In Search of the "Bank Lending Channel":
Causality Analysis for the Transmission Mechanism of U.S. Monetary Policy

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Abstract

The bank lending channel states that changes in monetary policy cause changes in bank loans thus causing changes in real income. This implies the Federal Reserve can influence real income by controlling the level of intermediated loans. We apply a new method to test for an operative bank lending channel in the transmission mechanism of monetary policy. Combining an error correction model with directed acyclic graphs, we explore the existence of a bank lending channel and the effectiveness of U.S. monetary policy since 1960. This paper shows when an operative bank lending channel existed, explains its impact, and evaluates other channels of monetary policy.

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1. Introduction

There is no doubt that monetary policy plays an important role in the real macro economy, and it is important to know how monetary policy achieves its goal; therefore the transmission mechanism (channel) is a key component to monetary policy.   However, very little is known about the specifics of the monetary transmission mechanism and the means by which monetary policy affects the economy (i.e. the monetary transmission mechanism).   These issues have long been debated.   The traditional view of monetary transmission places emphasis on the money, attributing all of the forces of monetary policy to the shift of money supply, which changes the interest rate and spending.   That is to say, when policy makers decide to tighten the money, they drain bank reserves. The loss of reserves reduces the supply of deposits that require reserves, which drives up interest rates.   The higher cost of capital then reduces investment spending by firms and consumers.   The key assumption here is a perfect financial market; the possibility that policy also affects the relative sources of funds that firms use to finance their spending is not considered.   All funds are assumed to be perfect substitutes.   If information problems occur, preventing firms from substituting easily among alternate sources of funds, the credit view of monetary policy identifies two possible credit channels: a bank lending channel and a broader balance sheet channel.

These two channels are broadly acknowledged as operative.   The balance sheet channel takes effect when an increase in liquidity lowers interest rates and pushes people to transform their excess liquidity into investment and thus provide better returns. Interest rates are the major policy tool in this channel, thus it can also be called the interest channel.   Kashyap and Stein (1994) define the bank lending channel as follows: "…monetary policy can work not only through its impact on the bond-market rate of

interest, but also through its independent impact on the supply of intermediated loans…" The bank lending channel implies that the Federal Reserve can influence real income by controlling the level of intermediated loans.

Economists often believe that the interest channel is the major channel between monetary policy and the real economy, yet the relative ineffectiveness of falling interest rates to promote economic growth in the 1990s highlighted the importance of exploring additional channels for monetary policies. One of the alternatives worthy of more attention is the bank lending channel.

The bank lending channel was brought to the forefront of economic discussion by Bernanke and Blinder in 1988. They present conditions that must be satisfied for the lending channel to be operative: (1) the supply of bank loans is not fully insulated from changes in reserves induced by the monetary policy, and (2) the demand of bank loans is not fully insulated from changes in the availability of bank loans. When the first condition holds, a tightening of monetary policy directly causes the contraction of credit issued by banks. The second condition implies that the bank loans are an imperfect substitute for other sources of finance for business. Put together, these two conditions state that bank loans are special, and cannot be substituted with other items on the balance sheets of both banks and non-financial firms.

Several papers have demonstrated the empirical evidence for the existence of a bank lending channel. Gertler and Cilchrist (1994) find that banks lend more to large firms and less to small ones after a tightening of monetary policy. Lang and Nakamura (1995) argue that banks make proportionally more safe loans during a financial crisis. Morgan (1998) uses a contractual difference between loan under commitment and loan

without commitment across commercial bank loans to test for credit effects.   Perez (1998) found that the bank lending channel did exist in the 1960s but is no longer operative.   Kishan and Opiela (2002) provide evidence of a bank lending channel in the United States from 1980 to 1995.

Despite widespread empirical studies on the bank lending channel, the existence of an operative lending channel remains uncertain.   The major criticism is that aggregate data used in previous approaches does not control the demand factors (Olinear and Rudebusch 1996).   A decline in bank loans during tightening of monetary policy may be caused either by a cutback in lending by banks or by a decline in loan demand brought on by the weakened economy through other channels of monetary policy.   Thus many researchers turn to the bank level and firm level data to study the individual borrower's reactions.   This type of approach has two major drawbacks: (1) it fails to directly measure the macroeconomic significance, and (2) it inadequately distinguishes isolated loan demand and supply.

The way to identify loan demand and supply remains unsolved, thus more work is needed on this topic.   Peek et al. (2003) propose a creative way try to solve this problem. They use the commercial forecasts of GDP to control demand shocks, use the bank health variable to capture the supply effects, and apply ensuing tests to ensure the identification of loan supply effects.   However, they admit the commercial forecasts of GDP fail to account completely for the disturbances of demand shocks in the short-run and so the possibility of errors exists.   Moreover, the tests they conducted were insufficient to show the existence of an operative bank lending channel.   We will solve this problem by dividing the whole sample into four sub-periods, which have been publicly known as a

"credit crunch" or a "credit boom" individually, meaning the obvious loan supply shift has been identified in each period, and we do not need to worry about the identification problem.

In the short-run, macroeconomic theory suggests that the monetary policy will have an effect on the economy as the economy adjusts to the shift in monetary policy. However, rational expectations of agents will prevent monetary policy from having effects in the longrun. Thus conducting our study in four relatively short intervals is consistent with the classical theories.

The bank lending channel theory posits that during monetary contractions, banks restrict some firms' loans, thus reducing their desired investment independently from interest rates. It is well known that the US economy entered a period of rapidly contracting loan supply in the 1960s, known as the famous "credit crunch." In that period banks greatly cut back the supply of loans, which has been publicly recognized as mainly a shock of loan supply. We start our study by checking whether the contractionary monetary policy via the bank lending channel actually did slow down real economic activity during this period. A similar causality analysis between the bank loans and economic growth will be applied in the other sub-samples (1970s, 1980s and 1990s to present). The other general assumption is that the bank lending channel is currently not operative. We also will investigate this assumption. The basic task of our paper is to test these assumptions and to see whether the bank lending channel did exist in the early period but ceased to be operative in the later periods.

The Federal Reserve can control bank loans by reducing the quantity of reserves. The reduction in reserves forces a reduction in the level of deposits, and this must be

matched by a fall in loans.　In other words, the contraction in bank balance sheets reduces the level of loans.　Theory suggests that one of the mechanisms through which bank loans affect the real economy is by influencing investment and thus indirectly impacting the real economy.　This paper will test this hypothesis as well.

The paper proceeds as follows. The next section (section 2) briefly introduces the methodology used, section 3 describes the data set, and section 4 investigates the causality in the four sub-samples.　Last, we compare and contrast the results in these sub-samples and conclude with the policy implications.

2. Methodology

The previous bank lending causality literature is largely ambiguous on the relationship between loan and output such as GNP, the literature does not identify whether loans cause GNP or vice versa.　The inability to clearly distinguish this type of relationship has made it difficult to justify the bank lending channel in the monetary transmission mechanism.

A frequent method to identify the causality follows the seminal paper of Granger (1969), but this method has obvious drawbacks.　For example, variable A Granger causes variable B if knowledge of variable A and its past history help to predict variable B.　In essence, variable A Granger causes variable B is a test that variable A precedes variable B in a predictive sense.　Nevertheless, as Granger himself notes, Granger causality implies temporal predictability but does not address the issue of control: "If Y [Granger] causes X, it does not necessarily mean that Y can be used to control X." (Granger, 1980) The difference is important; because an analysis based on Granger causality can answer the question, "Does knowledge of the level of loans extended help

the Federal Reserve predict real income?" However, it cannot answer the question "Will the Federal Reserve's attempt to restrict the availability of loans reduce real income?" (Perez, 1998)

Another method to determine the causal order is suggested by Hoover (1990). The notion of causal order employed by Hoover is due to Simon (1953); a variable L causes Y if control of L renders Y controllable. This methodology requires examination of the stability of the marginal and conditional distribution of Y and L across interventions in the data generating process. The pattern of structural breaks in the regressions corresponding to the conditional and marginal distributions provides evidence of the underlying causal order. The causal inferences made are based on the structural stability of various conditional and marginal regressions.

Previous evidences of an operative lending channel cited above have been hindered by problems of identification or strict assumption. Their methodologies have problems in either elusive or restrictive argumentation. The elusive problem is that of identification. Bank loans and real income are often observed at the same time; whether the demand for loans responds to the change of real income or real income responds to a change in bank loans (which is the bank lending channel) is generally difficult to specify. It is an issue of causation versus correlation. The observational equivalence in contemporaneous time often makes the causality elusive. On the other hand, Perez and others have used the econometric model to derive a clear path of causality, but at the expense of too restrictive assumptions about the intervention in the generating process of bank loans and real income. Such a method is not likely to be applied in cases that are more general. Therefore, we use a more effective and general method in this paper to

provide empirical evidence of the existence of an operative bank lending channel. This new method is called Directed Acyclic Graphs (DAGs).

