SBP Research Bulletin
Volume 6, No. 1, May, 2010

What Explain Credit Defaults? A Comparative Study

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The paper argues that although key improvements in credit risk modelling have been made - motivated by Basel-II capital adequacy standard - yet the current turmoil in the global credit markets couldn't be forecasted and subsequently avoided. The aim of the study is to investigate the cyclical implications of aggregate defaults in an economy. The approach used here is to construct a macroeconomic credit model that provides a basis to perform scenario analysis. Within this framework, investigation is based on comparing two countries, a relatively immune economy from the current global crisis - Australia and the worst affected economy - USA. The key questions to solve are which macro-economic variables are important for each country and the impact adverse macroeconomic shocks will induce to it. The analysis is based on quarterly data from 1995Q1 to 2009Q2 for both the countries. The results show that the same set of macroeconomic variables indicates different default rates for the two countries and that the US economy is much more susceptible to adverse macroeconomic shocks than Australian economy.

JEL Classification: *G32*
Keywords: *financial stability, credit risk, Basel-II*

1. Introduction

The advent of globalisation has given rise to the kind of risk management innovations that is now embraced by academics, practitioners and central bank authorities alike throughout the world. As a result, the perception about risk at both micro and macro level changed altogether, and since the 1990's we have seen an array of new risk tools being sought after and invented at an ever greater pace. For instance, a key development that took place in June 2004 is the availability of

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a new regulatory framework, Basel II. Although, Basel II doesn't serve as a mandatory standard, it does provide a risk management framework that can identify potential weakness in the financial system and could help us avoid severe discontinuous imbalances in the global economy.

The framework of Basel II makes the overarching theme of this research. Keeping this view, we investigate the macroeconomic determinants of aggregate credit risk and implications for capital requirements by constructing an aggregate credit default model that relies on various macroeconomic variables to explain default rates in the economy. We used quarterly data for 15 years from 1995Q1 to 2009Q2. We confirm the findings of the previous studies in the case of the level of economic activity and total indebtedness as meaningful indicators of aggregate default. Other indicator, i.e., level of industrial activity failed to explain default as in the case of previous studies conducted in this domain. Our investigation also reveals that the US economy is, ceteris paribus, more susceptible to adverse macroeconomic shocks than does the Australian economy.

The research is organised as follows. Section 2 outlines the literature on the topic. Section 3 presents information on data, model specification and estimation. Section 4 discusses the empirical results and the last section gives conclusion and discusses the potential for future research in this area.

2. Literature review

For several decades leading up to early 1970s, there was relatively little interest paid to financial stability (Goodhart, 2005). That all changed as a result of the mid 1970s banking crisis in Europe and the failure of Franklin National Bank in the US, when the Basel Committee on Banking Supervision (BCBS) was formed, and it put in place in 2004 the Basel II standards relating to financial stability (FS). It is important that national supervisors (say central banks) and academia work in a cohesive manner to explore issues relating to the inter-linkages between portfolio risk and macro risk from the FS point of view. According to Goodhart, of the two main objectives of a central bank authority, FS remains a challenge to measure and forecast. While there remain a broader consensus between practitioners and academics on the issue of price stability, the need exists to do a lot more on the financial stability front. The current global financial crisis has once again highlighted the complex nature of the latter objective.

In the study of financial crisis caused by some 'discontinuous' Alexander and Sheedy (2008, p. 102) imbalances in the economy, credit risk modelling takes centre stage. Firstly, in its own right to be used for efficiently allocating capital to most productive uses according to the regulatory regime of Basel II, and secondly, as a means to forecast the build up of a potential financial crisis. Financial crisis can also be analysed by their inherent dynamics. According to Mishkin (2009) financial crises develop as a result of severe contraction in the capital markets characterised by financial institutions failures and sharp decline in asset prices. Asymmetric information resulting in 'adverse selection' and 'moral hazard' explain the later freezing of credit markets once a crisis has been set in motion. Starting in mid-2007, defaults in the sub-prime mortgage market sent a 'bad news' signal to the financial markets, ultimately ending up in the worst financial crises since the Great Depression of the 1930s. Allan Greenspan, former Chairman of Fed., called it as the 'once-in-a-century credit tsunami.' Although, low in intensity to the current global financial crises (GFC), the world has experienced quite a number of them in the past. So, what exactly is different about the current GFC is a question, and one of particular importance, that academics and central bank authorities are now trying to answer. With many financial institutions going bust and significant stall in the credit markets, this sub-prime crisis has completely changed the outlook of money and financial markets (Mishkin 2009). As a result, the study of money and banking has completely changed and in need of a complete overhaul.

