

Banking Crisis in Japan: Prediction of Non-Performing Loans

Introduction

It was not until 1991, that Japanese bankers first warned their government of an impending Japanese banking crisis. So secret were these internal deliberations and so closely held were the grim statistics that only the keenest of outside economic analysts grasped the dimensions of the challenge facing Japan.

Japan's language and culture provided an ideal cloak for secrecy. Still this conscious pattern of concealment could not be prolonged. By 1995, the magnitude of the crisis became clear. The Japanese banking system held some 70 trillion yen in bad loans. Of the top twenty-one Japanese banks, thirteen were effectively bankrupt.¹

When international analysts finally began to probe the real state of the Japanese banking system, they found Japan's non-performing loans to be from 50 to 80 trillion yen. One pessimistic analyst estimated that problem loans would climb to 100 trillion yen by 1995.²

Japan's success in hiding the problem served only to magnify the impact once the facts emerged. As world economic analysts studied the available data, they identified bad underwriting as the key factor causing the banking crisis. It is the task of underwriters not only to assess the risk of each individual loan but also to ensure that the bank has a balanced portfolio, with the risk spread across many sectors. Excessive concentration of loans in any one sector exposed the banks to heavy losses. Japanese banks held heavy concentrations in real estate loans. When the real estate market crashed (residential property values fell 30 percent) mortgage delinquencies and defaults rose and the value of the assets held by Japanese banks dropped accordingly. With liabilities continuing to grow and asset values declining, the thinly capitalized banks had trouble maintaining positive cash flows. Several banks probably should have been closed by the regulators. Japanese regulators appeared to be caught unaware that this problem could occur and did little to rectify it when it became obvious. The banks continued to engage in business and suffered additional losses.

Non-disclosure and a lack of transparency resulted in domestic and international uncertainty about the soundness of the Japanese financial system. As a result, Japan came under intense international pressure to take decisive action to solve the non-performing

¹ See Ulrike Schaede, "The 1995 Financial Crisis in Japan", School of International Relations and Pacific Studies (IR/PS) BRIE Publication: Working Paper-85, (February 1996), pp.1

² See Dick K. Nanto, specialist in Industry and Trade Economics Division, "Japan's Banking Crisis: Causes and Probable Effects", (Congress Research Report 95), (October 6, 1995), pp.34

loan problem. However, the Japanese government resisted these pressures and as late as 1995 an international Monetary Fund report, criticized Japanese authorities for their lack of action in coping with the challenge.

During the early 1990's, asset deflation cut into the profitability of Japanese financial institutions. Although a drop in real estate values was the chief culprit, the problem was compounded by losses in the banks' large equity holdings coupled with a period of slow growth and recession.³ During this period, the yen appreciated with an adverse effect on the export-dependent economy. The slowdown in the economy caused such a rise in unemployment that by December 2001, the unemployment rate rose to 5.6% the highest since the Second World War.⁴ In real terms, this meant that one million heads of households were thrown out of work.

Despite the heavy price Japan has paid for its lack of candor, secrecy continues to haunt the Japanese regulatory and banking system. Market discipline depends upon transparency. Lack of transparency mutes risk signals and undermines the efficiency of the financial sector. In addition, it does little to inspire confidence in the international financial community. Better planning and timely precautionary measures might have prevented a bad situation in the 1980s from becoming worse in the 1990s.

This analysis takes the investigation into the issue of non-performing loans one step further, by asking why policy makers and regulatory authorities could not have anticipated the banking crisis. Had Japanese analysts recognized the problem in a timely fashion and had they recommended prompt remedial action, the crisis might have been alleviated or perhaps averted entirely.

Toward this end, this thesis demonstrates that an econometric model of non-performing loans, estimated on data during the 1980s, could have provided bank regulators with sufficient information to allow them to anticipate the banking crisis. A simple analysis of their banks' portfolios, the ratio of assets to liabilities and the state of the economy provides an early warning system that provides reasonably accurate out-of-sample predictions. With this information in hand, policy makers could have explored steps necessary to lessen the impact of non-performing loans on the economy.