Causal inference on directed graphs (DAGs) has recently been developed by Spirtes, Glymour and Scheines (2000), and Pearl (2000). This method is able to shed light on contemporaneous relationships. The directed graphs literature is an attempt to infer causal relations from observational data. The key idea is to use a statistical measure of independence, commonly a measure of conditional correlation, to systematically check the patterns of conditional independence and dependence and to work backwards to the class of admissible causal structures. (Hoover, 2005) While computers can be used to sort out causal flows from spurious flows and can sometimes distinguish an effect from a cause, human intelligence is helpful to select the set of candidate variables (causal sufficient set) for the computer to study. The causal sufficiency assumption suggests finding a sufficiently rich set of theoretically relevant variables upon which to conduct the analysis, i.e., there is no omitted latent variable that causes two variables included in the study. One of the advantages of using directed graphs is that results based on properties of the data can be compared to a prior knowledge of a structural model suggested by economic theory or subjective intuition (Awokuse and Bessler, 2003).

If data is measured over time, time series correlation is likely. Observations can be separated by a fixed interval, say n quarters apart in time. Further, these time series data observations are probably non-stationary, in the sense that they may move away from their historical means or variance over long periods of time. Accordingly, we might well expect to model the time series patterns in U.S. banking and monetary data as

an error correction model. Modeling the innovations from such a model will allow us to comment on the causal structure in contemporaneous time. Such models were first introduced in Swanson and Granger (1997), and have been used by others (Bessler and Yang (2003).

Basically, we will use the error correction model combined with directed graphs to show the contemporaneous causality structure on innovations. Such structures can be identified through the directed graphs analysis of the correlation (covariance) matrix of observed innovations $\hat{e}_t$. In this paper, directed graphs are used to help in providing data-based evidence on causal ordering in contemporaneous time, assuming the information set is causally sufficient. Moreover, the error correction model will allow us to identify the long-run and short-run time structure of the series. In summary, we will study the complete properties of the time series that we are interested in and propose a clear, contemporaneous causality between loan and output, thereby providing stronger support for the existence of bank lending channel.

An advantage of our model is that we can explore whether the interest channel and the bank lending channel are independent in contemporaneous time. The DAGs will be helpful to assign the causal flows among the variables we investigate, and such a causality picture will also show whether or not these two channels include a common path. If they do, we have to say that these two channels take the effect jointly and we cannot isolate one from the other. If they do not, then we believe they act independently.

3. Data

As the economic theory suggests, bank loans, interest rates and real output are indispensable components in the study of the monetary transmission mechanism, thus they are included in our model, and we can compare and contrast the interest channel and bank lending channel simultaneously. The improvement of our paper compared to previous empirical studies is that investment is added to our model to explore the nature of how the lending channel takes effect. Traditional macroeconomic theory suggests that the change of money will cause the investment shift and change the equilibrium output. If we can verify that the change of loans causes the change of investment and thus forces the change of real output, it will be very strong evidence for the existence of an operative lending channel.

In summary, the data in this paper focuses on quarterly observations of the real gross national product, commercial loans, 3-month T-bill rates and real investments from 1960:1–2003:3. The real measures for GNP and investment are used to counterbalance the impact that other factors—such as inflation—have, and it will allow us to get more accurate estimates. The data is from the website of the Federal Reserve Bank of St. Louis. Variable GNP, LOAN and INVEST are seasonally adjusted and quarterly recorded with total observations of 203 on each series, while the 3-month T-bill rate has not been seasonally adjusted.

The analysis is aggregate and all of the data are in the aggregated level. Industrial and commercial loans (LOAN) in all commercial banks are grouped to address the lending channel. The 3-month T-bill rate is included to explore the traditional channel of monetary policy via interest rates. We selected the gross private domestic investment (INVESTMENT) to represent investments and this consists of fixed

investment and change in private inventories.   Real GNP is used as proxy for real output level.

A monetary policy indicator is needed to address the shift of monetary policy (tight or loose).   Most previous empirical studies focus on M2, however, in our view, M2 includes too many endogenous shocks responding to the shift of the money base and cannot represent the pure stance of monetary policy.   Our way to handle this problem is to isolate the typical period named "credit crunch" from the period named "credit boom" identified in the history to study the particular effect of tightening and loosening monetary policy.   The data will be investigated within four sub-samples.   The first one is the 1960s (1960:1-1970:4), which is a famous "credit crunch."   The second is the 1970s (1971:1-1980:4), which is known for being dominated by loose monetary policy as well as being a period of credit boom.   The third sub-sample is the 1980s (1981:1-1990:4), the other "credit crunch" period.   The final sub-sample is the current period (1990:1-2003:3), which has been publicly recognized as an "investment boom" associated with moderate monetary policy (Weiss 1999; Ireland 2000; Tevlin and Whelan, 2003; et. al.).   The other reason we separately investigate the data is to show that the bank lending channel did exist in the early period (1960:1 – 1970:4), but is no longer operative (Perez, 1998).

Since we use directed graphs to identify the order of the innovations, we have to consider the causality sufficient condition that is required in DAGs.   It is generally understood that the change of monetary policy will shift the demand indirectly through real economy as well as directly shift the supply side of bank loans.   The innovation of commercial loans that we use here could be caused by the demand shock or the supply

shock.   The use of DAGs will allow us to tell whether the loan shock comes from the demand side or supply side.   That is to say, if we observe that the contemporaneous innovations of loans are caused by the real economy, we can say that the shock comes from demand.   Vise versa, if we observe that the loan innovations cause the real economy, we can believe the shock comes from the supply.   Either way, DAG allows us to determine the causality from the data.

4. Error Correction Models and Directed Graphs in 4 Sub samples

Preliminary plots of the data and formal tests on unit root in each sub-sample are applied.   Briefly, we fail to reject the null hypothesis of a unit root on each series (using the Augmented Dickey Fuller test) in each sub-sample.   Since these four series all have a unit root, it is possible that they have cointegration-like behavior.

The common procedure recent studies have used to set up the error correction model (ECM) is to use either a trace test or information criterion to determine the lag order of the unrestricted VAR in the first step, and then use the same criterion to determine the cointegration rank and appropriate specification for ECM in the second step.   In this paper, however, we will use a one step Schwart Loss Criterion (SLC) to determine the lag order and the cointegration vectors in the ECM simultaneously, which has been proven to work at least as well as or even better than the traditional trace test or two steps approach in both efficiency and consistency (Wang and Bessler, 2004).   Step by step, we check the Schwart Loss (SL) for each rank = 0, 1, 2... and each model specification by lags and find the one that yields the lowest SL.   Because our data set excludes the seasonality (GNP, LOAN and INVEST are seasonally adjusted numbers; we do not believe the three month T-bill rate will include any seasonality), 0 lag does not

make sense in our case, and we start our search from lag 1 to lag 2, 3…5.   (Detailed

statistics are available from the corresponding author).

Then we can conduct the Error Correction Model based on the test results.   Both

coefficient estimates and associated t-statistics will be reported, and these estimates will

help us have a cursory view of the long-run and short-run structure of series investigated.

We can obtain the lower triangular elements of the correlation matrix on innovations

(errors) from the error correction model as well (see correlation matrix charts 1-4).   It is

this matrix that provides the starting point for our analysis of contemporaneous causation

using directed graphs.   By using TETRAD III, we get the directed graphs in figures 1-4.

The directed graphs are then helpful in identifying the contemporaneous structure.

Once we have identified the order of contemporaneous innovations by using the direct

graphs, the next step is to check the impulse response associated with this error correction

model in 32 periods (We believe that 8 year segments will cover both short-run and

long-run responses) in figures 5-7.   Below we will explain the models and results in 4

sub-samples individually.

Sub sample I (1960:1-1970.4)

The test results indicate that the appropriate specification of the model assumes no

deterministic trend in data, and no intercept or trend in the cointegrating equation (CE) or

test VAR.   With the existence of cointegration, the data generating process of these

series can be appropriately modeled in an ECM with 1 lag and 1 cointegration vector.

