuing assets using marked-to-market prices and incorporating contingent liabilities provides a more nuanced assessment of the inherent risks within the balance sheet of either a private firm or a sovereign nation. It must be noted that the market value of assets of a corporation, financial institution, or sovereign cannot be observed directly at high frequencies. However, one can use option-pricing theory to derive the implied value given the availability of high-frequency prices and volatilities of market traded securities (Merton and Bodie, 1995). Option-pricing models prove to be an effective methodology whereby the information from these markets can be extracted to deduce forward looking estimates of the probability of default over a specified time horizon.

Based on the Merton's (1974) extension of the Black-Scholes model (BSM), the firm's equity can be modeled as a call option on the value of the entity's assets.² As such, when the value of the assets of the entity falls below the face value of the liabilities the 'call option' will not be exercised. In this case, the bankrupt entity is turned over to its debt holders. Once the BSM model is employed to estimate the marked-to-market value of an entity's assets as well as its volatility then a set of risk indicators can be formulated to serve as a gauge of the likelihood of bankruptcy of the entity. Contingent claims analysis (CCA) then is the application of the BSM model to a wide range of entities including corporates, financial institutions and sovereign nations.

The framework can be used to understand many types of crises as well as risk transfers between various sectors of an economy that cannot be easily analyzed with other methodologies. The framework can, for example, help identify situations where volatility in one sector gets amplified and negative feedback loops within the financial markets then trigger severe crises in other sectors of the economy. This risk-transmission process is a function of the linkages in the capital structure between various sectors as well as the correlations between asset prices across various sectors of an economy.^{3,4} For example, financial distress in the banking sector can be transmitted

² The buyer of the call option has the right, but not the obligation to buy an agreed quantity of a particular commodity or financial instrument (the underlying) from the seller of the option at a certain time (the expiration date) for a certain price (the strike price). The pay-off for holding a stock in an entity is similar to that of holding a call option in that holder of a stock gains when the value of the firm goes up and receives nothing if the firm goes bankrupt.

³ See, for example, Gray et. al (2003).

to the government by an increase in the value of the implicit guarantees the government provides to the financial sector. In the case of Jamaica, this implicit guarantee became explicit after the financial system distress in the 1990s. The cost of the banking crisis has been conservatively estimated at 35.0 per cent of Gross Domestic Product (GDP).⁵

On the other hand, government's sovereign risk of default can present risks to the stability of the financial system. This is particularly true where the bank and non-bank sectors hold a significant proportion of government securities within their investment portfolios. In this case, a negative shock to the government's balance sheet, arising from say an exogenous supply shock or negative market sentiment in global financial markets, can have a detrimental impact on the viability of these financial institutions. A vicious cycle could then arise, when the lower value of government securities held by the financial sector in turn lowers the value of financial sector assets, and raises the implicit financial guarantee offered by the Central Government, further lowering the value of government assets.⁶

In another scenario, the inability of a government to sustainably finance its fiscal accounts and its contingent liabilities can cause distress for the government which can transmit risk to holders of government debt. In this case, higher spreads demanded by the debt holders to compensate them for increased exposure to credit risk in government debt will lead to higher borrowing costs on government debt which could further worsen the sovereign's financial position and lead to depreciation in the exchange rate. The resulting feedback of these dynamics could potentially further worsen the sovereign's financial position if the sovereign has issued a portion of its debt in a foreign currency and/or has a substantial proportion of variable rate debt as part of its debt portfolio. CCA analysis can help to shed light on such dynamic spill-over of risks between various actors within the domestic and external financial markets.

The organization of the paper is as follows. The next section presents a brief survey of the bankruptcy/credit risk literature. **Section III** discusses the Merton model for bankruptcy risk and **Section IV** presents the datasets used in the analysis. Two metrics for bankruptcy risk, namely distance-to-default and probability of default for the Government of Jamaica (GOJ) as well as deposit taking institutions (DTIs) and non-bank financial institutions (NBFIs) in Jamaica between 2005 and June 2010 are then presented in **Section V**. This period gives us an opportunity to evaluate the solvency of both the government and the financial sector throughout the recent global financial distress. The paper concludes in **Section VI**.

⁴Banking sector distress arising from a significant increase in non-performing loans, a deposit run and precipitous decline in the value of assets can result in a large increase in the government's implicit guarantee.

⁵ The total cost of the Financial Sector Adjustment Company's (FINSAC) intervention in the financial sector amounted to J\$106.9 billion, approximately 35.3 per cent of GDP as at January 2000 (Government of Jamaica, 2000: 47). FINSAC Limited was established by the Government of Jamaica in January 1997 with the mandate to restore stability to Jamaica's financial institutions following the banking crisis.

⁶ See Gray et. al (2007).

2.0 Literature Review

Some of the earliest works in the area of insolvency risk used balance sheet data to derive probability of default metrics (see for example Altman (1968) and Ohlson (1980)). The Altman's z-score, for example, is a discriminant model where borrowers are classified into either high or low default risk categories.⁷ Although the framework does not directly give a probability of default, the results can be mapped to a credit rating system which would in turn yield the desired estimates.⁸ The framework uses five fundamental balance sheet ratios: retained earnings, working capital, sales to total assets, earnings before interest and taxes and as well as the ratio of the market value of equity to the book value of total liabilities. Similar to Altman, Ohlson (1980) uses linear discriminant analysis to derive the probability of default of a firm. The framework proposed by Ohlson uses nine balance sheet ratios and utilized the maximum likelihood techniques to estimate a logit model of the probability of default for various firms.

There are several reasons why one may not want to use accounting-based methods to estimate the probability of insolvency. Firstly, financial statements are by design backward-looking assessments of entities performances, and thus, may not be very informative about the future status of the firm. Financial statements are formulated under the going-concern principle, which assumes that firms will not go bankrupt whereas the task at hand is the estimation of the future likelihood of bankruptcy. Additionally, the 'conservatism principle' used in accounting causes asset values to be understated relative to their market values which results in accounting-based leverage measures to be overstated. Finally, the volatility of an entity's assets is not accounted for in the estimation of the likelihood of failure. 'All things being equal, the probability of bankruptcy is increasing with volatility and therefore two firms with identical financial ratios can have substantially different insolvency risk profiles depending on their asset volatilities' (Hillegeist et al. 2003).