³ See Thomas Cargill, Michael Hutchison and Takatoshi Ito, *"Big Bang Financial Deregulation: Implications for regulatory and Supervisory Policy"*, Center for Pacific Basin Monetary and Economic Research Department, Japan Information Access Project, (June, 1997), pp.3

⁴ See The Economist, Global Agenda, "Non-Performing Country", February 15,2002, pp.1

I. Background:

In The End of History and the Last Man, Francis Fukuyama speaks of, “The phenomenal economic growth” in countries “willing to adopt market principles and integrate themselves fully into the global, capitalist economic system.”

Fukuyama sees a clear link between democracy and economic progress, but praises culturally authoritarian societies like Japan that seem to achieve growth through a mixture of government and private sector risk sharing. Such societies reward group loyalty and investment excluding some firms and rewarding others because, the government believes, those firms have an advantage over competitors. This exclusion and pre-selection, he argues avoids destructive competition and gives Japan an advantage over open societies organized around individual initiative and marketplace competition. His conclusion seems to be refuted by the events leading up to the Japanese banking crisis.

In the wake of World War II, Japan established a democracy under the watchful eye of General Douglas McArthur, and the American occupation. Yet so great was Washington’s fear of socialism that the United States encouraged the establishment of what amounted to a single-party political system. With Washington’s help, the liberal Democratic Party has controlled the Japanese government since 1955, reducing the socialist party to the role of permanent opposition.

Japanese authorities established a financial system designed to encourage massive household savings, and then channel those savings to strategic industries under government direction. The state controlled financial system directed savings to business investment and public sector capital investment in infrastructure. Financial institutions and financial markets were fragmented, regulated, segmented, and protected to reduce competition among banks and firms, reducing some risks while increasing others and facilitating government control.

In Japan, the checks and balances of a two-party system had the potential to play an important role in limiting the excesses of Keiritsu, the relationships that dominate Japan’s industrial system. In this arrangement, one main bank or general trading company presides over a limited number of firms that produce large volumes of similar goods and services—a circumstance that tends toward explicit and implicit cartels, price-fixing, and other abuses. The consequence of this closed system was an institutionalized corruption that when it was finally revealed in 1992-1993 shocked both the citizens of Japan and the entire world.

Yet, for the forty years (1945-1985) following World War II, Japanese bureaucrats presided over rapid economic growth that brought unprecedented prosperity not only to

Japan but also to most Asian nations, in particular the four tigers, Hong Kong, Singapore, Malaysia and Taiwan.

In the late 1980s, Japan threatened to eclipse America as the economic model for the world. Analysts dubbed the cooperation between Japan's government and its business world "Japan Inc." This term connoted a system that ran cleanly and efficiently, managed not by politicians but by an anonymous horde of highly educated, mandarin bureaucrats. The truth was quite different.

Complacency combined with corruption to produce a "public works state." The cure for every problem became government subsidies to large-scale construction projects. Yet as expenditures were climbing, the government's revenues were sinking. By the mid-1980s, the national debt was close to half of its GNP, and the interest on the national debt, the government's largest expenditure.

Waves of corruption swallowed up successive Japanese prime ministers and governments. In 1989, U.S. negotiators seeking greater access to Japan markets attacked Japan's machine-style politics, the cozy ties that exist between government and industry, and the lack of transparency in governmental decisions.

Although there was a slow recovery, economic growth still averaged less than 1 percent for the years 1989 and 1990. The Japanese economy fell into recession in 1991 and never recovered after the bubble burst. The impact of the investment banking system on the entire economy has lasted throughout the 1990's and into the present day. If the investment bankers and the Japanese government had faced the problem instead of trying to salvage the situation with talking heads and public relations experts, the economic crisis might have been alleviated. Although the banking system is the underlying cause, the government bears the ultimate responsibility for the longevity of the economic crisis in Japan. As several experts point out, political courage has been in short supply in Japan. The economy stagnated in good part because the Bank of Japan did not divulge their non-performing loans. Twenty years after the onset of the crisis, Japanese banks are still waiting for a recovery of their asset prices. This passivity in the face of a serious financial crisis makes no economic sense. It provides a dramatic example of the impotence of Japan's bureaucracy when faced with political and administrative obstacles.

