UNIVERSITY OF SOUTHAMPTON

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Reconsidering the role of nominal monetary policy variables: evidence from four major economies

by

Min Zhu

Thesis for the degree of Doctor of Philosophy

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To my dear parents and grandparents

UNIVERSITY OF SOUTHAMPTON

Abstract

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This thesis aims to contribute to monetary policy studies by conducting fundamental research and gathering empirical evidence on the effectiveness of monetary policy in the U.S., U.K., Germany and Japan. The financial crisis in 2007/08 highlighted the weakness of using nominal interest rates as the main monetary policy instrument. Before the financial crisis in 2007/08, the new monetary consensus (Bernanke 1992, 1995, and 1996, Woodford, 2003) that interest rates could be the effective intermediate instrument to influence the economy was widely accepted by central banks. It had developed since the failure of monetarism in the late 1970s. Some central banks (BOE, ECB, and RBNZ) have adopted specific inflation targeting, and approach it through the short-term interest rate. However, as the short-term interest rate has approached zero in a number of countries, it has become apparent that new monetary policy instruments are needed. Quantitative variables (including measures of money and credit) have since become of greater concern again, especially since a policy of "quantitative easing (QE)" was adopted by the Bank of England in 2009.

The main goal of this research is to provide empirical evidence on the interaction between financial variables (interest rates, money and credit) and economic variables (nominal GDP). Three main questions are being dealt with:

(1) Are financial variables (interest rates, money and credit) appropriate to target nominal GDP?
(2) Do quantitative variables (money and credit) have superior predictive abilities to the price variable (interest rate) in predicting nominal GDP?
(3) Do credit variables perform better than money aggregates in explaining nominal GDP?

The empirical analysis employs simple regressions, Granger causality tests, the general-to-specific modelling methodology and VARs model. The empirical results suggest that quantitative variables (money aggregates and GDP-circulation credit) have more predictive power for nominal GDP than price variables (interest rates). Meanwhile the GDP-circulation credit displays more accurate features than money aggregates to target nominal GDP. Overall the outcomes not only enrich the literature regarding the monetary policy in the U.S., U.K., Germany and Japan but also provide further empirical support for a modified 'credit view' of the transmission of monetary policy. They also have implications for the design of a successful monetary policy implementation regime.

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Declaration of Authorship

I, **Min Zhu** declare that the thesis entitled

Reconsidering the role of nominal monetary policy variables: evidence from four major economies

and the work presented in it are both my own and have been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
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Southampton, March 2011
Min Zhu

Acronyms and Abbreviations

BoJ	Bank of Japan
BoE	Bank of England
CPI	Consumer price index
CD	Certification Deposit
ECM	Error Correction Model
ERM	Exchange Rate Mechanism
EMU	European Economic and Monetary Union
EMS	European Money System
FAS	Financial Services Authority
FRB	Federal Reserve Board
FOMC	Federal Open Market Committee
GDP	Gross Domestic Product
GNP	Gross National Product
M1, M2, M3, M4	Money stock aggregates
OECD	Organization for Economic and Cooperation Development
NGDP	Gross Domestic Product (non-seasonally-adjusted, current-year, national currency)
RGDP	Real Gross Domestic Product
RBNZ	Reserve Bank of New Zealand
PGR	Annual Growth Rate of Consumer Price Index
R-90	3-month Treasury bill
R -10YR	Treasury bonds with constant ten-year maturity

Chapter 1

1 Introduction

> "The tool cannot be the interest rate. It is too imperfect for that. There was a need for direct controls on the supply of credit to prevent the build-up of dangerous asset price bubbles. Policy makers needed more than interest rates to tame asset price booms and urged the setting of a new macro-prudential body in the UK able to take preemptive action. "

Lord. A. Turner at Davos, 27th Jan. 2010

1.1 Motivation

As stated at the beginning, there has been a call for new monetary policy rules following the 2007/08 financial crisis, because this crisis revealed the weakness of interest rate as the monetary policy instrument. Before the financial crisis of 2007/08, the new popular monetary consensus (Bernanke, 1992, 1995, and 1996), that interest rate was the effective intermediate tool to influence the real economy, had dominated central banks' operations since the failure of money aggregates as the intermediate target to the real economy in the 1970s. The public also accepted this notion that the interest rate has a real effect on economic conditions; thus, the financial markets would respond after the minutes of the central banks' committee had been published.(Dominguez, 1991, Eijffinger and Geraats, 2006) However, the use of only short-term interest rate to target inflation failed to predict or prevent the financial crisis, and this has provoked the debate. In addition, the interest rate has been cut to almost zero in the main developed countries following the financial crisis of 2007/08, but economies are still suffering from lacklustre performance, especially in the U.S. and the U.K. Therefore, at this point, the monetary authorities have demanded a search for a new monetary policy rule.

Response to the crisis

The monetary authorities have realize the mistake in the assumption that price stability will lead the financial stability, thus they propose the new monetary policy tools. Some suggest that we need stricter capital adequacy requirements and accounting standards. But it does not recognize the core problems that cause the financial crisis, because it is hard to see that bank crisis could avoid by raising the ratio of capital adequacy from 8 percent to 12 percent. Someone suggest that restructured pay, more competition, greater monitoring, some type of a Volcker rule, and counter-cyclical capital adequacy rule, even further step to implementation of macro-prudential policy over the cycle. There are many new thoughts on monetary policy tools. My study also attempts to propose a possible way to keep financial stability and help promote prudential banking system, and basically the idea is that we might pay more attention on other tool-credit, besides the focus on interest rate.

Given the uncertain effect of monetary policy on the economy, it is not surprising that there are also extensive debates in academic circles on the ultimate target of monetary policy and the rules upon which it is based. The more recent natural experiment in monetary policy covering three episodes of growth and decline in the economy and the stock market carried out by Friedman (2005) confirmed that the quantity of money has a determinative effect on what happens to national income and to stock prices. The results strongly support Anna Schwartz's and Friedman's 1963 conjecture about the role of monetary policy in the Great Contraction. The noticeable feature of the experiment was that Friedman used nominal GDP instead of real GDP to represent the economic conditions; thus, the researcher regards this as an indication that the academics are starting to re-emphasise nominal GDP rather than real GDP as the monetary policy target.

A number of researchers have previously advocated nominal income targeting in theory (Tobin,1980; Meade, 1984; Hall,1984; Frankel,1995; Gordon,1985; Taylor, 1985; McCallum, 1990; Pecchenino and Rasche, 1990; Hess et al., 1993; Feldstein and Stock,1993; and Hall, 1993), but few empirical works have examined it (Judd and Motley,1992; Feldstein and Stock,1993; Werner,1997, 2003, 2005). Consequently there is a big gap in the literature concerning empirical work on the use of interest rate, money aggregates and credit to target nominal income or nominal GDP. Meanwhile, considering the need to find a new monetary policy tool besides the interest rate following the financial crisis of 2007/08, it will be constructive to explore the effect of quantitative variables (money, credit) or price variable (interest rate) on the nominal output. This research intends to provide the empirical evidence on using interest rate, money aggregates and GDP-circulation credit to target nominal output in the context of a developed economy.

Before a discussion in this introductory chapter of what the research intends to achieve, the researcher will firstly review the ultimate and the intermediate monetary policy target to achieve the economic goals of the central banks of the U.S., U.K., Germany and Japan in the time before the financial crisis of 2007, and then summarise what the central banks have actually done following the recent financial crisis. The study indicates the change in monetary policy instruments in the monetary policy process of central banks before and after the financial crisis and points out that the different notions about monetary policy signal the need to find a new monetary policy instruments-credit supply control; furthermore, it also suggests the possibility of using another ultimate monetary policy target - nominal GDP.

1.2 The world before the financial crisis of 2007/08

1.2.1 The relationship between interest rate and real economy in theory

After the collapse of monetarism in the late 1970s and early 1980s, many researchers advocated the use of interest rate as the monetary policy. Taylor (1993) also argues that, since it is the interest rate that directly affects spending, the central banks should think in terms of choosing interest rate rather than a rate of nominal money growth. He proposed a simple monetary policy, where the Federal Reserve puts the same weight on both inflation and output gap. The central banks can rely on the output gap and inflation gap to adjust the interest rate, although the empirical work has not always fully supported the Taylor rule (Svensson, 2003). The " Interest and Prices" (Woodford, 2003) shows how interest rate policy can be used to achieve an inflation target in the absence of either commodity backing or control of a monetary aggregate. Woodford dropped the word "money" from the name of the famous economics book "Money, interest rate, and prices: an integration of monetary and value theory" by Don Patinkin (1965), which points to Woodford's contention that money is not important. [1] Although there is a disconnection between theory and practice, the central banks in industrialised countries started to target inflation based on an interest rate approach from the late 1980s. The summaries of the monetary policy statements of the Federal Reserve, Bank of England (BOE), Bank of European (ECB) and Bank of Japan (JOB) in the following part will confirm the interest rate approach that central banks have been using until now.

1.2.2 Monetary policy target in the U.S., U.K., Germany and Japan

Federal Reserve Board

The goals of monetary policy are laid down in the Federal Reserve Act, which specifies that the Board of Governors and the Federal Open Market Committee should seek "to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates." The consensus is that stable prices are a precondition for maximum sustainable output growth and employment as well as moderate long-term interest rates in the long run

In the implementation of monetary policy, the Federal Reserve influences the conditions in the market for balances that depository institutions hold at the Federal Reserve Banks.

The operating objectives or targets that it has used to affect desired conditions in this market have varied over the years. Now the FOMC sets a target for the federal funds rate that are balances traded between depository institutions but, in the past, the FOMC sought to achieve a specific volume of those balances.

> *"By the means of open market operations, imposing reserve requirements, permitting depository institutions to hold contractual clearing balances, and extending credit through its discount window facility, the Federal Reserve exercises considerable control over the demand for and supply of Federal Reserve balances and the federal*

[1] Marcus Miller suggested that Woodford's intention to drop the word "money" indicated Woodford's attitude to the money in monetary policy.

funds rate. Through its control of the federal funds rate, the Federal Reserve is able to foster financial and monetary conditions consistent with its monetary policy objectives. "[2]

Bank of England

The Bank of England explains the monetary policy framework as follows:

"The Bank's monetary policy objective is to deliver price stability – low inflation – and, subject to that, to support the Government's economic objectives including those for growth and employment. Price stability is defined by the Government's inflation target of 2%"[3]

The Bank of England announces the interest rate, which is used to control the inflation target, and explicates that the changes in interest rate will influence market rates, asset prices, expectations and exchange rates, which are crucial factors affecting the total demand. The interest rate influence on the overall demand, and then the inflation pressure is the result. Therefore, in brief, the change in interest rate is intended to control the inflation.

European Central Bank

The European Central Bank declaims a similar framework and points out that the maintenance of price stability is the primary and single monetary policy objective. This is spelled out in the Treaty establishing the European Community, in Article 105 (1).

"Without prejudice to the objective of price stability", the Eurosystem will also "support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community". These include a "high level of employment" and "sustainable and non-inflationary growth".

[2] The source: Chapter of The Implementation of Monetary Policy, The Federal Reserve System: Purposes Function

[3] Source: Bank of England

The ECB's Governing Council has specified price stability as "a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the Euro area of below 2%. Price stability is to be maintained over the medium term".

The operational framework of the Eurosystem consists of three instruments: open market operations, standing facilities, and minimum reserve. Open market operations have the significant role of steering the interest rate, while standing facilities bind the overnight market interest rate, signalling the general monetary policy; the intention of the minimum reserve system is to stabilise the market interest rate, and create a structural liquidity shortage.

Overall, this set of instruments is the middle process in achieving the ultimate growth goal, and the three instruments mentioned above are all relevant to interest rate. In conclusion, the interest rate is the technique used by the European Central Bank to reach the price stability.

Bank of Japan

The Bank of Japan, as the central bank of Japan, also states that, because the price stability provides the foundation for the nation's economic activity, maintaining price stability is the aim of monetary policy in Japan.

> *"The Bank controls the amount of funds in the money market mainly through money market operations, thereby bringing the uncollateralized overnight call rate to the target level specified in the guideline for money market operations. Money market rates, in turn, affect interest rates in other financial markets and the lending rates that financial institutions apply on loans to firms and individuals. In this way, the Bank's monetary policy influences economic activity overall."* [4]

By interpreting the statements made by these most important central banks in the world, one can discern the fact that the price stability is the main target for these central banks

[4] Source: The outline of monetary policy, Bank of Japan

nowadays, as they assume that the price stability is a precondition for high and stable levels of growth and employment, which will in turn assist in creating the conditions for price stability on a sustainable basis. The way the central banks exert their influence in general is to control the interest rate through the open market operation, the volume of money, and minimum reserve requirement. As the goal is economic growth, common sense would suggest that there is a certain negative correlation between the nominal interest rate and economic growth. The central banks intend to control the interest rate, combined with inflation-targeting, to influence the economic activity.

However, since the 2007 financial crisis, using the interest rate as the instrument with which to achieve the effect on the economy that the central banks expected has been in doubt. The high economic growth rate accompanied by low inflation in the last three decades demonstrates the interest rate's effect on the real economy, but the academic world has realized the necessity of re-examining the limitations of the interest rate in affecting the real economy, as the current macroeconomic theory has been put under strain since the financial crisis of 2007/08 and the subsequent recession. The theories of both New Classical and New Keynesian economics were undermined after the financial crisis; thus the academics have started to acknowledge the problem with interest rate as the monetary policy. It was a complex matter to distinguish movements of real interest rate versus nominal rate when inflation became the problem. Before this financial crisis, the central banks had been proud of themselves, as it seems they had found the key to mordant monetary economics, which is inflation-targeting. However, they now know that, although the inflation includes certain information, this information might not reflect what is happening in the current financial market.

When the researcher started to review the monetary policy tools and goals in these four countries at the beginning of the research, the financial crisis of 2007/08 had not yet occurred. If one looks through the statement of the monetary policy tools in the central banks of these four countries after the financial crisis of 2007/08, the interesting change is that there is more emphasis on the tools being relative to credit, especially in the U.S. and the U.K. [5] The innovations in the financial market, the boom in developing countries' economies, and the trend of free global capital flow after the 1990s made the

[5] The terms are Asset-Backed Securities Loan Facility in the U.S., Quantitative Easing in the U.K

monetary policy transmission mechanism more complex. As Lord Turner said, we need a new instrument: credit control.

1.3 The world after the financial crisis of 2007/08

After the initial downturn of the financial crisis in 2008, the immediate action taken by the central banks was to reduce the short-term interest rate. The Federal Reserve carried out a number of significant actions, which included cutting the target federal funds rate by 325 basis points from the second half of 2007 to the first four months of 2008, in response to the steep increase in commodity prices boosting consumer price inflation and the deteriorating financial market conditions threatening economic growth. [6] The central banks around the world also took the extraordinary, co-ordinated step of cutting interest rates amid slumping world stock markets in 2008. Remarkably, six central banks took this action in concert, including the Bank of England, the US Federal Reserve, and the central banks of Canada, Sweden and Switzerland, cutting interest rates by half a percentage point in an effort to steady the faltering global economy in October 2008. [7]

1.3.1 The actions of central banks in the liquidity trap

When the central banks found that the reduction of interest rate alone could not prevent the collapse of financial markets and the weakening of real economic conditions, they began to inject billions of pounds into the market to avoid the continuing drop in prices. The central banks started to employ "Quantitative easing"[8], which made the public at last realize that the "helicopter drop" of money had become a reality in order to fight

[6] Source: Monetary policy of the Federal Reserve report to Congress published on July 15th, 2008.

[7] "Six central banks, including the Bank of England, have cut interest rates by half a percentage point in an effort to steady the faltering global economy. No decision on UK rates had been expected until Thursday - and the move puts the interest rate at 4.5% from 5%. The US Federal Reserve has cut rates from 2% to 1.5% and the European Central Bank (ECB) trimmed its rate from 4.25% to 3.75%. The central banks of Canada and Sweden and Switzerland all took similar action in the co-ordinated move. China also cut its rate, but by 0.27 percentage points." BBC News "Central Banks cut interest rates" 8 October 2008

[8] When the Bank is concerned about the risks of very low inflation, it cuts bank rate – that is, it reduces the price of central bank money. But monetary policy- nominal short-term interest rates cannot significantly fall below zero. So if they are almost at zero, and there is still a significant risk of very low inflation, the Bank can increase the quantity of money – in other words, inject money directly into the economy. That process is sometimes known as 'quantitative easing- source: Bank of England

deflation. Actually, the use of "Quantitative easing" acknowledges that interest rate as the monetary policy tool is not sufficient.

Quantitative easing has been acknowledged as the next logical policy step by the central banks as the base rate approaches zero. In the U.S., the Federal Reserve has bought $1.7trillion (£1.1trillion) in bonds to shore up its recovery from recession. In the same time period, the Bank of England was driven to inject 200bn pounds into the economy. The ECB has implemented a process that led to bonds being "structured for ECB", which is a form of quantitative easing without it being referred to as such. The ECB expanded the assets that banks can use as collateral which can be posted to the ECB in return for Euros in the long term. In Japan, the BOJ has flooded commercial banks with excess liquidity to promote private lending, accomplished by buying more government bonds than would be required to set the interest rate to zero. Basically, to conclude, quantitative easing is the practice of loosening the loan supply by expanding the liquidity in the financial market with the expectation of boosting the economic conditions.