In contrast to the balance sheet approach, the Merton model is a structural model of bank insolvency, which can be used to derive the probability of default for an entity. The incorporation of market based price in this framework is significant since these reflect the collective views and expectations of investors making CCA a forward looking approach to risk assessment. The probability of default of a firm or sovereign is then captured as an endogenous process and measures the likelihood that a firm's or sovereign's assets in the future are likely to fall below its liabilities rendering the entity bankrupt. The Merton model and the contingent claims approach (CCA) which extends the framework to assess multiple sectors is based on three principles: (i) the value of liabilities flows from assets; (ii) liabilities have different levels of seniority; and (iii) there is a random element to the way an asset's value evolves over time (Gapen, et al. 2004).⁹

In addition to using balance sheet data the CCA/Merton model also incorporates the use of financial market data which can be used to compute return and volatility measures in the

⁷ The discriminant analysis methodology identifies [linear combinations](#) of [features](#) that characterize or separate two or more classes of objects or events.

⁸ Some practitioners utilized a logistic function to convert the z-scores derives from the discriminant analysis into a probability function.

⁹ Asset values have a random component due in part to the impact of unanticipated shocks, the nature of how new information reaches the market and changes in market perceptions of valuation, among other things.

derivation of the likelihood of insolvency. The CCA approach therefore combines the capital structure of the balance sheet with high-frequency price information from financial markets to construct a market value estimate of the current balance sheet along with forward looking indicators of vulnerability.¹⁰ The CCA methodology also incorporates nonlinearities which tend to be ignored in traditional linear-based estimation techniques. The nonlinearity of the Black-Scholes methodology allows for a more accurate description of changes in vulnerabilities arising from large changes in asset prices. Linear relationships, on the other hand, may fail to be adequate indicators for surveillance purposes as they may understate the evolution of risk over time as result of exogenous shocks (see Gray et al. 2003).

There are, however, several drawbacks to utilizing the CCA approach which should be noted. These drawbacks stem primarily from some of the framework's (over) simplifying assumptions, many of which do not hold in applied settings. These assumptions can introduce errors and biases into the resulting insolvency estimates. For example, most estimates of probability implicitly assume that all of the entity's liabilities mature in one year which can result in higher insolvency estimates.¹¹ The framework also assumes that if the value of the firm's or a sovereign's assets is less than its total liabilities at time T , then the firm or nation simultaneously defaults, declares bankruptcy and without cost turns control over to the bondholders. In practice, the bankruptcy process is very dynamic if not complicated. For example, for firms bankruptcy filings may never materialize as firms attempt to avoid the deadweight costs associated with the proceedings or as firms attempt to renegotiate their long-term liabilities while meeting their current liabilities. For a sovereign nation, they may choose rather than to declare bankruptcy explicitly to enter into multi-year restructuring agreements. On the other hand, some perfectly solvent firms may go into bankruptcy proceedings 'early' in order to protect themselves from litigations. The CCA framework ignores all these nuances. The Merton model/CCA approach also focuses on cases of insolvency where the value of assets falls below that of the total value of liabilities; however, in practice firms (especially financial firms) can have problems meeting even their short-term liabilities and may become insolvent if liquidity is unavailable to meet these obligations. Similarly, sovereign nations may have problems meeting short-term liabilities and may face higher default risk due to increasingly unsustainable debt dynamics and heightened roll-over risks. Finally, the option-based approach is predicated on the assumption that the stock market, foreign exchange and bond markets impound all publicly-available information about future prospects of insolvency into prices. This, however, may not hold in practice. In particular, prior studies suggest that the market does not always accurately reflect all the information in financial statements. Ultimately, whether it is better to derive the probability of bankruptcy from an option-pricing model or an accounting-based insolvency measure is an empirical question.

¹⁰ As mentioned earlier, the CCA also distinguishes itself from other vulnerability analysis by recognizing the important role of volatility in determining default probabilities. Increases in volatility increase the option value and benefits of equity holders at the expense of bondholders. By capturing volatility, the CCA accounts for the fact that firms with the same capital structures may have different distances-to-distress and default probabilities.

¹¹ The Merton model is easily modified to compute the probability of bankruptcy over any time horizon by changing the time parameter T .

3.0 Methodology

The Merton model is a structural model of bank insolvency, capturing the likelihood that a firm's assets in the future are likely to fall below its liabilities rendering the institution bankrupt. The distance to default is a function of the growth in firm's assets, the volatility of the firm's assets, as well as the difference between the market value of the firm and the default barrier (see **equation 1**). The numerator measures the distance between the expected one-year ahead market value of the firm's assets and the distress barrier while the denominator is used to scale the numerator with respect to units of standard deviations.

$$d^* = \frac{LN\left(\frac{V_A}{DB}\right) + \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \quad (1)$$

where d^* is the measure of the distance to default, V_A is the value of the assets, DB is the value of the default barrier, σ is the volatility of the assets, μ is the mean return on assets and T is the time horizon.

The distance to default therefore measures the number of standard deviations from the mean before a firm's assets falls below the default barrier (see **Figure 1**). Assuming that the natural log of future asset values is distributed normally then the firm's value can be represented as shown in **equation 2** below:-

$$\ln V_A(t) \sim N \left[\ln V_A + \left(\mu - \frac{\sigma_A^2}{2} \right) t, \sigma^2 t \right] \quad (2)$$

Equation 1 can be converted into a probability of default, $N(-d^*)$, using the cumulative normal distribution shown in **equation 3** (McDonald, 2002). That is, the probability that $V_A(T) < DB$ is as follows:

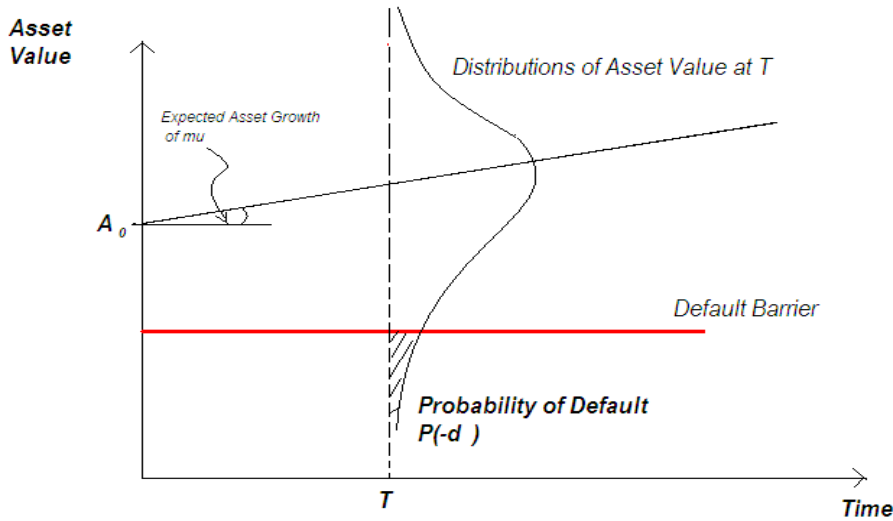
$$\text{Probability of Insolvency} = N \left(- \frac{LN\left(\frac{V_A}{DB}\right) + \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \right) \quad (3)$$

The use of the normal distribution for the evaluation of the probability of default warrants some discussion. The option pricing formula used in the derivation of the distance to default generally overstates the actual probability of default. This is primarily because the Black-Scholes option pricing formula results in risk neutral probabilities of default since it is derived from no arbitrage conditions. Consequently, many applications of CCA use historical information on past insolvency episodes to derive empirical distributions that map computed distances to default to probabilities of default.¹² In the absence of such a database the paper uses the normal distribution.