Various studies have been conducted in this domain. The study by Jakubik and Schmieder (2008) investigates the issue of credit risk modelling under a top-down approach. They've realised credit risk analysis by means of carrying out a stress test exercise. The study compares two countries, a transitional economy (Czech Republic) and a developed economy (Germany) and investigates the macro determinants of defaults in these two countries. Quarterly data is employed and observation for Czech Republic are for 8 years (1998-2006) and 12 year for Germany (1994-2006). The time horizon is selected because it includes several severe crises (e.g. the 1997 Asian crises). They carry out their research in three stages: First, they construct separate macroeconomic models for corporate and household sectors of both countries by employing different specifications. Different diagnostic tests were performed to validate the results. In the second stage, they perform a stress test using various scenarios[1] and lastly, they construct a micro driven hypothetical credit portfolio as normally done under Basel II minimum capital requirements and induce the result of stress tests to compare vulnerability of the financial system of each country. Separate credit models are constructed for corporate and household sectors of Czech Republic and Germany.

[1] They have used a moderate (10 percent) change, a severe (20 percent) change and an expert judgement scenario. Change here refers to one in the unfavourable direction only.

The results on the average validate the previous studies, however, more promising is the corporate sector modelling; the household sector model doesn't exhibit broad explanatory power, which needs obvious improvement.

In the case of corporate model, a macroeconomic shock of moderate severity (10 percent change) has greater impact on the Czech economy (more than 100 percent increase in default rates and 60 percent increase in capital requirement) than the German economy (40 percent increase in default rates and only 30 percent increase in capital requirement). Although the study provides broader implication for credit risk, the selection of scenarios for stress tests performed to capture adverse macroeconomic shocks are based on arbitrary selection rather than basing them on sound macroeconomic foundations. Selection of stress scenarios on this basis are devoid of explanatory power and Alexander and Sheedy (2008, p. 7) has termed them 'ad hoc methods of stress testing.' This results in many extreme but realistic scenarios being ignored. It is, therefore, necessary to investigate fat tails distribution of default events. According to Basel Committee on Banking Supervision (2004, p. 89), an IRB[2] bank must have in place sound stress testing processes for use in the assessment of capital adequacy. Stress testing must involve identifying possible events or future changes in economic conditions that could have unfavourable effects on a bank's credit exposures and assessment of the bank's ability to withstand such changes. Examples of scenarios that could be used are (a) economic or industry downturns, (b) market-risk events, and (c) liquidity conditions.

Alfaro and Drehmann (2009) have carried a critical research on the validity of stress tests. They have studied 43 crises in a group of 30 countries and found out some interesting facts that underline the importance of not mis-specifying the model based approaches of stress tests. The current crisis has underscored the importance of applying a holistic macro-prudential approach to financial regulation instead of only a micro-driven evaluation of risk. Measuring risk of individual financial institutions and then aggregating it to assess system-wide vulnerability in the economy can hardly simulate a real world scenario. They have cited various problems with stress testing approaches. The failure of these methodologies is often associated with ignoring intra- feedback and inter-feedback effects of an economy. The majority of macro stress tests also use domestic indicators of risk; while cross-border effects of contagion pose important implications for credit risk. Scenarios based on historical perspective do not necessarily translate into an ex-ante estimation of system-wide risk. In their

[2] IRB stands for internal ratings-based approach used for credit risk under the Basel II regulatory framework.

research, model robustness check being imperative for any stress testing scenario reveals that in the majority of the cases (about 65 percent), the hypothetical relationship fades away especially at the onset of a financial crises. Stress tests design should possess judgment based scenarios apart from working out merely a statistical relationship among determinants of default risk.