As SAM JAMESON points out in his speech in 1998, "Systemic disruption in Japanese's financial markets caused critical damage and loss of creditability to every firm in the supply chain for a given industry, and across industries globally. The banking crisis continues to expand -- at least of the actual amount of bad loans written that the Finance Ministry is finally acknowledging. After years of assurances that the bad loan problem was "over the peak," the ministry suddenly announced in January 1998, that the bad loans amounted to 77 trillion yen, or 3.5 times, what the ministry had acknowledged until then. (Actually, the new official total came to 83 trillion yen, including bad loans that smaller banks had disclosed earlier in a separate announcement)."

“Even after the new announcement, analysts charged once again that the real amount of bad loans was probably still bigger -- perhaps 110 trillion yen, as suggested by former Chief Cabinet Secretary Seiroku Kajiyama in a conversation with newspaper editors a week after the Finance Ministry announcement. As a reference, 77 trillion yen amounts to 15.2% of Japan's 1997 GDP of 507.3 trillion yen, (110 trillion yen is 21.7% of the 1997 GDP). Bad loans in other crisis-stricken Asian countries range between 20% and 25% of the GDP.”⁵

According to Yasuhisa Shiozaki, a member of Koizumi's Liberal Democratic party and a former Bank of Japan official in 2000, “Japanese banks and other deposit-taking institutions' problem loans add up to the equivalent of 8.8 percent of the country's GDP. At the height of the U.S. banking crisis of the early 1990s, doubtful loans came to less than 3 percent of America's GDP, Japan's bank-loan crisis is thus a far bigger threat to the country's stability than was the U.S. banking crisis to America's.”⁶

⁵ See Sam Jameson (Nihon no Sesō o Kiru) “*Cutting Open Japan*”, Speech to Chiinkai Imperial Hotel, Tokyo [US-Japan Links: Resources](#), (June 11, 1998), pp.1

⁶ See Charles Smith, “*Solving Japan's bad-debt crisis is the key to reviving its moribund economy. So why won't the Koizumi government get serious?*”, Institutional Investor, New York, (Nov 2001), pp.3

It is helpful to review Table-1 for a detailed understanding and status of non-performing loans. The table provides yearly data 1992 through 2001 for loss on disposal of bad loans, risk management loans and outstanding amount of allowance for loan loss.

Table-1
Status of Non Performing Loans for All Banks: Loss on Disposal of Bad Loans