The error correction model for this sub-sample is given below:

$$
\begin{bmatrix} \Delta GNP \\ \Delta LOAN \\ \Delta TBILL \\ \Delta INVEST \end{bmatrix} =
\begin{bmatrix} -0.019 \\ (-0.79) \\ -0.004 \\ (-2.49) \\ 0.0004 \\ (1.45) \\ 0.023 \\ (1.88) \end{bmatrix}
\begin{bmatrix} 1 & 1.746 & 49.711 & -12.073 \\ & (1.47) & (0.93) & (-21.07) \end{bmatrix}
\begin{bmatrix} GNP(-1) \\ LOAN(-1) \\ TBILL(-1) \\ INVEST(-1) \end{bmatrix}
$$

$$
+ \begin{bmatrix}
0.644 & -0.762 & 23.440 & -0.899 \\
(2.14) & (-0.32) & (1.77) & (-1.80) \\
0.0002 & 0.444 & -0.488 & 0.016 \\
(0.01) & (2.69) & (-0.54) & (0.46) \\
0.003 & 0.050 & 0.437 & -0.008 \\
(0.79) & (1.61) & (2.55) & (-1.28) \\
0.330 & 1.735 & 15.331 & -0.606 \\
(2.11) & (1.38) & (2.22) & (-2.33)
\end{bmatrix}
\begin{bmatrix} \Delta GNP\ (-1) \\ \Delta LOAN\ (-1) \\ \Delta TBILL\ (-1) \\ \Delta INVEST\ (-1) \end{bmatrix}
$$

The first parameter estimates on the right-hand-side of equation can be written as $\pi = \alpha\beta'$. Because we have one cointegrating vector, α is represented as a 4×1 matrix and β' as a 1×4 matrix; this could be used to identify the long-run structure. The long-run component of the error correction model is given as β'. The long-run adjustment of each series to perturbations in the long-run component is given by α matrix. In the cointegrating vector we see a negative coefficient (-12.073) associated with variable INVEST lagged one period in the first difference equation of variable GNP. This estimate is significantly different from zero (-21.07) at usual levels (5% or 10%). It means that investment in the long run will not promote economic growth but economic growth will promote investment in the long-run. This is a new idea, considering many economists believe that increasing investment will promote economic growth. Further, there is a positive coefficient (1.746) associated with LOAN lagged one period in the first difference equation of GNP. However, this estimate is not significantly different from zero with a t-statistics of 1.47.

The second parameter matrix on the right-hand-side equations shows the short-run correlations among these series. It is clear that the changes in GNP are positively and significantly correlated with TBILL, and negatively but insignificantly correlated with LOAN and INVEST. In terms of causal view of short-run responses, the error correction model supports that in the short-run the expansion of credit will yield a decrease in economic growth, while changing the Treasury Bill rate will cause a positive change on the real economy. However, these are cursory view of the long-run and short-run relationships among the series directly from the model; a more definitive view should be confirmed by further tests. We have not conducted further tests here, because we are more interested in contemporaneous causality.

The directed graph results (see figure 1) show that TBILL and LOAN both significantly cause GNP at the 10% level. Because the sample size is small (only 44 after adjustment), a 10% significance level is used. This evidence supports our previous assumption that the bank loan-lending channel did exist contemporaneously in the 1960s, which is consistent with Perez's study.

Moreover, it provides stronger evidence that a lending channel existed, because we add the variable INVEST and illustrate the nature of the bank lending channel and interest channel is to take effect through the change of investment. In other words, the shift of bank loan supply causes the corresponding shift of private investment and thus causes change in the real output. The contemporaneous credit effect of monetary policy was strongly shown and both the interest channel and the bank lending channel were operative in this period.

On the other hand, we can obtain from this directed graph the conclusion that the

interest channel effect and the bank lending channel effect could not be quantified separately; they are both acting through the lever of INVEST and then influencing the real economy.   In this sense, we cannot say the money channel and credit channel are independently acting mechanisms.   Instead, they are interactive monetary tools. Thereby, the decision maker should comprehensively evaluate the impact from both the interest and the loan side before making decisions.

Since we have identified the contemporaneous order, which is LOAN, TBILL, INVEST, GNP shown from the directed graphs, we will check the impulse response next (See figure 5).

We find that a positive shock to LOAN yields a slow and trivial increase in output and then a decline after about 5 quarters, finally staying at a constant level after about 15 quarters.   A positive shock to TBILL rate will cause a dramatic decrease in output during the first 6 quarters and stabilize after that.   A positive shock to INVEST will make GNP increase for the first 8 quarters and then decline to its normal level in the following 8 quarters.   GNP will stay at the lowest level after shock to the interest rate and at the highest level after shock to INVEST.   The fact that GNP responds more sensitively to the shock of TBILL than LOAN implies that the interest channel might be the stronger of the two channels.

We notice that LOAN and INVEST have almost no response to the shock of GNP, and TBILL only fluctuates in response for the first 5 quarters and then has no response. It might be the evidence to support the existence of a money channel and a lending channel from the other side: GNP is influenced by the LOAN, TBILL and INVEST, but not vice versa.

In summary, the impulse response summarized in this period appears to be consistent with a monetarist's view of the economy with adaptive expectations (with no hyperinflation): real variables show strong response to LOAN, TBILL and INVEST in the short-term, but show little or no response to these channels in the long-run.   Results show that the identified error correction model using direct graphs can offer theoretically consistent impulse response for policy analysis.

Sub sample II (1971:1—1980:4)

The one step SLC procedure tells us that the appropriate specification is the model that assumes linear deterministic trends in data and assumes intercept and trend in the cointegrated equation, but no trend in VAR.   With the existence of cointegration, the data generating process of these series can be appropriately modeled in an ECM with one lag and one cointegration vector.   The error correction model for this sub-sample is given below:

$$
\begin{bmatrix} \Delta GNP \\ \Delta LOAN \\ \Delta TBILL \\ \Delta INVEST \end{bmatrix} =
\begin{bmatrix}
0.050 & -1.051 & 11.790 & -0.029 & 48.798 \\
(0.12) & (-1.50) & (0.96) & (-0.05) & (2.94) \\
-0.056 & 0.685 & 3.740 & 0.006 & 7.037 \\
(-0.65) & (4.57) & (1.43) & (0.05) & (1.99) \\
-0.01 & 0.012 & 0.780 & 0.005 & 0.314 \\
(-1.59) & (1.08) & (4.03) & (0.55) & (1.20) \\
0.224 & -0.792 & 8.951 & -0.286 & 9.777 \\
(0.92) & (-1.90) & (1.23) & (-0.82) & (1.00)
\end{bmatrix}
\begin{bmatrix} \Delta GNP\,(-1) \\ \Delta LOAN\,(-1) \\ \Delta TBILL\,(-1) \\ \Delta INVEST\,(-1) \\ 1 \end{bmatrix} +
$$

$$
\begin{bmatrix} 0.316 \\ (1.72) \\ 0.068 \\ (1.74) \\ 0.019 \\ (6.59) \\ 0.138 \\ (1.27) \end{bmatrix}
\begin{bmatrix} 1 & 2.065 & -94.231 & -1.092 & -52.941 & -1426.570 \\ & (7.21) & (-9.56) & (-6.52) & (-12.91) & \end{bmatrix}
\begin{bmatrix} GNP(-1) \\ LOAN(-1) \\ TBILL(-1) \\ INVEST(-1) \\ @TREND \\ 1 \end{bmatrix}
$$

The first parameter matrix on the right-hand-side equations shows the short-run correlations among four series.   Almost none of the coefficients are significant except the LOAN and TBILL to its own lag difference; that is to say, the changes in LOAN and TBILL are positively and significantly correlated with their own change.   Because there are so many insignificant estimates, the short-run structure is hard to identify in this period.

Next we use the second parameter matrix to identify the long-run structure of these four series.   The second parameter matrix of estimates on the right-hand-side of the equation can be written as $\pi = \alpha\beta'$, because we have one cointegrating vector, α is represented as a 4×1 matrix and β' as a 1×6 matrix.   The long-run component of the error correction model is given as β'.   The long-run adjustment of each series to perturbations in the long-run component is given by α matrix.   For the change of GNP, all of the estimates are significant, and such results imply that GNP is affected by its own past levels, loan supply, the interest rate and investment in the long-run.   However, it is still a cursory view of the relationship among the series.   A more definitive view should be given by further tests.

The directed graph results (see figure 2) shows that there is a link (also called edge in DAGs terminology) between INVEST and GNP, as well as TBILL and LOAN at

10% significance levels, but cannot specify the directions between these two edges.   The causality analysis in this period is indeterminate, which prevents us for the further impulse response analysis.   It is understandable, since the U.S. monetary policy was in transition during this period, known as "Pre-Volcker years."   After that, the U.S. entered the "Volcker-Greenspan Era" and the Federal Reserve changed its goal to "Maximum Employment, stable prices and moderate long-term interest rates" (Favero and Rovelli, 2003).