Apart from the several issues that can arise along with designing scenario-based stress tests, they hold good promise for the future development in the area of credit risk management. The importance of stress tests has also been underlined in various research papers of Basel committee on banking supervision (BCBS). They particularly mention it as an important risk assessment and control mechanism used by banks as part of their own risk models and in their regulatory environment. It has been found to provide an ex-ante assessment of system-wide risk and ability to overcome shortcomings of models that primarily rely on replicated data[3].

This study provides a basic framework for stress-testing exercise of the financial system. The importance of this exercise is underlined by Lopez (cited in Alexander & Sheedy 2008), as a means to assess the potential vulnerability of the financial system. On an ex-ante foresight, the journal of Wall Street & Technology (1999) reported Alan Greenspan, the former Chairman of Federal Reserve (US) emphasizing the importance of stress tests as one of delegating the responsibility of risk management to the incumbent institutions and a limited role for the regulatory authorities in the domain of risk management. The stakeholders are to adapt a new way of thinking about portfolio diversification and consider adverse events which may not be seemingly correlated and statistically significant. Scenario analysis can point in the direction of declining asset quality and problems associated with liquidity. According to Alexander and Sheedy (2008), stress tests are used to analyse distribution of losses under a typical value at risk (VaR) scenario. The overarching theme of this research is that it provides a direct comparison of the US and Australian economies.

3. Data and model specification

Quarterly time series data for the following variables (for a period from 1995Q1 to 2009Q2) obtained for both countries.

[3] For a good discussion of replicated models like Monte Carlo simulation see "An introduction to value-at-risk" by (Choudhry 2006, p. 102).

- Default rate
- Gross domestic product (s.a.)
- Interest rate (6-m Treasury Bill)
- Industrial production (indexed s.a.)
- Debt-to-GDP ratio

We outline the two main approaches to modelling default risk. The first approach is what is attributed to Merton (1974), Wilson(1997a, 1997b) and called a 'structural approach'. Wilson (1997a) has tried to explore the many questions associated with the financial innovations i.e. how to measure risk on an aggregate level and especially of the derivative products. It identifies expected loss and threshold capital as the two most important parameters for capturing credit risk. Pricing of credit risk of derivative products is much more complex than conventional instruments. The assumptions are the following.

- Actual loss distribution instead of normal distribution is assumed. The shape of the distribution (in this case skewed and multinomial) is important consideration as it tends to be dynamic and a function of degree of portfolio concentration and changes to the portfolio mix.
- For the first time, loss(gain) are measured on a discounted basis, and marked-to-market for credit exposures that are illiquid; and
- The loss distribution takes account of the current state of the economy rather than relying only on the ex-post averages. This might under/overestimate the actual extent of risk.

Here, average default rate is related to the state of economy, being proxied on GDP and unemployment rate, i.e., *df* = *f*(*GDP*, *u*). Where *df* represents probability of default, and *u* is the unemployment rate. The results show that default rate is well explained by these variables, sectoral differences, however, might be present. Such a probabilistic model can well be represented by a logit form as follows:

$p_{\mathrm{j,t}} = \dfrac{1}{[1+\exp(yj,t)]}$, where $p_{\mathrm{j,t}}$ denotes probability of default of a counter party in segment *j* and time *t*, $y_{j,t}$ is segment specific index of the macro economy.

The second strand of models involves pricing of credit derivatives from the term structure of interest rates[4]. This approach is termed "reduced form". In the reduced-form model, the relationship among indicators tends to significantly weaken as evidenced from both theory and practice (Alfaro & Drehmann, 2009).

[4] See also (Jarrow & Turnbull 2000).

This is because these models are based on the assumption that abrupt change in the behaviour, i.e. change in the macro fundamentals or speculative bubbles causes financial crises. According to Cihak (2007) the most popular credit risk model is that of Merton (1974), which considers default as an option, which is exercised if asset return falls below a certain threshold.

$$P\ (Y_{it} = 1) = P\ (R_{it} < T) \quad (1)$$

Where Y denotes a binary variable with two possible states; borrower defaults (1), no default (0), respectively. R_{it} denotes asset return, T is the default threshold.