1.3.2 A rule based on credit

Green (2009), the chairman of HSBC, stated the necessity of directing the supply of credit because, in the current global open financial market, the ability of central banks to influence national economies through the control of interest rate has been weakened.[9] As he pointed out, although the interest rate could be used to influence the banks' demand for credit, global capital flow makes the monetary policy dynamic path more complex, and the irony exists that the central banks could increase interest rate and end up with looser monetary conditions. The increase in interest rate has not reduced the quantity of credit in the market, and has instead attracted more international capital inflow. Monetary policy works efficiently if the policy can be transmitted smoothly through the banking system, but this process is distorted by the global capital flows. Therefore, Green points out that it is time to give the central banks two weapons. One is interest rate, while the other is credit. The direct control of supply of credit is, to his mind, an effective policy. Actually he is not the only person who believes this, and his thoughts are in line with proposals by Lord Turner, the chairman of FAS.

[9] "Let central banks direct the supply of credit", Stephen Green, Financial Times, on April 26th 2009.

Turner (2010)[10] said, in Davos, that interest rate could not be the only monetary policy tool - it is far too imperfect for that. He called for efforts to do something about this situation, because the bubble could not be pricked with the monetary policy used nowadays. As he pointed out, the massive expansion of credit made the property bubble of 2004-2007 far more serious than the dotcom bubble of the late 1990s and more dangerous to the real economy, because high levels of lending for property had led to instability of macro-economic and self-reinforcing processes involving both borrowers and lenders, and had made the situation worse. Turner said the committee should be able to target both borrowers and lenders; furthermore, it could monitor the supply of credit flowing into those parts of the economy most likely to experience bubbles.

Turner (2010) suggested that this had already happened in countries like China and India, and both countries had used the direct control of credit to prevent the build-up of asset price bubbles earlier in the decade. He added that the idea he was promoting is not new to academia. The importance of credit has been discussed by academics for a long time, but had been forgotten due to the dominant school of thought which assumed that economic management could be left to a combination of free-market forces and manipulation of interest rate, as in the past three decades.

GDP-circulation credit

In introducing the Federal Reserve's response to the 2007/08 financial crisis, Fed Chairman Ben Bernanke (2009) used the term "credit easing" to distinguish it from the "quantitative easing" in Japan during the period 2001 to 2006. He emphasised, "in contrast to a pure QE regime- gauged primarily in terms of target for bank reserves, the Federal Reserves' credit easing approach focuses on the mix of loans and securities that it holds and on how this composition of assets affects credit conditions for households and businesses." [11]The difference reflects the economic circumstances. "Credit spreads are much wider and credit markets more dysfunctional in the U.S. today than was the case during the Japanese experiment with quantitative easing," Bernanke said.

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10 Speaking in Davos, Lord Turner, FSA chairman, calls for direct controls on the supply of credit 27th January 2010

11 The speech "The Crisis and the Policy Response" by Chairman Ben S. Bernanke, at the Stamp Lecture, London School of Economics, London, England January 13, 2009

The announcement made by Bernanke reveals that various types of lending have heterogeneous effects due to the recent fundamental change in the financial markets, which require a more sophisticated credit policy. Turner (2010) also said, “We need new macro-prudential tools that directly focus on the supply of credit to those parts of the economy most likely to see bubbles.” Turner made the point that some streams of credit are used to fuel the bubble, not the real economy, so the new monetary policy should not only monitor the total amount of credit flow, but also differentiate what the credit is used for.

As a result, this research will develop the GDP-circulation credit flow, which is the part of credit directed to GDP growth while another part flows into the asset market[12], because the control of credit supply seems a useful tool not only to monitor the price bubble but also to prevent the economic downturns The GDP-circulation credit reflects the complex credit flow transmission in the market nowadays, and it is also an innovation in empirical research that uses the GDP-circulation credit to explore the link between credit and economic conditions. A number of earlier studies during the 1980s focused on monetarism. As the most important paper, “the role of monetary policy” by Friedman (1968), pointed out, the quantity of money could be the control target to influence the real economic conditions. The subsequent researchers (Sims, 1972; Davidson, 1972; Litterman and Weiss, 1985; Bernanke and Blinder, 1988; Hayo, 1999; Amato and Swanson, 2001; Meyer, 2001) mainly explored the link between money aggregates and real GDP or GNP. However, due to the failure of monetarism in 1970s and the leading position subsequently taken by the New Classical economics, a limited number of studies have since paid attention to the effect of quantitative variables on the real economy. Research on credit has mainly emphasized the credit channel in the framework of the monetary transmission mechanism. Most empirical studies (Bernanke and Blinder, 1988, 1992; Kashyap, Stein and Wilcox, 1993) aimed to find supporting evidence that credit has an effect on the real economy, but this empirical test is still part of the New Classical economic theory. This research will examine the effect of GDP-circulation credit on the economy in a framework that is different from the New

[12] The concept of credit to real transaction was firstly provided by Werner (1997). He suggested that the credit flow could be divided into two groups. One flows into the real economy sector and the other flows into the financial sector.

Classical economic theory. The most remarkable feature is the notion of targeting nominal GDP in that framework. [13]

1.3.3 Goal of monetary policy: targeting nominal GDP

Although academics have mainly focused on the real GDP, we actually live in the nominal world. In daily life, when companies make investments, or households calculate their expenditure, they not only weigh the quantity of real goods but also consider how much they will pay and how much they will have in nominal terms. The tendency of people to consider currency in nominal terms, rather than real terms, is called money illusion. [14] If the fundamental process of the economy is in nominal terms, it should attract research that emphasises the nominal variables. Furthermore, to ensure value in the statistical quality of research, it would be better to couple real GDP with real interest rate, or nominal interest rate with nominal GDP. Otherwise, there is a mismatch problem. Thus, this study uses the aggregate nominal GDP to provide a new insight into the effectiveness of the monetary policy.

Targets for nominal GDP, as it is maintained, would help policy-makers balance the policy goals of sustainable economic growth and price stability. With a good target variable, keeping the variable on target should help stabilize real GDP in the short term and also yield inflation consistent with the long-term objective of price stability. Advocates of rules for nominal GDP-targeting have proposed a number of specific rules. Typically, these rules call for the adjusting of short-term interest rate. Some analysts argue for rules that adjust another instrument of monetary policy, the monetary base, to keep nominal GNP on target (McCallum 1987, 1988; Judd and Motley 1993), and Werner (1997, 2003, and 2005) supported the use of GDP-circulation credit to target nominal GDP.

Our research advocates the targeting of nominal GDP, because nominal GDP-targeting contains the economic growth and price information, which would help to stabilize the economy. In addition, the financial crisis of 2007 has heightened interest in the effect of

[13] More details about the framework provided by Werner (1997, 2003, 2005) will be discussed in chapter 6

14 An economic theory stating that many people have an illusory picture of their wealth and income based on nominal dollar terms, rather than real terms. Real prices and income take into account the level of inflation in an economy.

quantitative variables on economic conditions, while the lack of empirical studies in this area since the 1980s reveals the gap therein. As a result, using quantitative variables - money aggregates or credit aggregate - to target the nominal GDP is the main focus of this thesis. The research will employ empirical tests to target nominal GDP using the interest rates, money aggregates and GDP-circulation credit through simple regression, "causality" test and VARs model.

There have been two important innovations in the empirical research. First, most empirical studies used the credit data that are published directly by central banks or commercial banks, but these credit data have not been classified according to the distinction underlying credit flow, one part of which flows into the asset market, and other part of which flows into the real economy sector. In our research, the credit data used have been classified as credit flow into real economic transactions or financial speculation. Second, most studies investigate the effect of financial variables on real GDP, but this research considers the nominal GDP as containing more information than real GDP; thus, it is used instead of real GDP to represent the economic conditions.

1.4 The structure of thesis

The study seeks to provide the empirical results of using interest rates, money aggregates and GDP-circulation credit to target nominal GDP in a world of instant communications and ever more efficient financial markets. The effectiveness of financial variables (interest rates, money aggregates and GDP-circulation credit) on output is tested on data from the U.S., U.K., Germany and Japan during the period 1960 to 2008, using several approaches that are thought to be suitable for the task. First, the empirical evidence will seek to clarify whether the financial quantities variables, such as money or credit, are stable variables to target nominal GDP; second, it will try to establish whether they are better than interest rate for targeting nominal GDP. The most important feature of the empirical tests is that the research distinguishes between credit to the real sector and credit to the financial sector, which reflects the recent development of financial markets in the developed countries. Based on the empirical results, meaningful conclusions can be drawn concerning the success of money aggregates and GDP-circulation credit in affecting nominal GDP.

The thesis begins in chapter 2 with a discussion of the theories on the effectiveness of monetary policy and monetary policy rules. As an ongoing debating topic, the literature on the intermediate target and the goal of monetary policy development in the U.S., U.K., Germany and Japan is presented. In the literature chapter, the empirical works on monetary policy transmission in these four countries are also summarised to provide the general channels that link financial variables and economic conditions.

The methodology is presented in chapter 3. As a starting point, the single regression demonstrates that money aggregates are better than interest rate for explaining nominal GDP. However, simple regression is not sufficient to demonstrate that the quantitative variable could be used to target nominal GDP, and that it is better than interest rate, so the Granger causality test, General-to-specific models (GETS) and the Vector autoregression (VAR) approach are heavily employed and discussed in the methodology chapter.

Interest rates are claimed to be the most important and frequently-used policy to affect the economy in the U.S., U.K., Germany and Japan. Therefore, in chapter 4, the research first tests the link between interest rate and nominal GDP. In this chapter, the Granger causality test is applied to find the "causal" direction between short-term interest rate and nominal GDP. In order to supply more information on the relationships between interest rates and other economical variables such as inflation and real GDP, the research also employs the Granger causality test to explore the link between interest rates and real GDP or inflation. The results give a mixed picture, because the interest rate does not Granger cause real GDP or nominal GDP as the theory might have suggested in some countries. It is certain that using only the Granger causality test is not enough, and further empirical tests will be used in the following chapters.

The abandonment of monetary aggregates as an intermediate target occurred because of the development of financial deregulation and innovation. The difficulties in calculating money aggregates and the link between money aggregates and real GDP seem to have been eased following the innovations in the financial market. It seems that the quantitative variables also only affected the price; thus, in chapter 5 the research attempts to explore the link between money aggregates and nominal GDP in the short term. The research presents the econometric evidence of the strong link between nominal GDP and money aggregates by simple regression, also pointing out that money aggregates is better than interest rate in predicting nominal GDP. The research also applies the Granger causality test to find whether money aggregates could provide future information for nominal GDP. The VARs model is used to examine the large effect of money aggregates on nominal GDP. The empirical results based on Granger causality and VARs model suggest a strong link between money aggregates and nominal GDP, which is stronger than the effect of interest rate on nominal GDP.

Due to the financial crisis of 2007/08, the academics and the public have finally had to admit the important role of credit in affecting the economic conditions. Therefore, the research intends to examine the effect of credit on economic conditions. In chapter 6, the analysis of monetary policy focuses on the GDP-circulation credit. First, the discussion on the theoretical framework of using GDP-circulation credit to target nominal GDP is presented. Then the statistical analysis will be used to provide the empirical evidence on using GDP-circulation credit to target nominal GDP. In this part, the general-to-specific model (GETS), Granger causality test, and VARs model are employed. The results of the general-to-specific model reveal that GDP-circulation credit could be a good explanatory variable to nominal GDP; however, the Granger causality test yielded weak causal results between nominal GDP and GDP-circulation credit. The VARs model, which included interest rate, money aggregates and GDP-circulation credit, provided solid evidence for the importance of GDP-circulation credit in affecting nominal GDP. The VARs model captures the dynamic consistent positive response of nominal GDP to GDP-circulation credit innovation in all four countries. In addition, the subsample tests are also implemented in the GETS model, Granger causality test, and VARs model, which produces the stability of the link between credit to real transaction and nominal GDP.

Finally, in chapter 7, the study summarises the findings of the research, and evaluates the robustness of the findings across the different methodologies. Furthermore, the study points out the limitations in the empirical research of using quantitative variables to target nominal GDP and suggests that further studies are needed.

The research aims to introduce the empirical tests on using financial variables -interest rate, money aggregates and credit data - to target nominal GDP in the long term, as tests conducted during a sufficiently lengthy time period would provide the creditable link between these variables. However, the governments (for example: Canada, France, Australia, etc.) did not provide sufficient and long-term data for nominal GDP and credit. The only countries that provided the nominal GDP and credit data over 30 years were the U.S., the U.K., Germany and Japan, and data on credit and nominal GDP from Canada, France, and Italy were not from a sufficiently lengthy time period. That is the reason why only four countries are included in the research.

Chapter 2

2 General literature review

A rich wealth of literature has explored whether monetary policy is effective; meanwhile, there have been attempts to improve economic models to explain the relationships among macroeconomic variables. There has been a degree of divergence in monetary policy theories over the last decade so, in the literature review chapter, the research firstly provides a brief presentation of the important theories on the effectiveness of monetary policy in an attempt to highlight the disagreements on the effectiveness of monetary policy in academic circles. Secondly, the literature on the discussion of monetary policy targets is provided in section 2.2. Because our study intends to provide empirical research on using financial variables (interest rate, aggregated money and GDP-circulation credit) to target nominal GDP, a review of the theories on monetary policy targets will help us to understand the advantage of each monetary policy target. As an ongoing topic for debate, there will be a review of the monetary transmission mechanism, and the extensive empirical results on the monetary transmission mechanism will enrich an understanding of how financial variables (interest rate, money and credit) affect the economy. Lastly the history of the development of monetary policy in the U.S, U.K., Germany and Japan is reassessed.

2.1 A theoretical discussion on the effectiveness of monetary policy

It is commonly known that there are persistent disagreements between competing camps in macroeconomics. One frequently discussed divergence is the distance between the sticky-price models of the Neoclassical Synthesis, Monetarism, and New Neoclassical Synthesis, in which monetary policy is regarded as essential to real activities, and the flexible price models of real-business-cycle (RBC) economics, in which monetary policy is viewed as unimportant for real activities. After the introduction of the neoclassical synthesis, monetarism, new neoclassical synthesis and real-business-cycle, it was realized that there was widespread disagreement on the effect of monetary policy on the economy among the macroeconomic school of thought, so our study will contribute by providing further empirical results on the effect of monetary policy on the economy.

2.1.1 The neoclassical synthesis (New Keynesian)

The neoclassical synthesis was dominant in the 1950s and 1960s, and popularized by the mathematical economist Paul Samuelson.[15] Neoclassical synthesis was a post-war academic movement in economics that attempted to amalgamate the macroeconomic ideas of Keynes with the ideas of neoclassical economics. Because the neoclassical synthesis attempted to interpret and formalize Keynes' writings, and to synthesize them with the neoclassical models of economics, neoclassical synthesis is also known as the New-Keynesian model. The literature has only described the role of monetary policy in the neoclassical synthesis.

The standard IS-LM model is basically a static disequilibrium in the neoclassical synthesis. In the assumption of sticky prices, an increase in the money aggregate will shift the LM curve outwards, while the IS curve holds firm; thus, interest rate will decrease, resulting in a real output rise. In this process, the IS curve links with real output and the short-term nominal interest rate.

At first, the nominal price and wages were supposed to be constant in econometric models in the neoclassical synthesis, and practical policies also followed this assumption. However, economists soon found that fluctuations in inflation increased, and the assumption that price was independent of real economic activities was no longer maintained. Consequently, the inflation associated with economic growth is a serious concern of monetary policy. The Phillips curve[16] thus became the central part of monetary policy analysis. Although the neoclassical synthesis admits that monetary policy can control inflation, the neoclassical synthesis regards monetary policy as playing the supporting role in fiscal policy because, according to the neoclassical synthesis, monetary policy will increase the instability in those sectors that are most dependent on financial intermediaries: small businesses and individuals. Economists consider that direct credit control is better than interest rate in affecting the aggregate demand. They believe that credit control can have an effect on the economy by affecting

[15] An early description of the neoclassical synthesis is presented in Samuelson's Economics (1955 edition), and the mature synthesis is discussed in the 1967 edition (Samuelson, 1967)

[16] In economics, the Phillips curve is a historical inverse relationship between the rate of unemployment and the rate of inflation in an economy. Stated simply, the lower the unemployment in an economy, the higher the rate of inflation.

the availability of financial intermediary credit through the spread between market rates and the regulated deposit rates.

Neoclassical synthesis dominated mainstream economics in the post-war period through the 1950s, 1960s, and 1970s. However, in the 1970s, the recession shocked the neoclassical synthesis. The beginning of stagflation and monetarism cast doubts on the neoclassical synthesis theory.

2.1.2 Monetarism paradigm

The tendency for high inflation following the end of the Bretton Woods system of fixed-but-adjustable exchange rate and the first oil price shocks between 1973 and 1974 indicated that something was seriously wrong with the assumption of a stable unemployment-inflation trade-off. In the same period, academic ideas developed into a new framework.

Friedman and Schwartz (1963) were the first to model the idea that there was a positive correlation between money aggregates and economic fluctuations; then the well-known paper "The role of monetary policy" by Friedman (1968) was published, and their empirical evidence is probably still the most important proof that money does matter for real economic conditions. They interpreted the evidence as showing that the change in money growth rate leads the change in real economic activities as money causes output movements. Tobin (1970) was another leading economist who supported the idea of a positive relationship between money aggregates and income.

Friedman's paper led to the flourishing of monetarism during the period 1970-1980. According to the ideas of monetarism, inflation was correspondingly related to the money supply, and monetarist economists proposed that the direct control of money supply through the reserve requirement could manage inflation. The idea of using the money aggregate as the control target to influence the real economic conditions in the short term was accepted and implemented by the central banks for decades.

