Insolvency risk in the Jamaican banking sector and its implications for financial stability

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Abstract

The paper develops an insolvency risk index to assess the fragility of the banking sector in Jamaica. In particular, an aggregate measure of banking sector distress is developed by extending the definition of the Z-statistic proposed by Hannan and Hanweck (1988). Additionally, the paper proposes substituting the traditional measure of performance, ROA, with RORAC as a risk-adjusted performance measure which uses the Bank for International Settlements (BIS) regulatory capital requirement. The RORAC is adjusted to include capital in excess of the BIS regulatory minimum for the purpose of investigating the market behavior of banks. This adjustment allows policy makers to analyze the effect of higher capital ratios in reducing insolvency risks in the banking system. The paper also examines the manner in which macro-economic factors affect bank insolvency risk and illustrate how forecasted Z-scores can provide regulators with an early warning signal of banking sector insolvency. The results illustrate that a regulatory framework that properly monitors insolvency risk should also consider the quality of a bank's capital in promoting financial stability.

JEL: E44, E47, E58, G21, G32, G33

Keywords: financial stability, macro forecasting, bank capital, financial risk, insolvency risk

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1.0 Introduction

The 2007-2008 global financial crisis highlighted the need for improved assessment of systemic risk. As many banks were overleveraged both on- and off-balance sheet, the rapid deleveraging of these institutions resulted in significant losses, declines in bank capital, and a severe contraction in liquidity. Due to the interconnectedness of many of these global financial institutions, the losses accrued by counterparties contributed to the meltdown of the financial system. The speed and depth of the recession surprised authorities requiring a massive rescue of the global financial system. The extent of the support required illustrated the need to review the prevailing approaches to monitoring and regulating the financial system as the crisis raised serious concerns about the presence of systemically important financial institutions (SIFIs) reflecting the heightened awareness of contagion risk.[1] A major step to resolving this weakness was the adoption of a series of reforms known as Basel III developed by the Basel Committee on Banking Supervision (BCBS). The Basel III rules were geared towards correcting the widely held conclusion that the financial crisis was precipitated by low solvency levels in many of the global SIFIs. Regulators and central banks embarked on fundamentally reforming international prudential frameworks to improve internal risk controls and strengthen capital and liquidity regulations given the interaction between liquidity and solvency.

In regards to Jamaica, the Jamaican economy has suffered from a crushing debt burden since its domestic financial crisis in 1995-1998. This precipitated a massive rescue programme by the Government of Jamaica (GOJ) resulting in a steady increase in its debt levels which had increased rapidly to 123.0 per cent of GDP by mid-2003. Consequently as a result of the debt burden which has now reached 135.7 per cent of GDP, Jamaica has teetered on the brink of an economic crisis making the nation's economy vulnerable to various domestic and external economic shocks.

[1] Systemically Important Financial Institutions (SIFIs) is any financial institution that if in default would pose significant contagion risk to the financial system, disrupt financial intermediation and subsequently have an inauspicious impact on the real sector. BCBS suggests that SIFIs be identified investigating an institution's comparative size, interconnectedness, substitutability, complexity and cross-jurisdictional activity relative to the system.

While Jamaica's financial system was somewhat insulated from the direct impact of the fallout of the subprime mortgage crisis, Jamaica's real economy was, however, impacted by second round effects given that the United States remains its largest trading partner.[2] For Jamaica, this impact largely affected the tourism sector, remittances and tourism-related construction activities which were underwritten by the banking sector. In addition, the financial sector was also impacted as financial institutions experienced tight liquidity conditions due to excessive margin calls. The impact on the Jamaican economy required the GOJ to reengage the International Monetary Fund (IMF) in 2009 on discussion for a Stand-by borrowing arrangement. Furthermore, given its dire fiscal state, the GOJ completed a preemptive debt restructuring programme in order to stave off a likely default on its domestic debt dubbed the Jamaica Debt Exchange (JDX) in early 2010.[3]

Following two years of mixed growth, uncertainty surrounding the timing and content of an agreement with the IMF on a new medium-term economic programme contributed to significant instability in the foreign exchange market, delays in investment projects, and significant loss in consumer confidence during 2012. However, in Jamaica, the stability of the banking system plays an especially important role as the financial system is bank-centric and is largely dominated by commercial banks which account for approximately 40.0 per cent of total system assets. Consequently, these macroeconomic shocks and severe fiscal adjustments created instability in the profitability of the banking sector and contributed to concerns of solvency of the system.

The global financial crisis reignited discussions of the impact of insolvency and liquidity risk to financial stability. However, many financial regulators seek to create this notion of systemic soundness to domestic

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[2] Note that the banking sector in Jamaica is prevented by regulation from holding a trading book although they are allowed to trade bonds on their own account thus limiting its exposure to the market risks prevalent during the global financial crisis.

[3] King, D. and Kiddoe, A. (2010). Achieving Fiscal Sustainability in Jamaica: The JDX and Beyond. *Caribbean Policy Research Institute.* Retrieved June 18, 2013 from http://www.capricaribbean.org

and international stakeholders. Moreover, research has aimed to develop an easily understood aggregate risk metric which accurately measures systemic soundness within the financial system. One widespread measure of bank stability is the z-score given its ease of use and availability of information. The z-score is an insolvency risk measure that represents the probability that an individual bank's losses exceeds its shareholder equity. The development of the z-score, in its general form, can be attributed to Hannan and Hanweck (1988) and Boyd *et al* (1993). The z-score is an asset-based measure which determines the risk of insolvency to depend on the interaction of an institution's leverage, profitability, and potential magnitude of return shocks.

This paper shows that by using return on assets (ROA) as the traditional measure of profitability completely ignores the risk of the activity of a bank. As such, a more robust measure of the probability of insolvency can be achieved by using the return on risk-adjusted capital (RORAC) instead of the ROA. As more firms place greater emphasis on firm-wide risk management, RORAC incorporates the market risk embedded in the balance sheet, the credit risk costs associated with credit quality deterioration due to firm specific events or due to economic downturns, and unmitigated operational risk in particular strategic risk i.e. those associated with a firm's business model.

Given the existing vulnerabilities within the Jamaican economy and the ongoing uncertainties prevalent within the global financial system, investors have been cautious to invest in jurisdictions like Latin America and the Caribbean and other developing economies, where the solvency of the system may be in question. As such this study proposes an appropriate metric to accurately measure the solvency the banking system within Jamaica.

The paper also develops a prudential threshold based on the Jamaican financial crisis focusing on the period 1997-1998 which was viewed as the most severe point of the crisis. Motivated by De Nicolo (2000), this study also attempts to investigate the historical decomposition of adverse shocks to the system so as to determine the long and short term effects of relevant macroeconomic variables on banking system solvency. This was achieved using a Vector Error Correction model (VECM) using time series data.[4] The paper investigates the concept of prospective financial stability by using the VECM to forecast z-scores and extend the analysis to illustrate possible policy implications.

Section 2 discusses the traditional definition and interpretation of z-scores, undertakes retrospective analysis of solvency in the Jamaican banking system with Section 2.3 and 2.4 then introducing the refinements proposed by this study; Section 3 presents the empirical results, and the relationship between capital levels and solvency risk within the system with Section 3.1 discussing the implications of the results for forecasted z-scores; and Section 4 concludes the paper.