Sub sample III (1981:1-1990:4)

The one step SLC procedure indicates that the appropriate specification is the model that assumes no deterministic trends in data, has an intercept (no trend) in CE, but no intercept in VAR.   With the existence of cointegration, the data generating process of these series can be appropriately modeled in an ECM with one lag and one cointegration vector.   The error correction model for this sub-sample is given below:

$$
\begin{bmatrix} \Delta GNP \\ \Delta LOAN \\ \Delta TBILL \\ \Delta INVEST \end{bmatrix} = \begin{bmatrix} -0.208 & -1.112 & 31.712 & 0.195 \\ (-0.89) & (-2.80) & (4.80) & (0.67) \\ 0.101 & 0.618 & -1.884 & -0.043 \\ (0.90) & (3.29) & (-0.60) & (-0.31) \\ 0.001 & -0.010 & 0.179 & -0.0002 \\ (0.15) & (-0.99) & (1.05) & (-0.02) \\ 0.186 & -0.320 & 17.393 & -0.190 \\ (0.94) & (-0.96) & (3.12) & (-0.78) \end{bmatrix} \begin{bmatrix} \Delta GNP(-1) \\ \Delta LOAN(-1) \\ \Delta TBILL(-1) \\ \Delta INVEST(-1) \end{bmatrix}
$$

$$
+ \begin{bmatrix} -0.248 \\ (-4.88) \\ 0.008 \\ (-0.32) \\ -0.0002 \\ (-0.15) \\ -0.021 \\ (-0.48) \end{bmatrix} \begin{bmatrix} 1 & -1.619 & 9.923 & -1.502 & -2960.634 \\ & (-14.21) & (1.18) & (-5.83) & (-18.32) \end{bmatrix} \begin{bmatrix} GNP(-1) \\ LOAN(-1) \\ TBILL(-1) \\ INVEST(-1) \\ 1 \end{bmatrix}
$$

The first parameter matrix on the right-hand-side equations shows the short-run correlations among series. We see the changes in GNP are positively and significantly correlated with LOAN and TBILL, negatively but insignificantly correlated with its own change, and positively but insignificantly correlated with INVEST. In causal view of short-run responses, the error correction model supports that in the short-run the expansion of credit (bank loans) will stimulate economic growth, and changing the treasury bill rate will cause a positive change on the real economy as well.

The second parameter estimates on the right-hand-side of equation identify the long-run structure. The long-run component of the error correction model is given as β'. The long-run adjustment of each series to perturbations in the long-run component is given by α matrix. Here we see in the cointegrating vector, a negative coefficient (-1.619) associated with variable LOAN lagged one period in the first difference equation of variable GNP; this estimate is significantly different from zero (-14.21) at usual levels (5% or 10%). Many researchers believe that the shock of loan supply will influence the real economy, but the direction of this type of shock here is strange. We also see the other negative and significant coefficient associated with INVEST lagged one period in the first difference equation of GNP.

The DAG results (see figure 3) show that TBILL and INVEST both significantly cause GNP at a 10% significance level. This evidence supports that the interest channel did exist contemporaneously in the 1980s period. There is no evidence that the bank lending channel also existed in this period, while, INVEST still independently influences the real economy. There is no edge between LOAN and any other variables; the causality here is ambiguous. Consider what was said by Volcker, the chairman of Fed,

"Given that we are in the early stages, if I can put it that way, of any success in the face of very high interest rates despite the distortions in the economy and the very different impacts on different sectors—it seems to me that there is still a considerable danger, and maybe an overriding danger, of underkill rather than overkill…"   The U.S. entered a new era with an emphasis on controlling inflation. Interest rates had been controlled and became the government's strongest policy instrument in this period.   It was expected that the interest channel was the dominant monetary channel in this sub-sample.

On the other hand, we can compare it with the DAGs in sub-sample 1 (1960s), where the interest channel also existed but had an indirect impact on the economy through the INVEST.   In this sense we could say the interest channel plays a more important role in this period, so it was easily overrated in the following years.   Thereby, decision makers seemed to rely more on interest rate control in the 1990s; we see that falling interest rates in the 1990s did not work as well as in the 1980s.

Since we have identified the possible order of contemporaneous innovations (which is: TBILL, INVEST, GNP, LOAN), the next step is to check the impulse response associate with this error correction model.   We find that a positive shock to LOAN yields a dramatic increase in output steadily after a short period with lower down effects on the economy, and a positive shock to the TBILL rate will cause a short-term positive effect on output and then keep GNP in a stable higher level compared to the base level. A positive shock to INVEST will always make the GNP increase to higher and higher levels.   To see the response of LOAN to INTEREST and INVEST, we note that a positive shock to INTEREST and INVEST will stimulate the growth of LOAN, while a positive shock of GNP will have the opposite effect on LOAN.   So we could expect that

the relation between the shock of LOAN and GNP is not identified in this period, since the INTEREST, INVEST and GNP could offset the possible LOAN effect on GNP.

Sub sample IV (1991.1—2003.3)

The one step SLC procedure shows that the appropriate specification is the model that allows for quadratic, deterministic trends in data and assumes an intercept and trend in CE and linear trend in VAR.   With the existence of cointegration, the data generating process of these series can be appropriately modeled in an ECM with one lag and one cointegration vector.   The error correction model for this sub-sample is given as below:

$$
\begin{bmatrix} \Delta GNP \\ \Delta LOAN \\ \Delta TBILL \\ \Delta INVEST \end{bmatrix} = \begin{bmatrix} 0.030 & 0.286 & 30.771 & 0.067 & -40.470 & 0.693 \\ (0.13) & (0.73) & (1.42) & (0.22) & (-0.51) & (1.30) \\ 0.257 & 0.224 & 33.354 & -0.216 & 89.745 & -0.579 \\ (3.51) & (1.82) & (4.89) & (-2.32) & (3.62) & (-3.44) \\ 0.004 & 0.006 & 0.638 & -0.223 & -0.034 & -0.002 \\ (3.15) & (2.49) & (5.08) & (-1.59) & (-0.07) & (-0.71) \\ 0.383 & 0.301 & 34.456 & -0.405 & 68.173 & -0.480 \\ (2.32) & (1.09) & (2.24) & (-1.93) & (1.22) & (-1.26) \end{bmatrix} \begin{bmatrix} \Delta GNP(-1) \\ \Delta LOAN(-1) \\ \Delta TBILL(-1) \\ \Delta INVEST(-1) \\ 1 \\ @TREND \end{bmatrix}
$$

$$
+ \begin{bmatrix} 0.028 \\ (1.04) \\ -0.035 \\ (-4.21) \\ 0.0004 \\ (2.92) \\ 0.032 \\ (1.73) \end{bmatrix} \begin{bmatrix} 1 & 1.381 & -369.989 & -4.501 & -41.162 & 1537.327 \\ & (1.82) & (-4.23) & (-3.01) & (-41.16) & \end{bmatrix} \begin{bmatrix} GNP(-1) \\ LOAN(-1) \\ TBILL(-1) \\ INVEST(-1) \\ @TREND \\ 1 \end{bmatrix}
$$

We use the first parameter matrix to identify the short-run structure of these four series.   None of the coefficients associated with the change of GNP is significant; that is to say, the changes in GNP could not be explained by the change of its own lag, TBILL, LOAN or INVEST in the short-run.   We feel that monetary policy is not effective in the short-run in this period from a cursory view of our error correction model.

Next we use the second parameter matrix to identify the long-run structure of these four series.   This parameter matrix of estimates on the right-hand-side of the equation can be written as $\pi = \alpha\beta'$ where α is a 4×1 matrix and β' is a 1×6 matrix in this case, because we have only one cointegrating vector with one constant and one trend variable in this vector.   The long-run component of the error correction model is given as β', the long-run adjustment of each series to perturbations in the long-run component is given by α matrix.   For the change of GNP, almost all of the estimates are significant with the exception of the coefficient associated with the lag of LOAN, and

such results imply that GNP is affected by its own past levels, interest rates, INVEST and time trend in the long-run.   More explicitly, it implies that monetary policy might be useful in the long-run view for this period.

The directed graph results shows that there is a direct edge between INVEST, TBILL and GNP.   GNP and TBILL innovations cause the INVEST innovations at 10% significance levels in contemporaneous time.   We can see that there is no edge between LOAN and all the other variables, which means no contemporaneous causality exists for LOAN and other variables in this period.   That is consistent with our belief that the bank lending channel has not been an operative channel recently.

Since we have identified the order of contemporaneous innovations (which is: GNP, TBILL, INVEST, LOAN), we could check the impulse response in the following step.   We find that a positive shock to LOAN yields a slow and trivial increase in output, followed by a decline after approximately 6 quarters, and finally stabilizes and remains at a constant level after about 15 quarters.   It is very similar to the impulse response pattern in figure 1 that we discussed in sub-sample I.   A positive shock to the TBILL rate will cause a slight increase of output in the first 3 quarters and then decrease the output in the following 10 quarters, after which it keeps the shock to output stable at a lower lever than the original base.   A positive shock to INVEST will make GNP decrease in the first 5 quarters and then stay constant at a lower level compared to the original output.   Compare these three responses: GNP will stay at a lower level after shock to either interest rates or investment, and at a higher level after shock to LOAN.