In fact, monetarism and neoclassical synthesis have totally different views on the effectiveness of monetary policy; as a result, the monetary transmission mechanism in each school of thoughts is different. The neoclassical synthesis regards the credit channel working through the interest rate as the main monetary transmission mechanism, while monetarism emphasises money supply's influence rather than credit's influence on the real economic conditions.

However, the implementation of money supply as the monetary policy failed in practice. The relationship between money supply and inflation has been proved unstable in reality. At the end of the 1970s, inflation could not be controlled through management of the money supply when the second oil price crisis occurred, and serious damage was caused to the real economic conditions. The problem with the quantity of money theory is that conventional monetary aggregates are hard to identify one-on-one with the economic activities. Economists have tried to identify which money aggregate variable - M_1, M_2 or M_3 - is more significant in relating to the real economic conditions, but the size of money supply actually changes with the economic activities.

The idea that money aggregates are the intermediate target to control real economic conditions was abandoned by monetarist economists after the failure of the implementation of money supply control in the early 1980s. Academic ideas gradually gathered around the new monetary consensus, which was developed after decades of intellectual work by numerous monetary economists represented by Bernanke since the 1980s. However, before the literature review turns to the new monetary consensus, the real business school should not be ignored, as it is an important school that believes that monetary policy has not had much effect on the real economic conditions.

2.1.3 Real-business-cycle school

Researchers' view on the value of monetary policy has been divided since the failure of monetarism and the abandonment of the quantity theory of money at the end of the 1970s. The RBC (Real Business Cycle) school represented by Sims (1980) advocated that the predictive power of interest rates is due to real, rather than monetary, factors; on the other hand, the new monetary consensus represented by Bernanke (1992) regarded the Fed fund rate as a measure of monetary policy and, if short-term interest rate affects the real economy, then the effectiveness of monetary policy should be recognized.

In the Real Business Cycle (RBC) model, the output is always at the natural level. According to the model, the economy only responds to exogenous shock, such as technological innovation. In other words, the economy will experience a boom when technological shocks are above average, and will go into recession when the shocks are below average. Thus, in RBC school thought, there is no room for monetary policy or fiscal policy.

The explanation for the predictive power of interest rates in the RBC school

In the early stages, the interest rate was added to the bivariate context of the relationship between money and output in RBC. Some researchers found that the predictive power of money was reduced when interest rate was added. The most reprehensive paper is that by Sims (1980).

Sims (1980) was interested in whether there was supporting evidence for the effectiveness of monetary policy and tried to find what percentage of nominal interest rate innovation could explain the real output. He established a vector autoregression (VAR) model that includes the industrial production as the real output indictor, wholesale price as the inflation indicator, and the M1 money stock, which became the standard VAR model in the empirical test of monetary policy. Sims' (1980) results suggested that M1 could account for 37% of the forecast variance of industrial production at a horizon of 2 years; however, the explanatory power of money to industrial products decreased greatly when interest rate was added in. Money only accounted for 4% of forecast variance of industrial production. Sims explained this evidence as the interest rate absorbing the explanatory power of money aggregate to real output, and interest rate is a good predictor of real output.

Litterman and Weiss (1985) also investigated the co-movement between money, interest rate, inflation and output, with an attempt to find whether the link between money to real interest rate to output was compatible with the existing monetary theories of the business cycle. Their results showed a negative correlation between nominal interest rate and real output, and also revealed that nominal interest rate tended to dominate money as the predictive power for output in a vector autoregression model and absorbed the forecasting power of money. Litterman and Weiss (1985) proposed an alternative model in which the money supply does not affect output and the money supply process is controlled by policies that aim to achieve short-term price stability.

Sims (1992) estimated the VAR systems for data from France, Germany, Japan, the U.K and the U.S from the 1950s and 1960s to 1990. The results showed the persistent negative impulse response of money and output to positive interest rate innovation. The empirical evidence fits the notion that interest rate as the monetary policy shock lead the contraction of money aggregate and decline of real output.

Sims, Litterman and Weiss regarded the evidence that money supply did not have predictive power for the future real output when interest rate was added as demonstrating the ineffectiveness of monetary policy. However, this view was challenged by the new monetary consensus. MaCallum (1995) pointed out that the evidence that money supply has not been a forecaster of future real output does not inevitably indicate the ineffectiveness of monetary policy, because the interest rate might be closer to the indictor of monetary policy. Bernanke and Blinder (1992) have advocated the Treasury bill rate as the monetary policy indicator, and revealed that nominal interest rate provides the future information on real output. After decades of hard work by researchers, the New Monetary Consensus has dominated the economics world in recent years.

2.1.4 New neoclassical synthesis

After the high inflation levels at the end of the 1970s, mainstream economists abandoned the use of the monetary aggregate to target inflation, and started to use interest rate to target inflation. This phenomenon reflected the fact that macroeconomics has been moving toward the New Consensus Macroeconomics since the 1990s. The New Monetary Consensus is rooted in the new neoclassical synthesis; thus, the study firstly reviews the New Neoclassical Synthesis (NNS), and then discusses the New Monetary Consensus.

The principal view of the New Neoclassical Synthesis does not change, and inherits the spirit of the old ideas. NNS models proposed that aggregate demand is the key determinant for the real economy in the short term, based on the idea that prices are sticky. The New Neoclassical Synthesis combines the features of Keynesian ideas, and elements of Classical and RBC models. Moreover, it also embodies the insights of monetarists, recognizing the effectiveness of monetary policy. In terms of methodology, rational expectation and optimization are applied in the new synthesis. The new neoclassical synthesis has a dynamic microeconomics foundation, as it involves the application of the pricing and output decision, which is the core of Keynesian models, and of the consumption, investment, and factor supply decisions, which are at the heart of classical and RBC models.(Goodfriend and King, 1997)

The new monetary consensus (NMC) embedded in the new neoclassical synthesis proposes several conclusions on monetary policies. First, NMC recognize the effect of monetary policy on the future real economic conditions through the gradual price adjustment. Secondly, there is little evidence to support the existence of a trade-off between inflation and real activities in the long run. Thirdly, there are obvious gains from keeping prices stable, as the stable price increases the efficiency of monetary transmission. Lastly, the creditability of central banks took on the central role in the transparency of monetary policy, which would lead rational expectations.

The literature review only focuses on the monetary policy role in the new consensus. As with monetarism, the New Consensus acknowledges the possible effectiveness of monetary policy rather than fiscal policy on real economic conditions in the short term in the conventional IS framework, but there is no effect on the real economy in the long term. However, the central difference between the New Consensus and monetarism is that interest rate is regarded as the instrument to adjust in the New Consensus while the money supply is the central instrument of control in monetarism. Furthermore, although interest rate had been used as the intermediate target in the 1960s, the underlying theory is different.

The central banks try to set a natural interest rate as the monetary policy instrument, meanwhile allowing the public to anticipate the movement of future interest rate, which influences the real economy as the central banks expected. As a result, the transparency of the monetary policy-making process, the predictability of monetary policy and communication with the public became important. Based on this idea, the central banks in practice target inflation through interest rate in most developed countries.

Figure 1 illustrates the process of NMC monetary transmission process, which is the central idea of NMC, modified from Palley (2005)

Monetary Transmission in the NMC

Instruments	**Intermediate Target**	**Ultimate target**
Overnight interest rate →	**market nominal interest rate →**	**inflation real GDP**
Communication	**(‘neutral’)**	

Source: adapted from Palley (2005)

The underlying logic of monetary transmission in NMC is that market interest rate directly responds to monetary policy interest rate[17] and the variation of interest rate influences the real economy by adjusting the demand of consumption, investment, and book value of assets. Moreover, the prediction of inflation based on the central banks' communications will also influence the economy.

After reviewing the most important theories on the role of monetary policy, the next step is to inspect the monetary policy rules under the assumption that monetary policies have an effect on the economic activities. Even if the role of monetary policies in the economy is conceded, there is less agreement about how the different instruments of policy achieve the ultimate economic goals.

2.2 Monetary policy rules

The objective of monetary policy

The objective of monetary policy generally is to affect the economic conditions as reflected in aspects such as output, inflation, and employment. The aggregated demand of people and firms to spend money on services and goods will be influenced by monetary policy. Against this background, the main intention of monetary policy is to maintain stability in the market, because proper stability will help the market operate with greater confidence. According to Mishkin (1998), six concepts are broadly mentioned by central banks when they talk about the goal of monetary policy:

Economic growth

High employment level

[17] Monetary policy interest rate: the Federal Reserve rate in the U.S., Bank Rate in the U.K.

Price stability
Stability of financial markets
Interest rate stability
Stability in foreign exchange rate market

As mentioned above, the central banks have conducted monetary policy to achieve the final goal, which could be the GDP, inflation and others. Mishkin (1998) has explained that the central banks' strategy is to set a number of variables as the intermediate targets to reflect the final goals that have been decided. The intermediate targets are normally the variables such as interest rates, money aggregates, and even nominal GDP etc, which have a direct effect on the final goals. The central banks do not use the policy to directly influence these intermediate targets; besides this, they select a series of variables to target, named as instruments variables or operating targets. Mishkin suggested that the reason the central banks attempt to use intermediate targets rather than aim at final targets is so they can judge whether their policies are on the proper path, and make changes immediately if necessary; otherwise they would have to wait until the final effects of policies.

The central banks use the monetary policy tool to aim for the operating targets, subsequently affecting the intermediate targets; lastly, the final targets are achieved. In academia, or in practice, there are certain criteria for selecting the intermediate targets. The study summarises three points provided by Mishkin (1997) as follows:

Measurability: The central banks must be able to measure the intermediate target quickly and accurately. This is because intermediate targets are only useful when they indicate more quickly than the final goals that the policy is off track.

Controllability: Easy and effective control over the intermediate target by the central banks is important.

Predictability: The intermediate target must have a predictable effect on the final goals.

Similar criteria are useful for choosing the operating targets. A good operating target should have a closer link with the decided intermediate target. In the following part, the study will firstly summarise the intermediate target proposed by academics, and then review the operating targets.

2.2.1 Money supply targeting

The concept of using money aggregate as the intermediate target is supported by monetarist theory. Monetarists believe that the fluctuation in the money aggregate is responsible for the output in the short term, although it does not have much effect on the economy in the long term. This view argues that money demand is a function of nominal income or nominal GDP, while the elasticity of the interest rate of money demand is very steady; therefore, money aggregate is better than interest rate as the intermediate target. They proposed that the steady growth of money supply would contribute to the stable output and price growth. This view can be expressed in the Cambridge equation:

$MV=PY$

Where M represents the money supply, V represents velocity of money, P represents the price level and Y represents the real output level.

The term on the right of the equation is therefore nominal output or nominal income. As a result, the nominal output is closely linked to the money supply. The quantity theory has certain assumptions about the causes and effects. The assumptions are as follows:

- Velocity is assumed to be constant

- Money supply is considered as the exogenous variable and can be fully controlled by the central banks

- The aggregate demand component is supposed to effect changes in nominal output (causal relationship is from MV to PY)

- Real Output Y is set at the full level of employment.

However, in practice, these assumptions do not hold. For example, the assumption of constant velocity is not proved by the empirical results. The empirical evidence showed that the velocity of money aggregate has become unstable and unpredictable in the last few decades. Therefore, the policy is not practical if the velocity is not stable.

In addition, the money multiplier [18] is also assumed to be stable; however, this traditional view on the controlling ability of central banks over money supply has been challenged, as financial products innovation and deregulation in the financial market have made the money supply hard to measure and control. Mankiw (2000) suggested that, although monetary policy has been used to prevent fluctuation in the economy many times in history, it may not be the best policy rule. Sometimes, shocks to the economy cause a shift in money supply demand, and then the velocity becomes unstable; however, the money supply has a stabilising effect on the economy only if the velocity of money is steady. Thus some economists believe that, if money supply were allowed to change in response to numerous shocks, the effect of monetary policy would be better. More specific literature review on the empirical relationship between nominal GDP and money aggregates are presented in chapter 5.

2.2.2 A nominal GDP targeting

The one principal goal of monetary policy is to aim to stabilize nominal quantity. Monetarists have sought to stabilize the growth of nominal money stock, but the failure of reliability of monetary supply as a policy rule has caused researchers to look for better rules. Traditionally, policy has been committed to fixing the nominal price of gold, as the development of the financial market, and economists have proposed the rule in targeting nominal income.

Nominal GDP targeting has two options: growth targeting and level targeting. This thesis has discussed nominal GDP growth targeting; however, this is simply adapted to nominal GDP-level targeting. A significant number of macroeconomists support the nominal GDP growth rate target because they think it better reflects the objectives of government policy. Tobin (1980), Bean (1983), Meade (1984), Hall (1984), Gordon (1985), Taylor (1985), McCallum (1990), Pecchenino and Rasche (1990), Judd and Motley (1991), Hess et al. (1993), Feldstein and Stock (1993), Hall (1993) and Frankel (1995), have examined and supported nominal GDP targeting.

[18] In monetary economics, a money multiplier is one of various closely related ratios of commercial bank money to central bank money under a fractional-reserve banking system.

Tobin (1983), an early advocator of nominal GDP targeting, pointed out the short-run relationship between nominal GDP growth and real GDP growth in 1980. Bean (1983) developed a formal analysis of the implication of nominal income stabilization in a general equilibrium macro model. In the model, nominal income targeting minimizes the variance of the deviation of real output from its equilibrium value. The extensive academic support for nominal income targets has been advocated since the 1980s (McCallum, 1999).

How to achieve the nominal GDP target rule

Two essential approaches have been proposed in the literature on nominal output targeting. The first approach includes financial variables with the concern of nominal output targeting. In practice, policy-makers will determine the appropriate indeterminate targets to achieve the potential level of nominal output targeting (Gordon, 1985). Researchers suggest various nominal indictors, which include interest rates, money aggregates, consumer price index and exchange rate, to aim at nominal output (or nominal income) as the final target. Mankiw (2000) proposed that the nominal GDP targeting rule works as follows: the central banks declare a target of nominal GDP growth rate and, if nominal GDP is higher than the target, the central banks can reduce the money growth to limit aggregate demand. If nominal GDP is lower than the target, the central banks will increase the money aggregate growth to stimulate aggregate target.

The second approach, in contrast to the first approach, uses nominal output (nominal income) itself as the intermediate target. The nominal output (or nominal income) becomes the only target of monetary policy. The central banks can set the nominal output target in line with monetary policy goals (Hall, 1983). When nominal output is below the target, the expansionary monetary policy will be conducted, and vice versa.

The advantage of nominal GDP targeting

There are several advantages in adopting nominal income targeting. Firstly, monetary policy will balance the disturbances in aggregate demand. For example, a decrease in the demand from a downturn in the foreign trading economy would lead to a slowdown in the real GDP growth rate and, accordingly, nominal GDP growth. In response to a fall in nominal GDP growth due to the disturbance of aggregated demand, the monetary policy-makers will normally adopt an easing policy, which causes the nominal GDP growth to return to the target level.

Secondly, nominal GDP growth targeting will help to balance the goals of stable price and growth rate. Judd and Motley (1993) explained a straightforward way to calculate the influence of nominal GDP growth on inflation and also pointed out why nominal GDP may have some appeal as an intermediate target of monetary policy, especially as an alternative to the monetary aggregates when their velocities become unstable. They explained that inflation is equal to the difference between growth in nominal and real GDP. Real GDP growth rate generally is affected by the real factors such as the growth in labour, capital and productivity in the long run; thus, the nominal GDP growth rate could be simply translated into inflation rate. Meanwhile they also pointed out that the growth in nominal GDP is equal to the growth of money aggregate, if the growth of velocity of money aggregate is stable. Thus, the money aggregate target could be regarded as an indirect way of nominal GDP target. However, the relationship between money aggregate, price and output has deteriorated due to financial innovation and deregulation, which is the reason why the money aggregate target is less reliable. The velocity of money aggregates is unstable, so the direct nominal GDP target has the advantage that it will not be affected by the unpredictable deviation in velocity. Actually, nominal GDP targeting is a good policy to avoid problems with velocity of money aggregates in conducting monetary policy.

Svensson (1999) argued that nominal GDP targeting was inappropriate because monetary policy can only determine nominal GDP growth, but not the decomposition of nominal GDP growth into inflation and real GDP growth. In addition, the nominal aggregate demand does not play any role in the transmission of monetary policy by itself. Svensson's view represents those who are most critical of nominal GDP targeting, but Jensen (2002) argued that, although inflation targeting is preferable when the economy is primarily subject to shocks which do not result in a monetary policy trade-off, nominal income targeting might be better because it involves inertial policy-making, which improves the inflation-output-gap trade-off in society. Furthermore, when considering the economic conditions, the mainstream view greatly emphasises the nominal variable. Friedman (2005) advised that, although it is important to consider how changes in nominal GDP are divided into real GDP and inflation, the money aggregate is the nominal variable; thus, using nominal GDP is more relevant to the experiment. Werner (1997, 2005) has provided the concept of credit creation, in which the credit to real activities aims to target nominal GDP.[19] Nominal GDP might play an important role in the monetary transmission mechanism.

A further review of nominal GDP targeting will be discussed in chapters 4, 5 and 6. In each chapter, the researcher will attempt to revise the previous researches on the relationship between nominal GDP and the financial variables (short-term interest rates, money aggregates and GDP-circulation credit).