¹²The most popular commercial product is the KMV model utilized by the rating agency Moody's Analytics. They utilize 30 years of historical data from over 6,000 public and 70,000 private company default events along with

Equity can be viewed as a call option on the value of the firm's assets (Merton, 1974). Since equity holders have a junior contingent claim on the residual value of assets, the value of equity can be viewed as a call option where holders of equity receive the maximum of either assets minus the default barrier, or nothing in the case of default. That is, equity holders are the residual claimants to the firm's assets and are only subject to limited liability when the firm is bankrupt. Given that the firm's equity behaves like a call on the firms' assets, the Black-Scholes-Merton (BSM) model can be used to compute the (unobservable) value of the firm (V_A) and the (unobservable) volatility of the firm's assets (σ_v) as well as the growth rate of assets μ .

Figure 1: Merton's Structural Model of Bank Insolvency



These parameters can be deduced by solving the BSM model given the volatility in equity, σ_e , the market value of the firm's equity, V_E , and the default barrier of the firm, DB , over a given time horizon (T).

The BSM equation for valuing equity as a European call option on the value of the firm's assets is shown in **equation 4**.

$$V_E = V_A N(d_1) - DB e^{-rT} N(d_2) \quad (4)$$

where $N(d_1)$ and $N(d_2)$ are the standard cumulative normal of d_1 and d_2 , respectively, and

$$d_1 = \frac{\ln\left(\frac{V_A}{DB}\right) + \left(r + \frac{\sigma_A^2}{2}\right)T}{\sigma_A \sqrt{T}} \quad (5)$$

and

corresponding observations of sector-specific non-defaults to derive empirical distributions that map distance to default to probabilities of default.

$$d_2 = d_1 - \sigma_A \sqrt{T} \quad (6)$$

The value of assets, V_A , asset volatility, σ_A , are estimated by solving simultaneously the call option formulation in equation (4) and the optimal hedge equation shown in **equation 7**.¹³

$$V_E = \frac{\sigma_A N(d_1) V_A}{\sigma_E} \quad (7)^{14,15}$$

Finally, the expected return on assets, μ , is computed based on the derived market value of assets, V_A , using equation 8.

$$\mu(t) = \max \left[\frac{V_A(t) - V_{A,t-1}}{V_{A,t-1}}, r \right] \quad (8)$$

where r is continuously compounded risk-free rate.

Gapen, *et al.* 2004 treats each industry sector as if it were one large firm. As pointed out by the authors, a negative feature of aggregating across an industry or sector is that it may be possible for the strength of one entity to offset the weakness in another in ways that do not reflect the underlying and systematic risk exposure of the industry or sector in times of stress. Hence, this paper in contrast computes the distance to default for each firm within an industry (DTIs and NBFIs) and then uses the market values derived from option pricing theory to weight each observation to get a single index of systemic risk for each industry. Also, the distance-to-distress for each institution is computed and the inter-quartile range is used to derive an alternative systemic risk index for both DTIs and NBFIs over the period under review.

This framework is general enough to be applied in the assessment of insolvency risks for corporates, banks as well as sovereigns. Indeed, what changes is merely what constitutes the default barrier (DB) and the market value and volatility of the entity's 'equity.' Specifically, for financial institutions the DB is determined as a function of the short-term and long-term liabilities of the entity, r is the one-year Treasury Bill rate, and the market value of the firms' equity, V_E , is set equal to the market value of the firm's equity based on the closing price at the end of the evaluation period and the number of stocks outstanding. T is set equal to one year so that the probability emerging out of the assessment is the one-year ahead probability of default on an *ex ante* basis. Following closely the methodology used in Gray, Merton and Bodie (2003) and Gapen *et al.* (2004), this framework can be altered to assess the likelihood of a sovereign default. As discussed earlier, to the extent that the corporate sector holds government debt directly, any severe public sector distress is transmitted to the asset side of the balance sheets of

¹³ Recall, that the market value of assets, V_A , asset volatility, σ_A , and the expected return on assets, μ , have to be estimated since these values are not directly observable.

¹⁴ The General Algebraic Modeling System (GAMS) software is used to solve for the market value of the firm's assets and the volatility of those assets. The code is available from the author upon request.

¹⁵ Equation 7 shows the relationship between volatility of the firm's assets and the volatility of the firm's equity where $N(d_1)$ is the change in the price of equity with respect to a change in the underlying assets of the firm.

the financial and corporate sectors (Gapenet *al.* 2004). Many of the assets on the balance sheet of a sovereign, with the possible exception of international reserves, are not traded, and if they are can only be observed at infrequent intervals.

The CCA approach described above can be used to impute the value and volatility of a sovereign's assets. On the asset side of the government's balance sheet there are foreign currency reserves, net fiscal assets and other public assets such as land and corporations owned by the government. Net fiscal assets represent the present value of the difference between all future tax receipts less all future government expenditures. On the liability side of the government's balance sheet there are implicit or explicit financial guarantees, such as those offered to critical industries, and foreign currency debt. The 'equity' section of the sovereign's balance sheet consists of base money and debt denominated in local currency. For a sovereign nation, both the short-term foreign-denominated debt and long-term foreign denominated debt make up the DB. This is sovereign's analog for the firm's DB since one sovereign cannot 'print' another sovereign's currency. So if the country in question does not have sufficient foreign currency reserve and by extension cannot export enough goods and services, borrow funds from capital markets or earn enough remittances to cover its foreign currency obligations, then it will default. Changes in the DB for the public sector come from two sources: (i) changes in the liability structure of external debt from changes in the maturity structure of foreign currency debt, and; (ii) currency movements for the foreign currency debt. On the other hand, the local currency liabilities made up of base money and domestic currency debt behave like a call-option on the Government's assets. Hence, the value of domestic currency liabilities (base money and domestic debt) can be viewed as a call option on sovereign assets with a strike price equal to the level of the distress barrier. The holders of domestic currency liabilities receive the maximum of either sovereign assets minus the distress barrier, or nothing in the case of default.¹⁶ Thus the framework outlined above can be used to determine the implied asset value of a sovereign nation and the volatility of those assets, which in turn can be used to estimate the probability of default of the sovereign. This approach assumes that foreign currency debt is senior to local currency debt. That is, governments in distress situations are more likely to 'dilute' the holders of local currency through, for example, inflation before defaulting on foreign currency debt.