Next we are going to check the response of investment to the other variables. GNP has a relatively large effect on investment in the first 15 quarters, and then converts

to a keep investment at a stable level.   A positive shock to LOAN will yield an increase in investment for the first 6 quarters, and then cause investment to revert back to its original level for the next 12 quarters, and after that investment won't respond to the shock of LOAN and stays stable at that level.   The response of investment to the TBILL rate has a similar pattern as to LOAN, that is, to be pulled to an even lower level and then remain stable at that level.   Compared to the impulse response of investment to the shock of GNP in sub-samples I and III, it is obvious that the response of investment in this period is much bigger, and no wonder the 1990s is historically called an "investment boom" (Tevlin and Whelan, 2003).

The fact that GNP responds less sensitively to the shock of TBILL and LOAN as before implies that either the interest channel or the bank lending channel gradually decrease their power in the real economy.   It can be expected that the U.S. economy has fully developed in the past four decades, and is now entering a stable era with less reliance on monetary policy than there was in the previous developing stages.   Thus, now the monetary policy in the U.S. is more focused on stabilizing the money supply and moderating interest rates to ensure an environment beneficial to economic growth.

5. Discussion and Policy Implication

Ongoing changes in the banking industry have brought renewed attention to the role banks play in the monetary transmission mechanism.   In this paper we validate the theory that an operative bank lending channel existed in the transmission mechanism of monetary policy in U.S. history.   The bank lending channel implies that the Federal Reserve exerts some control over real income by controlling the level of intermediated loans traded in the economy.   Independent of movements in interest rates, an increase in

loans will raise aggregate output as bank-dependent firms have increased access to working capital.

We find that in contemporaneous time bank loans did cause the real growth in the 1960s—convincing evidence that the bank lending channel did exist during that period. But the bank lending channel appears to no longer be of aggregate importance currently (i.e. the expansion of commercial/industrial loans does not cause aggregate output growth). Our error correction model and causality analysis do not provide evidence supporting the hypothesis that the lending channel is currently effective.

Some perspectives other than the factors we addressed above can be used to understand why a lending channel existed in the 1960s but not recently. Recall the two conditions for a bank lending channel to exist that we addressed in the beginning: (1) changes in policy affect the supply of bank loans and (2) some borrowers depend on banks for credit (Bernanke and Blinder 1988). With this in mind, it is easier to understand the shifting role of the bank lending channel. One of the reasons for the existence of a lending channel in the 1960s is that there were a number of firms without alternative sources of investment funds at that time, thus the second condition was satisfied. As Cecchetti pointed out, "…It [the lending channel] arises when there are firms who do not have equivalent alternative sources of investment funds and loans are imperfect substitutes in investors' portfolios" (1994). The access to capital market, especially in the period marked as "new economy", turns out to be easier, and more substitutes to traditional bank financing emerged. Hence, we can expect the bank lending channel would not be as strong a policy tool for impacting the real economy as it was in 1960s. Moreover, the first condition for a lending channel—that tight monetary

policy reduces the bank loan supply—is more difficult to hold in current days.   Banks now have several alternatives to cutting their lending when reserves decline; they could issue certificates of deposits (CDs) or other liabilities other than those that require reserves (Romer and Romer 1990).

Another possible explanation is that lending has an asymmetric impact on the real economy; that is to say, the tightening of monetary policy will exacerbate the decline of the economy in the recession, although the ease of monetary policy won't accelerate the development in the upswing.   If this is true, it can well explain why the lending channel seems less operative recently than in the famous period of "credit crunch".   We are fairly confident that the contraction of monetary policy will cause a recession, but not vice versa.

There is no strong evidence to support the existence of a bank lending channel recently.   On one hand, this might be due to the emergence of a great deal of financing substitutes.   On the other hand, it may be because of the relatively stable stance of monetary policy; the Federal Reserve has not enacted any dramatic tightening policies recently.   It will be a good topic for our future research to test whether or not there are asymmetric responses of real economy to positive and negative monetary innovations.

In summary, the Federal Reserve can use explicit action, such as changing the base deposit rate to control loans supply, which will have a differential impact on the real economy that depends on time.   Though the bank lending channel seems no longer to be of aggregate importance, it does not imply that the bank lending channel is unimportant. It still has structural effect on the real growth, because the change of bank loans supplied has differential effects on individual firms that are more or less dependent on bank credits.

If some firms cannot access credit market when monetary policy gets more tight, but other firms still have access to the contracted credit market, then some firms win and some firms lose when the stance of monetary policy changes.   Therefore, the distribution of bank lending loans will have effects on economic growth, and how to efficiently allocate these bank loans should be our future research topic on the bank lending channel.

References

Andres, D.W. (1993). "Tests for Parameter Instability and Structural Change with Unknown Change point." *Econometrica* 61, 821-856.

Arestis, P., P.O. Demetriades, and K.B. Luintel. (2001). "Financial Development and Economic Growth: The Role of Stock Markets." *Journal of Money, Credit, and Banking* 33, 16-41.

Awokuse, T.O, and D.A. Bessler. (2003). "Vector Autoregressions, Policy Analysis, and Directed Acyclic Graphs: an Application to the U.S. Economy." *Journal of Applied Economics* VI-1, 1-24.

Bernanke, B.S., and A.S. Blinder. (1992). "The Federal Funds Rate and the Channels of Monetary Transmission." *The American Economic Review* 82-4, 901-921.

Bernanke, B.S, and A. S. Blinder. (1998). "Credit, Money, and Aggregate Demand." *The American Economic Review* 78-2, 435-439.

Bessler, D., and S. Lee. (2002). "Money and Prices: U.S. Data 1869-1914 (A Study with Directed Graphs)." *Empirical Economics* 27, 427-446.

Bessler, D., and J.Yang. (2003). "The Structure of Interdependence in International Stock Markets." *Journal of International Money and Finance* 22, 261-287.

Cecchetti, S.G. (1995). "Distinguish Theories of the Monetary Transmission Mechanism." *Federal Reserve Bank of St. Louis Review* 77-3, 83-97.

Chick, V. (1983). *Macroeconomics After Keynes: A Reconsideration of the General Theory*. Oxford, UK: Philip Allan.

Chick, V. (1986). "The Evolution of the Banking System and the Theory of Saving, Investment and Interest." *Economies et Societies*, Series MP, 3.

Favero, C.A., and R. Rovelli. (2003). "Macroeconomic Stability and the Preferences of the Fed: A Formal Analysis, 1961-1998." *Journal of Money,Credit, and Banking* 35-4, 545-555.

Gertler, M. and S. Gilchrist. (1994). "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms." *Quarterly Journal of Economics* 109-2, 309-340.

Glymour, C. (1997). "A Review of Recent Work on the Foundations of Causal Inference." In *Causality in Crisis,* edited by Vaugn McKim and Stephen Turner, pp. 201-248.   Notre Dame, IN: The University of Notre Dame Press.

Glymour, C., and G. F. Cooper. (1999). *Computation, Causation, & Discovery*. Menlo Park, CA: AAAI Press/The MIT Press.

Granger, C.W.J. (1980). "Testing for Causality: A Personal Viewpoint." *Journal of Economic Dynamics and Control* 2, 329-352.

Guiso, L., P. Sapienza, and L. Zingales. (2002). *Does Local Financial Development Matter?* National Bureau of Economic Research—Working Paper No. 8923.

Hamilton, N.D. (1994). *Time Series Econometrics*.   Princeton, NJ: Princeton University Press.

Hicks, J. (1969). *A Theory of Economic History*. Oxford, UK: Clarendon Press.

Hoover, K.D. (1990). "The Logic of Causal Inference, Econometrics and the Conditional Analysis of Causation." *Economics and Philosophy* 6, 207-231.

Hoover, K.D. (1991). "The Causal Direction between Money and Prices." *Journal of Monetary Economics* 27, 381-423.

Hoover, K.D. (2005). "Automatic Inference of the Contemporaneous Causal Order of a System of Equations." Forthcoming *Econometric Theory* 21-1.

Ireland. P.N. (2000). "Interest Rates, Inflation, and Federal Reserve Policy Since 1980." *Journal of Money, Credit and Banking* 32-3, 417-434.

Kashyap, A.K., and J.C. Stein. (1994). "Monetary Policy and Bank Lending."   In *Monetary Policy,* edited by N. Gregory Mankiw, pp. 221-256.   Chicago, IL: The University of Chicago Press.