2.2.3 Inflation targeting

There has been increasing interest in price stability in recent years after the adoption of inflation targeting by the central banks of New Zealand.[20] Rather than applying money supply as the intermediate target, the inflation target has been used as the intermediate target in several countries, especially in developed countries such as New Zealand, Canada, the UK, Sweden and Australia over the last decade. [21] In general, the process of inflation targeting involves central banks deciding on an inflation target rate (normally a low one) and then adjusting the money supply or interest rate to influence inflation when it deviates from the target at a particular horizon (Mankiw, 2000).

It is generally believed that the most important aim of any central banks is to keep prices stable. The reason for this is basically that monetary policy's principal and final goal is price stability, which will lead to sustainable economic growth (Mishkin and Posen, 1997).

Inflation targeting as the intermediate target has some advantages in practice and in principle (Svensson, 1997, 1999 and 2000). Firstly, under this framework the central

[19] "Enhancing Monetary Analysis", published by the European Central Bank in 2010, mentioned that Werner's method of disaggregated credit is easy to use to target nominal GDP.
[20] For discussions of inflation targeting see Mishkin and Posen (1997), McCallum(1997), and individual papers in the volumes edited by Haldane (1995) and Leiderman and Svensson (1995)
[21] Svensson (1998) stated that the inflation targeting in these countries is characterized by (1) a policy-announced numerical inflation target (either in the from of a target range, a point target, or a point target with a tolerance interval, (2) a framework for policy decisions which involves comparing an inflation forecast to the announced target, thus providing an inflation-forecast targeting regime for policy where the forecast serves as an intermediate target and (3) a higher-than-average degree of transparency and accountability

banks can achieve the final goal of price stability by focusing on the monetary policy. Secondly, setting the inflation target has a political advantage: the precise figure or range of inflation is easy for the public to understand, and it can provide a transparent ex post measurement of monetary policy. This is because, after the central banks have announced a clear inflation target, the public can easily judge whether or not this target has been met by comparing it to other variables, such as money supply. Thus, this action will increase the central banks' accountability (Mankiw, 2000). Thirdly, the increasing accountability of central banks and the low level of inflation has made the process self-enhancing. The process is likely to be a potential commitment mechanism, which could stabilize the inflation expectation (Svensson, 1997). A further feature of inflation targeting that is easily overlooked is that it avoids the velocity instability problem better than the money aggregate (Bernanke and Woodford, 1997).

Based on the advantages of inflation targeting set out above, its success can be well-summarised. However, it also has some disadvantages, as Mishkin (2000) argued:

Firstly, the central banks hardly have complete control over inflation due to the uncertain effects of monetary policy on inflation. Mishkin also stated that the inflation target is harder for policy-makers to attain than the money aggregate target or the exchange rate. Cecchetti (1995) suggested that the relationship between monetary policy instruments, such as the U.S. Federal Funds Rate, and inflation differs considerably over time and cannot be precisely ascertained.

Secondly, the time lag of the effect of monetary policy on inflation is another negative aspect. According to the empirical results, the time lag is estimated at around two years in the developed countries. Thus, in practice, the implementation of inflation targeting becomes hard, because the effect of the initial shock has still not shown that it will lead to a radical monetary policy.

The last point is that inflation is affected not only by the monetary policy but also by many other factors, which are sometimes disturbances in the economy. Although it has been acknowledged that there are problems with the inflation target and, in practice, inflation targeting in the developed countries has been successful over the last decade, the financial crisis of 2007-2008 has challenged the inflation target, because the inflation targeting did not reflect the disorder in the market, and did not include enough price information; on the contrary, a steady inflation target has produced the appearance of a false boom in the market.

2.2.4 The Taylor rule: a rule for an operating target

The Taylor rule was originally provided by the economist John Taylor, and it is simply known as an interest rate rule. The Taylor rule is an easy regulation that central banks could follow to achieve stable prices while avoiding the significant fluctuations in employment and output (Mankiw, 2000).

Taylor (1993) advised that most central banks take action on monetary policy based on the particular rule that guides the short-term interest rate, considering the process of monetary transmission channels transmits the monetary policy decision according to changes in real GDP and inflation. In other words, the Taylor rule argued that the central banks should change the short-run interest rate according to real GDP and inflation in the economy. The Taylor rule suggested simply that the federal fund rate reacts to two factors: the deviation of inflation growth rate from a target inflation rate, and the departure from real GDP growth rate to potential GDP growth rate.

Over the years following the formulation of the Taylor rule, there has been considerable interest in testing whether the Taylor rule is a good description of the central banks' monetary policy rule. Mankiw (2000) has shown that Taylor's rule has a reasonable resemblance to the Federal Reserve's behaviour in conducting monetary policy. However, other empirical studies criticized the usefulness of the Taylor rule, and their results did not support it. Orphanides (2003) suggested that, although the Taylor rule is a systematic and prudent guide to describe monetary policy behaviour, developments seem to indicate that it is not enough to certify that monetary policy will follow a stable course. Taylor (2007) has examined Federal Reserve policy decisions - in terms of the federal funds interest rate - from 2000 to 2006, and found that the actual interest rate fell below what the Taylor rule suggests it should be. This empirical result also argued that the monetary policy was too loose during this period, and it may have caused the recent financial crisis. So, the empirical research did not fully support the Taylor rule.

The problem with the Taylor rule is that, firstly, it is too restrictive: it is assumed to respond to limited variables, but it is probably not reasonable to assume that the central banks do not respond to other variables such as asset price, money and credit aggregates, in pursuit of price stability. Secondly, the Taylor rule might be not robust over the period, especially after the structure of economic change. Further, the central banks are reluctant to accept the simple instrument rules, as it is necessary to be flexible in response to changes in the economy.

2.2.5 Exchange rate rule

The exchange rate regime is considered to play a strong role in influencing monetary policy in the small, open countries. The exchange rate means the price of one country's currency compared with that of another currency. Mishkin (1997) advised that, if the central banks do not like to see the value of their currency fall, they will conduct a contractionary monetary policy by reducing the money supply or increasing the interest rate in the country; thus the value of the currency will strengthen. In a similar way, if the currency in one country experiences an appreciation, the central banks may increase the money aggregate supply to lower the exchange rate.

Exchange rate targeting was practised by a number of European countries prior to Monetary Union in the term of the exchange rate mechanism of the European Monetary System. Production and consumption largely depend on the international trade in the small, open economies, and therefore a change in exchange rate will have a significant effect on the price level, and further influence consumption and investment. However, exchange rate targeting is not regarded as appropriate for large and closed economies, because the exchange rate only has a modest impact on the economic conditions in these countries.

An overall assessment of the different monetary regimes

In the light of the different monetary policy rules mentioned above, it is not easy to apply a simple monetary policy rule to achieve economic performance. Five basic types of framework have been reviewed: 1) money supply targeting, 2) a nominal GDP rule, 3) inflation targeting, 4) the Taylor rule, and 5) exchange rate targeting. Generally speaking, every rule has its own disadvantages in comparison with all the others, but one monetary regime might be more efficient in producing the desirable economic performance than the rest. Exchange rate targeting is problematic in the emerging market countries due to financial fragility and the cost of losing the independent monetary policy in the industrialized countries (Mishkin, 1999). The performance of monetary aggregate largely depends on the stable relationship between money supply and inflation, which has become unstable in most countries (Estrella and Mishkin, 1997). More recent empirical results have suggested that the central banks' behaviour is no longer consistent with the Taylor rules (Taylor, 2007). The critique to inflation targeting has become wide after the financial crisis. Because low inflation in the developed countries did not indicate all the price information in the market, even more disregard the boom of asset price, which make the central banks undermine excessive economic fluctuations. For these reasons, some economists have argued that nominal GDP growth rate rather than inflation could be the target for the central banks (Taylor, 1985; Hall and Mankiw, 1994). The advantage of nominal GDP growth rate is that it does put some weight on output in monetary policy-making (Mishkin, 1999). In the framework of nominal GDP targeting, it automatically increases the inflation target when there is a decline in proposed real GDP growth rate, which tends to stabilize the economic conditions because the monetary policy would automatically be loosened. Cecchetti (1995) argued that, because of the difficulty of forecasting and controlling inflation, the nominal GDP growth rate would be better than the inflation target for delivering a better economic outcome.

There have not been many studies on targeting nominal GDP using quantitative variables, especially in recent years; it seems that most emphasis has been placed on inflation targeting, but nominal GDP targeting has come back into focus since the 2007/08 financial crisis. This study contributes to the empirical research on targeting nominal GDP by presenting the empirical results on using financial variables - interest rates, money aggregates, and credit data - to target nominal GDP. Our study also extends the time period and sample countries and involves more complex econometric models compared to previous research. Our results enhance the understanding of the effect of using monetary policy instruments to target nominal GDP in major developed countries.

2.3 The monetary policy transmission mechanism

The intermediate target is important and, in the meantime, how to achieve the intermediate target raises the question of the monetary transmission mechanism. The monetary transmission mechanism is an on-going issue of debate, and economists are certainly interested in discovering the black box of the monetary transmission mechanism if the monetary target is determined. Mishkin (1995) and Taylor (1995) have given good summaries of monetary transmission.[22] The literature review explores the up-to-date studies on the monetary transmission channels in order to gain an understanding of monetary policy instruments' influence on the economy. On the other hand, the most widely-discussed channels are not the main focus of our study; thus, we only briefly introduce them, and more attention will be paid to the credit channels in chapter 6. Some of these channels are commonly discussed, namely the interest rate channel, monetarist channel, asset price channel, wealth effect channel, exchange rate channel, and credit channel.

2.3.1 The interest rate channel

Interest rate is an important variable in the monetary transmission mechanism: in practice, due to the stickiness of price, the interest rate will be changed according to when to the central banks adjust the bank reserve in the banking system. Then investment will respond negatively to the change in interest rate, which is eventually reflected in the economic output. At first, the focus on the interest rate channel was concerned with the effect on investment; later, however, many economists recognized that the change in interest rate will also influence consumer spending on housing and durable goods.

The essential issue in the interest rate channel is the liquidity effect.[23] A considerable amount of literature has focused on the liquidity effects, but mixed evidence was found. Early studies (Cagan,1972) found some evidence of liquidity effects, but later there was much disagreement on the liquidity effect. Melvin (1983) claimed there was a vanishing liquidity effect, and Leeper et al. (1991) also suggested that a successful search for the liquidity effect required careful identification of private and policy behaviour in the U.S. In our study, the results from the VAR model will show whether there is a liquidity effect in the U.S., U.K, Germany and Japan. Further literature review

[22] The summaries of monetary transmission by Mishkin (1995) are shown in the Appendix 6.A

[23] The liquidity effect -a decrease in nominal interest rates accompanying monetary expansion - is an important feature in many theories of the monetary transmission mechanism

that focus on the relationship between nominal GDP and short-term interest rate would be discussed in detail in chapter 4.

2.3.2 The asset price channel

The asset price channel implies that the monetary policy could impact on the real economy through the asset price, such as the stock market, real estate and bond prices.

Tobin's q effect

There are only two kinds of asset in Tobin's portfolio theory of the economy: money and physical capital. People will change the portfolio according to the return and risk of different assets. Tobin's q was the ratio between the market value and replacement value of the same physical asset, which could be desirable for comparing the prices of two assets. If $q>1$, it implies that the market value of a firm is greater than the substitute price of capital, and the recorded asset price of a firm is cheaper than the market price of the company, which suggests that companies take advantage of the high equity by issuing more shares and using the capital raised in the market to buy equipment. If $q<1$, it means that the value of a company is undervalued; thus, the companies might issue fewer shares and decrease investment, which would have a negative effect on the real economy. This underlying process illustrates the asset price channel.

2.3.3 The wealth effect channel

The life cycle hypothesis (LCH) is an economic concept of individual consumption patterns, and was advocated by Ando and Modigliani (1963). Unlike the Keynesian consumption function, LCH assumes a pattern of individual consumption spending based on the long-run income, and individuals consume a constant percentage of the present value of lifelong income. The consumption in LCH is constrained by consumers' human capital, real capital and financial wealth. The monetary constriction will reduce share prices, and also influence the property market. The reduction of individual personal asset price will lead to a decline in consumption spending, and the real economic output will decrease.

2.3.4 The exchange rate channel

More and more attention has been focused on the exchange rate channel because of economic globalization. In the exchange rate channel, the policy-introduced change in interest rate will lead to fluctuations of in the exchange rate in an open economy. In the globalized economy, a higher interest rate in one country attracts the free flow of capital with the instinct of arbitrage; thus the exchange rate will change. The difference between the exchange rate channel and interest rate channel is that the interest rate will effect investment and output, while the exchange rate channel will change net exports and finally influence income.

2.3.5 The credit channel

The credit channel is another important channel in the monetary transmission. As it is the central point of discussion in our study, a deep discussion of the credit channel will be conducted in the literature review section of chapter 6.

2.4 Empirical research on monetary policy transmission mechanism

The purpose of a rich empirical study is to find evidence to support the monetary policy transmission channel. Empirical research usually establishes a model that includes macroeconomic variables: interest rate, price, money, credit and output. The Vector Autoregression (VAR) model became the standard model for exploring the relationship between these variables since the work of Sims (1980). This study will review the empirical research on monetary policy transmission in the U.S., the Euro area and Japan with an attempt to reveal the evidence to support the monetary policy transmission channels. The study reviews the empirical work based on the different regions because our study will investigate the use of financial variables (interest rate, money and credit) to target nominal GDP in the U.S, U.K, Germany and Japan; so, a detailed discussion of monetary policy transmission in each country will provide a better practical understanding of monetary policy channels in each country.

2.4.1 Empirical evidence from the U.S.

Sims (1980) began to use a standard VARs model to investigate the monetary policy, and Bernanke (1992) developed the effectiveness of monetary policy further, while Christiano, Eichenbaum and Evans (1999) have reviewed different monetary policy regimes from widespread studies on the monetary policy transmission in the U.S.

Bernanke and Blinder (1992) published an important paper, in which they established the new monetary consensus. In their paper, they claimed that short-term interest rate could be regarded as the measurement of monetary policy. Their results showed that interest rate has an effect on real output through credit using the structural vector autoregression approach and the Granger causality test. They interpreted the empirical results that interest rate has a negative effect on output as the effectiveness of monetary policy. However, Bernanke's (1992) findings also revealed a puzzle. In the textbook theoretical model, the long-term real interest rate is linked to output. For that reason, it is assumed that there is an imperfect link between long-term real interest rate and short-term nominal interest rates.

Under the classical interest rate channel, interest rate influences the real economy; however, interest rate will affect the economy in various ways, and is fairly broad in scope. The availability of credit for firms and the relative price of capital are both linked to the interest rate. Bernanke and Gertler (1995) proposed that the credit channel also played a key role in monetary transmission. They argued that demand for investment is as sensitive to the cost of funds as it is to the availability of funds; therefore, the external finance premium[24] improves the predictive power of monetary policy on durable goods spending.

Fuhrer and Moore (1995) presented a structural model that captures the dynamic negative correlation between real output and the short-term interest rate. At the same time, they conducted the vector autoregression model to find that the behaviour of long-term interest rate is similar to that of short-term interest rate, and long-term interest rate also predicts the future output well.

[24] The external finance premium is the different cost between internal funds and external funds. Internal funds include funds raised by retaining profits and external funds include issuing shares and debt to raise funds.

The interest rate channel is important because it represents a big challenge to the traditional view that money leads output in the short run. However, some empirical studies have revealed the fact that money aggregate has a stronger predictive power than interest rate of output. Stock and Watson (1999) have produced empirical findings showing that money has a statistically significant predictive power for industrial production, even with the presence of a short-term interest rate over the period, including the break in 1985. Furthermore, Stock and Watson pointed out that interest rate is negatively countercyclical leading with output.

Some empirical studies have pointed out that the link between interest rate and real economic activities is not as strong as experts thought. King and Levine (1993) constructed an endogenous model to find whether the better financial systems enhance the prospect of innovation success and improve the acceleration of economic growth; however, they did not find any evidence to support the relationship between real interest rate and economic growth in a cross-section of countries. Taylor (1999) reviewed the empirical investigation into the link between real interest rate and real economic activities. The empirical evidence suggests that the link between real interest rates and macroeconomic aggregates such as consumption and investment is, in fact, somewhat tenuous.

Friedman (2000) assessed the development of the monetary policy target, and suggested that there is a debate on the use of interest rate as the monetary policy. In his paper, he proposed that the Federal funds rate indicates highly important information for subsequent output and inflation, while pointing out the question of interest rate as the monetary policy in three aspects. However, he also realized that there is no better choice than interest rate.

Some researchers have pointed out that the trend in interest rate follows the change in real output rather than leads the future output. Kuttner and Mosser (2002) summarised the conclusion of papers presented at the conference on Financial Innovation and Monetary Transmission. They pointed out that financial innovation does not have a strong effect on the economy through the monetary transmission as expected, and spotted the simple correlations between real GDP and interest rate over the period of

1954-2000. The positive pattern between real GDP and current fund rate revealed that the Fed might raise interest rate in response to extraordinarily rapid economic growth. They also pointed out that the effect on output of increasing interest rate is apparent after a lag of two quarters. Moreover, the subsample test showed that the link between monetary policy and economic change is not stable over time and, in the subsample of 1984-2000, the link is weaker. Dotsey, Lantz and Scholl (2003) examined the behaviour of real interest rate. Their results disclosed that the real interest rate series is contemporaneously positively correlated with lagged cyclical output. Gurkaynak, Sack and Swanson (2005) provided evidence that long-term interest rate also reacts significantly to various macroeconomic variables shocks that were only expected to have an effect on the short-term interest rate in the conventional macroeconomic models.