Finally, the framework can also be used to determine the implicit or explicit guarantee that the government provides to the financial sector. The government can be modeled as holding a put option whose value is directly related to the implicit guarantees it provides to safeguard the integrity of the financial system. That is, the government is said to be the holder of risk debt, since they are 'obligated' to absorb losses in the event of default since debt holders receive assets

¹⁶ The framework posits that if a sovereign's assets falls below the level required to cover foreign currency debt payments, then default occurs.

of the defaulted firm (or equivalently, the assets of the firm get ‘put’ to the debt holders).¹⁷ The value of the implicit put option is shown in **equation 9**.

$$P = DBe^{-rT}N(-d_2) - V_A N(-d_1) \quad (9)$$

The value of this implicit guarantee is solved in a two-step process. Firstly, the observed market value of equity of the financial firms and their respective distress barrier’s are used with the call option formula to derive the value of the financial firm’s assets. Second, the marked-to-market value of the financial sector’s assets and the DB are then used with the put option formula in equation (9) to derive the implied market value of risky debt. The sum of the implicit put options for DTIs results in a systemic measure of the expected losses that the government guarantees over a one-year time horizon. The value of the put option requires an assumption over recovery rates, post-financial sector bail-out which is normally less than 100.0 per cent. For this analysis, a recovery rate of 80.0 per cent was assumed for the banking sector.¹⁸

4.0 Data

4.1 Government of Jamaica (GOJ) Data

The GOJ data is constructed using daily data from the Bank of Jamaica (BOJ) on the monetary base between December 2004 and June 2010. Daily foreign exchange rates, available from the BOJ, between the Jamaica and the United States (US), are used to convert the monetary base into US dollar equivalents. Quarterly balances for the domestic debt stock as well as short and long-term foreign denominated debt were also collated for the period under review based on data from the Ministry of Finance (MOF). Short-term foreign currency debt was classified as instruments with a maturity of less than five years and long-term foreign currency debt had maturity profiles in excess of five years. All debt-related data were collected from the MOF and converted (where necessary) into US dollar equivalents.

4.2 Financial Sector Data

The data set for the financial sector was constructed using balance sheet information from the Jamaica Stock Exchange (JSE) and the BOJ as well as stock market related data available from the JSE.¹⁹ The banking category consists of four highly liquid stocks listed on the JSE. These institutions are the Bank of Nova Scotia (BNS), National Commercial Bank (NCB), Capital and

¹⁷ Holders of risky debt receive either the default-free debt value or, in the event of default, the senior claim of assets. Since the value of default-free debt is equal to the distress barrier and the implicit put option on the assets of the firm yields $\max[DB - V_A, 0]$, the market value of risky debt can be modeled as, $D = \min[V_A, DB] = DB - \max[DB - V_A, 0]$.

¹⁸ Based on this structure, declines in the value of the financial sector equity and increases in loan delinquency rates causes the market value of bank assets to decline, increasing the probability of default. As the probability of default rises, the value of the government guarantee, adjusted for recovery rates, increases.

¹⁹ Information on Shares Outstanding was only available hard-copy back to December 2005.

Credit Merchant Bank (CCMB) and First Caribbean International Bank (FCIB). For the non-bank category, the five firms chosen were Mayberry (MBL), Pan Caribbean Financial Service (PANCAB), Jamaica Money Market Brokers (JMMB) and Life of Jamaica (LOJ).²⁰ These firms represent some of the largest financial institutions in Jamaica and their insolvency risk has a direct and significant influence on the health of the Jamaican financial system. The sample data covers the period from December 2004 to June 2010. Bank's balance sheet information, available quarterly from the BOJ, is used to gather information on the current liabilities and long-term liabilities and used to calculate the default barrier (DB). Balance sheet items including *Deposits, Due to BOJ, Commercial Banks, Specialized Institutions, Other Specialized Institutions* and *Securities sold under Repo*, and *Other Current Liabilities* are used to compute the short-term liabilities. *Other Liabilities* on the balance sheet are used to compute long-term liabilities. For the NBFIs annual balance sheet data available from filings made to the JSE by participants on the exchange are used to derive figures for both current and long-term liabilities that are factored into the computation of the DB. The descriptive statistics for both the bank and non-bank specific variable are shown in Table 1 and Table 2, respectively.

Table 1. Descriptive Statistics for Deposit-Taking Institutions Included in Sample, 2004 Q4 to 2010 Q2

²⁰Data for Royal Bank of Trinidad and Tobago (RBTT) and Guardian Holding Limited were omitted from the banking group and non-bank group, respectively as they were found to be relatively illiquid over the period of the analysis.

	Stats	2004	2005	2006	2007	2008	2009	2010
BANK 1	Max Volatility (%)	21.6	20.0	16.5	13.6	20.1	28.5	26.8
	Current Liabilities (E.O.P)	109.8	110.0	109.3	111.8	115.8	119.4	128.8
	LT Liabilities (E.O.P)	1.8	2.1	2.4	1.7	1.6	1.3	1.0
	Mean Value of Equity	56.9	48.3	43.0	52.9	54.4	34.4	40.7
BANK 2	Max Volatility (%)	22.48	45.84	32.84	12.90	17.71	22.37	23.05
	Current Liabilities (E.O.P)	111.8	110.8	108.0	111.4	117.3	125.3	122.8
	LT Liabilities (E.O.P)	1.7	1.7	2.6	2.0	1.9	1.9	2.1
	Mean Value of Equity	67.5	61.9	61.5	70.4	69.2	53.4	66.7
BANK 3	Max Volatility (%)	36.12	36.97	24.68	31.12	30.66	14.28	14.23
	Current Liabilities (E.O.P)	18.1	18.3	19.1	20.9	21.6	22.3	24.9
	LT Liabilities (E.O.P)	0.1	0.0	0.0	0.0	0.1	0.0	0.0
	Mean Value of Equity	4.0	3.3	4.6	6.2	6.3	4.3	3.5
BANK 4	Max Volatility (%)	24.33	22.77	24.51	26.22	34.35	40.91	41.61
	Current Liabilities (E.O.P)	35.4	35.9	29.3	24.2	28.5	30.4	31.8
	LT Liabilities (E.O.P)	0.8	0.6	0.5	0.4	0.5	0.3	0.3
	Mean Value of Equity	11.0	14.9	9.6	6.7	7.0	3.5	3.6

Notes:

(i) Unless otherwise stated all units are in Jamaica Dollar billions. Data for 2010 covers the period January 2010 to June 2010.