Keynes, M.J. (1936). *The General Theory of Employment, Interest and Money.* London, UK: Macmillan.

Kishan, R.P., and T.P. Opiela. (2000). "Bank Size, Bank Capital and the bank lending channel." *Journal of Money, Credit and Banking* 32-1, 121-141.

Lang, W.W., and L. Nakamura. (1995). " 'Flight to Quality' in Bank Lending and Economic Activity." *Journal of Monetary Economics* 36-1, 145-164.

Layaratne, J., and P.E. Strahan. (1996). "The finance-growth nexus: Evidence from Bank Branch Deregulation." *Quarterly Journal of Economics* 111, 639-670.

Lucas, R.E. (1988). "On the Mechanics of Economic Development." *Journal of Monetary Economics* 22, 3-42.

MoKinnon, R.I. (1973). *Money and Capital in Economic Development.* Washington, DC: Brookings Institution.

Morgan, D.P. (1998). "The Credit Effects of Monetary Policy: Evidence Using Loan Commitments." *Journal of Money, Credit and Banking* 30-1, 102-118.

Morris, C.S., and H.S. Gordon. (1995). "Bank Lending and Monetary Policy: Evidence on a Credit Channel." *Federal Reserve Bank of Kansas City Economic Review* 80-2, 59-74.

Oliner, S.D., and G.D. Rudebusch. (1996). "Monetary Policy and Credit Contractions: Evidence From the Composition of External Finance: Comment" *American Economic Review* 8, 300-309.

Pearl, J. (1999). "Graphs, Structural Models, and Causality." *Computation, Causation, & Discovery*. Menlo Park, CA: AAAI Press/The MIT Press.

Pearl, J. (1995). *"Causal Diagrams for Empirical Research." Biometrika* 82, 669-710.

Pearl, J. (2000). *Causality*, Cambridge, MA: Cambridge University Press.

Peek, J., E. S. Rosengren, and G. M. B. Tootell. (2003). "Identifying the Macroeconomic Effect of Loan Supply Shock." *Journal of Money, Credit, and Banking* 35, 931-946.

Perez, S. J. (1998). "Causal Ordering and the Bank Lending Channel." *Journal of Applied Econometrics* 13, 613-626.

Robinson, J. (1952). "The Generalization of the General Theory." In *The Rate of Interest, and Other Essays*, pp. 67-142. London, UK: Macmillan.

Romer, C. D., and D. H. Romer. (1990). "New Evidence on the Monetary Transmission Mechanism." *Brookings Papers on Economic Activity*, 149-214.

Rousseau, P.L., and P. Wachtel. (1998). "Financial Intermediation and Economic Performance: Historical Evidence from Five Industrial countries." *Journal of Money, Credit, and Banking* 30, 657-678.

Simo, H.A. (1957). *Causal Ordering and Identifiability.* Reprinted in *Models of Man*, edited by Herbert A. Simon. New York, NY: Wiley.

Sprites, P., C. Glymour, and R. Scheines. (2000). *Causation, Prediction, and Search.* Cambridge, MA: The MIT Press.

Swanson, N.R., and C.W.J. Granger. (1997). "Impulse Response Functions Based on a Causal Aproach to Residual Othognalization in Vector Autoregression." *Journal of the American Statistical Association* 92, 357-367.

Tevlin. S., and K. Whelan. (2003). "Explaining the Investment Boom of the 1990s." *Journal of Money, Credit and Banking* 35-1, 1-22.

Wang, Z., and D.A. Bessler. (2004). "A Monte Carlo Study on the Selection of Cointegrating Rank Using Information Criteria." Forthcoming *Econometric Theory* 2004.

Weise. C.L. (1999). "The Asymmetric Effects of Monetary Policy: A Nonlinear Vector Autoregression Approach." *Journal of Money, Credit and Banking* 31-1, 85-108.

Yuan. M.W., and C. Zimmermann. (1999). "Credit Crunch, Bank Lending, and Monetary Policy: A Model of Financial Intermediation with Heterogeneous Projects." CREFE—Working Paper No. 89.

Chart 1.   Correlation Matrix of Innovations (Errors) during sub sample I (1960:1-1970.4)

	ε_{GNP}	ε_{LOAN}	ε_{TBILL}	ε_{INVEST}
ε_{GNP}	1			
ε_{LOAN}	0.3556	1		
ε_{TBILL}	0.3517	0.2176	1	
ε_{INVEST}	0.8902	0.4590	0.4016	1

Chart 2.   Correlation Matrix of Innovations (Errors) during sub sample II (1971:1—1980:4)

	ε_{GNP}	ε_{LOAN}	ε_{TBILL}	ε_{INVEST}
ε_{GNP}	1			
ε_{LOAN}	0.3361	1		
ε_{TBILL}	0.1119	0.7340	1	
ε_{INVEST}	0.8357	0.3740	0.2170	1

Chart 3.   Correlation Matrix of Innovations (Errors) during sub sample III (1960:1-1970.4)

	ε_{GNP}	ε_{LOAN}	ε_{TBILL}	ε_{INVEST}
ε_{GNP}	1			
ε_{LOAN}	-0.0066	1		
ε_{TBILL}	0.4290	0.1648	1	
ε_{INVEST}	0.8036	0.2167	0.2519	1

**Chart 4.   Correlation Matrix of Innovations (Errors) during sub sample IV (1991.1—2003.3)**

	ε_{GNP}	ε_{LOAN}	ε_{TBILL}	ε_{INVEST}
ε_{GNP}	1			
ε_{LOAN}	0.3959	1		
ε_{TBILL}	0.2076	-0.0196	1	
ε_{INVEST}	0.7416	0.4021	0.3381	1

Directed Graphs

Figure 1:   Sub sample I (1960:1-1970.4)

```
┌─────────┐              ┌─────────┐
│  LOAN   │              │  TBILL  │
└─────────┘              └─────────┘
      ↓                        ↓
          ┌──────────────┐
          │   INVEST     │
          └──────────────┘
                 ↓
          ┌──────────────┐
          │     GNP      │
          └──────────────┘
```
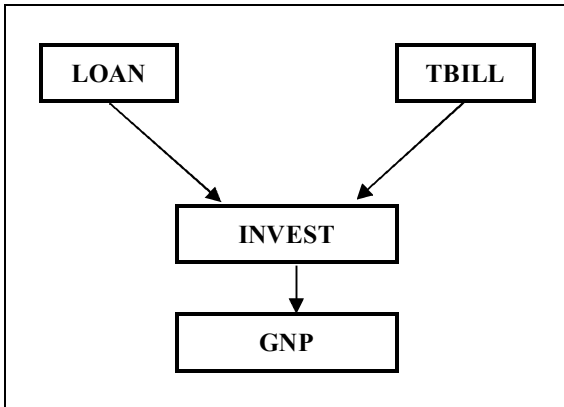
Figure 2:   Sub sample II (1971:1—1980:4)

```
┌─────────┐              ┌─────────┐
│  GNP    │              │  TBILL  │
└─────────┘              └─────────┘
      │                        │
┌─────────┐              ┌─────────┐
│ INVEST  │              │  LOAN   │
└─────────┘              └─────────┘
```
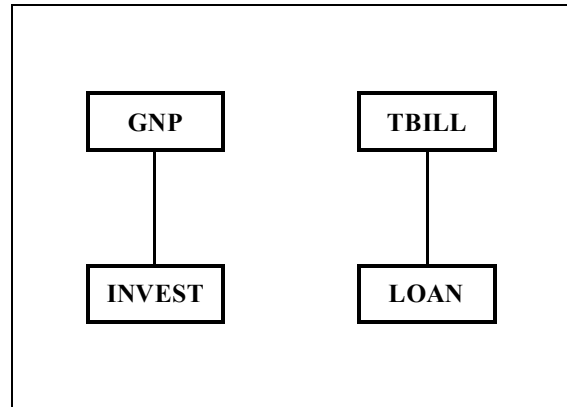
Figure 3:   Sub sample III (1960:1-1970.4)

```
┌─────────┐              ┌─────────┐
│  LOAN   │              │  TBILL  │
└─────────┘              └─────────┘
                               ↓
┌─────────┐              ┌─────────┐
│ INVEST  │ ──────────→  │   GNP   │
└─────────┘              └─────────┘
```
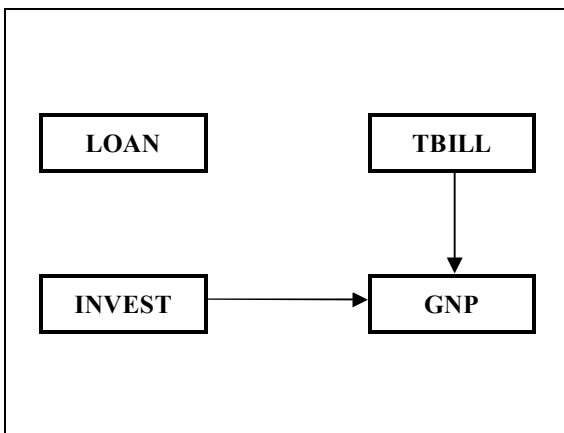
Figure 4:   Sub sample IV (1991.1—2003.3)

```
┌─────────┐              ┌─────────┐
│  LOAN   │              │  TBILL  │
└─────────┘              └─────────┘
                              ╱
┌─────────┐  ↙            ┌─────────┐
│ INVEST  │ ──────────→   │   GNP   │
└─────────┘               └─────────┘
```
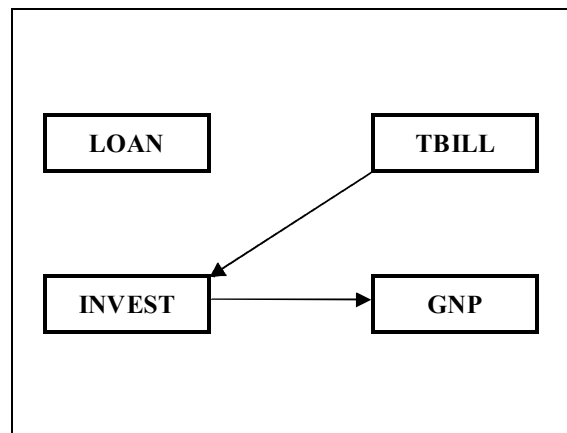
Impulse Response in 32 Periods