Credit risk is the most important aspect in the study of financial stability. This is underlined by Lange et.al (2007, p.556) 'credit risk is still more likely to cause a financial institution to fail than either interest rate risk or foreign exchange risk. While other risks types are important, the focus of this study will be credit risk. In this regard, while Merton (1974) is useful, Wilson (1997a, 1997b) explains default as a logit function of a vector of various macroeconomic factors. The generalisation of Jakubik and Schmeider (2008) model for estimation of default would take the following form.

$$df_t = \alpha + \Sigma\beta_i X \quad (2)$$

Where df_t denotes the response variable of the model; and defined as ratio of non-performing loans to total loans. β_i is the coefficient vector and X is the vector of the macroeconomic variables and α is a constant. Previous studies have found various macroeconomic variables to be useful determinants of credit risk (Virolainen 2004). However, relatively very few macroeconomic factors can explain credit risk in a rational manner, including in time of financial downturns.

This study has found GDP, interest rate, industrial production; and the level of debt as useful macroeconomic factors in the context of financial stability. The choice among the aforesaid models would however, be based more on an interactive stress-testing process, involving both the banking sector and the regulatory regimes and less on the complexity involved in the models (Haldane, Hall & Peziini 2007). We have estimated the following model by ordinary lest square for the economies of USA and Asustrlia.

$$df_t = c + \beta_1 ir_{t-1} + \beta_{2,1} gdp_t + \beta_3\ indprod_{t-3} + \beta_4\ debt_{t-4} + \varepsilon \quad (3)$$

The time series data used in the estimation was assumed to be stationary. The Augmented Dickey-Fuller test also indicates the same result. The other diagnostic tests validate the results of the above model. The issue of autocorrelation was addressed by running a weighted routine instead of equal weighting for each observation.[5]

4. Empirical results

Case of Australia

Table 1 describes the variables used in the model along with their time lags, coefficients, significance levels and the standard errors. The Australian Growth variable is highly significant and negatively correlated with the default rate. The short-term interest rate (nominal) has a negative coefficient, but is insignificant and so is the cyclical indicator industrial production. The level of debt in the Australian economy as indicated by the debt-to-GDP ratio is positively correlated with the default rate, *df* and is highly significant. The fit of the model as indicated by adjusted R^2 is significant in explaining the default rate.

Table 1. Credit risk estimation for Australia

Dep. Variable: default rate

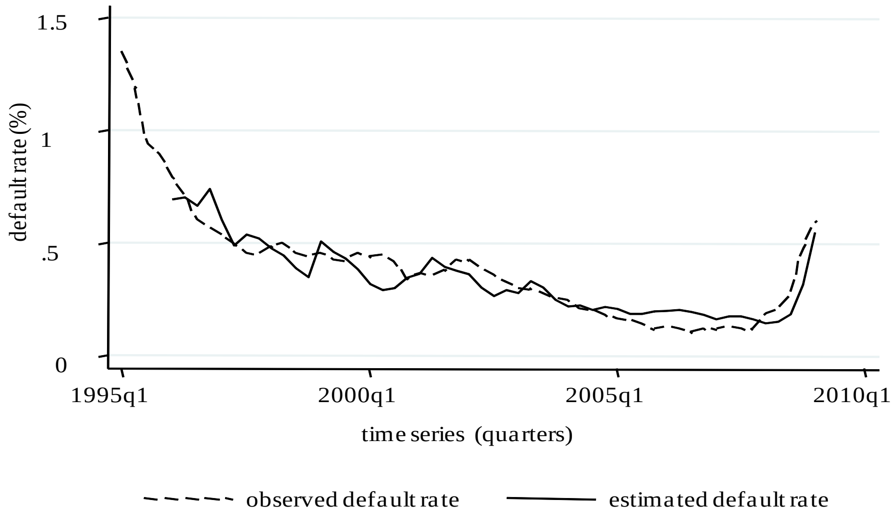
Regressors	Estimated parameters	
GDP	-6.00E-06	(7.52E-07)
Interest Rate (lag 1)	-0.053	(0.036)
Industrial production (lag 3)	0.041	(0.015)
Debt-to-GDP ratio (lag 4)	1.119	(0.172)
Adj R^2	0.83	

Figure 1 shows the performance of our modelling for default rates for Australia over the period 1995Q1-2009Q2. The graph indicates that non-performing loans (NPL) initially fall rapidly until the beginning of the new millennium, they then declined slowly until early 2005 after which default rates began to accelerate in its rate of decline until the end of 2007, after which they again increased rapidly until the middle of 2009. The onset of the rapid expansion in the availability of household credit over the latter period of our study has clear implications for default rates over this period as indicated by an increase in default rates from 0.2 percent (mid-2007) to 0.7 percent at the peak of the global financial crisis in mid-2009. The late nineties clearly indicate a rapid decrease in default rates as given

[5] Baum (2006) provides a good resource on weighted models.

by a decline from 1.5 percent in beginning of (1995Q1) to a low level of 0.2 percent (Q2-2007). The former period followed the recession of the latter half of the nineties.