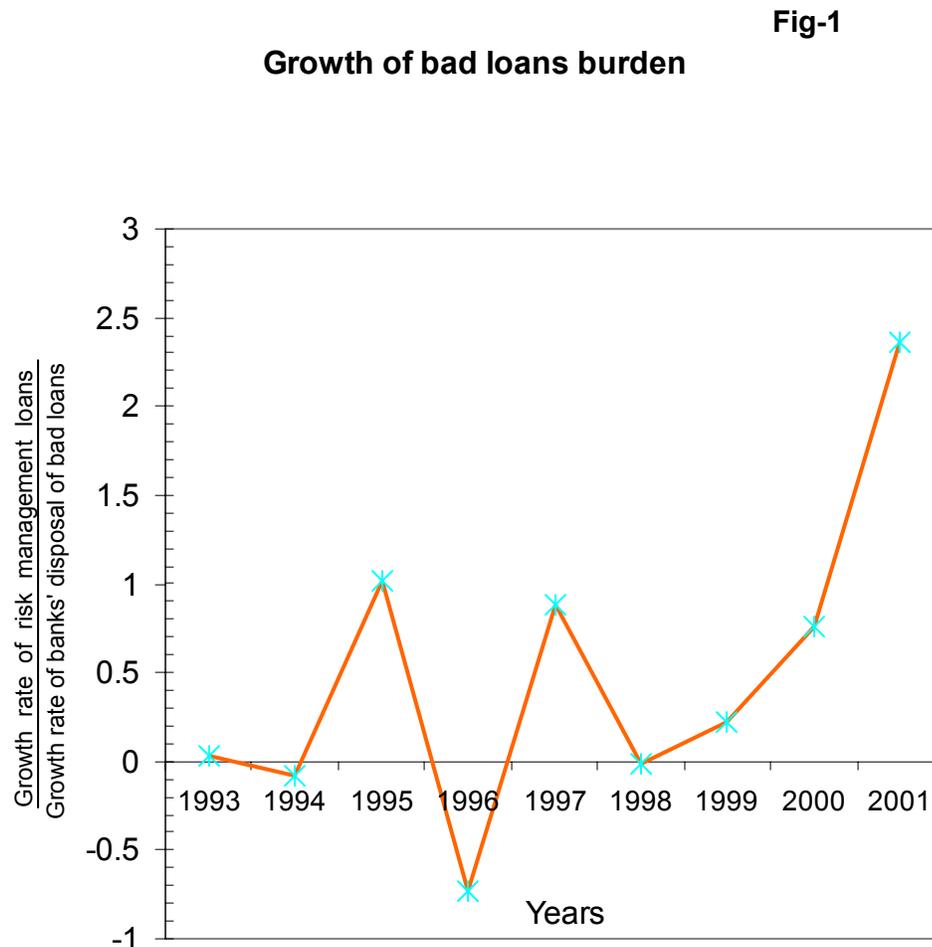
	(billion yen)									
	FY1992	FY1993	FY1994	FY1995	FY1996	FY1997	FY1998	FY1999	FY2000	FY2001 Sept
Loss on Disposal of Bad Loans	1,640	3,872	5,232	13,369 [11,067]	7,763 [6,210]	13,258 [10,819]	13,631 [10,440]	6,944 [5,398]	6,108 [4,290]	2,955 [2,046]
Net Transfer to Allowance for Loan Losses	945	1,146	1,402	7,087 [5,576]	3,447 [2,534]	8,403 [6,552]	8,118 [5,490]	2,531 [1,339]	2,732 [1,371]	1,491 [875]
Direct Write-offs	424	2,090	2,809	5,980 [5,490]	4,316 [3,676]	3,993 [3,501]	4,709 [4,268]	3,865 [3,609]	3,072 [2,650]	1,322 [1,059]
Write-offs of Loans	204	235	706	1,721 [1,568]	973 [850]	851 [791]	2,377 [2,255]	1,881 [1,734]	2,520 [2,201]	1,199 [958]
Loss on Sales to the CCPC	219	1,855	2,103	2,526 [2,132]	1,133 [971]	1,043 [921]	359 [339]	278 [272]	163 [156]	57 [53]
Loss on Sales through Bulk Sales etc.	0	0	0	1,733 [1,791]	2,210 [1,855]	2,099 [1,789]	1,973 [1,674]	1,706 [1,604]	389 [293]	67 [49]
The Others	271	636	1,022	302 [1]	0 [0]	863 [766]	804 [683]	548 [449]	304 [269]	142 [111]
Aggregate from FY 1992	1,640	5,512	10,744	24,113 [21,811]	31,877 [28,021]	45,135 [38,840]	58,766 [49,280]	65,710 [54,678]	71,818 [58,967]	74,773 [61,013]
Aggregate of Direct Write-offs	424	2,514	5,322	11,302 [10,812]	15,618 [14,488]	19,611 [17,988]	24,320 [22,256]	28,185 [25,865]	31,256 [28,515]	32,578 [29,575]
Risk Management Loans	12,775	13,576	12,546	28,504 [21,868]	21,789 [16,441]	29,758 [21,978]	29,627 [20,250]	30,366 [19,772]	32,515 [19,281]	35,673 [21,754]
Outstanding Amount of Allowance for Loan Losses	3,698	4,547	5,536	13,293 [10,345]	12,334 [9,388]	17,815 [13,601]	14,797 [9,258]	12,230 [7,678]	11,555 [6,939]	11,564 [6,907]

(Note)