Figure 5:   Sub sample I (1960:1-1970.4)

Response to One S.D. Innovations
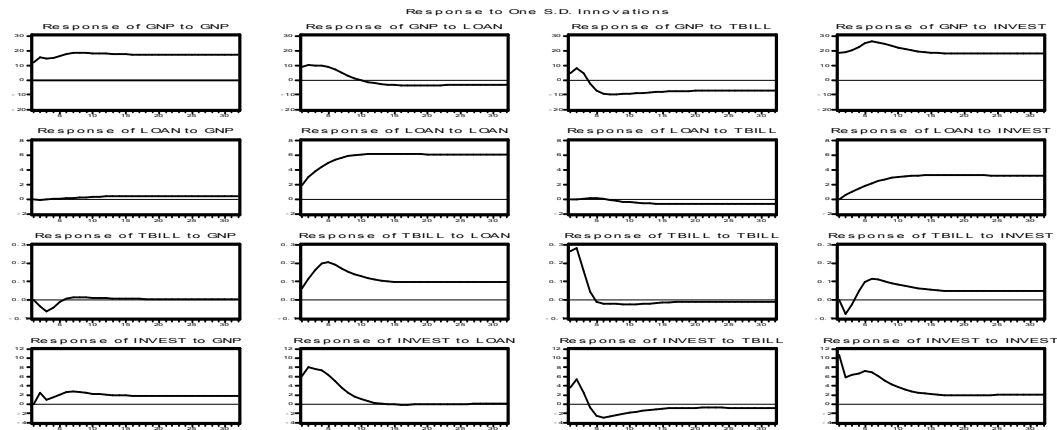
Figure 6:   Sub sample III (1960:1-1970.4)

Response to Cholesky One S.D. Innovations
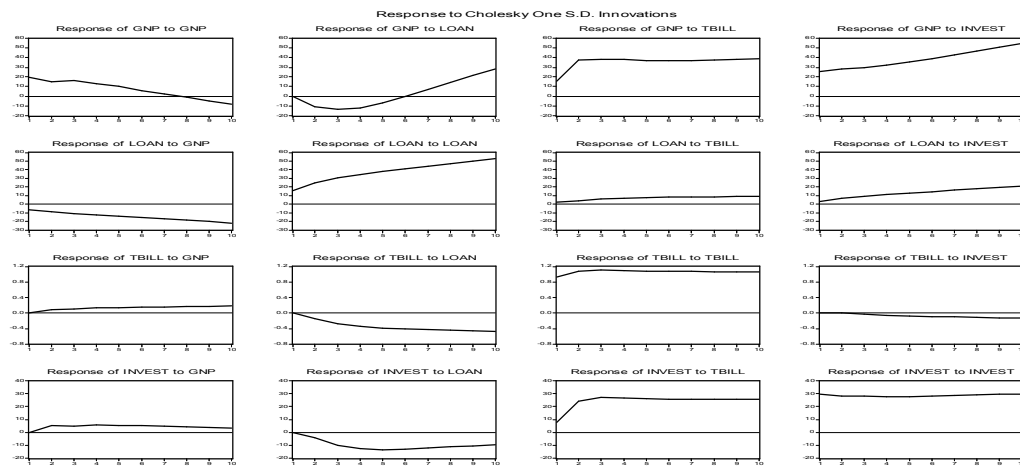
Figure 7:   Sub sample IV (1991.1—2003.3)

Response to Cholesky One S.D. Innovations
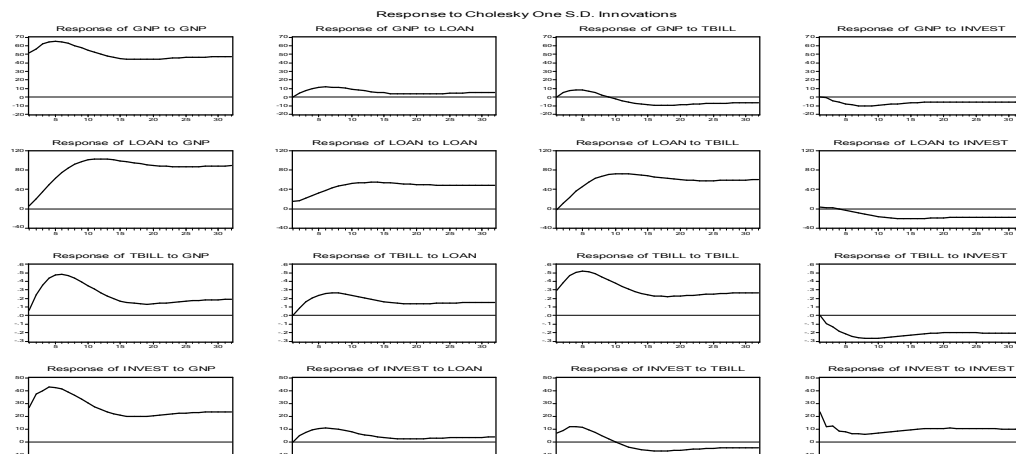
Appendix:

TABLE 1

One step Schwarz Loss Criteria (SLC) by Lags on the number of cointegrating vectors (*r*) and model specifications fit over the period 1960:1-1970:4

Rank	Models				
	No intercept No trend[1]	Intercept No trend I[2]	Intercept No trend II[3]	Intercept Trend I[4]	Intercept Trend II[5]
---------------------------------------Lag 1--					
0	22.4991	22.4991	22.5423	22.5424	22.6372
1	*22.3338*	22.4227	22.5648	22.6279	22.6996
2	22.5547	22.7319	22.7973	22.9219	22.9789
3	23.0994	23.1401	23.1258	23.3217	23.4008
4	23.7773	23.7746	23.7746	23.9928	23.9928
---------------------------------------Lag 2--					
0	23.2936	23.2939	23.4335	23.4334	23.5320
1	23.4384	23.5139	23.5644	23.3696	23.5800
2	23.7010	23.8559	23.8756	23.7226	23.8830
3	24.3199	24.2945	24.3153	24.2487	24.3215
4	25.0023	25.0040	25.0040	24.9117	24.9117
---------------------------------------Lag 3--					
0	23.7339	23.8434	23.8434	23.8434	23.8764
1	23.8563	23.9386	23.9573	23.8567	23.8769
2	24.0193	24.1538	24.3129	24.1908	24.2702
3	24.4621	24.6826	24.7732	24.7433	24.8257
4	25.1998	25.3300	25.3300	25.3923	25.3923
---------------------------------------Lag 4--					
0	24.6760	24.6760	24.7308	24.7308	24.7365
1	24.6171	24.5846	24.6390	24.7024	24.6143
2	24.8438	24.7306	24.6927	24.7516	24.5909
3	25.1706	25.1477	25.0892	25.1182	25.1880
4	25.8705	25.7346	25.7346	25.8432	25.8432
---------------------------------------Lag 5--					
0	25.4646	25.4646	25.5232	25.5232	25.3061
1	24.5627	24.6384	24.6153	24.7102	24.6309
2	24.7464	24.6594	24.5905	24.2098	24.1141
3	25.2647	24.9871	25.0683	24.6504	24.7084
4	26.0200	25.7102	25.7102	25.3411	25.3411

Table 1 Continued

[1]   Test assumes no deterministic trend in data, and no intercept or trend in cointegrating equation (CE) or test VAR;

[2]   Test assumes no deterministic trend in data, have intercept (no trend) in CE, but no intercept in VAR;

[3]   Test allows for linear deterministic trend in data, and assume intercept (no trend) in CE and test VAR;

[4]   Test allows for linear deterministic trend in data, and assume intercept and trend in CE, but no trend in VAR;

[5]   Test allows for quadratic deterministic trend in data, and assume intercept and trend in CE and linear trend in VAR.