Figure 1. Observed and estimated default rates in Australia



Case of USA

Table 2 indicates the relevant variables used in the estimation of the model for the US economy over 1995Q1-2009Q2 along with their coefficients, lags, significance levels and standard errors. The GDP variable for the US economy as expected has a negative coefficient with default and is highly significant in explaining aggregate default rate over the period. The nominal interest rate and industrial production variables are both insignificant indicators. The level of debt represented by the debt-to-GDP ratio on the other hand has a positive sign and is highly significant in explaining the default rate for the US economy. The fit of the model indicated by the adjusted R^2 is significantly higher in the case of the US than that for Australia.

Figure 2 shows the performance of the macroeconomic model of default for the US economy where the default rate is plotted along the y-axis and time against the x-axis. The fit of model looks promising as the estimated graph (dotted) closely tracks the observed (delinquency rate). The graph clearly shows an increasing trend, as it remains flat at 2.5 percent from the beginning until 2001 and spikes before going down to its lowest level of 0.6 percent at the end of 2005, rising again sharply to its highest level of 6.5 percent during the peak of GFC in mid-

2009. The model also has good predictive power as we can see the estimated inflow of default has risen above the observed delinquency rate in 2009.

Table 2. Credit risk estimation for USA
Dep. Variable: default rate

Regressors	Estimated parameters	
GDP	-1.98E-06	(1.22E-07)
Interest Rate (lag 1)	-0.015	(0.010)
Industrial production (lag 3)	0.011	(0.005)
Debt-to-GDP ratio (lag 4)	6.248	(0.290)
Adj R^2	0.9	

Figure 2. Observed and estimated default rates in USA

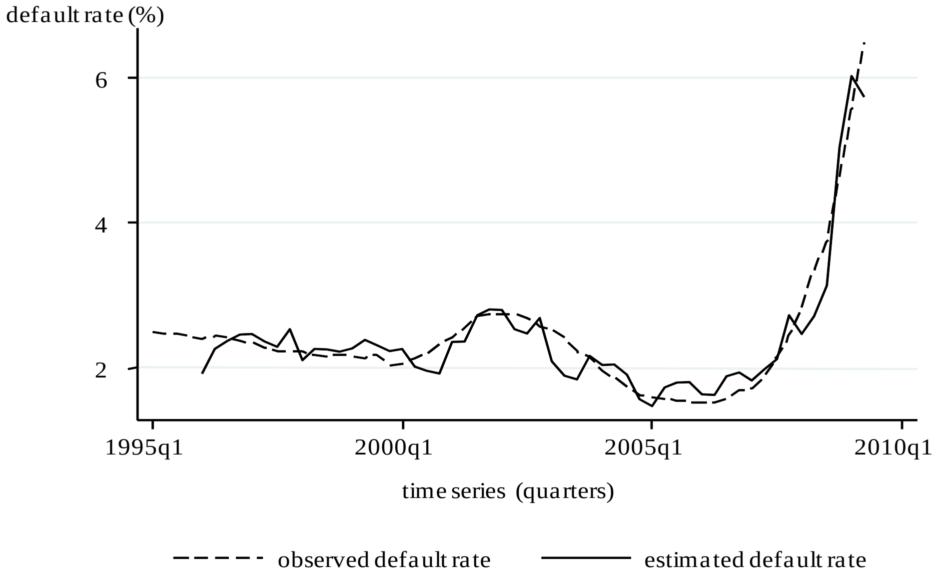


Table 3 shows elasticity for both countries. As the relationship among the variables is non-linear, a caution is in order to explain the effect of independent variables on the default rate. In this case, the mean elasticity approach is utilised to overcome the problem of how one explains elasticity in the context of a non-linear model. As we observe from the table below, GDP is negative for both economies; we also find that the US default rate is much more sensitive to adverse macroeconomic shocks than in the case of Australia. Similarly, a relatively large coefficient for our debt variable for the US only shows more sensitivity to default rates than in the case of the Australian economy. This was particularly evident from the toll the recent financial crisis has taken on the US economy.