From the review of empirical studies in the U.S., it seems that there are conflicting views on the effect of interest rate on the real economy. It is not surprising that the brief of a strong link between short-term interest rate and real macroeconomic activity is imbued in the minds of economists and policy-makers. However, the weak empirical evidence for this link highlights the need to search the alternative monetary policy transmission channels, such as the credit channel.

2.4.2 Empirical evidence from the Euro area

A large amount of empirical literature on the Euro area has focused on two points. Firstly, it enquired whether the empirical results found in the U.S. could also be found in the Euro area. Secondly, the researchers attempted to find the different monetary policy transmissions across countries. While there are some real problems with the data, such as from the period before 1999, the researchers in this area have still reached some practical conclusions and confirmed that the widely accepted facts are also valid in the Euro area. In these studies, the vector autoregression (VAR) model is the standard methodology to investigate the differences between individual countries in the Euro area, and the effect of the main monetary policy variables on the major macroeconomic variables is compared.

Gerlach and Smets (1995) applied a structural vector autoregression (SVAR) model with restrictions in the short term and long term for the G-7 countries. Only output, the price level and the interest rate are included in their VAR model. The price puzzle disappeared in their SVAR model, and they found that the effect of monetary policy is similar in these countries.

Barran, Coudert and Mojon (1996) used a VAR model to show that the impact on output from monetary policy shock is quite similar in time and in scale across countries. Their research also suggested that the credit channel could be effective in these European countries, because credit supply tends to contract more after a negative monetary policy shock although the empirical results found in Germany and France do not support the hypothesis. Their results also showed that the GDP significantly declines in Germany, Austria and the Netherlands when long-term interest rate is introduced into the VARs model, although this effect is not as strong as that found in the U.K. and Italy. They interpreted this result as indicating that the credit supply mainly depends on the short-term interest rate in the U.K. and Italy.

Ramaswamy and Sloek (1997) established the three-variable VARs model (output, price level and interest rate) for 12 European Union (EU) countries. The main findings of the paper are that the EU countries roughly fall into two groups according to the response of output to monetary policy shock. The total effects of a negative monetary policy innovation on output in one group (Austria, Belgium, Finland, Germany, the Netherlands, and the United Kingdom) are approximately twice as long, but roughly twice as deep as in the other group (Denmark, France, Italy, Portugal, Spain and Sweden). They also discussed the implication of this result for the monetary policy-makers. There are also some other empirical studies[25], but we do not discuss them in detail here.

In addition, more disaggregated analyses are needed to complement the aggregated investigation. The researchers started to stress the importance of analysing the impact of monetary policy on investment, consumption and other components. A number of researchers also take the national monetary policy regimes into account, and recent work in this respect has been undertaken by Dedola and Lippi (2000), Sala (2001),

[25] Barran, Coudert and Mojon (1997) estimate several VARs including combinations of GDP, prices, DM exchange rate, world price index, money, credit and the long-term interest rate for nine European countries. Peersman and Smets (1999) simulate the effects of a German monetary policy shock while allowing for the interaction effects among the countries.

Benedict, Kontolemis and Levy (2001), Rebucci and Ciccarelli (2002), Peersman and Smets (2003) and Peersman (2004).

Dedola and Lippi (2000) used disaggregated industry data for five industrialized countries to investigate the effects of short-term interest rate on industrial production. Their research attempted to find whether monetary policy has different effects across industries, and to relate the effects with underlying microeconomic determinants at firm-level. Their findings confirm that the effects of monetary policy depend on the industry output-durability, borrowing capacity, financing requirement and firm size. Moreover, they suggested the essential role of the credit channel.

Commercial investments are more sensitive to changes in the cost of capital, which is more likely to be linked with short-term interest rate. It is also influenced by the liquidity condition (the credit supply for firms) in the market. The empirical research suggested that the exchange rate channel could be important in the Euro area because the change in consumer prices following an interest rate shock will depend on the effect of interest rates on the exchange rate as well. For example, the appreciation of the Euro currency following an increase in interest rate will trigger a larger and faster decline in inflation.

Peersman and Smets (2003) established the standard VAR model for the Euro area from 1980 to 1998 to investigate the impulse response of the main macroeconomic variables to an unexpected monetary policy shock. A temporary increase in the short-term nominal interest rate and real interest rate is likely to be followed by a fall in output and a real appreciation of the exchange rate. Prices are stickier and only start to decline several quarters later. Their results are similar to those found in the U.S using similar methods. Moreover, the impulse response appears to be stable over the long sample periods.

They also explored the reaction of components of GDP and other macroeconomic variables to a monetary policy shock. The most significant contribution to GDP decline is accounted for by investment. The magnitude of impulse response of investment is three times as that of GDP, but private consumption is less extent to the response of GDP. Their findings revealed the immediate response of M1, but a slower effect on M3 and credit aggregate data. The long-term interest rate shows features that are consistent with the expectation of term structure theory. In addition, they also pointed out that the share price responds more quickly and deeply after the impact, although house prices are more sluggish.

Benoit Mojon and Gert Peersman (2001) established a VAR model to investigate the effect of monetary policy in each country in the Euro area over the pre-EMU period. Their results confirm that the qualitative effect of monetary policy on output in the Euro area is similar to that described in a large body of literature in the U.S. and by Peersman and Smets (2001). The contractionary monetary policy innovation leads the fall of GDP after the four quarters of initial shock.

Boivin, Giannoni and Mojon (2008) used the factor-augmented VAR (FAVAR) framework to investigate the transmission. They show how the monetary transmissions changed after the launch of the Euro, and attempt to explain the changes. They found different effects of monetary shocks across countries before the introduction of the Euro. An interest rate shock was more significant in Germany and the response of consumption in Italy and Spain was stronger than that in Germany. They conclude that the launch of the Euro has contributed to the homogeneity of the transmission mechanism in the Euro area and, in general, it reduces the effect of monetary policy shock. They also thought that the change of monetary policy reaction function and the elimination of exchange rate risk have contributed to the evolution of monetary transmission in the Euro area.

2.4.3 Empirical evidence from Japan

In contrast to the extensive empirical research that has been carried out in the U.S. and Euro area, there is only a small body of monetary policy literature for Japan, based in particular on the VAR model. Sims (1992) used a recursive structural model to identify the impulse response to short-term interest rate shock in numerous countries including Japan. Kim (1999) extended Sims' (1992) work by incorporating a non-recursive model and also applied it to G-7 countries. West (1993) adopted M2 as the monetary policy indicator in Japan following Blanchard and Watson's (1986) non-recursive framework. Bayoumi (2001) regarded real short-term interest rates as the monetary policy shock in the recursive model framework. Shioji (2000) extended Kim's (1999) work by including high power money and loans. James and Tamim (2001) demonstrated that banks' balance sheets play an important role in transmitting monetary shocks to the economy, as households and corporations largely depend on bank loans, and business investment is particularly sensitive to bank loan shocks. They concluded that policy measures to strengthen banks might be a precondition for restoring the efficiency of monetary transmission mechanism. Ryuzo (2002) tried to provide a credible VAR analysis of the effect of monetary policy in Japan, and the main finding was that monetary policy shock, which is assumed as a call rate innovation, has a constant effect on real output in Japan, especially in the late 1980s. However, these researchers only selected their particular monetary policy indicator, and barely discussed the features of the Bank of Japan's operating procedure and the underlying monetary policy strategy in practice in Japan.

A discussion on the limits of methodology in the empirical work

Most empirical studies on the monetary policy transmission area have followed Sims (1972, 1980, 1986), and analysed the core question with the vector autoregression model. The most notable papers are those by Bernanke and Blinder (1992), Eichenbaum (1992), Sims (1992), Leeper and Gordon (1992), Christiano and Eichenbaum (1992), Strongin (1995), Gordon and Leeper (1994), Christiano et al. (1996, 1997, 1999) and Kim (1999) in the earlier period. In these studies, the common feature is to use vector autoregression, and they differ by including certain other variables; for example, the commodity price index is included to avoid the price puzzle[26], and non-borrowed reserves are involved to investigate the credit channel. Bernanke and Mihov (1998a, b) have attempted to organise the different approaches into one framework, and Leeper et al. (1996) have also introduced new directions to the current literature. This extensive literature reviews points out that those robust studies have provided a list of facts into which further investigations are required.

The most important step in using a VAR model is to identify the monetary policy shock. While the information order is normally chosen based on the arrival of the shock, the negative side of this subjective choice is that researchers are likely to make the results

[26] The positive relationship between inflation and interest rate is named as the price puzzle.

look reasonable through an appealing order. The conventional wisdom holds that a rise in short-term interest rate will lower prices and reduce future output. If the empirical results show otherwise, then a puzzle will emerge, while a good identification should deliver results identical to the conventional wisdom. Thus there is an a priori problem. The results have often already been narrowed down by the a priori theories. There is a danger here, and the empirical studies only seek what has been assumed, so it is hard to distinguish between assumption and conclusion. As a result, it might be essential to undertake further work searching for a more theoretically and econometrically sophisticated link between macroeconomic variables. The current studies have highlighted the need for further empirical work.

2.5 The development of intermediate targets in the U.S., U.K., Euro area and Japan

The collapse of the Bretton Woods system during 1971-1973 meant that the central banks, for the first time, faced a new situation: they found themselves in charge of carrying out monetary policy without an externally-imposed monetary standard. Then the central banks made it clear that monetary policy was pursuing two broad goals: economic growth and price stability; and the process to achieve these objectives has been determined by intermediate targets (they are monetary aggregates and interest rates most of the time). The world's central banks have experienced several stages of different monetary targeting, because the good intermediate target variables should be readily observable and capable of being managed by monetary authorities. Moreover, the most important feature is a predictable link between intermediate target and the policy goals. In this part, the study briefly reviews the intermediate target histories in the U.S., U.K, Euro area and Japan with the intention of describing the progress of intermediate targeting in the real world.

2.5.1 The development of monetary policy targets in the U.S.

Conducting monetary policy in most central banks in the world will depend on the action of Federal Reserve, so the development of the monetary policy regime in the U.S reflects the main progress of monetary policy regimes around the world. Therefore, the study will discuss the development of the monetary policy target in the U.S. first as an example. [27]

The market participants can normally sell and buy a large amount of securities in well-developed financial markets like that of the U.S., even more than the Federal Reserve's daily operation. However, the market participants find it hard to move the market, and have less influence on the economic conditions. In contrast, the central banks can have a more powerful influence on economic activities. These days, the Federal Open Market Committee (FOMC) makes monetary policy decisions by setting a short-term interest rate and, in 1968, FOMC also made monetary policy decisions by setting a short-term interest rate. It seems that the policy-making process is still based on the somewhat arbitrary beginning and end points; however, in reality there has been an extremely rich set of developments during this period. (Friedman 2000).

Interest rates as Federal Reserve intermediate target since 1968

The committee decided to use the short-term interest rate as the intermediate target in 1968. Although, in the following year, the Federal Reserve focused on controlling the net free reserves in the banking system, most participants in the market understood that the net free reserve is closely linked with the interest rate. The central banks' use of the net free reserve as the intermediate target has the political advantage of avoiding the responsibility for manipulating the market rate. However, the inflation problem that it is difficult to distinguish movements of nominal versus real interest rates make to against the interest rate strategy. Later, the monetary aggregate backed by monetarism was to become the Federal Reserve intermediate target.

In the light of the empirical work by Friedman and Schwartz (1963), Poole (1970) and others, the Federal Reserve adopted the money aggregate as the intermediate target in 1975 under Concurrent Resolution 133. The U.S. Congress required the Federal Reserve to specify an explicit money aggregate target growth rate. For a short period, the FOMC even gave up direct control of interest rates, and they used the non-borrowed reserve to hit the money growth rate. However, a reversal soon occurred with high inflation spiralling out of control. The Federal Reserve declared that it had reduced

[27] Some of the literature review focused on the monetary policy development in the U.S. Belongia and Batten (1992), Goodfriend (1991,1993, 1997, 1999, 2007), Friedman (2000)

money growth targets in October 1982 and, during the following seasons, the public realized that the monetary aggregate was less important as the monetary policy. In 1987, the committee publicly announced that it was abandoning the narrow money stock (M1) as the target, but continued to publish information on broad money (M2 and M3). 2000 was the first time that the Federal Reserve submitted the monetary policy report to Congress without the mention of money growth rates.

After experiencing the failure of the monetarist experiment, the Fed resorted to using the Federal funds rates as its instrument to contain inflation and achieve the target. During the period when Alan Greenspan served as Chairman of the Federal Reserve Broad, the Fed's implicit inflation target demonstrated the principle of the new consensus. Bernanke (1997, 2001, and 2005) has shown that inflation targeting significantly lowers inflation in most industrial countries. An inflation target has been the solution to the unpredictable link between money growth rate and inflation. In the recession of 2001, the Fed demonstrated another principle of the new consensus: that low inflation provides credibility for central banks, thus giving central banks the power to counteract recession. In contrast, the recession of 2007-2009 illustrated that inflation targeting might not reflect what has happened in the asset market, thus leading to fluctuations in economic conditions. The need to reconsider inflation targeting was raised after the financial crisis of 2007/2008; thus there is still a long way to go before a consensus on the appropriate monetary policy targeting is reached.

2.5.2 The development of monetary policy targets in the U.K.

Monetary policy emphasised the direct control of credit flows throughout the 1950s and most of the 1960s in the U.K. The special deposit has been used as the instrument variables to influence liquidity. Towards the end of the 1960s, the government began a new arrangement for the rule of the monetary system, identified in 1971 as Competition and Credit Control. The new regulation was intended to encourage competition among credit institutions, which led to less dependency on the direct control of credit, and greater reliance on the interest rates. The Bank of England implied that the special deposits and the minimum reserve ratio were designed to indirectly control credit supply; furthermore, these regulations were intended to strengthen the effect of the interest rate on liquidity.

Because of the problem of high inflation, the Bank of England introduced the monetary aggregate (M3) as the intermediate target in 1973, although the monetary aggregate target was realized by the public in 1976. However, the M3 target in practice was generally missed due to the unstable link between M3 and nominal income; consequently the central banks used M1 instead between 1983 and 1987. But the monetary aggregate never met the target, so it was clear that the central banks no longer used the monetary aggregate target in any meaningful sense from around 1986.

Between 1987 and1989, the Bank of England engaged in a brief episode of exchange rate targeting. In order to benefit from the low inflation level in Germany, the monetary authority started to shadow the Deutschmark with the pound against the 3 DM level (Bowen 1995). The U.K. remained in the Exchange Rate Mechanism until 1993. During this period, the exchange rate was officially the intermediate target, but this target was abandoned when the U.K. dropped out of the Exchange Rate Mechanism. Early inflation targeting was started in October 1992. After the inflation target was adopted as the intermediate target, a greater emphasis on transparency, independence of central banks, and price stability began to represent the final goal.

2.5.3 The development of monetary policy targets in the Euro area

German monetary policy

The basic responsibility of German monetary policy is indeed to maintain the stability of the currency based on the Bundesbank Act of 1957. In practice, it has been interpreted as the requirement to ensure price stability in the domestic economy and stabilise exchange rates against other currencies. It is hard for the Bundesbank to insist on price stability having declared money growth rate targeting under the fixed exchange rate; however, after dropping out of the fixed exchange rate regime, the Bundesbank shifted towards the money growth rate target, which highlights the dispute about the design of monetary policy in 1974. Actually, the Bundesbank was the first central bank to announce a monetary target, in December 1974, and the money growth target was 8 per cent between December 1974 and December 1975. In 1979, the Bundesbank specified a range of suitable rates rather than a single rate. Because the rate was exceeded in 1986 and 1987, the Bundesbank introduced the monetary aggregate M3 and adopted it as the formal intermediate target in 1988.

The empirical evidence (Kole and Meade, 1995) pointed out that the demand for M3 in Germany remained stable over the past two decades even with the unification of East and West Germany in 1990. The Bundesbank supposed that M3 targeting is the most reliable measurement to achieve the final goal, and therefore the Bundesbank continues to use M3 as its main intermediate target to pursue price stability while the other central banks have started to abandon the money aggregates as the intermediate target. The Bundesbank Council described the monetary policy at its meeting on December 22nd 1994 as follows (Deutsche Bundesbank, Monthly Report January 1995. P.23):

> *"The deutsche Bundesbank will conduct its monetary policy in such a way as to ensure that inflation continues to decline and, at the same time, that the monetary conditions for sustained economic growth remain in place. To this end, the bank regards it as appropriate for the money stock M3 to expand by 4 per cent to 6 per cent between the fourth quarter of 1994 and the fourth quarter of 1995…"*

The process of monetary policy determined in Germany is very transparent, because the Bundesbank will estimate a potential economical growth rate and determine a long-term inflation target; then the corresponding monetary aggregate growth rate is calculated based on the quantity equation. The Bundesbank will strictly target the monetary aggregate growth rate, although the target will be adjusted with changes in economic conditions.

After EMU introduced the Euro on January 1st 1999, the Bundesbank's monetary policy has been affected by the European Central bank, and M3 targeting is not as important in the European Central Banks as it is in the Bundesbank.

European Union

The major progress is that the emergence of the European Monetary Union outside the U.S. and the inflation targeting has formed the core of a new framework of monetary policy.