1. For FY 1992 to FY 1994, above data are composed of City Banks, Long-term Credit Banks and Trust Banks. Figures in [] refer to the amount of City Banks, Long-term Credit Banks and Trust Banks.
2. Hokkaido Takusyoku Bank, Tokuyo City Bank, Kyoto Kyoei Bank, Naniwa Bank, Fukutoku Bank, and Midori Bank are excluded from FY 1997 onward. Kokumin Bank, Kofuku Bank and Tokyo Sowa Bank are excluded from FY 1998 onward. Namihaya Bank and Niigata Chuo Bank are excluded from FY 1999 onward. Ishikawa Bank is excluded from FY 2001 Sept. Long-term Credit Bank of Japan (Shinsei Bank at present) is excluded from FY1998. Nippon Credit Bank (Aozora Bank at present) is excluded from FY 1998 and FY 1999.
3. "Net Transfer to Allowance for Loan Losses" refer to the total amount of Net Transfer to Specific Allowance for Loan Loss and Net Transfer to General Allowance for Loan Loss, etc.
4. "Risk Management Loans" figures had been composed of Loans to Borrowers in legal Bankruptcy [LBB], Past Due Loans [PDL], and restructured loans for FY1995 and FY1996. For FY 1992 to FY 1994, the figures had been composed of LBB and PDL.
5. "Loss on sales through Bulk Sales etc." refer to the total amount of Loss on Sales through Bulk Sales, Loss on Supports to subsidiary etc.
6. "The Others" in Loss on Disposal of Bad Loans refer to the total amount of Allowance for expected losses brought by the Loans Sold to CCPC, Allowance for expected Losses brought by the Supports to Subsidiary etc.

Source: Economic and Planning Agency of Japan.

Fig-1 explains the growth rate of risk management loans relative to growth rate of banks' disposal of bad loans 1998 through 2001.



Source: Economic and Planning Agency of Japan.

The troubled Japanese banking system damaged not only Japan itself and the countries of East Asia, but its impact was felt as far away as the United States. It had a particularly adverse effect on American companies with large overseas branches in Asia.

II. Review of Literature

Authorities are not only unanimous in identifying Non-performing loans as the key cause of Japan's financial crisis; they display a surprising degree of substantive agreement on the reasons behind the economic malaise.

Michael Hutchison and Kathleen McDill, applied a multivariate probit model to the banking crisis.⁷ They compared the Japanese banking crisis to banking crises in other industrial countries. Their analysis of macroeconomic developments before and after the bank crisis indicates that Japan followed a pattern similar to many countries, and the model successfully predicts the increased likelihood of a banking crisis in Japan in the early 1990s.

The crisis in Japan was far more serious than in other countries because inordinate delay was combined with a series of half measures that only made a bad situation worse.

According to Hutchison's and McDill's analysis the main reasons for banking crisis in Japan were:

- i. The failure by regulatory authorities to come to a timely recognition of the full magnitude and implications of the banking crisis;
- ii. The delayed response of regulatory authorities, especially the failure to deal decisively with bankrupt institutions;
- iii. The lack of political courage required to confront the bank crisis and the reluctance to commit public funds to financial restructuring.

Cargill, Hutchison and Ito, argue: "Japan's financial system, however, is at a juncture today which is not comparable to any other episode during the past 45 years. Stress in the Japanese financial system, especially failure to quickly resolve the non-performing loan problem, continues to hold back the economy and has stagnated a large part of the real estate market. And the shortcomings of the existing regulatory and supervisory structure, pit against vastly different financial institutions (and markets) than just 15 years ago, is readily apparent. Market forces and competition among financial institutions make the existing financial structure incompatible with Japan's regulatory and supervisory structure. For these conflicts to be resolved,

⁷ See Michael Hutchison and Kathleen McDill, "Empirical Determinants of Banking Crises: Japan's Experience in International Perspective", working paper series PB99-02 from Center for Pacific Basin Monetary and Economic Research Department, (December, 1998)

reform is necessary. Hence, economic as well as political pressure for fundamental reform will continue even if the present wave of popular opinion against Japan's financial institutions and regulators, especially the Ministry of Finance, wanes.”⁸

These analysts also conclude that the main causes of the banking crisis are:

- i. The failure for most of the decade to resolve non-performing loans that held back the economy and stagnated a large part of the real estate market;
- ii. Japanese bank bureaucrats who feared to take measures that would result in the piercing of the bubble;
- iii. The choice by regulatory authorities to adopt the easy course of relying on administrative guidance to monitor bank and non bank depositors rather than breaking new ground and writing tough, adequate criteria that might have driven the more unsound banks into failure.