(ii) The term E.O.P represents the end of period which is a calendar year with the notable exception of 2010.

(iii) Liabilities which mature in excess of a year are deemed to be long-term and are denoted LT Liabilities.

Table 2. Descriptive Statistics for Non-Bank Financial Institutions Included in Sample, 2004 Q4 to 2010 Q2

	Stats	2004	2005	2006	2007	2008	2009	2010
NON-BANK 1	Max Volatility	21.9	21.7	22.4	22.5	23.1	28.6	20.4
	Current Liabilities (E.O.P)	57.3	57.7	74.2	82.0	93.2	93.2	100.2
	LT Liabilities (E.O.P)	0.0	0.4	0.5	0.5	2.6	2.6	0.0
	Mean Value of Equity	23.4	22.5	18.8	15.4	14.9	6.9	5.9
NON-BANK 2	Max Volatility	-	-	-	28.6	26.4	33.8	36.0
	Current Liabilities (E.O.P)	12.7	12.9	18.0	17.8	19.4	19.4	9.4
	LT Liabilities (E.O.P)	2.8	1.9	1.1	2.7	2.2	2.2	9.4
	Mean Value of Equity	-	3.8	2.9	4.9	3.9	2.3	2.9
NON-BANK 3	Max Volatility	34.8	28.0	25.5	24.6	23.6	24.1	23.4
	Current Liabilities (E.O.P)	34.3	33.5	37.2	42.1	54.2	54.2	47.5
	LT Liabilities (E.O.P)	0.9	0.3	0.4	0.1	5.2	5.2	2.2
	Mean Value of Equity	9.9	16.3	10.1	10.7	10.8	8.0	9.6
NON-BANK 4	Max Volatility	27.1	25.4	18.7	26.1	24.4	31.9	32.1
	Current Liabilities (E.O.P)	22.3	26.3	27.0	33.4	60.2	60.2	57.2
	LT Liabilities (E.O.P)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean Value of Equity	4.9	6.6	5.8	10.2	8.8	6.8	9.0
NON-BANK 5	Max Volatility	29.1	24.2	21.7	16.2	16.2	28.0	26.8
	Current Liabilities (E.O.P)	2.1	39.7	54.0	60.6	60.8	60.8	60.8
	LT Liabilities (E.O.P)	12.0	15.1	6.1	6.6	37.4	37.4	37.4
	Mean Value of Equity	19.4	36.3	28.9	27.8	28.6	19.9	24.2

Notes:

- (i) Unless otherwise stated all units are in Jamaica Dollar billions. Data for 2010 covers the period January 2010 to June 2010.
- (ii) The term E.O.P represents the end of period which is a calendar year with the notable exception of 2010.
- (iii) Liabilities which mature in excess of a year are deemed to be long-term and are denoted LT Liabilities.

The analysis uses daily stock price data between end-December 2004 and 30 June 2010. Monthly data on the shares outstanding were gathered from hard-copy data available from the JSE. Both

these series are used to compute the market value of each institution's equity as well as the volatility of the institution's equity. The historical volatility of equity is measured by taking the standard deviation of the returns on the equity valuations for traded securities over 250 trading days where returns are computed as the log of the ratio of value of equity at time t and closing value of equity at time $t-1$. Daily volatility of equity returns are then annualized by multiplying by the square root of 250 trading days.

5.0 Results

5.1 Government of Jamaica Distance-to-Default and Probability of Default Experience in the Context of the Jamaica Debt Exchange

Prior to 2008, Government of Jamaica's (GOJ) assets were on average three-and-a-half standard deviations away from its distress barrier, peaking in August of 2007 at 4.3. This distance to default corresponded to low levels of probability of default over a one-year ahead time horizon. However, in the aftermath of the September 2008 global financial sector meltdown both the domestic non-bank financial sector and the Jamaican Government faced external funding shortfalls. This, in addition to the fall-out in the main sources of foreign currency earnings, also resulted in increased pressure on the domestic currency. In response, the Bank of Jamaica intervened in the foreign exchange market and provided liquidity to the non-bank sector and the inter-bank market. The Bank also tightened its monetary policy stance sharply through higher cash reserve requirements and a **680 basis point** increase in the policy rate to **21 1/2 per cent** on 1st December 2008.

By the second half of 2009, fear over the sustainability of fiscal policy in a context of the closure of international capital markets combined with a weakening domestic economy led to a further deterioration in financial market conditions in Jamaica. The Jamaica Dollar depreciated to J\$89.05 per US dollar in June 2009 from J\$71.56 per US dollar in September 2008 before ending the year at J\$89.60 per US dollar.²¹ At end-November 2009, approximately 40.0 per cent of the total domestic debt was maturing in less than 24 months. Of that 40.0 per cent, which would mature within 24 months, 55.0 per cent was variable rate debt. This presented significantly high levels of roll-over risk over the short-term and left the Government vulnerable to sudden adverse shifts in market sentiments. As a direct result, interest payments as a ratio of GDP had tripled relative to the preceding five years, with interest payments accounting for 23.5 per cent of GDP at end-2009, reflecting an average of 60.0 per cent of Government revenues annually.²²

The CCA provides some indication of these vulnerabilities prior to the financial market volatility that would ensue with the distance-to-default falling precipitously to two standard deviations by end-2008 (see **Figures 2** and **3**). The value of equity in the public sector began to decline in early 2009, further reducing the distance to distress for the GOJ. Additionally, the increased volatility in the exchange rate and the reduction in the NIR served to reduce the value of the GOJ's assets.

²¹In the aftermath of the September 2008 global financial sector meltdown both the domestic non-bank financial sector and the Jamaican Government faced external funding shortfalls. This in addition to the fall-out in the main sources of foreign currency earnings resulted in increased pressure on the domestic currency. In response, the Bank of Jamaica intervened in the foreign exchange market and provided liquidity to the Securities Dealers and the inter-bank market.

²²These high and rising levels of debt service costs inhibited investment in infrastructure and other essential services, generated excessive high real and nominal interest rates and catalyzed recurring fiscal slippages.

All this culminated in the distance to default decreasing to one and the corresponding one-year-ahead probability of default rising to 14.0 per cent by end-March 2009.