2.0 Z-index: Insolvency risk decomposition

The z-score is defined as a statistical measure used to determine the likelihood of bankruptcy from a company's credit strength. The z-score has become a popular measure of bank stability. Its popularity stems from the fact that it is inversely related to the probability of a bank's insolvency. This relationship is made possible by applying Chebyshev's theorem which states that assuming the return distribution has mean, μ and variance, σ^2 :

$$P\{X - \mu \geq k\sigma\} \leq \frac{1}{k^2} \tag{1}$$

where X, is a random variable. Defining the z-score as the risk of insolvency as presented by Hannan and Hanweck (1988) as:

$$z = \frac{\mu + C}{\sigma} \tag{2}$$

where, C, represents an institutions' leverage, and z, represents the number of standard deviations k, above the mean of the distribution, therefore inequality (1) reduces to:

$$P\{X - \mu \geq k\sigma\} \leq \frac{1}{z^2} \tag{3}$$

[4] Error Correction Models were first used by Sargan(1964)

Thus,

$$P\{X - \mu \geq z\} = \Phi_{X-\mu}(z) \tag{4}$$

where Φ_{X-x}represents the probability distribution of the bank's standardized returns.

Therefore, the z-score can be interpreted as a bank's distance-to-default (De Nicolo *et al*., 2005 and Cihak, 2007). Specifically, it measures the left tailed probability that a bank's returns decline beyond expectations exhausting shareholder equity. As such, a higher z-score implies a decreased risk of insolvency and thus indicate increased stability within the financial system. It is important to note that the parameters μ and σ^2 represent the population, however, parameter estimates would more than likely be determined from a sample distribution. As such for increased precision, one would need to consider the frequency of the data series and whether there exist any structural breaks.[5]

2.1. Alternative forms of performance measures

This paper proposes that the z-score cannot be equally applied to high risk-high return strategies and low risk-low return strategies as one of the principal components of the z-score is the ROA. The ROA is the traditional indicator of how profitable a company is before leverage, but must be compared to institutions within the same industry. Therefore, applying the ROA in the context of an aggregate measure of bank stability would imply that the asset structures of banks within the Jamaican banking system would need to be similar. However, this is not the case, in particular, if the aggregate measure is extended to include entities within the entire financial system as some sectors of the financial system undertake far more risk than banks.[6] Given the importance of systematic risk following the global financial crisis and the impact

[5] See Ivičić, Kunovac, and Ljubaj (2008)

[6] The Jamaican banking system comprises Deposit-taking institutions (DTIs) which consist of commercial banks, building societies and FIA licensees (inclusive of merchant banks and Finance houses). Building societies' business model involves originating mortgage loans while commercial banks and FIA licensees focused on personal and business loans. However, given the markedly different funding sources of commercial banks and FIA licensees, the cost of capital to these two sectors would require their asset structures to be somewhat different with FIA licensees' investments being riskier.

of SIFIs outside of the banking system on the wider financial system, being able to extend an aggregate z-score to the entire financial system would be advantageous to regulators.

Though the net income in the ROA is risk adjusted for mitigated market risk and non-interest expenses such as insurance expenses and loan loss provisions, it does not account for the big risk management elements which include market risk embedded in the balance sheet, credit risk and operational risk. On the other hand, RORAC uses the BIS regulatory capital requirement as a measure of the capital at risk from the institution's investment activities. Regulatory capital is defined as the capital a bank is required to hold according to regulatory guidelines which are designed to assure that a bank has sufficient capital to withstand shocks.

$$RORAC = \frac{Adjusted\ Income}{BIS\ risk\text{-}based\ capital\ requirement} \tag{5}$$

Basel II, the second accord developed by the BCBS, incorporated in Pillar 1 of the accord new methods of measuring and mitigating credit, market and operational risks. Under Basel II the amount of capital required depends on whether a bank uses economic capital models (VaR models) or Internal ratings-based (IRB) models, and the accuracy of probability of default (PD) transition matrices utilized in determining individual investment's losses given default (LDG).[7]

As such, firms set aside reserves in anticipation of expected losses. However, economic capital is allocated to provide a cushion for unexpected losses. Therefore, it follows that most banks hold actual capital levels in excess of that required by regulators. This will be discussed further in Section 3.2. Given that the Jamaican banking system is transitioning from Basel I, the inclusion of the *Buffer Capital*, that is the capital in excess of the minimum required capital, would capture the bank's view of its unexpected

[7] Saunders, A. & Allen, L. Credit Risk Measurement in and Out of the Financial Crisis: New Approaches to Value at Risk and Other Paradigms. (Wiley 2010) p. 230.

losses.[8] To the extent that Basel II regulatory proposals accurately assess capital adequacy, the paper's modification of RORAC should capture the true risk profile of an institution.[9]

2.2. Measuring economic leverage

Leverage, on the other hand, allows an institution to enhance it returns on a position beyond what would be possible on its own investment. However, it creates and enhances the risk of default as a result of an adverse price movement. Leverage can therefore be thought of as the link between the risk of an asset relative to the risk to shareholder equity. The inability for counterparties to properly assess an institution's leverage especially in down markets can result in the rapid unwinding of positions which can have a destabilizing effect on the financial system.

Similar to the 1998 financial crisis triggered by the unilateral Russian default, the 2007-2008 global financial crisis was partially attributed to overleveraged global SIFIs. It is for this reason that observers argue that the traditional on-balance sheet measurement of leverage has be deemed inadequate. Critics argue that the measure does not adequately capture the degree of an institution's leverage in the context of a significant degree of leverage assumed through off-balance sheet activity. Calls for the development of a comprehensive and appropriate measurement of a gross leverage inclusive of off-balance sheet leverage was explored by the President's Working Group on Financial Markets (1999) following the 1998 financial crisis. However, it was the Counterparty Risk Management Group (1999) that presented the first attempt to develop a comprehensive leverage ratio that aggregates on-and off-balance sheets leverage.[10]

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[8] Buffer capital consists of unappropriated profits, retained earnings reserve funds, and revaluation reserve funds.

[9] Return on risk-adjusted capital in per cent, $RORAC = \frac{adjusted\ income}{(regulatory\ capital + Buffer\ capital)}$

[10] See Breuer (2000)

Breuer (2000) proposed the modification of the traditional leverage ratio which captures off-balance sheet exposure embedded in derivatives, and repos by adding the on-balance sheet asset equivalent of an institution's off-balance sheet items. This off-balance sheet exposure is added to the on-balance sheet assets and is divided by on-balance sheet equity. In essence, Breuer proposed the development of an economic leverage ratio that roughly approximated the excess risk assumed in leverage. This paper proposes the incorporation of an economic leverage ratio in determining insolvency risk within the banking sector as this would allow the z-score to more accurately measure the potential risk of insolvency arising from both on-and-off-balance sheet activity (see Equation 6).

$$L = \frac{BIS\ capital\ requirement}{Assets_{on-balance} + Assets_{off-balance}} \tag{6}$$

However, the limitations with the economic leverage measurement proposed by Breuer (2000) are that, given the limitations with the data reported on off-balance sheet activity, the measure uses notional amounts as it is impossible to precisely measure leverage for institution without having knowledge of their positions including hedges (Breuer 2000) and makes no differentiation of the maturity horizons. On the other hand with more precise data, a more sophisticated leverage ratio could be attained.

2.3. Historical decomposition

Motivated by De Nicolo (2000), Cihak and Hesse (2006) and Machel et al (2007), the paper undertakes a retrospective analysis of insolvency risk by relating the z-score for the Jamaican banking system, *z-Jamaica*, to five macroeconomic variables. These macroeconomic variables capture financial, fiscal, external, monetary and supply shocks. More specifically, the z-score measure is calibrated such that it captures bank stability, debt to GDP which measures the fiscal impact, terms of trade which measures the external sector effect, interest rates provides a monetary measure, and nominal GDP captures supply shocks.[11] For that purpose a VECM is estimated for Jamaica:

[11] See Canakci (2008)

$$\Delta\Psi_t = \alpha + \Pi\Psi_{t-1} + \sum_{i=1}^{l} \beta_i \Delta\Psi_{t-i} + \varepsilon_t, \qquad \varepsilon_t \sim N(0, \Gamma) \tag{6}$$

and the cointegrating equation is:

$$\Psi_t = \alpha + \rho\Psi_{t-1} + \varepsilon_t \tag{7}$$

where $\rho = 1$ and ε_t is a stationary process. Ψ_t represents the vector of macroeconomic variables (see Appendix A6). Since the macroeconomic variables are non-stationary, it was determined that all variables follow I(1) processes. Despite this, the linear combination of variables might be stationary. The model also includes lagged z to capture capital reserve accumulated in previous periods. The VECM is then used to forecast system insolvency over a one year horizon.