The study only reviews the latest strategy of monetary policy in the European Monetary Union. In contrast to Federal Reserve monetary policy strategy and other central banks which have adopted the inflation target, the European Central bank has kept a separate and essential role for money aggregate in its two-pillar strategy. (Gerlach, 2004, Beck and Wieland, 2007, Beck and Wieland, Issing, 2008)

The two pillars

The ECB's strategy for classifying, assessing and cross-checking the information about price stability is based on two perspectives, known as the two pillars (the term "two pillars" was officially adopted by the ECB in 2000). This approach was first adopted by the Government Council in October 1998, and explained in detail in the Monthly Bulletin of January 1999 (ECB, 1999); it was confirmed and further explained by the ECB in May 2003. There are three elements in the strategy shown as follows:

- A quantitative definition of price stability;
- A prominent role for money;
- A broadly-based assessment of the outlook for future price developments.

The ECB's monetary policy strategy is based on the broad analysis of the risk to price stability. The strategy is based on two complementary perspectives. The first perspective aims to assess the price development in the short-to-medium term with the focus on the real economic activities and financial conditions, because the price development in the short-to-medium term is affected by supply and demand in the goods, services and factor markets. The ECB regards the first perspective as the economic analysis. The second perspective is known as the monetary analysis, emphasising the link between money and price in the long term. The monetary analysis is always regarded as a way of cross-checking, which is an indication of monetary policy in the medium-to-long term.

The ECB consider the money aggregate targeting is not only the fact that money growth is closely linked to inflation, but also a recognition of the fact that monetary targeting is a key element of the Bundesbank's monetary policy strategy. The policy-makers of the European Central bank believe that a strategy including the monetary aggregate elements in the monetary policy will enable them to inherit the spirit and credibility of the Bundesbank (Mishkin 1999). The European Monetary Institute (1997, p11) expressed this view as follows:

> *"the adoption of monetary targeting in Stage Three (of the unification process) would offer the advantage of ensuring continuity with the strategy of the EU central bank which has performed an anchor function in the ERM, in view of its long-term track record of fighting inflation. Following a monetary targeting strategy might therefore help the ESCB (European System of Central Banks) to inherit credibility from the start of its operation."*

2.5.4 The development of monetary policy targets in Japan

The credit supply was the intermediate target during the first two decades after the war, because banks were the main external financial resource for companies during that time. At the same time, the interest rates were determined by the central banks. In the 1970s, when the monetary aggregate began its role in monetary policy, the Bank of Japan (BoJ) also started its monetarism experiments, and monetary aggregate was employed as the intermediate target. From 1978, the BoJ published the quarterly M2 information, and then changed to M2+CD. However, the same situation that had occurred elsewhere happened in Japan as well, and the M2+CD gradually lost its efficiency in indicating inflation during the 1980s.

Mikitani and Posen (2000) suggested that the BOJ may have adopted the implicit inflation target after the 1970s based on the empirical evidence. However, Werner (2005) proposed that, in actual fact, bank lending was used as the intermediate target before the 1990s, and central banks could manipulate economic activities through window guidance. Nowadays, Japan's monetary policy is at a crossroads. The overnight call rate has been close to zero for years, although it is still the instrument variable. Monetary easing was used by the BOJ as well, when the interest rate lost its efficiency.

After summarising the objectives of monetary policy in each country, it has been found that the inflation target is still the primary target in each country, and price stability is an important aim for each central bank. The review of monetary policy targeting in the

U.S., U.K., Germany and Japan helps us to gain a good understanding of the aim of monetary policy in practice.

Chapter 3

3 The methodology

As this empirical research concerns the behaviour of macroeconomic variables, econometric models are largely employed. This section will describe the main econometric methods used to explore the links between those macroeconomic variables in the research. Firstly, unit root and cointegration tests will be employed to examine the features of the data, as all data are time series data. Furthermore, vector autoregression (VAR) and vector error correction autoregression (VECM) models will be utilized to inspect the dynamic behaviour between macroeconomic variables. Regarding the Granger causality test, the study employed two methods. One is to use the VECM model and the other is to apply a structural break test on the simple regression to test "causality" between nominal GDP and financial variables (interest rates, money aggregates and GDP-circulation credit). The econometric software Eviews 6.0 is applied to analyse the data.

Econometric methods

Before choosing the appropriate econometric models to analyse, it is necessary to know the features of the data. The data used in the research are macroeconomic time series data, such as interest rates, CPI, money aggregates, GDP-circulation credit and nominal GDP. [28] In order to avoid the spurious regression problem, the first step is to test the stationarity.

3.1 Unit-root test for stationarity

Nelson and Plosser (1982) sparked the most important implication of the unit root hypothesis and argued that almost all macroeconomic time series have a unit root. If a series is stationary (absence of unit root), the variance of the time series is not time-dependent and has the tendency to return a long-run mean. Conversely, a series with a variance does depend on time, and fluctuates away from a long-run deterministic path. A non-stationary series endures a lasting effect from random shocks. The identification of the absence or presence of unit root helps us to recognize the features of the series.

[28] See Appendix 4.A for data resource

Three main types of unit root tests are employed in the study: Augmented Dickey and Fuller (ADF), Phillips and Perron (PP), and Zivot and Andrews test. The latter principally takes into account the structural break in the testing of the unit root. In the following parts, three types of unit root tests will be discussed in detail.

In general, the basic unit root test method is the Augmented Dickey and Fuller (ADF) but, in order to avoid the autocorrelation in the error term, the Phillips-Perron (PP) test is applied. The PP test still uses the original Dickey-Fuller regressions, but modifies the DF-statistic with consideration of the possible autoregression in the errors.

ADF Test

Dickey and Fuller (1979) developed their ADF test as in the following equation:

$$\Delta y_t = \alpha + \beta t + (\rho - 1) y_{t-1} + \sum_{i=1}^{k-1} \theta_i \Delta y_{t-i} + a_t \qquad (3.1)$$

Where Δ=1-L, y_t is macroeconomic variable at time period t, t =trend variable, and a_t is a white noise term. The null hypothesis is $H_0 : \rho = 1$ and y_t is said to possess the unit property if one fails to reject $H_0 : \rho = 1$

Perron (1989) challenged the standard ADF test, because he argued that the ADF tests would be biased towards the non-rejection of the null hypothesis, if a structural break is considered. Perron (1989) also pointed out that almost all macroeconomic time series are not characterized by the presence of a unit root, because the persistence arises only from infrequent and large shocks and, following the fluctuations, the economy returns to its deterministic path after the small and frequent shocks.

Perron (1989) applied the new method by supposing or visually determining a particular year as the structural break point. However, the hypothesis of a known break endures some criticisms, because one could resort to pre-testing and manipulating data by selecting a particular date. Furthermore, a particular event happens in a particular year, but its effect might be shown in the following years.

The PP procedure estimates the non-augmented DF test equation and modifies the t-ratio of the α coefficient so that serial correlation does not affect the asymptotic distribution of the test statistic. The PP test is based on the statistic:

$$\tilde{t}_{\alpha} = t_{\alpha} \left(\frac{\gamma_0}{f_0}\right)^{\frac{1}{2}} - \frac{T(f_0 - \gamma_0)(se(\hat{\alpha}))}{2 f_0^{\frac{1}{2}} s} \qquad (3.2)$$

Where $\hat{\alpha}$ is the estimate, and t_{α} the -ratio of α, se ($\hat{\alpha}$) is coefficient standard error, and s is the standard error of the test regression. In addition, γ_0 is a consistent estimate of the error variance (calculated as $(T-k)S^2/T$, where k is the number of regressors). The remaining term f_0 is an estimator of the residual spectrum at frequency zero (Eviews 6.0 handbook).

When implementing the PP test in Eviews, one needs to make two choices. Firstly, one has to choose whether to include a constant, a constant and a linear time trend, or neither, in the test regression. Secondly, one must choose an estimated method. The study assumes a constant and linear time trend for the interest rates and annual growth rates and applies the default (Bartlett-Kernel) method to estimate them. Eviews reports the p-value for the PP test.

Zivot and Andrews Unit root test

As has been mentioned in regard to the PP test, the assumption of a known break is subject to criticism. Christiano (1992) is most famous critic, pointing out that the known break could constitute data mining. Subsequently, some studies have emphasized the different methodologies used to detect the break date endogenously. These include Banerjee, Lumsdaine and Stock (1992), Zivot and Andrews (1992), Perron and Vogelsang (1992), Perron (1997) and Lumsdaine and Papell (2003). These researchers have demonstrated that an endogenously-determined structural break could reduce the bias under the usual unit root tests. The most heavily-used test in empirical research is the Zivot and Andrews test. In our research, the Zivot and Andrews (ZA) unit root test is also employed, so we will discuss the ZA test in detail.

The Zivot and Andrews unit root test is a sequential test in which the full sample is utilized and different dummy variables are used for each possible break date. The endogenous structural break date is selected at the point where the t-statistic from the ADF test is at a minimum (most negative). As a result, the beak date will be chosen where the evidence is least favourable for the unit-root null. The critical values in Zivot and Andrews (1992) are different from those in the PP test, because the selection of the break date depends on the outcome of an estimated procedure in the ZA test, unlike in the PP where it is exogenously predetermined. (Stock, 1994)

Consequently, the significant difference between the ZA (1992) test and PP (1989) method is that the former endogenously estimates the structural break, while the latter assumes a known timing break. Moreover, the null hypothesis in the PP test is that the investigated series contains a unit-root with a drift that excludes any structural break, while the null hypothesis in the ZA method states that variables constitute a trend stationary process, with one break at an unknown point in time. Hence, the ZA approach is more general, allowing for the shift in the level of growth rate of data.

ZA test model

The TB (time of the break) is chosen to minimize the one-side t-statistic of α =1 in the ZA test in equations 2 to 4. The ZA model incorporates one structural break in a series (such as y_t) as follows:

$$H_0 : y_t = \mu + y_{t-1} + e_t \qquad (3.3)$$

Model A:

$$\Delta y_t = \mu + \beta t + \theta DU_t + \alpha y_{t-1} + \sum_{j=1}^{k} c_i \Delta y_{t-j} + \varepsilon_t \qquad (3.4)$$

Model B :

$$\Delta y_t = \mu + \beta t + \gamma DT_t + \alpha y_{t-1} + \sum_{j=1}^{k} c_i \Delta y_{t-j} + \varepsilon_t \qquad (3.5)$$

Model C:

$$\Delta y_t = \mu + \beta t + \theta DU_t + \gamma DT_t + \alpha y_{t-1} + \sum_{j=1}^{k} c_i \Delta y_{t-j} + \varepsilon_t \qquad (3.6)$$

Δ is the first difference operator, ε_t is a white noise disturbance term with variance σ^2, and t=1,…,T is an index of time. The Δy_{t-j} terms on the right-hand side of equations

3.4, 3.5 and 3.6 allow for serial correlation and ensure that the disturbance term is white noise. Finally, DU_t is an indicator dummy variable for a main shift occurring at time TB and DT_t is the corresponding trend shift variable, where DU_t=1 and DT_t=t-Tb if t>TB or zero otherwise. The null hypothesis here is that the series y_t is an integrated process without a structural break, against the alternative hypothesis that y_t is trend stationary with a structural break in the trend function which occurs at an unknown time. (Zivot and Andrews 1992)

Model A is used to test the structural break in the intercept. Model B allows for the change in the trend, and Model C is employed to test the one-time change in both intercept and trend, which is the most comprehensive model of the three. DU_t is a continued dummy variable capturing a shift in the intercept, and DT_t is another dummy variable representing a shift in the trend occurring at time TB. The time of structural break could be any time except the first and last years. The optional lag length is determined by the BIC, and the most significant t-ratio is determined by the general-to-specific approach. The alternative hypothesis is that the series y is I(0) with one structural break. TB is the break date, and DU_t=1 if t>TB, and zero otherwise, DT_t is equal to t-TB if t>TB, and zero otherwise. The null is rejected if the α coefficient is statistically significant. All three models are adopted in this research, as the ZA test provides the most reliable results.

Seasonal Adjustment

The research usually handles the trend and seasonal effect by measuring the variables in logarithms, and then taking seasonal difference variables. In that way, the annual growth rate can be obtained. For example: the seasonal difference of nominal GDP then becomes the annual nominal GDP growth rate. Because most of the original data used in the study are non-seasonally adjusted, the research takes the seasonal difference of variables in logarithms to remove the seasonal factor and then obtain the growth rate.

Econometric models adopted in this research

After testing the stationarity of the data, the first step is to use a simple regression test to find the predictive power of independent variables to dependent variable.

3.2 Advanced single equation models

3.2.1 Comparison of predictive power of independent variables

In order to find whether the regression fits the data better, when the given variables are included in the simple regression, the statistics R^2 and Adjusted R^2 are compared.

R^2

The statistic R^2 is the square of the correlation between the values of the dependent variable and the corresponding fitted value from the model (Stock and Watson, 2003)). R^2 is mostly used for goodness-of-fit statistics, and measures how well the regression model actually fits the data. The equation shows how R^2 is calculated

$$R^2 = \frac{ESS}{TSS} = \frac{TSS - RSS}{TSS} = 1 - \frac{RSS}{TSS} \qquad (3.7)$$

However, the problem with R^2 is that it is never reduced when more regressors are added into the regression, and it quite often reaches the value of 0.9 or higher, which makes it difficult to distinguish between models, as a large number of models have similar R^2 values. Hence, the adjusted R^2 is introduced.

Adjusted R^2

In order to avoid the problems with R^2, the loss of freedom degree is considered when adding more regressors. As a result, the adjusted R^2 can be described as: $\overline{R}^2 = 1 - \left[\frac{T-1}{T-k}(1-R^2)\right]$. Thus, when the extra variables are added to the model, only if R^2 increases more than the k decreases will $\overline{R}^2$ actually fall. Hence, when including a given variable, if $\overline{R}^2$ increases (which means that the given variable increases the predictive power to the dependent variable, if $\overline{R}^2$ does not change much or falls) this indicates that the given variable does not have much predictive power for the dependent variable. As a result $\overline{R}^2$ can be used as the decision-making tool for determining whether a given variable should be included in a regression model or not, with the rule being: include the variable if $\overline{R}^2$ rises and do not include it if $\overline{R}^2$ falls. The problems, however, still exist with $\overline{R}^2$ as the criterion for model selection. Firstly, it is a flexible rule. Under this rule, the results would include more regressors than necessary in the regression, containing some unimportant variables. Secondly, there is no distribution available for $\overline{R}^2$ and R^2; thus it is impossible to compare the significant level of $\overline{R}^2$ or R^2 in one model with that in other model (Stock and Watson, 2003).

3.2.2 General-to-specific (GETS) model [29]

The general unrestricted equation model can be expressed in the following form:

$$Y_t = \alpha + \beta_1 X_{1t} + \beta_2 X_{2t} + ...\beta_k X_{kt} + \mu_t \qquad (3.8)$$

Y_t denotes the dependent or explained variable, while X_{kt} represent those potential independent or explanatory variables. α is the intercept and β_k are coefficients for each explanatory variable.

The GETS modelling (Hendry 1984, 1995, 2000) procedure could be specified as containing three steps: 1) Establish a general unrestricted model (GUM) which is congruent[30]; 2) simplify the model sequentially in an attempt to derive a parsimonious congruent model while at each step checking that the model remains congruent; and 3) test the resulting congruent model against the GUM. (Bauwens et al., 2006)

Through a stepwise regression which aims to find the best final model, the unimportant variables are eliminated and only the important explained variables are left; this process is designed to test whether the insignificant information is lost. According to Hendry (1984:235), “a model with relatively few independent parameters is not only easily

[29] GETS modelling is sometimes referred to as the "LSE methodology" after the institution in which the methodology to a large extent originated, or the "Hendry methodology" after the most influential and arguably the most important contributor to the development of the methodology, and sometimes even "British econometrics", see Gilbert (1986), Gilbert (1989), Mizon (1995) and Hendry (2003).

[30] The term "congruent" is borrowed from geometry: By "analogy with one triangle which matches another in all respects, the model matches the evidence in all measured respects." (Hendry 1995, p. 365)

understood; but also, it avoids the danger that an excessive number of variables induced overfitting".

A fundamental core of the GETS modelling is that empirical models are derived. GETS modelling is generally used as explanatory econometric modelling and is quite popular for use among a large scale of econometric models, because it gives a systematic framework for statistical economic hypothesis-testing. GETS modelling, however, initially contains many explanatory variables, which is still a challenge for researchers.

3.3 Multiple equation models analysis

3.3.1 Vector Autoregressions (VARs)[31] model

Economic theory has been used in the design of structural modelling of time series. However, the problem is that economic theory is not rich enough to identify all the relationships between the variables of interest. Furthermore, the appearance of endogenous variables in both sides of the equation would make the inference and estimation more complicated; thus, another non-structural approach is required.

One of the structural models - the Cowles Commission approach - is subjective to the well-know Lucas critique (Lucas, 1976), though it can trace the feedback response between variables by estimating the equations simultaneously. [32] The famous Lucas critique (1976) argued that the problems with the structural approach are the change of monetary policy regime and the change in expectation. Therefore, the structural model is not quite reliable in terms of the changeable real economy world. As a result, Sims (1980) suggested an alternative econometric framework: the vector autoregressions (VARs) model.