By the end-2009 the GOJ was in advanced stages of negotiating a Stand-by Arrangement with the International Monetary Fund (IMF) and other Multi-lateral Financial Institutions (MFIs) for balance of payments support of US\$2.4 billion. The GOJ also undertook a significant debt re-profiling exercise of its domestic debt of \$700.0 billion or 65.0 per cent of GDP in January 2010 in a financial transaction dubbed the Jamaica Debt Exchange (JDX). The transaction targeted the full participation of domestic bond holders, with the aim of doubling the average age of the domestic debt profile while at the same time lowering the interest costs of the GOJ by an average of 850 basis points. The GOJ also took many steps to address the market uncertainty, focusing on core policies that would entrench fiscal discipline and restore market confidence. Successful implementation of the Jamaica Debt Exchange (JDX), the signing of an IMF agreement by February 2010 and improving fundamentals served to increase the distance to default to four standard deviations by end-March 2010. The mapping of the distance to default into probability of default indicated that at end-March 2010 the one-year ahead probability of default had declined to 0.001 per cent.

Figure 2. Distance to Default for Government of Jamaica (GOJ)

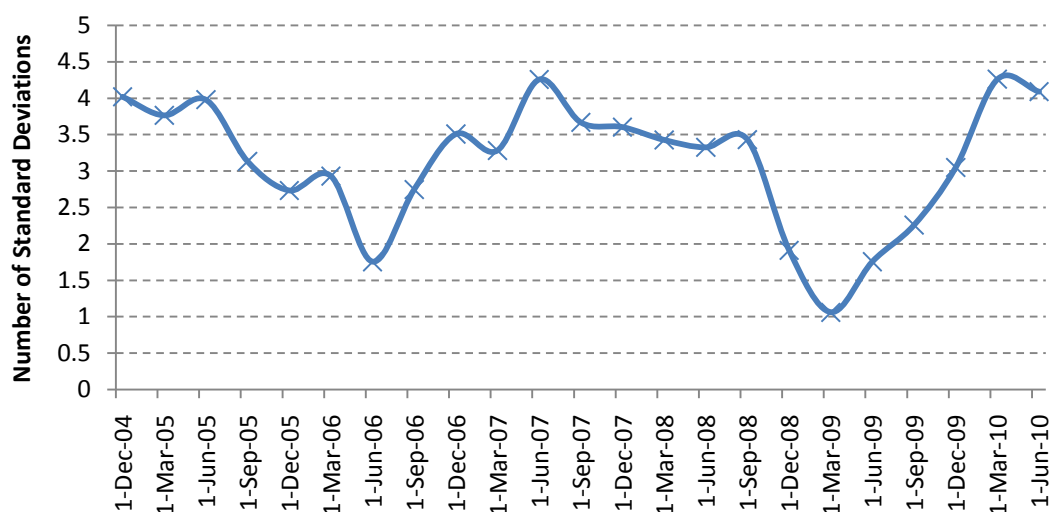
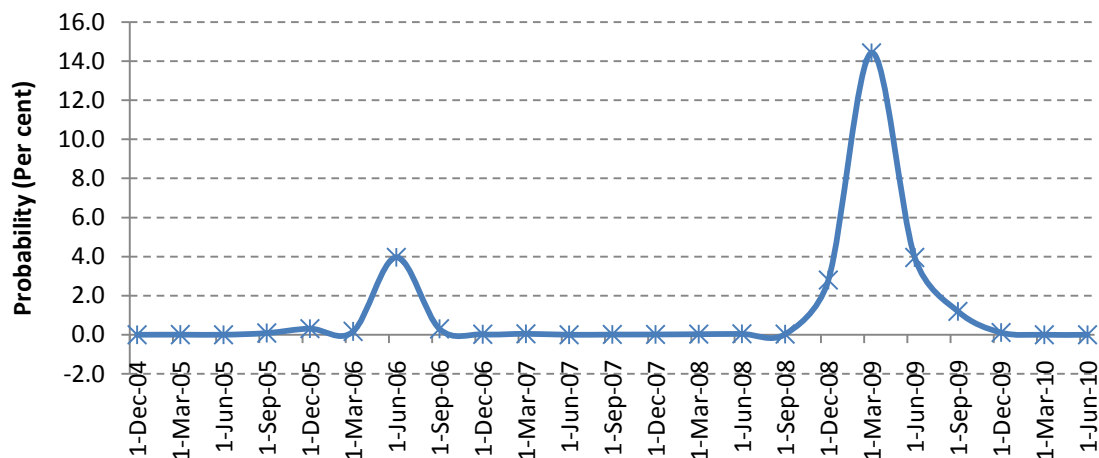


Figure 3. Probability of Insolvency for the Government of Jamaica (GOJ)



5.2 Non-Bank Financial Institutions

Macro-economic weaknesses in the Jamaican economy and increasing uncertainty in the vulnerability of domestic financial institutions were transferred to the balance sheets of the financial sector, reflecting itself in lower equity prices, increased asset volatility and consequently decreasing distance to distress metric. The non-bank financial sector was particularly vulnerable as a direct consequence of (i) their large holdings of GOJ securities, (ii) the short-term nature of their funding base, and (iii) their leveraged investment positions in GOJ global securities. Equity valuations began to decline in September 2008 and continued to decline on a near-continuous basis before bottoming out in March 2009 (see **Figure 4**).

Figure 4. Value of Equity for Non-Bank Financial Institutions (NBFIs)²³



At end-March 2009 the value of equity for NBFIs since the collapse of Lehman Brothers at end-September 2008 had declined by 44.8 per cent to J\$39.4 billion. In addition, the default barrier

²³ As the market value of equity declines then the firm has less of an equity cushion to fund its liabilities.

for NBFIs increased by 41.3 per cent to J\$353.4 billion at end-2008 relative to end-2007. As equity valuations declined significantly and the default barrier increased, the distance-to-default for many firms in the NBFIs sector decreased precipitously (see **Figure 5**).