Table 3. Elasticities of default rate w.r.t. key macroeconomic variables

	USA Case	Australia Case
GDP	-3.77e-06	-4.72e-08
Interest Rate	-0.029	-0.0002
Industrial Production	0.021	0.00015
Debt-to-GDP	11.92	0.0013

The elasticity calculated here is corresponding to the coefficients of the estimated parameters of the model. Economic expansion will influence default rate for the aggregate economy as demand for goods & services increase. Accordingly, increase in profitability decreases default rate. GDP with a positive coefficient turned out to be a significant factor in explaining default risk in the case of both countries. This is consistent with the view of Moody's (cited in Jarrow & Yu 2001) reports on historical default rates that argues that cyclical indicators are highly correlated with the number of defaults, the number of credit rating downgrades and credit spreads. Regarding debt-to-GDP ratio, weakness in the aggregate economy would depend on level of indebtedness. The magnitude would thus, depend on the correlation between leverage and probability of default. This will occur in the case of macroeconomic shock like debt-to-GDP ratio. As expected, debt has a positive effect on default rate in the case of both models[6].

Although, interest rates generally have a positive influence on default risk, this was not the case here. This is so because we have used short-term (6-month) interest rates instead of longer-term interest rates. This view is also expressed in a recent study by the German Central Bank. 'The one-year interest rate, by contrast, reflects the economic setting; its sign is therefore negative (Deutsche Bundesbank 2009, p. 59). Unlike other factors, industrial production being cyclical and forward-looking variable is significant, but has an unexpected positive influence on the default rate.

5. Conclusion and future prospects for research

In this study we have found that GDP, short-term interest rates and total indebtedness explained default risk in a more meaningful way than industrial

[6] The alternative argument by Grossman and Hart (cited in Lange et al., 2007) states that flip side of high leverage may be managerial efficiency which can lead to a reduction in the level of default risk.

production did. Default rate for the US economy is, ceteris paribus, much more sensitive to changes in GDP, interest rates and total debt than in the Australian case. We plan to further expand this research by exploring the preposition how credit risk model can be used for macro stress testing. The key question however, will be how to select scenarios – simulation like Monte Carlo holds a good prospect here. This exercise is useful in the context of both ensuring financial stability as a welfare goal of state regulators and for Basel II on a micro level. This exercise would allow simulating various scenarios to help regulators identify and manage potential vulnerability in the financial system. However, as default data generally is available only recently especially in the case of developing countries, this seems to be a major hurdle in carrying out this research. One possibility is to use other credit risk parameters namely, probability of default, exposure at default and loss given default.

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Appendix: Definition and Sources of Variables

Case of Australia

- Interest rate is measured as money market bank accepted bill,180 days maturity, percentage , p.a.(source: Reserve Bank of Australia).
- GDP is measured as quarterly levels in million of US$ (converted) seasonally adjusted (source: Australian Bureau of Statistics).
- Industrial production is seasonally adjusted, indexed to year 2005 (source: International Finance Statistics of IMF).
- Debt-to GDP ratio represents ratio of total loans and advances of all financial institutions to GDP (Source: Reserve Bank of Australia).
- Default rate is measured as ratio of provision on bad debts to total loans and advances of all financial institutions (Source: Statistics Bulletin of Reserve Bank of Australia).

Case of USA

- Interest rate is measured as market yield on US Treasury notes at 6-month constant maturity, quoted on investment basis (source: Federal Reserve Board, USA).
- GDP is measured in million of US$ at current prices, quarterly levels, seasonally adjusted (source: national accounts set of OECD stat).
- Industrial production is measured as production of total industry, seasonally adjusted and indexed to year 2005 (source: main economic indicators of OECD stat).
- Debt-to GDP is measured as all interest bearing loans and leases, quarterly average of all commercial banks, Million of US$ (Source: Federal Reserve Board, USA).