2.4. Data

The data set consists of monthly total assets and contingent accounts, quarterly pre-tax profits, and capital adequacy summary estimates of each bank's regulatory capital (Tier 1 and Tier 2 capital). However, balance sheet estimates were used to determine regulatory capital when data was not available for the off-quarter months. In addition, monthly balance sheet data was used to determine each bank's capital buffers. The data set also consist of monthly macroeconomic data on public debt, the 180-day interest rates and an index of terms of trade which were obtained from the BOJ database (see Table 1). As it relates to real and nominal GDP, these variables were also obtained from the BOJ database. However, the series was converted from a quarterly series to monthly series by interpolating the data.

Table 1. Descriptive statistics of bank insolvency and macroeconomic variables

	z-Jamaica	Debt to GDP	Terms of Trade	180-day rate	Nominal GDP
Mean (μ)	8.51	4.693	4.351	0.012	178895.400
Std. Dev. (σ)	7.40	0.192	0.212	0.004	81967.010
Skewness (S)	24.50	-1.015	-0.454	0.239	0.348
Kurtosis (K)	2.20	2.550	1.924	2.731	1.726
Jarque-Bera	3.95	33.330	15.277	2.320	16.254
Probability	0.96	0.000	0.000	0.313	0.000

As mentioned earlier, the *z-Jamaica* measure is used as an aggregate measure to indicate insolvency risk in the Jamaican banking system. One limitation of using an aggregate indicator is that it fails to capture the vulnerabilities of individual banks. However, the paper determines *z-Jamaica* as a weighted sum of the z-score for each bank (see Table 2). Therefore, as would be expected, domestic systemically important financial institutions (D-SIFIs) will have the greatest impact on the solvency of the banking system within Jamaica.

Table 2. Descriptive statistics of z-scores across banking sectors

	Commercial Banks	Building Societies	FIA licensees
Mean	6.34	1.72	0.45
Median	5.54	1.44	0.28
Maximum	19.98	5.75	2.34
Minimum	1.48	0.32	0.00
Observations	185	185	185

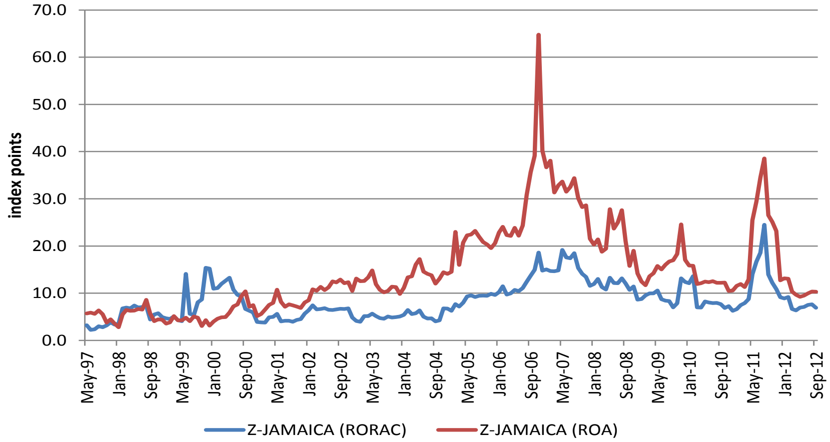
The sample period runs from May 1997 to September 2012, yielding a total of 185 observations. The rationale for the starting date is that it allowed for inclusion of the Jamaica financial crisis in order to develop a prudential threshold while the end point is dictated by the availability of data at the time of this study. Of note, however, the data series covers the period consisting of the 2007 to 2008 global financial crisis, the introduction of the Jamaica Debt Exchange (JDX) program, the credit downgrade of United States sovereigns, the ongoing Euro-zone debt crisis and the negotiations between the GOJ and the IMF over a new medium-term economic program.

3.0 Empirical Results

The results in this study indicate that insolvency risk in Jamaica, as measured by *z-Jamaica*, significantly decreased starting in end-2004 (see Figure 1).[12] This was indicated by an upward trend in the index. Relative to the levels of the index during the financial crisis in Jamaica, the increased bank stability corresponded with amendments to regulatory framework governing the Jamaican financial system. The legislations impacted by the amendments were the Bank of Jamaica Act 1960, The Banking Act 1992, The Financial Institutions Act 1992, and the Building Societies Act 1897.

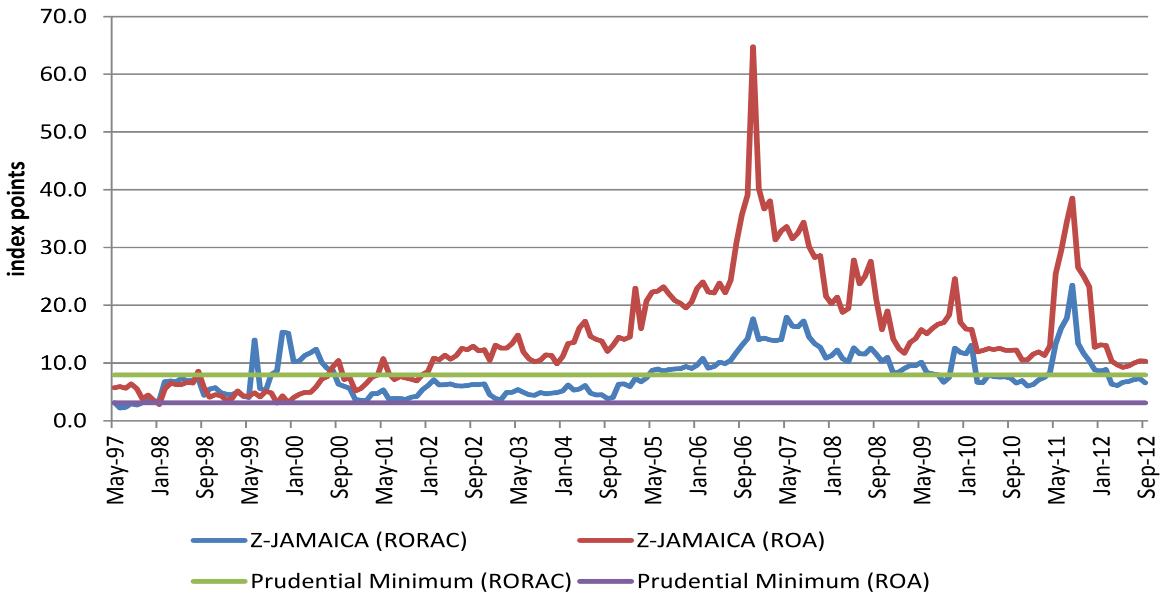
[12] The slight improvement in mid-1999 was due to the consolidation of failed institutions and the *cleaning up* of their balance sheets under Financial Sector Adjustment Company (FINSAC).