Figure 5. Distance to Default for Non-Bank Financial Institutions (NBFIs)

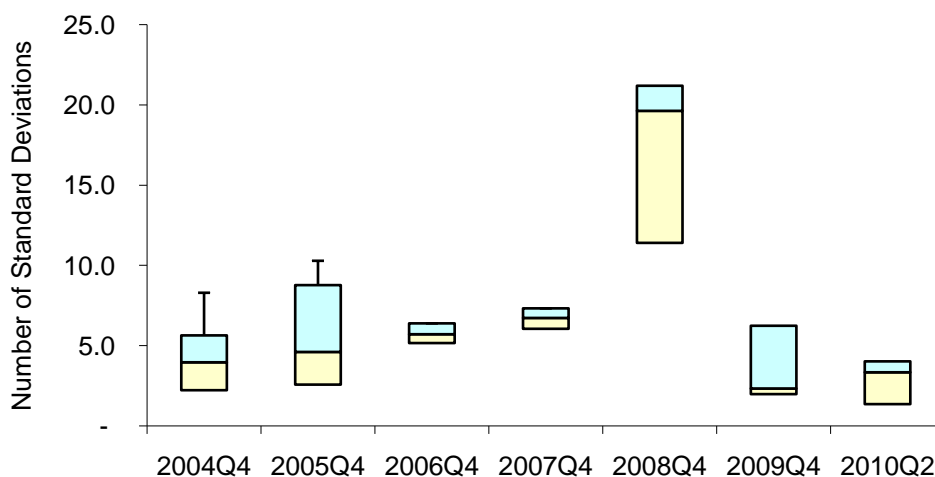
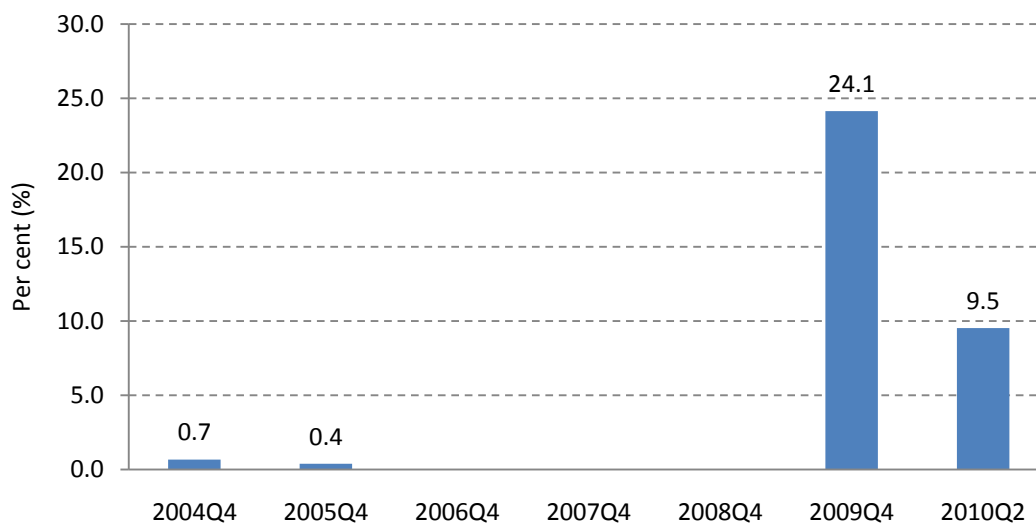


Figure 6. Probability of Insolvency for Non-Bank Financial Institutions (NBFIs)



At the height of the macro-financial uncertainties, the 25th percentile and 75th percentile of the distance to default for NBFIs ranged from 0.37 standard deviations to 4.63 standard deviations, respectively. This distance-to-default mapped to a one-year probabilities of default of 24.1 per cent for the NBFIs sector at end-2009 when financial uncertainties had peaked (see **Figure 6**).

5.3 Deposit Taking Institutions (DTIs)

Equity markets in Jamaica were selective in terms of the sectors for which it had a negative outlook post-Lehman Brothers. In spite of the increasing uncertainty in financial markets and deteriorating macro-economic conditions, equity price declines were more significant for non-bank financial institutions relative to their banking sector counterparts. For the period end-September 2008 to end-March 2009 the value of equity for DTIs declined by 37.0 per cent. While over the same period, the volatility of equity increased by five percentage points to 16.0 per cent. In spite of this, the marked-to-market value of the assets of DTIs continued to grow peaking at \$543.4 billion at end-March 2009, representing an annual growth of 16.7 per cent (see **Figure 7**).²⁴

This positive outlook on the valuation on banks may have reflected lower risk aversion of investors to DTIs as a result of the access to deposit insurance that depositors had via the Jamaica Deposit Insurance Corporation (JDIC) as well as possibly the implicit guarantee from the GOJ for the solvency of systemically important financial institutions. **Figure 8** plots the evolution of the one-year ahead estimate of the value of the financial sector guarantee over the past five years. As shown in the figure, the value of the guarantee was approximately 50.0 per cent of nominal GDP at end-2009. The CCA estimated the value of the financial sector guarantee at between 69.1 per cent and 45.3 per cent of GDP over the period.^{25,26}

Figure 7. Marked-to-Market Value of Assets for Deposit-Taking Institutions (DTIs)

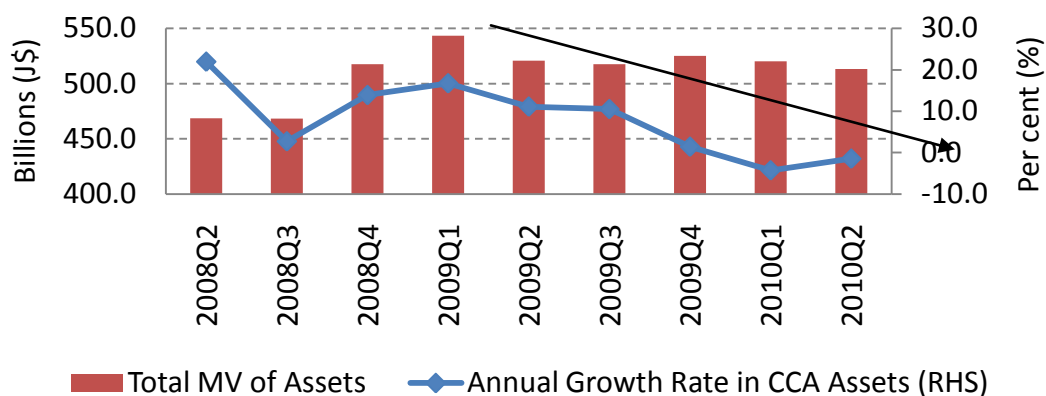
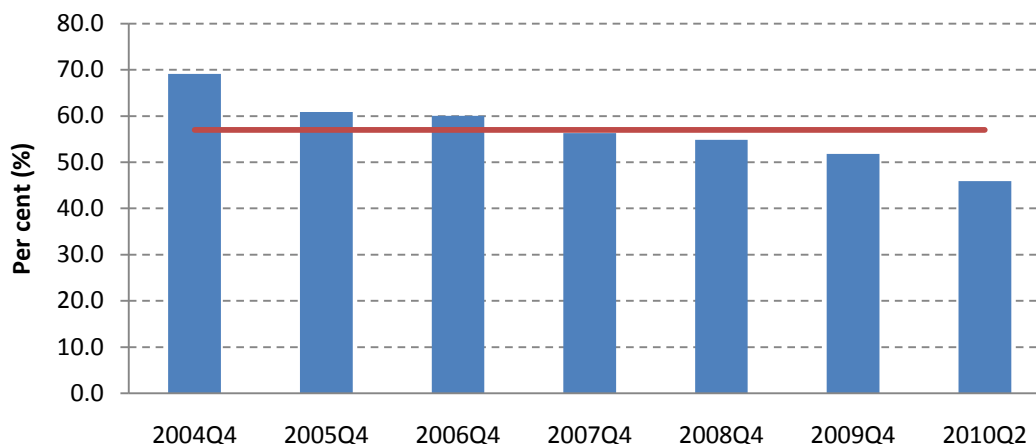