TABLE 2

One step Schwarz Loss Criteria (SLC) by Lags on the number of cointegrating vectors (*r*) and model specifications fit over the period 1971:1-1980:4

Rank	No intercept No trend[1]	Intercept No trend I[2]	Intercept No trend II[3]	Intercept Trend I[4]	Intercept Trend II[5]
			Models		
---Lag 1---					
0	30.5555	30.5555	30.4096	30.4096	30.7001
1	30.6104	30.6034	30.3770	*30.0694*	30.2735
2	30.8592	30.7790	30.6782	30.1605	30.3016
3	31.3813	31.1801	31.1670	30.7406	30.8096
4	32.1183	31.8872	31.8872	31.3631	31.3631
---Lag 2---					
0	31.0710	31.0710	30.5071	30.5071	30.7790
1	30.3754	30.4288	30.0916	30.1798	30.4539
2	30.4728	30.4433	30.1258	30.1613	30.3445
3	30.8164	30.7655	30.4700	30.4382	30.5292
4	31.5492	31.2021	31.2021	31.0645	31.0645
---Lag 3---					
0	30.9506	30.9506	30.8534	30.8534	31.2070
1	30.7805	30.8553	30.7094	30.8011	31.0667
2	31.0336	31.1851	30.9678	31.0920	31.2703
3	31.4480	31.5597	31.3942	31.4661	31.5522
4	32.1773	32.1226	32.1226	31.9915	31.9915
---Lag 4---					
0	31.6878	31.6878	31.4762	31.4762	31.8300
1	31.7186	31.6240	31.3610	31.3845	31.6465
2	31.8500	31.7983	31.4928	31.4537	31.6297
3	32.2402	32.0662	31.9325	31.9186	32.0108
4	32.9673	32.6702	32.6702	32.5628	32.5628
---Lag 5---					
0	32.4248	32.4248	32.3743	32.3743	32.7329
1	32.2504	32.1976	32.0559	31.6220	31.8932
2	32.4315	32.3085	32.1811	31.8115	31.9933
3	32.9693	32.7785	32.6974	32.1654	32.2576
4	33.7009	33.4339	33.4339	32.8475	32.8475

Table 2 Continued

[1]   Test assumes no deterministic trend in data, and no intercept or trend in cointegrating equation (CE) or test VAR;

[2]   Test assumes no deterministic trend in data, have intercept (no trend) in CE, but no intercept in VAR;

[3]   Test allows for linear deterministic trend in data, and assume intercept (no trend) in CE and test VAR;

[4]   Test allows for linear deterministic trend in data, and assume intercept and trend in CE, but no trend in VAR;

[5]   Test allows for quadratic deterministic trend in data, and assume intercept and trend in CE and linear trend in VAR.

TABLE 3

One step Schwarz Loss Criteria (SLC) by Lags on the number of cointegrating vectors (*r*) and model specifications fit over the period 1981:1-1990:4

	Models				
	No intercept	Intercept	Intercept	Intercept	Intercept
Rank	No trend[1]	No trend I[2]	No trend II[3]	Trend I[4]	Trend II[5]
--Lag 1---					
0	31.4999	31.4999	31.4625	31.4625	31.5451
1	31.4560	*31.1311*	31.2427	31.3147	31.3312
2	31.8413	31.4171	31.5377	31.6815	31.7314
3	32.3466	31.9506	31.9839	32.2101	32.1819
4	33.0410	32.5493	32.5493	32.7898	32.7898
--Lag 2---					
0	31.4792	31.4792	31.7191	31.7191	31.7237
1	31.5079	31.5993	31.7908	31.8320	31.7453
2	31.8389	31.7822	31.8924	32.0049	31.8686
3	32.3939	32.2098	32.2305	32.2320	32.2764
4	33.1205	32.8624	32.8624	32.9419	32.9419
--Lag 3---					
0	32.3541	32.3541	32.5365	32.5365	32.6959
1	32.2499	32.2676	32.4299	32.5219	32.6078
2	32.7144	32.4253	32.5027	32.6815	32.7025
3	33.2841	32.9841	33.0355	33.1284	33.2165
4	34.0209	33.6510	33.6510	33.7981	33.7981
--Lag 4---					
0	33.4739	33.4739	33.6099	33.6099	33.7080
1	33.2689	32.8636	32.9122	33.0009	33.0370
2	33.6366	32.7853	32.7711	32.9220	32.9909
3	34.1917	33.2476	33.2844	33.3844	33.4625
4	34.9270	33.9008	33.9008	34.0459	34.0459
--Lag 5---					
0	33.5376	33.5376	33.5774	33.5774	33.7328
1	33.4411	32.8561	32.8136	32.5523	32.6874
2	33.6806	32.9134	32.7803	32.5382	32.6506
3	33.9827	33.2933	33.1830	32.9375	32.9812
4	34.7171	33.8034	33.8034	33.5804	33.5804

Table 3 Continued

[1]   Test assumes no deterministic trend in data, and no intercept or trend in cointegrating equation (CE) or test VAR;

[2]   Test assumes no deterministic trend in data, have intercept (no trend) in CE, but no intercept in VAR;

[3]   Test allows for linear deterministic trend in data, and assume intercept (no trend) in CE and test VAR;

[4]   Test allows for linear deterministic trend in data, and assume intercept and trend in CE, but no trend in VAR;

[5]   Test allows for quadratic deterministic trend in data, and assume intercept and trend in CE and linear trend in VAR.

TABLE 4

One step Schwarz Loss Criteria (SLC) by Lags on the number of cointegrating vectors (*r*) and model specifications fit over the period 1991:1-2003:3

	Models				
	No intercept	Intercept	Intercept	Intercept	Intercept
Rank	No trend[1]	No trend I[2]	No trend II[3]	Trend I[4]	Trend II[5]
--Lag 1--					
0	30.7947	30.7947	30.4138	30.4138	30.4105
1	30.4499	30.5250	30.3940	30.4674	***30.3501***
2	30.4684	30.6206	30.6420	30.7784	30.6685
3	30.8600	31.0347	30.9958	31.2080	31.1887
4	31.3611	31.6101	31.6101	31.8053	31.8053
--Lag 2--					
0	31.2964	31.2964	31.3040	31.3040	31.1935
1	31.1654	31.2152	31.2225	31.1773	31.0003
2	31.1947	31.3190	31.3819	31.4068	31.3706
3	31.6139	31.7892	31.7953	31.8913	31.8659
4	32.1526	32.3896	32.3896	32.4778	32.4778
--Lag 3--					
0	31.7328	31.7328	31.7198	31.7198	31.5580
1	31.6655	31.7127	31.7103	31.5803	31.4272
2	31.6998	31.8204	31.9168	31.8406	31.6364
3	31.9836	32.1218	32.1470	32.1435	32.0595
4	32.5133	32.6064	32.6064	32.6526	32.6526
--Lag 4--					
0	32.2571	32.25707*	32.3679	32.3679	32.3029
1	32.3039	32.3281	32.3810	32.3311	32.2624
2	32.4416	32.5402	32.5251	32.5505	32.4127
3	32.6945	32.8593	32.8358	32.9332	32.8366
4	33.2223	33.2853	33.2853	33.4502	33.4502
--Lag 5--					
0	32.7506	32.7506	32.9047	32.9047	32.7258
1	32.7599	32.7994	32.8815	32.7862	32.6477
2	32.8534	32.9595	33.0252	32.9156	32.8230
3	33.1942	33.3552	33.4240	33.3567	33.2364
4	33.7868	33.8610	33.8610	33.8520	33.8520

[1]   Test assumes no deterministic trend in data, and no intercept or trend in cointegrating equation (CE) or test VAR;

[2]   Test assumes no deterministic trend in data, have intercept (no trend) in CE, but no intercept in VAR;

[3]   Test allows for linear deterministic trend in data, and assume intercept (no trend) in CE and test VAR;

[4]   Test allows for linear deterministic trend in data, and assume intercept and trend in CE, but no trend in VAR;

[5]   Test allows for quadratic deterministic trend in data, and assume intercept and trend in CE and linear trend in VAR.