Figure 1. ***z-Jamaica***



In addition, the study finds that the model proposed by Hannan and Hanweck, *z-Jamaica (ROA)*, indicate higher levels of bank solvency and greater volatility relative to the model used in this paper. During the Jamaican financial crisis (1996-1999), many institutions failed and were restructured as part of the GOJ attempts to restore stability to the Jamaican financial system. One important observation from the study was that the *z-Jamaica* was zero-bounded which could be due to the fact that institutions that were not sufficiently capitalized were closed by authorities prior to shareholder equity being wiped out. As such, the study sought to develop a prudential minimum based on the bank failures during the crisis period. It was determined that the average z-score of failed banks at the point of failure using the *z-Jamaica (RORAC)* was 7.94 while for *z-Jamaica (ROA)* was 3.07 (see Figure 2). Of note, the financial system exhibited significant risk of insolvency when compared to the prudential minimum leading up to the last quarter of 2004. This could be attributed to the fact that the financial system remained under distress and profitability was impacted by the continued reforms of the aforementioned legislative amendments beginning in 2000.

Figure 2. ***z-Jamaica*** **(RORAC)**



3.1. Regression results and Forecasted *z-Jamaica*

The paper adopts the strategies employed in De Nicolo (2000) and Maechler et al (2007) by using macroeconomic variables to decompose the risk of insolvency for the Jamaican financial system. Despite the lack of a strong statistical relationship between the macroeconomic variables and bank insolvency risk, the results provide useful information on the interaction among the variables in the system (see Appendix A4). This result was expected as bank insolvency risk (bank stability) assumptions are significantly impacted by microeconomic variables. Notwithstanding, these microeconomic variables do have an indirect impact macroeconomic variables and are reflected in the five most important segments of the financial system: bank and non-bank intermediaries, money markets, securities inclusive of equities and bonds markets and foreign exchange markets (Holló 2012).

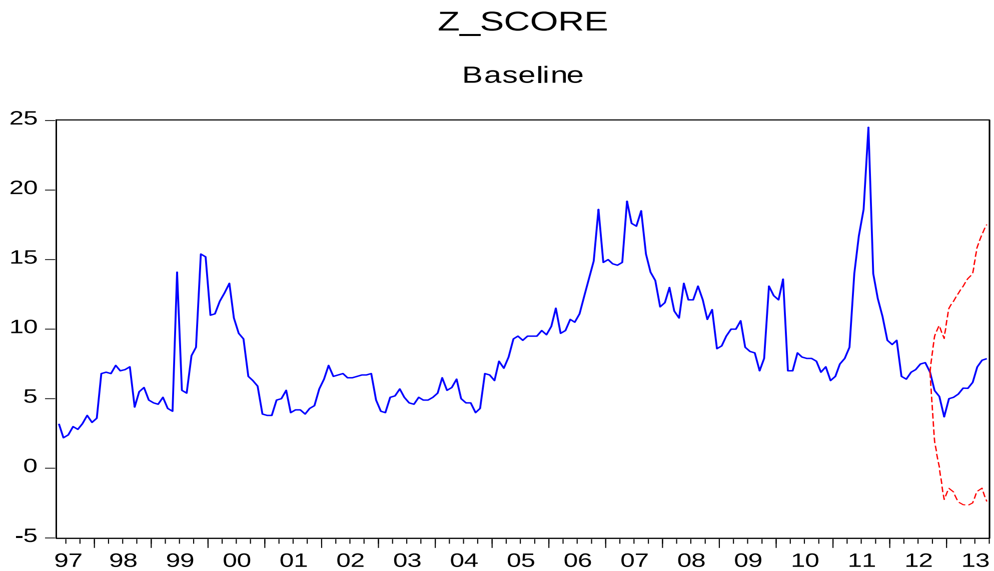
Expectations in relation to the risk of insolvency are of particular interest to regulators, creditors and investors as it has implications for profitability and financial stability. It is for this reason this paper develops a VECM for the purpose of forecasting system insolvency risk (see Appendix A6). However, to properly understand the forecast results, an investigation of the historical decomposition results would reveal the expected long run behavior of these variables within the system.

Analysis of the impulse responses of *z-Jamaica* to a one standard deviation increase in each macroeconomic variable can be seen in Appendix A7. The long run impact of Interest rates (INT) and debt to GDP (DEBT_GDP) on *z-Jamaica* resulted in a decrease in the index and hence increased solvency risk with has a lasting effect. While Terms of Trade (TOT) and nominal GDP (GDP_NOM) had the opposite effect increasing *z-Jamaica* and hence improving insolvency risk conditions within the system. Of note, only TOT and GDP_NOM were significant as measured by the t-statistic (see Appendix A6). The results of the impulse response functions (IRF) corresponded with intuitive expectations as an improvement in the real sector of the economy should result in an expansion of the banking sector through financial intermediation while an increase in bank funding costs and the overall debt overhang on the economy would have a dampening effect on the banking sector.

Having investigated the long run behavior of insolvency risk in the Jamaican banking system, the study attempted to forecast insolvency risk using the VECM. However, the limitation with any econometric forecast model of bank insolvency risk using macroeconomic variables is that, intuitively, insolvency is of a binary nature. Therefore, by viewing forecasted z-scores as a distance-to-default rather than in a discrete manner, results of forecasted z-scores would have more value to policy makers as an indicator of solvency risk and act as an early warning measure in ensuring sufficient capital within the system.

The paper investigated four periods of importance as it relates periods of financial distress such as the JDX and the global financial crisis. This included an out-of-sample (Baseline) one-year-ahead forecast from the time of this study which would include the most recent debt exchange offer by the GOJ, namely the National Debt Exchange (NDX) (see Figure 3). In addition, it investigates three in-sample forecasts which include periods before, during and after the global financial crisis as in-sample forecasts provide robustness tests of the VEC forecast model.

Figure 3. Forecasted *z-Jamaica* with 95 per cent confidence level (out-of-sample)



Results indicate that the model is a weak predictor of insolvency risk for both in-sample and out-of-sample forecasts (see Appendix A6). However, the model tended to over-forecast with an average absolute error of 4.19 units for *z-Jamaica* (Oct. 2008 – Nov. 2009; Feb. 2006 – Jan. 2007; Sep. 2011-Sep. 2012). The failure of the model is more likely due to inability for an aggregate measure to forecast bank specific risks and risks associated with individual investment holdings. One possible means of improving the accuracy of the forecast would be to model and forecast the macroeconomic variables separately and then apply to the *z-Jamaica* model.

3.2. Capital levels of banks and the quality of capital

Elizalde and Repullo (2006) analyzed *market discipline* on regulatory capital, economic capital and actual capital levels using the single factor model (Vasicek, 2002) of Basel II. As mentioned earlier, regulatory capital is the minimum capital required by regulators and depends on the confidence level set by regulators under the IRB model. On the other hand, economic capital, k^*determines the amount of capital that a bank needs to ensure that its realistic balance sheet remains solvent over a specified time period with specified confidence level. However, because of the risk to financial stability, regulators would more than likely choose to close undercapitalized banks. It is for this reason that banks will choose an actual capital level above the regulatory capital level.