Figure 8. Unexpected Losses (Implicit Government Guarantee) of Deposit Taking Institutions as a Percentage of Gross Domestic Product (GDP)

²⁴ In contrast, the marked to mark value of assets for the non-bank sector declined by 4.75 per cent between December 2008 and December 2009.

²⁵ This compares with the historical estimate of 40.0 of GDP based on the financial sector turmoil of the 1990s.

²⁶ The increase market value of the financial sector assets relative to the distress barrier decreased the value of the financial sector guarantee.



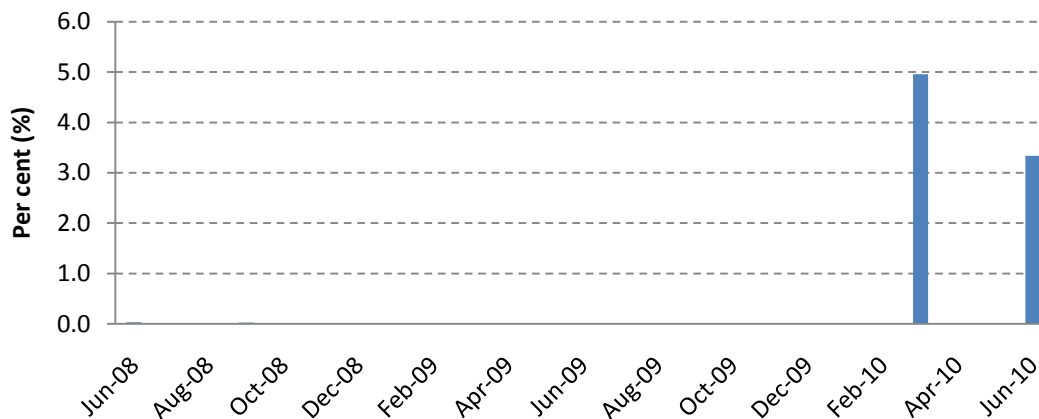
Outside of these factors, the banking sector weathered the financial volatility associated with the global financial turmoil by adjusting its business model. At the height of financial uncertainties banks sold much of their holdings of foreign currency GOJ securities and tilted their portfolio towards domestic currency GOJ securities and loans to the private sector which served to hedge their balance sheets from deteriorations in bond prices for GOJ globals after the collapse of Lehman Brothers.

Consequently, although the inter-quartile range for distance to default for DTIs showed a steady decline since September 2008, by end-December 2009 the inter-quartile range for the distance to default moved from 3.0 standard deviations to 4.95 standard deviations, respectively. This reflected a benign outlook of the risk of insolvency of the banking sector of 0.01 per cent at end-2009. Therefore equity markets discriminated against non-banks in favour of deposit-taking institutions up until the end-of 2009. However, by March 2010 the probability of default for the banking sector showed an uptick for the first time since the global financial turmoil registering a one-year ahead probability of default of 5.0 per cent (see **Figure 9**). This increase reflected the deterioration in the growth rate of the marked-to-market value of its assets, on the one hand, and deteriorating prospects for future profitability, on the other. The sharp drop in external demand emanating from the global financial distress had begun to impair the ability of borrowers to service their loans resulting in rising non-performing loans ratios for the banking sector. Further, the JDX transaction served to reduce the interest cost of the GOJ, meant that banks would have to absorb the impact of lower interest spreads between loans and deposits.^{27,28}

Figure 9. Probability of Insolvency for Deposit Taking Institutions (DTIs)

²⁷ Against this background, the Financial System Stability Fund (FSSF) of approximately US\$950.0 million was established in February 2010, funded by resources from the IMF, the World Bank and the IDB as a part of the agreement emanating from the successful execution of the JDX. These funds would be accessible to participating financial institutions in the event of, for example, a margin call on funds borrowed from overseas banks arising directly from the debt swap, a liquidity run on an institution, as well as those arising from liquidity mismatches emanating from the transaction.

²⁸ A reduction in the stock market resulting in a results the marked to market assets of the corporate sector which in turn leads to a reduction in the assets of banks and leads to an increase in the implicit guarantee of the financial sector by the Government. This leads to reduction in the assets of the sovereign which decreases the D2D and increases the Default Probability.



5.0 Conclusion

The paper explores the use of the contingent claims approach (CCA) to the estimation of bankruptcy risk of both financial institutions and the Government of Jamaica. This framework can be utilized by regulators as a forward-looking high frequency gauge of the potential build-up in risks to the sovereign as well as the financial system. In so doing the framework provides valuable estimates of the potential for macro-financial risk transfers across interrelated balance sheets of the financial and public sector so that these risk transfers can be monitored and policy adjusted accordingly. Finally, the valuation of the impact of a full or partial financial guarantee from the government to the financial sector provides a valuable means of evaluating how changes in the solvency of the financial sector can affect the central government's balance sheet. The CCA framework thus provides an interconnected framework within which policy makers can analyze the impact of potential policy mixes on financial system stability and evaluate which options may be more suitable in countering emerging vulnerabilities.

Applying the CCA framework retroactively to both the sovereign GOJ balance sheet and the balance sheet of the financial sector suggests that this approach would have provided an accurate view of the pending domestic macro-economic and financial turmoil in the wake of the global financial distress. The results show that the global financial crisis had its first impact primarily on the central government via the closure of access to global financial markets as well as significant increases in the financing costs of new debt-raising initiatives domestically. The risks then transferred to the asset side of the financial sector, which held GOJ securities via significant declines in the marked-to-market value of its holders of global GOJ bonds as well as margin calls sustained after the collapse of Lehman Brothers in September 2008. The assessment then highlights the pivotal role that the successful execution of the JDX, as well as the signing of the IMF agreement, played in mitigating the macro-financial risks that had become self-evident by end-2009.

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