The VARs model was first provided by Sims (1980), and was further developed by Bernanke (1986), Bernanke and Blinder (1992), and Leeper (1996), etc. The VARs model is a theory-free restrictions approach, and there is no requirement to distinguish between the endogenous or exogenous variables in the equations. According to the

[31] For more detail of the VARs model description, see Hamilton (1994)
[32] Favero (2007) has provided a good comparative analysis among the Cowles Commission approach, LSE approach and VARs approach.

concept of the VARs model, it is an n-equation, n-variable linear model in which each variable is in turn explained by its own lagged values, plus current and past values of the remaining n-1 variables. (Stock, 1994)

The VARs model can be represented as:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t \qquad (3.9)$$

where y_t is a vector of endogenous variables, x_t is a vector of exogenous variables, $A_1,\ldots,A_p$ and B are matrices of the coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables. (Hamilton 1994)

Simultaneity is not a problem and it applies OLS to estimate the VARs model, because only lagged values of endogenous variables are in the right-hand side of the equations. Moreover, although the innovations ε_t could be contemporaneously correlated, OLS is still efficient and equivalent to estimate, because the equations include the identical regressors. The VARs model is frequently used to forecast the relationships among the correlated times series data, and to analyse the dynamic effect of random disturbances on the variables in the system.

In the research, a structural analysis based on the VARs model is conducted, in which the Granger causality test, impulse response analysis and forecast error variance decomposition are included.

3.3.2 **Vector Error Correction Model (VECM)**

The vector error correction model can be simply described as adding an error correction feature to a vector autoregression model.

The VECM (p) form is written as

$$\Delta y_t = \delta + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Phi_i^{p-1} \Delta y_{t-i} + \varepsilon_t \qquad (3.10)$$

where $\mathbf{\Delta}$ is the differencing operator, such that $\Delta y_t = y_t - y_{t-1}$.

It has an equivalent VAR(p) representation as described in the preceding section.

$$y_t = \delta + (I_k + \Pi + \Phi_1^{p-1})y_{t-1} + \sum(\Phi_i^{p-1} - \Phi_{i-1}^{p-1})y_{t-i} - \Phi_{p-1}^{x} y_{t-p} + \varepsilon_t \qquad (3.11)$$

A Vector Error Correction Model (VECM) can provide a better understanding of the features of any non-stationarity among the different series and can also improve forecasting over an unconstrained model in the long run.

3.3.3 Cointegration tests

The concept of cointegration was first provided by Engle and Granger (1987), and they suggested that a linear combination of two or more non-stationary series may be stationary. The non-stationary time series are said to be cointegrated, if such a stationary linear combination exists.

There are several methods of testing the cointegration. The first one is the Engle-Granger two-stage procedure (Engle and Yoo, 1987), but the problem with Engle-Granger is that it cannot provide the number of cointegration vectors when there is more than one cointegration relationship. Thus, the Johansen cointegration test was introduced by Johansen and Juselius (1990) and Johansen (1991). The Johansen cointegration test is more reliable than the Engle-Granger two-stage approach but it does not consider the structural break in the test; so, in order to solve this problem, the Gregory Hansen cointegration test is proposed.

Gregory Hansen cointegration test

Gregory Hansen (1996) revises the Engle and Granger (1987) model to take account of the regime shift via a residual-based cointegration technique. The Gregory and Hansen model is also a two-stage estimation procedure of which the first step is to estimate the following multiple regression:

$$y_{1t} = \alpha + \beta t + \gamma DU_t(\lambda) + \theta_1 y_{2t} + e_t \qquad (3.12)$$

In which y_{1t} and y_{2t} are of I(0) and y_{2t} is a variable or a set of variables ; and $DU_t(\lambda)$ has the same definition as that in Zivot-Andrew. The second step is to test whether e_t in equation 3 is of I(0) or I(1) via the ADF or Phillips-Perron technique. If e_t is found to be consistent with I (0), one may claim that cointegration exists between y_{1t} and y_{2t}. (Huang et al., 2000, Gregory and Hansen, 1996)

3.3.4 Granger causality Tests

There are several ways to test the causality between time series variables, and the study will employ the two main approaches. The first is the Granger causality test, and the other is comparison of robustness to structural break to test causality. The Granger causality test will be discussed in depth here, as it has been heavily used in the study. The comparison of robustness to structural break will be briefly introduced in the chapter 6.

Causality is an essential concept to interpret and understand what is observed in practice; however, it is a subject of controversy in econometrics. One widely-accepted definition is Granger causality (Granger 1969). According to Granger (1969), a time series X could be said to Granger-cause Y, if X values provide statistically significant information about future values of Y when adding lagged values of X in the regression of lagged value of Y. Although Granger causality does not imply true cause from X to Y, and only provides the generic definition of causality, it still plays an important role in econometrics.

After the discussion of the VARs model and VECM model in the previous paragraphs, one can more confidently examine the Granger causality test, because Granger causality employs the VARs and VECM models in the test. If both X and Y are driven by a common third process with different lags, their measure of Granger causality could still be statistically significant. Thus the cointegration technique was introduced.

The cointegration techniques of Granger (1986), Hendry (1986), Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1990) have significantly contributed to the Granger causality test. If cointegration is found among the variables, the error correction term obtained from cointegration regression should be considered in the causality test to avoid the misspecification problems (Granger 1981). If the variable series are cointegrated, it will display the long-term relationship between variables that cause at least one Granger causality in unidirectional or bidirectional causality. However, the cointegration only shows the existence of causality, not the direction of causality among the variables; thus the Granger causality will be tested in the following models:

If the cointegration does not exist, the following formulation is needed to test hypotheses:

$$\Delta y_{1t} = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta y_{2t-i} + \varepsilon_{1t} \qquad (3.13)$$

$$\Delta y_{2t} = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta y_{2t-i} + \varepsilon_{2t} \qquad (3.14)$$

In which y_{1t} and y_{2t} represent nominal GDP and financial variables (nominal interest rates, money aggregates and GDP-circulation credit). Failing to reject the H_0 : $\alpha_{21} = \alpha_{22} = ...\alpha_{2k} = 0$ implies that financial variables (nominal interest rates, money aggregates and GDP-circulation credit) do not Granger cause nominal GDP. Likewise, failing to reject $H_0 : \beta_{11} = \beta_{12} = ...\beta_{1k} = 0$ suggests that nominal GDP does not Granger cause financial variables.

If cointegration exists between y_1 and y_2 an error correction term is required in testing Granger causality, as shown below:

$$\Delta y_{1t} = \alpha_0 + \delta_1 (y_{1t-1} - \gamma y_{2t-1}) + \sum_{i=1}^{k} \alpha_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta y_{2t-i} + \varepsilon_{1t} \qquad (3.15)$$

$$\Delta y_{2t} = \beta_0 + \delta_2 (y_{1t-1} - \gamma y_{2t-1}) + \sum_{i=1}^{k} \beta_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta y_{2t-i} + \varepsilon_{2t} \qquad (3.16)$$

In which δ_1 and δ_2 denote speeds of adjustment. According to Engle and Granger (1987), the existence of the cointegration implies a causality among the set of variables as manifested by $|\delta_1| + |\delta_2|$ >0. Failing to reject H_0 : $\alpha_{21} = \alpha_{22} = ...\alpha_{2k} = 0$ and δ_1 =0 implies that financial variables (nominal interest rates, money aggregates and GDP-circulation credit) do not Granger cause nominal GDP while failing to reject $H_0 : \beta_{11} = \beta_{12} = ...\beta_{1k} = 0$ and δ_2 =0 indicates that nominal GDP Granger causes financial variables.

The essential step in the Granger causality test is to choose the number of lags, since the results will mostly depend on the length of lags. Too many or too few lags, in general, will present misleading information. Too few lags will miss the important information and, furthermore, will usually lead to bias in the estimated coefficient. On the other hand, too many lags will increase the errors in the regression coefficient. In the research, the number of lags is decided based on the smallest AIC in VARs and VECM models.

3.3.5 Advantages and disadvantages of VARs model

Before concluding the methodology section, it is necessary to point out the limits of the VARs model as well as its advantages, as the VARs model is heavily used in the research.

The Advantages and Disadvantages of the VARs

According to Ramaswamy and Slok (1998:378), Lütkepohl (2005) and Favero (2003), the VARs approach has some advantages. Firstly, it is not necessary to specify which variables are endogenous and exogenous and, on the other hand, all variables are regarded as endogenous variables. Unlike the complicated traditional Cowles Commission approach, in which many assumptions are imposed, the VARs model is simple and allows the data to "speak". The VARs model can extract information from data without enforcing too many restrictions.

Secondly, the VARs model allows the value of a variable to depend on more than just its own lags or combinations of white noise terms, so it is more general than ARMA modelling; thus it is more useful when the main goal of empirical research is to find the statistical relationship between macroeconomic variables.

Thirdly, the simple OLS can be used to estimate the VARs models, on the condition that there are no contemporaneous terms on the right-hand side of equations. In addition, the sensitivity of the VARs model to shocks provides an opportunity for researchers to detect the response of macroeconomic variables to monetary policy innovations that are unanticipated by the market (Favero, 2003). Lastly, the forecasts obtained from the VARs model are often better than traditional structural models; furthermore, in empirical work in particular, the VARs approach provides an appropriate framework to compare the effect of monetary policy effects across countries.

Problems with VARs

As with any other model, the VARs model has also been subjected to criticism for its own drawbacks. Firstly, the VARs model is usually criticized for its theory-free background. However, it is unfair to perceive it in this way, since some assumptions are still needed when estimating the VARs model. For example, the order under the Cholesky decomposition indicates that the first variable has a contemporaneous effect on all other variables and, for the last variable, only its lag can have an effect on other variables. In addition, the variables in the models are chosen according to economic theories. Moreover, the structural VARs model also imposes some economic assumptions on the model in order to make it fit better with the specific economic theory. Secondly, there are many parameters, which consume many degrees of freedom. If an equation has g variables and k lags of each of the variables in the equation, then (g+kg^2) parameters need to be estimated. When more variables and more lags are added to the model, the estimated parameters will dramatically increase. In general, the length of lags will be determined by information criteria, such as the Akaike information criterion (AIC) and Schwarz information criterion (SIC).

The major problems in the empirical practice of the VARs model are the choice of appropriate monetary policy indicator and some impulse response from a VARs model derived from prior theories. An improper choice of monetary policy indicator may lead to inappropriate inferences of the VARs-based approach (Leeper *et al.*, 1996). The latter problems are found in the “price puzzle” and “liquidity puzzle”. The most important issue is that the VARs model is also subject to the Lucas critique, because of implicit expectation. However, the advocates of the VARs model argue that the disturbed variables are the shocks and the estimated parameters are not modified for simulation purposes (Favero, 2003).

Chapter 4

4 Empirical evidence on the relationship between interest rates and nominal GDP in the U.S., U.K., Germany and Japan from 1960s to 2008

Abstract: In this chapter, the study largely focuses on the interaction between short-term interest rates and nominal GDP growth rate. Previous research has advocated using the interest rate to target nominal GDP (Judd and Motley, 1993). This research involves the application of the Granger causality test to give an empirical correlation between the interest rate and nominal GDP growth rate. Additionally, chapter 5 will set out more empirical test results of the link between interest rates and nominal GDP in VAR model. The results of the Granger causality test suggest that interest rate does not Granger cause nominal GDP growth rate, and nominal GDP growth rate does Granger cause interest rate. This evidence supports the view that short-term interest rates follow the trend of nominal GDP growth rate rather than lead the nominal GDP growth rate.

4.1 Introduction

A proper monetary policy is always the intention of most monetary authorities across the world. Nowadays, inflation targets are used by several developed countries, such as the U.K., New Zealand, Canada and Sweden. Although a low inflation target is appropriately the main objective of monetary policy, this does not mean that inflation target is the best operation target. It is argued that an inflation target only makes sense when the level of output is independent of the inflation rate and determined by supply-side factors. A practical concern is to find the right anchor for monetary policy. Several possible anchors have been discussed in the literature part. Nominal output targets in the theory have been given considerable attention in the academic literature. With a nominal output anchor, the central banks would directly target the nominal output; although nominal output itself is not a traditional target variable, it is closely relative to two important monetary policy objectives: sustainable economic growth and price stability. There has been a considerable amount of work on the theory of nominal income targeting, but not many empirical works have focused on it. The research, therefore, intends to provide the empirical work on the targeting of nominal output.

There are two approaches to targeting nominal output. The first approach is to use nominal GDP as the only target of monetary policy. The monetary authority would try to keep nominal GDP close to its target; if it were below the potential level, the expansionary monetary policy would be employed and vice versa. Some economists support the view that simple nominal GDP targeting would help to stabilize the economy, because it captures the real GDP and the price level. The second approach is to use financial variables, such as interest rate or money aggregates, as the intermediate target to advocate a certain nominal GDP growth rate; thus the nominal GDP is the ultimate target. In this research, the main concern is to provide the empirical results for using financial variables (interest rate, money aggregates, and GDP-circulation credit) as the intermediate targets when aiming at nominal output. In chapter 4, the study focuses only on the interest rate as the instrument variable to target nominal output.

Previous research has doubted the reliability of the monetary aggregates as intermediate targets of monetary policy; in turn, other researchers have advocated using interest rate as the intermediate monetary policy to target output. (Bernanke and Blinder, 1988; Bernanke and Blinder, 1992; Taylor, 1985; Taylor, 1993; Rotemberg and Woodford, 1997; Woodford, 2003). Such a rule would try to identify how the central banks should adjust policy to affect short-term interest rates in response to deviations of output from the target. In such a framework, the essential point is to find the empirical correlation between nominal GDP and interest rate, and to answer the question of whether the empirical results would support the advocacy of using interest rate as an appropriate variable to target nominal GDP.

4.2 Literature review on the relationship between nominal GDP and short-term interest rate

The use of short-term interest rate to target nominal GDP

In the previous literature, nominal output (or nominal income) targeting has been recommended by many economists (Tobin, 1983; Hall, 1983; Gordon, 1985; Taylor, 1985; McCallum, 1988, 1991; Feldstein and Stock, 1994; and Hall and Mankiw, 1994). The argument was that the Central Bank should target nominal GDP using one of several policy rules. Such a rule would specify how the Central Bank should adjust policies to affect the short-tem interest rate or money aggregate in response to deviations in nominal GDP from the target (Clark, 1994).

As this chapter mainly concentrates on the link between interest rate and nominal GDP, it only reviews the literature on using interest rate to target nominal output. The idea of adjusting short-term interest rate to keep nominal output on target is due to the central banks typically having no direct control over nominal output. However, they have influence over short-term interest rates, such as the federal fund rate. The central issue is whether there is a stable relationship between nominal GDP and interest rate, and how to use interest rate to target nominal GDP.

The way that policy-makers react to deviations of nominal GDP from the target creates two different rules for targeting nominal GDP. One rule is that monetary policy should change when actual nominal GDP deviates from the target. Another rule is that, when forecasted nominal GDP deviates from the target, the monetary policy changes.

Lagged adjustment: In the lagged adjustment framework, the policy-makers adjust short-term interest rate through open market operations when the nominal GDP is observed as deviating from target nominal GDP. The rule would be that the current interest rate would change systematically by x per cent if the last quarter's nominal GDP growth deviated from the target by one percentage point. Judd and Motley (1993) specified the value rate as 0.2; however, in their previous study, Judd and Motley (1992) suggested a lower corresponding adjustment rate x of 0.125.

Forecast adjustment: Under the forecast adjustment rule, policy-makers in central banks will increase the interest rate if the forecasted nominal GDP growth rate exceeds the target nominal GDP growth rate, and reduce the interest rate if the nominal GDP growth rate falls below the target rate. Judd and Motley (1993) describe a monetary policy regime in which discretionary changes in short-term interest rate would be oriented around a baseline interest-rate path that would be designed to be consistent with a disinflation or low-inflation goal. Specifically, under this approach, the baseline option would be defined by a policy rule that would like changes in short-term interest rate to a nominal GDP target to be designed to be consistent with the inflation goal in the long run. The forecast adjustment rule might delay the effect of the monetary policy, which would be better for the stability of nominal GDP.

A considerable number of studies have discussed the theory of nominal output targeting, but very few have explored the practical features of nominal output targeting by conducting counterfactual simulated policies. There is a big gap between theory and practical studies that use financial variables to target nominal output, which leaves a large space for potential future research. The research intends to fill this gap; it will also be especially valuable for monetary policy-making.

4.3 Data and summary statistics

4.3.1 Description of data

The short-term interest rate: the interest rates are obtained from the IFS (International Financial Statistics). The study uses the 3-month Treasury bill rate to represent the short-term interest rate.[33]

In order to ensure the preciseness of the data, the study also made a comparison with data from a different source. It obtained the monthly 3-month Treasury bill (secondary market) from the Federal Reserve, converted it to quarterly data using the average method, and found that the two series are the same. In the U.K., it compared the 3-month Treasury bill rate from the IFS and the Bank of England; meanwhile, in Japan, it compared the 3-month Treasury bill rate with that from Eurostat, and found that the two series from different sources are the same in both countries. In Germany, it compared the 3-month money market rate with the 3-month Frankfurt Bank middle rate from datastream, and the two series show a similar trend.

Price: The study uses the consumer price, all items, and quarterly data from the OECD (Organisation for Economic Co-operation and Development) to indicate the price level.

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[33] The 3-month Treasury bill rate series code in the U.S., U.K and Japan is 60c...ZF. As the time period of the Treasury bill rate in Germany is not long enough in the IFS database, the study chooses the money market rate as the short-term interest rate in Germany.

The data obtained from the OECD are the growth on the same period from the previous year.

The definition of inflation is growth, on the same period from the previous year, in consumer prices: all items, quarterly average. As the consumer price is I (2), so the study uses the growth rate. The study also uses the consumer price index data from the IFS, and it calculated the seasonal difference logarithm of consumer price index, and compared it to the data from the OECD. The result shows no significant difference between the two data sets in these four countries.