By finding a solution to the Bellman equation, Elizalde and Repullo (2006) concluded that in addition to the probability of default, loss given default, exposure to systematic risk, loan rates and deposit rates, the banks funding cost, δ, and minimum capital requirement, $\hat{k}$, were also determinants of actual capital, k^a for which was derived: [13]

$$\frac{\partial k^a}{\partial \delta} < 0 \; and \; \frac{\partial k^a}{\partial \hat{k}} = 0 \tag{8}$$

Therefore, as a bank's funding costs increased it reduced the actual capital levels while increased capital requirements had no effect on actual capital. However, regulatory capital by definition places a floor on actual capital levels. Assuming shareholders chose to operate the bank, it follows that the actual capital level of a bank is the maximum of its economic capital and the regulatory capital i.e.

$$k^a \in \max\{k^*, \hat{k}\} \text{ except where } k^* < \hat{k} \tag{9}$$

For the purposes of this study, the inclusion of *buffer capital* in determining RORAC allowed the model to focus on the impact of risk-based capital requirements on banks' risk taking and by extension the impact of risk-taking on profits. However, it also takes into account an institution's *market discipline* in avoiding insolvency. Analysis of the bank capital levels over the study period reveal that banks within the Jamaican banking system at times opted to hold actual capital levels much greater than the regulatory minimum (see Figure 4). In particular, following the restructuring of the financial system in June 1999,

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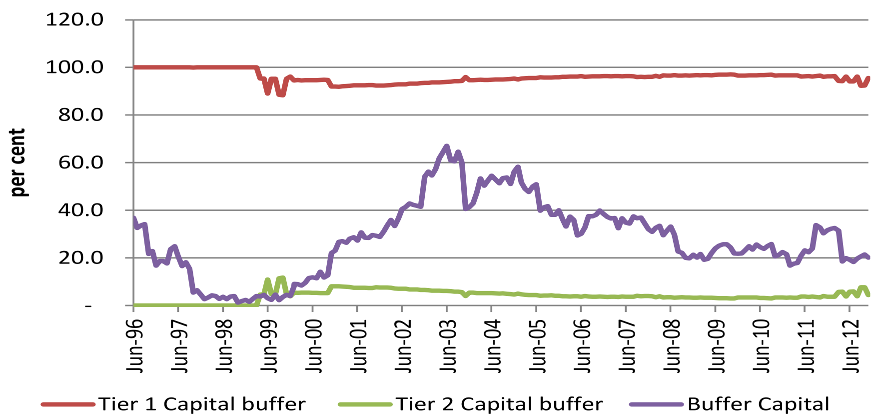
[13] Bellman Equation that characterizes the solution to the shareholder's maximization problem: $V = \max\left\{\max_{k_t \in [\hat{k},1]} \left[-k_t + \frac{1}{1+\delta}\left[E\left(\max\{k'_t, 0\}\right) + Pr\left(k'_t \geq \hat{k}_{min}\right)V\right], 0\right]\right\}$

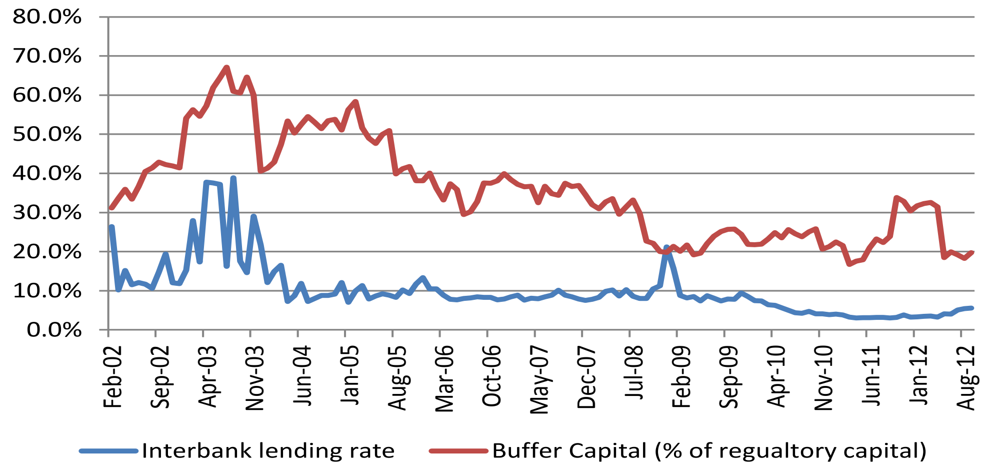
and the subsequent reforms of the financial regulatory framework in 2001 and 2002, banks opted to increase its actual capital to approximately 60.0 per cent above regulatory capital.

Figure 4. Decomposition of banking sector capital buffers (as a % of regulatory capital)



However, this study finds that despite an increase in funding cost, measured by the overnight interbank rate, banks chose to significantly increase actual capital in contradiction to Elizalde and Repullo (2006) findings (see Figure 5). This could be due to the significant uncertainty in the economy as a result of the regulatory reforms and a brief foreign currency (FX) crisis of the Jamaica Dollar vis-a-vi the US dollar in early 2003. In so far as banks tend to be long FX, the effect of the 2003 FX crisis was mitigated by FX gains on investments and heavy monetary policy intervention by the Bank of Jamaica (BOJ) to ensure financial stability.

Figure 5. Co-movement cost of bank capital and buffer capital

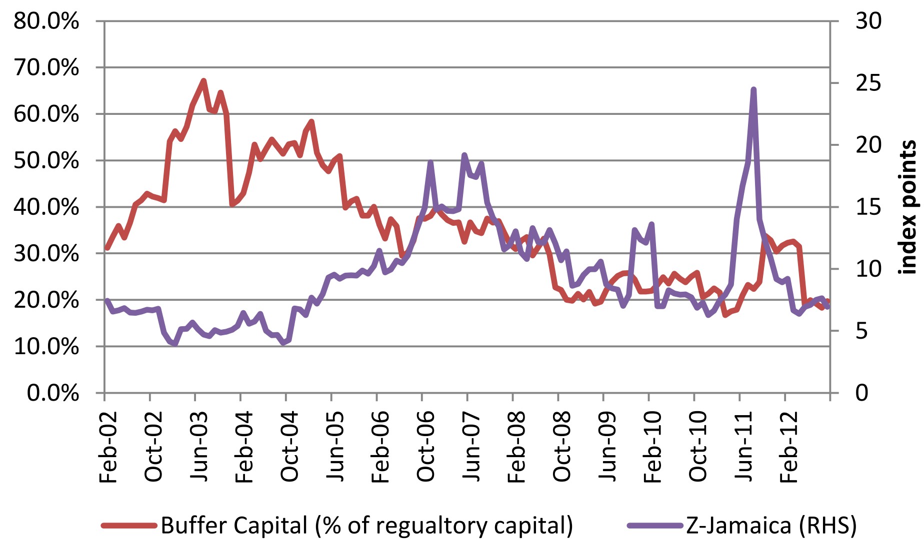


The regulatory reforms and macroeconomic instability experienced between 2000 and 2004 would undoubtedly increase the probability of default (risk of insolvency) within the banking system. Notwithstanding the deviation from the literature as it relates to the effect of funding cost, the results of the paper revealed that, as suggested by the literature, actual capital was positively affected by both the probability of default and by extension loss given default.[14,15] The increased risk of insolvency indicated by lower *z-Jamaica* scores corresponded with higher levels of buffer capital (see Figure 6).

Of note, this relationship was reversed during the financial crisis given the aforementioned reasons stated in Section 1. Moreover, the effect of the JDX, the consecutive increases in risk weights on foreign currency denoted holdings, and the continued effects of the IMF Standby Agreement (SBA) and the lead up the NDX, resulted in significant net interest income losses and tightened liquidity conditions within the banking system.

[14] Loss given default in this case assumes wrong-way exposure in that the exposure increases as the credit quality of a counterparty deteriorates due to financial distress. In other words, the future exposure is highly correlated with the counterparty's probability of default.
[15] Bailey-Tapper (2009)

Figure 6. Comparison of actual capital and *z-Jamaica* (2002:2-2012:9)



4.0 Conclusion

The paper determined that the Jamaican banking system had significantly improved its risk to insolvency since the financial crisis in the 1990s at least up until mid-2007. However, this trend has reversed and has implications for regulators. Much of this improvement was due to changes in the regulatory framework and the *market discipline* of participants. The paper employed a new technique for computing z-scores taking into account the risk-taking behavior of banks while including their internal solutions to the maximization of actual capital problem i.e. the capital levels believed sufficient to mitigate against insolvency. It concluded that risk of insolvency was markedly higher in the Jamaican banking system than suggested by the traditional approach proposed by Hannan and Hanweck. The paper investigated the relationship between macroeconomic variables and bank insolvency with the purpose of forecasting z-scores. As an early warning signal, the findings of the paper provided a workable predictor of the risk of insolvency and thus contribute to the forward-looking element of ensuring banking system stability in Jamaica.