Robert Fielder concludes that Japan’s banks may collapse if they do not cease focusing on the wrong priorities and begin to manage the dead weight of their non-performing loans that have badly depressed share prices and credit ratings⁹. Fielder goes on to say that unless solid progress is made soon, current and prospective shareholders will move their money elsewhere with devastating effects on Japan’s capacity to raise capital. He points out that if Japanese authorities had done a professional analysis of their banks balance sheets, share price position and credit rating, they could have drawn the proper conclusions from the tremendous number of non-performing loans and given some warning of the impending bank crisis.

Fielder argues that the current crisis could have been avoided had that Japanese authorities drawn up comprehensive scenarios designed to identify and assess risk. A key factor in any complete picture would not fail to take into consideration the asset as well as liquidity side of the balance sheet. It is of particular importance that any remedial measures undertaken flow from the analysis and that it include contingency funding plans.

While this paper covers the Japan banking crisis only from 1980 to 2001, it is worthwhile underlining that the Japanese economic predicament is still very much with us today. In

⁸ See Thomas Cargill, Michael Hutchison and Takatoshi Ito, *“Big Bang Financial Deregulation: Implications for regulatory and Supervisory Policy”*, Center for Pacific Basin Monetary and Economic Research Department, Japan Information Access Project, (June, 1997)

⁹ See Robert Fielder, *“Liquidity risk: What lessons can be learned from the crisis in Japan's banking system?”* Balance Sheet, MCB UP Limited, Bradford, (2002)

early June 2002, Moody's lowered Japan's credit rating several notches to the point that it now ranks below Botswana.

Writing in Washington Post of June 12, 2002, Robert J. Samuelson raised the specter that Japan might default on its government debt. The day before, National Public Radio began a two-part program on Japan's "Velvet Depression". This program emphasized that the depression is scarcely visible in Tokyo where in one day, the capital's bankers and businessmen bought out the entire stock of 100,000 Rolls-Royces while economic hardship and unemployment afflict several provincial cities.

The analysts I have referred to agree that the severity of the economic downturn and its prolonged duration can be traced to the failure of regulatory authorities to come to a timely recognition of the full magnitude and implications of the impending crisis. Of course, the longer remedial action is delayed the more difficult it is to adopt appropriate policies.

Banks loans with real estate as collateral dominated the portfolios of Japan's banks. Many of these loans were made above the full value of the properties. As long as the price kept rising, there was little incentive for any bank official or analyst to look for potential troubles or to recommend remedial measures. As the spiral went up and up, it should have become obvious to Japanese bankers that soaring prices of land and stocks could not continue indefinitely. Finally, stock prices began to decline and then urban land prices tumbled.

The cited literature demonstrates the general causes for the banking crisis and makes general observations about the need to adopt correct policies in a timely fashion. Keen observation combined with sound empirical analysis of the Japanese economy would have helped the decision makers to select appropriate policies in a timely fashion. This thesis is more concrete and specific than the cited literature. It is argued that the model developed and estimated here would act as an early warning system, an amber light signaling the appropriate juncture to take stock and explore the need for policy change.

III. The Japanese Problem: Asset Deterioration

Economists analyzing the Japanese banking crisis believe the fundamental cause of the Japanese banking crisis is to be found in the deterioration in the asset side of the banks balance sheets. The failure of regulatory authorities to recognize the magnitude of the deterioration and their delayed response exacerbated the problem.

How can banking regulators, a) anticipate asset quality deterioration, b) and monitor the extent at which assets deteriorate, and c) gauge the risks taken by the banks at the aggregate level?

IV. Hypothesis

As research suggests, one explanation for Japan's economic crisis during the 1990s were "bad loans" granted by banks. Had the banking regulators or the banks themselves anticipated the incidence of "bad loans" they might have taken actions to insulate the banks and their economy from unnecessary exposure to losses.

One way to test this hypothesis is to estimate a model of non-performing loans based on data spanning the period March 1980 through December 1990. If this model appears to explain non-performing loans during this period, then could it have been used to anticipate non-performing loans during the 1990's? Had such loans been anticipated, reserves for loan losses, higher capitalization levels, and other regulatory levers could have been employed to protect the Japanese economy from realized losses during the last decade.

- The analysis will attempt to construct an econometric model that can act as an early warning system thereby enabling analysts to recommend measures to ward off a banking crisis.
- The analysis will also attempt to demonstrate that working only with the limited data available international analysts can:
 - Anticipate asset quality deterioration
 - Monitor the velocity at which assets deteriorate;
 - Gauge the risks taken in the aggregate.