The paper determined that while the banking sector soundness is inextricably linked to various macroeconomic variables, it can also be deduced that microeconomic variables such as capital levels play a larger role in determining bank solvency. It is on that note, that further research could be pursued by modeling *z-Jamaica* with microeconomic variables.

In an increasingly competitive global financial market where the enhancement of returns is prioritized, it is understood that policy makers must balance financial system efficiency with stability. Therefore, in terms of policy prescription, the paper suggests the use of economic capital models in determining capital adequacy as this would promote efficient use of capital. To the extent that banks develop adequate internal risk controls, the adoption of economic capital models within banks would improve assessment of bank risk. In addition, in the absence of more rigorous risk monitoring, the introduction of a leverage ratio as a macro-and micro-prudential tool combined with BIS capital requirements will reduce the excess risk associated with leverage which would in effect limit bank risk and control systematic risk from bank insolvency within the Jamaican banking system.[16]

[16] D'Hulster (2009)

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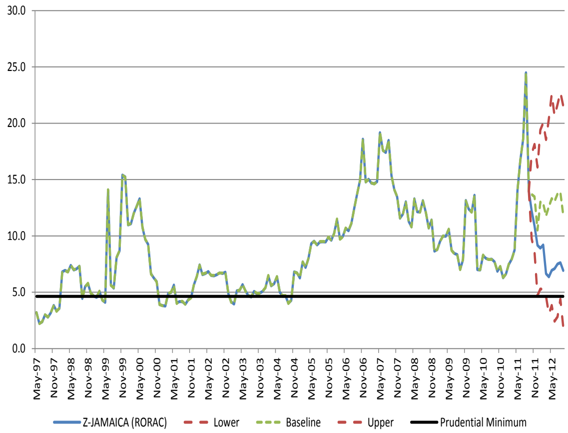
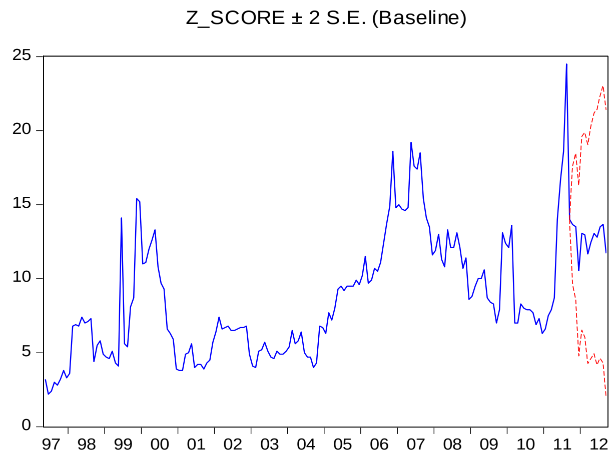
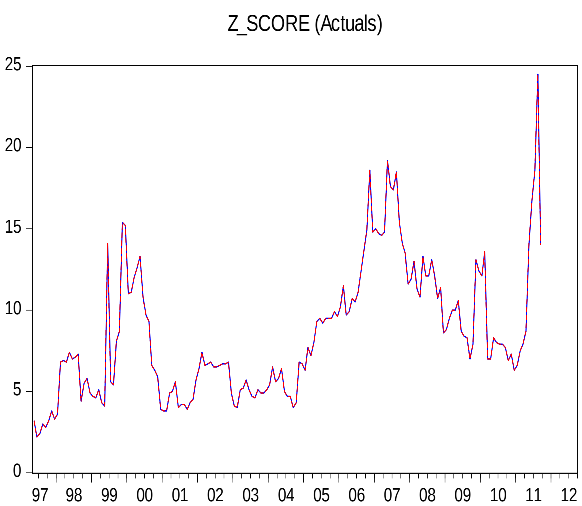
A. APPENDIX

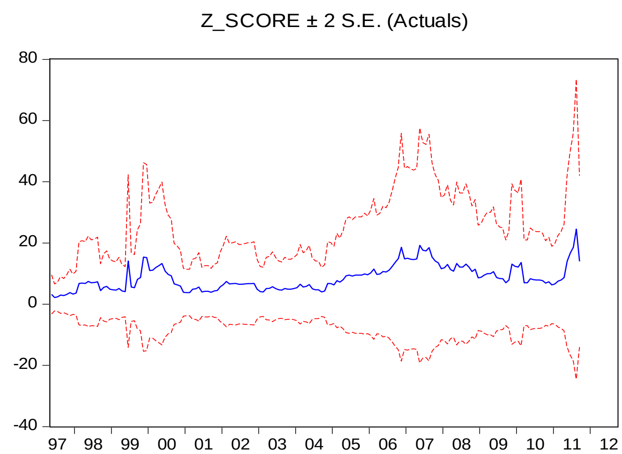
A1. In-sample Forecast Results

i) Sep. 2011-Sep. 2012;

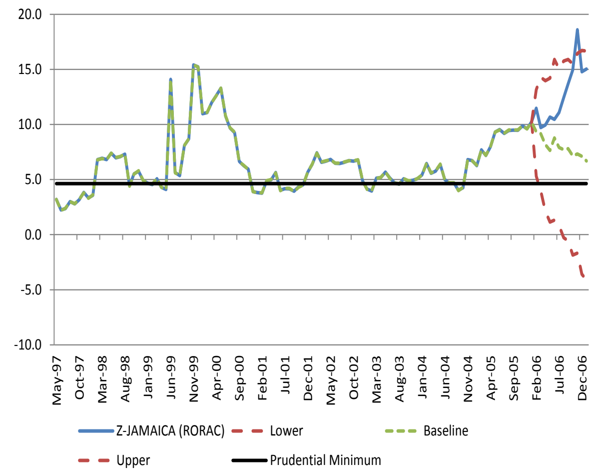


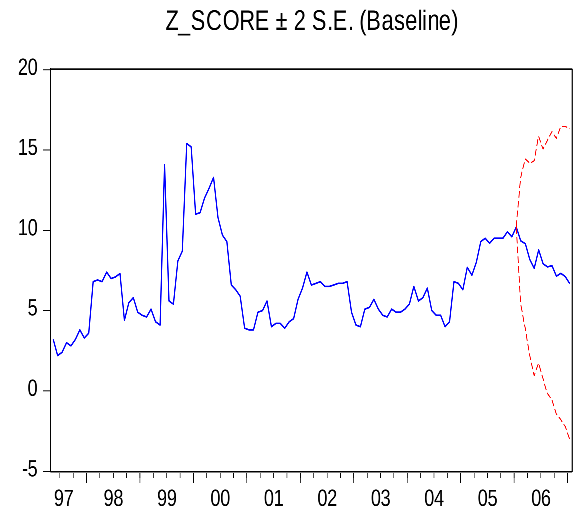


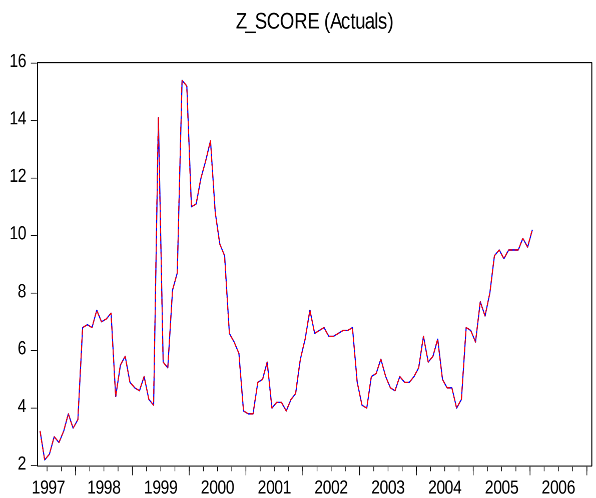


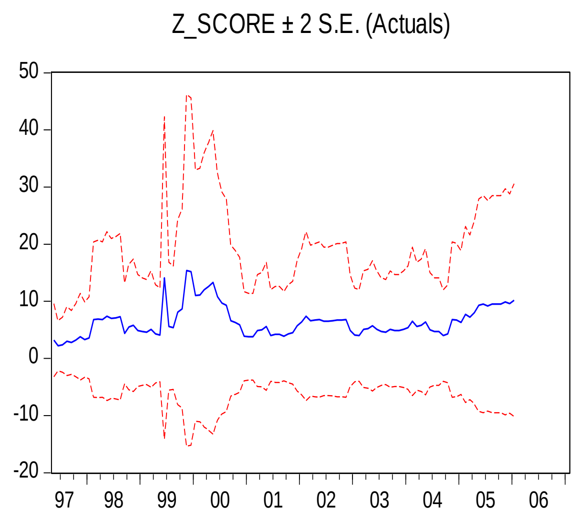


ii) Feb. 2006 – Jan. 2007;

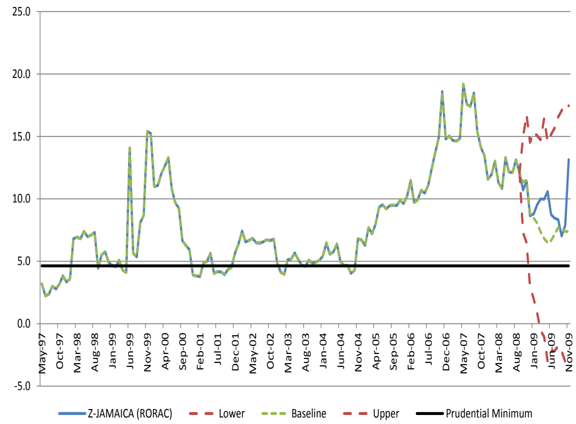


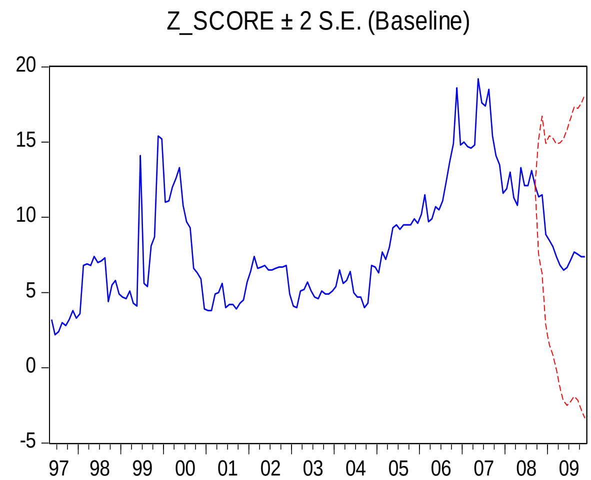


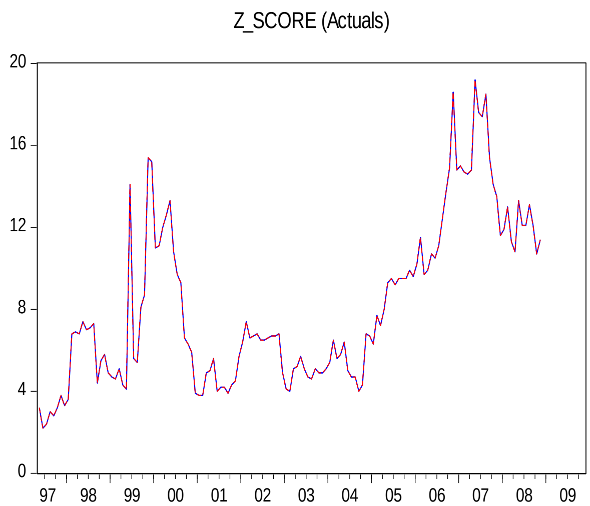


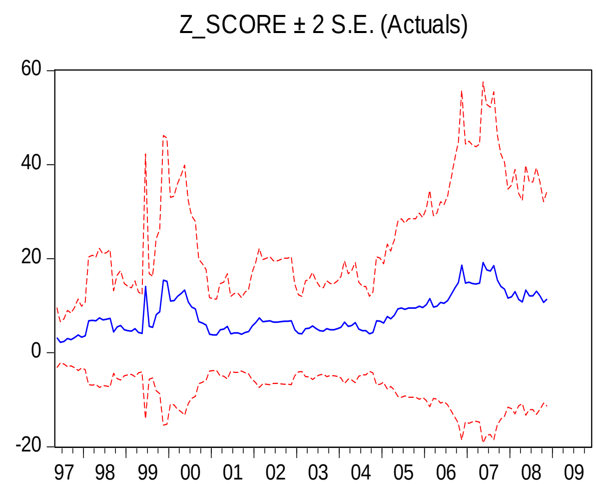


iii) Oct. 2008 – Nov. 2009 (Global Financial Crisis)

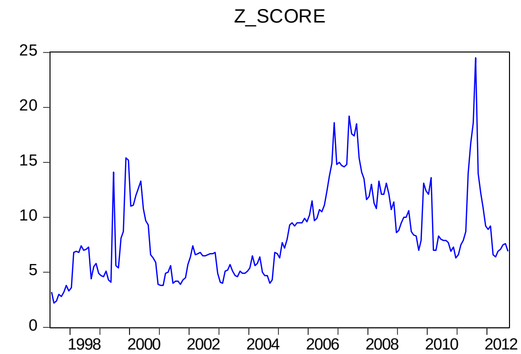


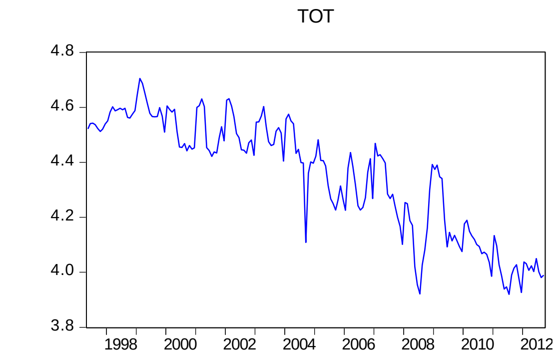


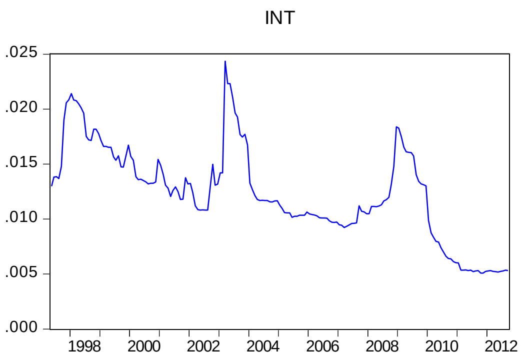


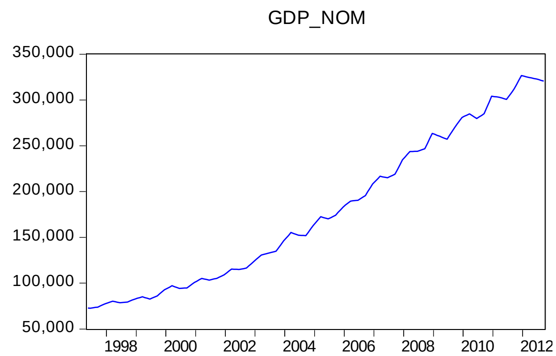


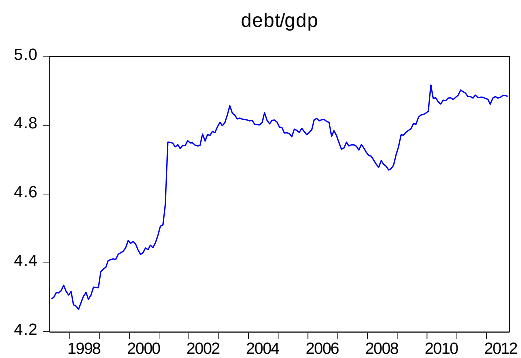
A2. Graphical representation of the variables of Interest