This hypothesis will be tested by using historical data to estimate the incidence of non-performing loans. Among the determinants employed will be the central bank discount rate, long term lending rate, real GDP growth rate, un-employment rate and overall wholesale price index. After estimating the parameters, the model is used to predict non-performing loans out-of-sample for the period 1991-2001.

One question this analysis raises is whether non-performing loans across the entire banking sector ultimately caused the economic downturn to become worse. This paper cannot answer the question because of data limitations. This paper utilizes data for only one bank- the bank of Japan.

V. Empirical Model and Methodology:

Economic theory suggests that non-performing loans are counter cyclical i.e when the economy expands NPLt contract and vice versa. To test this concept consider equation (1)

$$NPL_t = \beta_0 + \beta_1 \Delta(R_{it-1}) + \beta_2 UE_{t-1} + \beta_3 GDP_{t-1} + \beta_4 P_{t-1} + u_t \text{----- (1)}$$

Where

NPL_t = Non Performing Loans in period t.

ΔR_{it-1} = Difference between the long term lending rate and the central bank discount rate in period t-1, $\Delta(R_{it-1}) = R_{1t-1} - R_{2t-1}$

R_{1t-1} = Long Term Lending Rate in period t-1

R_{2t-1} = Central Bank Discount Rate in period t-1

UE_{t-1} = Unemployment Rate in period t-1,

GDP_{t-1} = Growth Rate in Real Gross Domestic Product in period t-1.

P_{t-1} = Overall Wholesale Price index in period t-1.

$u_t = \rho * u_{t-1} + v_t$ where $v_t \sim IN(0, \sigma_v^2)$

Economic theory suggests: that as the unemployment rate UE_{t-1} increases non-performing loans NPL_t increase, $\beta_2 > 0$; as the growth rate in GDP_{t-1} increases non-performing loans NPL_t decrease, $\beta_3 < 0$; as the wholesale price index P_{t-1} increases non-performing loans NPL_t decrease, $\beta_4 < 0$; as the spread between the long term lending rate R_{1t-1} and the discount rate R_{2t-1} increases NPL_t increase, $\beta_1 > 0$.

I estimate equation (1) for the years 1980-1990 using ordinary least squares (OLS) assuming that

$u_t \sim IN(0, \sigma_v^2)$, $\rho = 0$.

A Hildreth-Liu (HL)¹⁰ procedure that relaxes the assumption $\rho = 0$ provides estimates of the β_0, \dots, β_5 as well as estimates of the standard errors and t-statistics of these coefficients, estimates of ρ and estimates of σ_v^2 .

The mechanics of the HL procedure iterates and re-estimates the equation (2) below for different values of ρ such that $-1 < \rho < 1$.

$$NPL_t - \rho NPL_{t-1} = \beta_0(1 - \rho) + \beta_1 (\Delta R_{1t-1} - \rho \Delta R_{1t-2}) + \beta_2 (UE_{t-1} - \rho UE_{t-2}) + \beta_3 (GDP_{t-1} - \rho GDP_{t-2}) + \beta_4 (P_{t-1} - \rho P_{t-2}) + v_t \text{-----(2)}$$

¹⁰ See William H. Green, "Econometric Analysis", (2000), pp.246

The dependent and independent variables are transformed using different values of ρ . OLS regression is applied on the transformed variables. The R-square and sum of squared residuals from this regression on transformed variables will be different for different values of ρ . The Hildreth-Lu procedure searches for the particular value of ρ that minimizes the sum of squared residuals and gives the highest R^2 .¹¹

After transforming equation (1) into equation (2) and estimating equation (2), using the Hildreth-Lu procedure, the following steps were taken to predict non-performing loans from the model.

Step 1. Estimate Equation (2) with the data for the period March 1980 through December 1990 (129 observations).

Step 2. Use estimated coefficients from step 1 to simulate the model for January 1991 through May 2001. Actual data is used for the regressors during the simulation period to predict NPL_t .

Step 3. Compare the model predictions with the actual non-performing loans during the period January 1991 through May 2001.

¹¹ See Peter Kennedy, “*A Guide to Econometrics*”, (1998), pp.125-126