A3. Statistical summary of variables of interest

	Z_SCORE	DEBT_GDP	TOT	INT	GDP_NOM
Mean	8.51	4.35	0.0124	178895.40	4.69
Median	7.40	4.41	0.0118	166195.20	4.77
Maximum	24.50	4.71	0.0244	326569.80	4.92
Minimum	2.20	3.92	0.0051	72722.40	4.26
Std. Dev.	3.95	0.21	0.0043	81967.01	0.19
Skewness	0.96	-0.45	0.2391	0.35	-1.02
Kurtosis	3.84	1.92	2.7310	1.73	2.55
Jarque-Bera	33.91	15.28	2.3205	16.25	33.33
Probability	0.00	0.00	0.3134	0.00	0.00
Observations	185	185	185	185	185

A4. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1583.817	NA	6.53E+01	18.36782	18.45896	18.4048
1	-272.3057	2532.05	2.27E-05	3.494864	4.041678	3.716703
2	-201.071	133.4107	1.33E-05	2.960358	3.962850*	3.367063*
3	-185.8244	27.67303	1.49E-05	3.073114	4.531284	3.664685
4	-166.2247	34.4411	1.59E-05	3.135546	5.049393	3.911982
5	-151.2487	25.45059	1.80E-05	3.25143	5.620955	4.212732
6	-126.1291	41.23675	1.81E-05	3.250047	6.075251	4.396215
7	-70.80155	87.62859	1.29E-05	2.89944	6.180321	4.230474
8	-30.53915	61.4409	1.10E-05	2.722996	6.459555	4.238895
9	-8.759302	31.97734	1.16E-05	2.760223	6.952461	4.460988
10	25.73563	48.65182*	1.07e-05*	2.650455*	7.29837	4.536086
11	47.54486	29.49919	1.14E-05	2.687343	7.790936	4.75784
12	64.36152	21.77416	1.30E-05	2.781948	8.341219	5.03731

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

A5. Unrestricted Cointegration Rank Tests

Null Hypothesis: No Cointegration

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.284284	98.15587	69.81889	0.0001
At most 1	0.116289	37.28189	47.85613	0.3344
At most 2	0.056824	14.78214	29.79707	0.794
At most 3	0.022407	4.134728	15.49471	0.8924
At most 4	5.60E-05	0.010193	3.841466	0.9193

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.284284	60.87398	33.87687	0
At most 1	0.116289	22.49975	27.58434	0.1959
At most 2	0.056824	10.64741	21.13162	0.6823
At most 3	0.022407	4.124535	14.2646	0.846
At most 4	5.60E-05	0.010193	3.841466	0.9193

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

A6. Vector Error Correction Estimates[17]

Cointegrating Eq:	CointEq1				
Z_SCORE(-1)	1				
TOT(-1)	-45.98333				
	-9.6275				
	[-4.77625]				
INT(-1)	942.4918				
	-158.482				
	[5.94698]				
GDP_NOM(-1)	-0.000109				
	-2.30E-05				
	[-4.70595]				
DEBT_GDP(-1)	22.83162				
	-3.0657				
	[7.44745]				
C	91.8055				
Error Correction:	Δ(Z_SCORE)	Δ(TOT)	Δ(INT)	Δ(GDP_NOM)	Δ(DEBT_GDP)
CointEq1	-0.274196	0.006425	-5.88E-05	115.6881	0.000371
	-0.09232	-0.00293	-5.20E-05	-30.7297	-0.00101
	[-2.96997]	[2.18951]	[-1.12529]	[3.76471]	[0.36858]
D(Z_SCORE(-1))	0.0934	-0.005761	4.49E-05	-33.21752	-0.00053
	-0.11154	-0.00355	-6.30E-05	-37.1271	-0.00122
	-0.09616	-0.00306	-5.40E-05	-32.0056	-0.00105
	[-1.30056]	[-1.31232]	[-0.01161]	[-0.08981]	[-1.94736]
D(Z_SCORE(-5))	0.050456	-0.00323	-8.08E-06	-47.4719	-0.00095
	-0.09428	-0.003	-5.30E-05	-31.3827	-0.00103
	-0.09721	-0.00309	-5.50E-05	-32.3567	-0.00106
	[-0.05585]	[0.19255]	[2.10108]	[-1.53792]	[-0.70729]
D(Z_SCORE(-9))	0.068039	-0.001484	1.85E-05	-16.49694	-0.000686
	-0.0991	-0.00315	-5.60E-05	-32.986	-0.00108
	-4.60562	-0.14638	-0.00261	-1532.98	-0.05025
	[-2.19236]	[0.51940]	[-0.37595]	[1.75015]	[0.82405]
D(TOT(-2))	-11.10715	0.047001	-1.84E-05	1837.359	0.063619
	-4.30569	-0.13685	-0.00244	-1433.15	-0.04698
	[-2.57964]	[0.34344]	[-0.00752]	[1.28204]	[1.35429]
D(TOT(-3))	-9.973609	0.068136	-0.001577	1195.239	0.058093
	-3.86955	-0.12299	-0.00219	-1287.98	-0.04222
	[-0.63538]	[0.79654]	[-0.60130]	[0.84803]	[0.54137]
D(TOT(-5))	-10.47803	-0.024815	-0.002454	183.6685	0.048113
	-3.63759	-0.11562	-0.00206	-1210.77	-0.03969
	[-0.62235]	[-0.49964]	[-0.74592]	[2.91345]	[0.89045]
D(TOT(-10))	-2.051413	-0.129241	-0.001153	272.0149	0.016195
	-3.17073	-0.10078	-0.0018	-1055.38	-0.03459
	[-0.64698]	[-1.28243]	[-0.64182]	[0.25774]	[0.46815]
D(INT(-8))	99.37324	3.862813	0.048222	-25980.92	0.280333
	-149.489	-4.75133	-0.08467	-49757.3	-1.63095
	[-0.12672]	[0.53840]	[-1.28564]	[-0.83288]	[-0.47994]
D(DEBT_GDP(-3))	-0.478441	-0.328888	0.004028	-624.29	-0.015866
	-8.49463	-0.26999	-0.00481	-2827.43	-0.09268
	[-0.05632]	[-1.21814]	[0.83713]	[-0.22080]	[-0.17119]
D(DEBT_GDP(-6))	-5.864244	-0.090571	-0.002628	-1627.051	-0.060331
	-8.18865	-0.26027	-0.00464	-2725.59	-0.08934
	[-0.71614]	[-0.34799]	[-0.56667]	[-0.59695]	[-0.67529]
C	-1.921942	0.053396	-0.000543	1095.788	0.017103
	-0.87619	-0.02785	-0.0005	-291.638	-0.00956
	[-2.19353]	[1.91737]	[-1.09458]	[3.75736]	[1.78919]
R-squared	0.348532	0.379438	0.298696	0.920886	0.228197
Adj. R-squared	0.076196	0.120022	0.005528	0.887814	-0.094442

[17] t-statistics in [ ]

A7. Impulse Response Functions