Nominal GDP: The American authorities do not provide the non-seasonally-adjusted nominal GDP after 2006Q4, so the nominal GDP applied in the research is non-seasonally-adjusted data until 2006Q4, and seasonally-adjusted data from 2007Q1 to 2008Q4. There is no significant difference between non-seasonally-adjusted and seasonally-adjusted growth rates of nominal GDP, so the combined nominal GDP data will not affect the results. The data source is Thomas Datastream

In the U.K., nominal GDP is non-seasonally-adjusted, and was obtained from the Office for National Statistics (ONS). The sample period is from 1960Q1 to 2008Q4.

In Germany, the nominal GDP is obtained from the Deutsche Bundesbank, but the period only starts from 1970Q1. The nominal GDP is also non-seasonally-adjusted in Germany.

In Japan, nominal GDP data are combined from two series. One is from 68SNA, and another is from 93SNA. The 1968 System of National Accounts (SNA 68) stands for an essential landmark in national accounting, while the SNA 93 represents the "gold standard" for national accounts, covering every aspect of economic activity. Because of the change of standard, nominal GDP growth rate series in Japan is a combination of the two. The study used the non-seasonally-adjusted nominal GDP in Japan as well.

The study plots the 3-month Treasury bill rate and nominal GDP growth rate in the graph to view the co-movement of these two variables.

Figure 4-1U.S. 3-month Treasury bill rate and nominal GDP growth rate

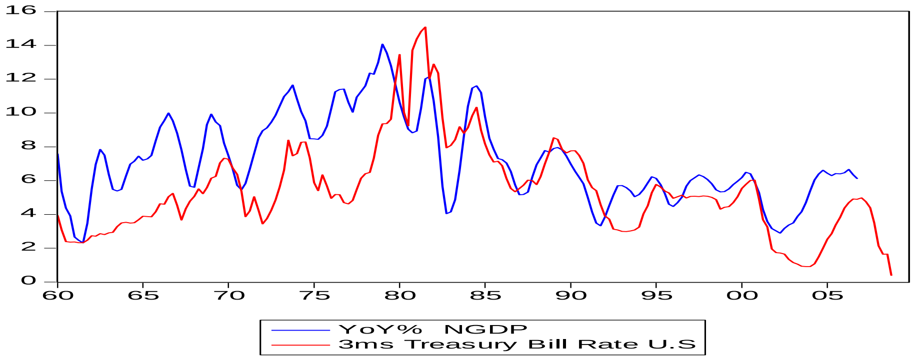


Figure 4-2 U.K. 3-month Treasury bill rate and nominal GDP growth rate

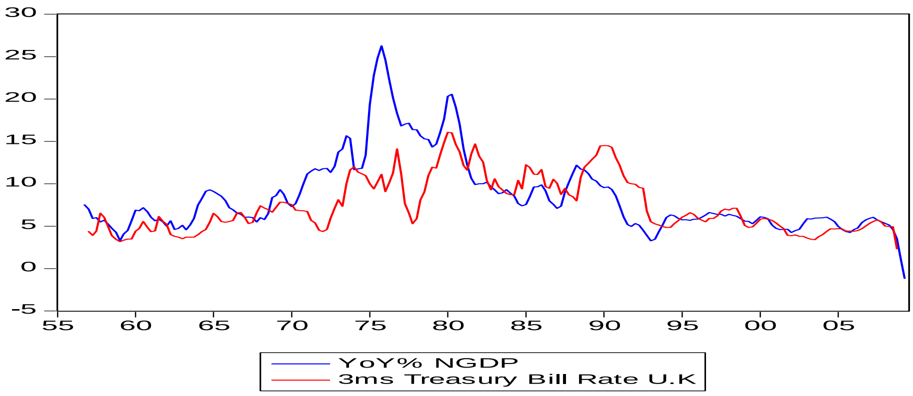


Figure 4-3 Germany 3-month money market rate and nominal GDP growth rate

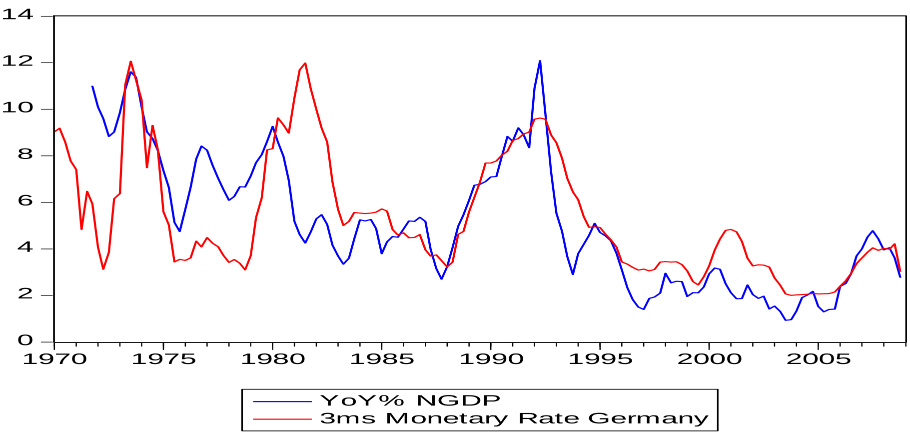
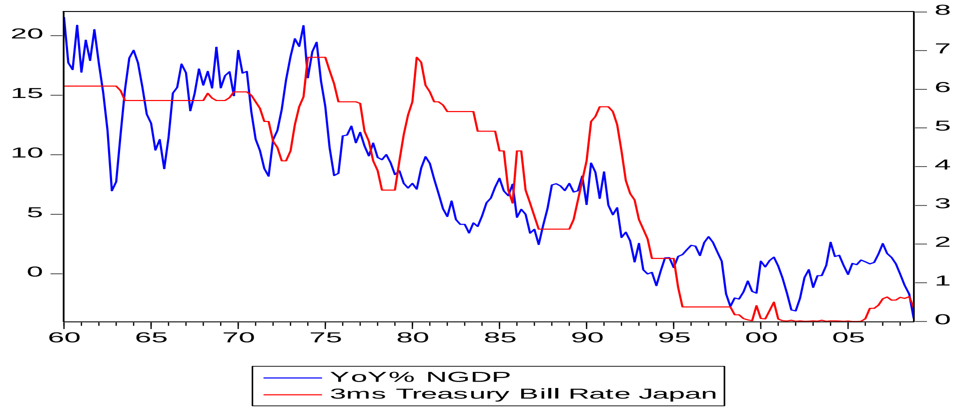


Figure 4-4 Japan 3-month Treasury bill rate and nominal GDP growth rate



A visual inspection of these graphs reveals that the rising interest rates follow high nominal GDP growth rate, with the lower nominal GDP growth rate decreasing the interest rates in U.S., U.K., Germany and Japan. Furthermore, it is revealed from the graph that there is a closer co-movement between the nominal GDP growth rate and nominal interest rate after the 1980s; before that, the difference between nominal GDP growth rate and 3-month Treasury bill rate is wider than that after the 1980s, except in Japan, because the short-term interest rate in Japan has been kept at an abnormally low level since the 1990s by the Bank of Japan. As we know, the central banks changed the monetary policy regime, abandoned the money supply target and changed to the interest rate as monetary policy target after the 1980s.[34] Therefore, the difference in the co-movement between interest rate and nominal GDP growth rate before and after the 1980s might reflect this regime change.

The short-term correlations of the 3-month Treasury bill rate and economic variables

The figures above show the simple co-movement correlation between the 3-month Treasury bill rate and the nominal GDP growth rate. In order to investigate more statistical features, cross-correlations are applied.

[34] In the U.S., the use of monetary aggregate as the monetary policy target was discontinued with the selection of Alan Greenspan as Fed chairman.
In the U.K, the 1998 Bank of England Act made the Bank independent, allowing it to set interest rates. The Bank is accountable to Parliament and the wider public. The Bank's monetary policy objective is to deliver price stability – low inflation – and, subject to that, to support the Government's economic objectives including those for growth and employment. Price stability is defined by the Government's inflation target of 2%. Source: Bank of England

The evidence of short-run cross-correlations of the 3-month Treasury bill rate and the economic variables for the U.S., U.K., Japan and Germany is provided in the figure4-5. The original nominal GDP and CPI index were seasonalized and the log form was taken. The Census X12 is used to seasonalize the original data, and the Hodrick-Prescott filter is applied to detrend the data. The figure shows the correlations between the detrended log of nominal GDP and 3-month Treasury bill rate.

The cross-correlation function here is:

$$\rho_{yx(k)} = \frac{\sum_{t=1}^{T-k}(y-\bar{y})(x_{t-k}-\bar{x})}{\sqrt{\sum_{t=1}^{T}(y-\bar{y})^2}\sqrt{\sum_{t=1}^{T}(x-\bar{x})^2}} \qquad (4.1)$$

(R_{t+j} j=0, $\pm 1, \pm 2, \pm 3, \ldots$)

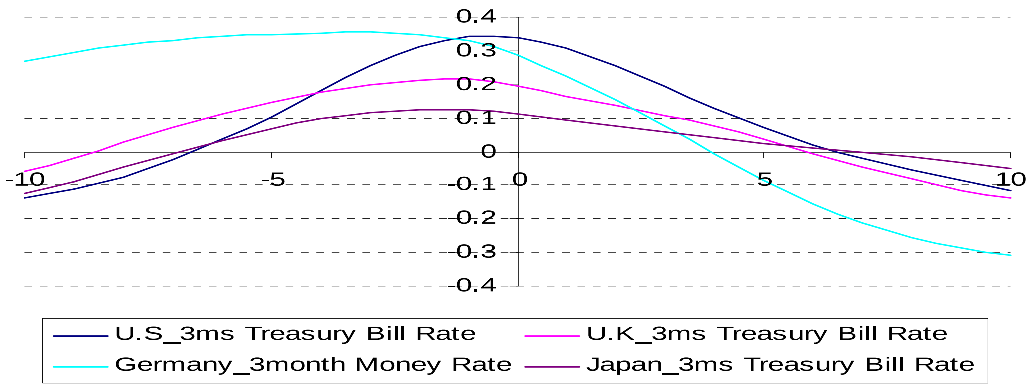
4.3.2 The cross-correlation between nominal GDP and 3-month Treasury bill rate

The figure4-5 plots the correlation between nominal GDP and short-term interest rates in the U.S., U.K., Germany and Japan. The short-term interest rates show the positive correlation with nominal GDP in the current period, and are significantly positively correlated with nominal GDP at roughly 5-quarters leads and lags. The positive correlation between nominal GDP and interest rate in the current period and 5-quarters leads indicates that high nominal GDP tends to lead to a high 3-month Treasury bill rate; meanwhile, the positive correlation between nominal GDP and short-term interest rates at 5-quarters lags points out that a rising 3-month Treasury bill rate is followed by an increase in nominal GDP growth after the initial first 5-quarter shock, which is in contrast to the standard theory. In the figure4-5, the nominal GDP is negatively related with the 3-month Treasury bill rate after 6 quarters in the U.S. and Japan, and the negative correlation between nominal GDP and the short-term interest rate exist after more than 6 quarters in the U.K. and Germany. This implies that the 3-month Treasury bill rate negatively impacts on nominal GDP after 6-to-10 quarter lags.

The traditional wisdom indicates that interest rates should negatively lead the nominal GDP growth; however, the information from the figure below contradicts this theory:

high nominal GDP in the current period tends to be followed by high interest rate in a future period. If we assume that the monetary authorities target nominal GDP, then the traditional knowledge does not hold, because the positive correlation between nominal GDP $NGDP_t$ and Interest rate i_t for j<0 implies that increasing interest rate raises the nominal GDP.

Figure 4-5 Cross-correlations, nominal GDP and 3-month Treasury bill rate in the U.S. and U.K. (1960:1-2008:4), and in Germany and Japan (1970:1-2008:4)



4.4 Data and time series trends, and cointegration

The nominal GDP data are the non-seasonally-adjusted, current value GDP, national currency quarterly average data. Because the quarterly data display strong seasonality, the study calculated the seasonally differenced logarithms of nominal GDP, [35] and thereby it is able to consider them as the growth rates.

The log nominal GDP growth from t to t+k expressed as a quarterly frequency represents the annualized growth rate = $100 * (LnNGDP_{t+4} - LnNGDP_t)$

Real GDP data used is an index number, 2000=100, which is obtained from the IFS. The researcher also has real GDP data from datastream, which is volume data, seasonally-adjusted, chained, at constant price. The researcher calculated the seasonal

[35] As mentioned in the data section, nominal GDP in Germany was obtained from datastream and Deutsche Bundesbank. The data from the two sources provided us with overlapping data; consequently the study could use the overlapping data to adjust the break point at 1991Q1.

logarithm of real GDP in both data sets for the U.S. and U.K., and found that the growth rate calculated from the two data sets is exactly the same. Considering real GDP data is I (1), the study needs to use the growth rate of real GDP in the test and, as the data period of real GDP in Germany and Japan in datastream is shorter, the research used real GDP index number from the IFS with confidence.

10-year Government bond rates are used as an indicator of long-term interest rate, which is obtained from the IFS. Both 3-month Treasury bill rates and 10-year Government bond rates are monthly average data, and the average method was used to convert to quarterly data. The detailed descriptions are shown in the data appendix following this chapter.

The time period in the test is generally from 1960s to 2008Q4 in the U.S., U.K., Germany and Japan, although some data series have shorter periods; for example, the real GDP in the U.K. ends at 2008Q3, 10-year Government bond rate in Japan is from 1966Q4, and real GDP in Germany is from 1961Q1. A slightly shorter period would not influence the empirical results significantly. The researcher believes that the sample countries represent a reasonable coverage of the various advantages of different economic banking systems.

4.4.1 Unit root test results

Prior to testing for cointegration and Granger causality, the research firstly examines whether the variables are stationary by applying three approaches: ADF, PP test and the Zivot and Andrews model. To account for the possibility of a structural break, the researcher employs the Zivot and Andrews (1992) sequential test for a unit root with the alternative hypothesis of stationarity with a single structural change in the deterministic trend.[36] When the results obtained from these three methods conflict, the researcher will judge the stationary properties of the data based on the analysis of the data's natural features.

[36] Other procedure that incorporate the possibility of a break at an unknown time under the alternative hypothesis are suggested by Banerjee et al. (1992), and Perron and Vogelsang(1992).

Use of the ADF and PP models to test the nominal GDP, real GDP growth rate, 3-month Treasury Bill rate, 10-year Government bond rate, and Consumer Price index (CPI) growth rate of the previous year is done under the assumption that there is an intercept in the data. The Zivot and Andrews test applies the Bayesian information criterion (BIC) to determine the lag and allow the break in both the trend and intercept.

The results illustrated in the appendix reveal that interest rates in both the short-term and long-term real GDP and growth rate of consumer price index (CPI) are I (1) in the level data respectively in ADF and PP test. The Zivot and Andrews test also confirms that the short-term interest rate, long-term interest rate, and real GDP is I (1), although growth rate of consumer price index displays the stationary feature trend in the U.S., U.K. and Japan. However, as the inflation is normally regarded as I (1), the research views the CPI growth rate, short-term interest rate, long-term interest rate, and real GDP as I (1).

The nominal GDP growth rate presents the stationary property trend in the Zivot and Andrews test but, in the ADF and PP test, nominal GDP growth displays the feature of unit root. In order to keep the empirical test results understandable and as, generally, the growth rate is I (1), the nominal GDP is regarded as I (1). The results of the Zivot and Andrews approach could be especially insightful when the null hypothesis of a unit root is not rejected by the conventional tests. When it is rejected by the Zivot and Andrews test, this provides an important indication that a stationary feature in fact exists.

Empirical results

The traditional wisdom implies that central banks nominally intend to lower interest rates to trigger economic conditions, and set the base bank rate to target inflation. Therefore, the study firstly applies the Granger causality test in an attempt to find the "causality" between interest rates, inflation, real GDP and nominal GDP.

4.4.2 Cointegration test results

The study starts with the Gregory and Hansen cointegration. The Gregory and Hansen (1996) test assumes the null hypothesis of no cointegration against the alternative hypothesis of cointegration with one structural break. The time of the structural change under the alternative hypothesis is estimated rather than selected. Gregory and Hansen suggest three alternative model specifications in the spirit of Zivot and Andrews (1992), accommodating changes in parameters of the cointegration vector under the alternative. Due to space limitations, the detailed results of cointegration are shown in the appendix.

No cointegration is found between the real GDP, nominal GDP and interest rates. It is obvious from the graphs that the real GDP and nominal GDP data are a straight line, and interest rates fluctuated; thus no cointegration correlation between those two variables exists.[37]

The outcome of the Gregory and Hansen cointegration tests between growth rate of CPI and interest rates are set out in the Appendix 4.C. As revealed, the cointegration tests are applied in consideration of whether the break is full, trend, or constant. The results of the cointegration tests show a cointegration between the short-term interest rate and growth rate of CPI at the 5% significance level in the U.K. and Germany, but no cointegration correlation between 3-month Treasury bill rate and growth rate of CPI in the U.S. and Japan at 5% significance level. Similar results were found in the cointegration test between the 10-year Government bond rate and growth rate of CPI, while cointegration exists between the long-term interest rate and growth rate of CPI in the U.K. and Germany, but does not exist in the U.S. and Japan.

4.5 Granger causality test

It is highly possible that the typical F-test mistakenly recognizes spurious Granger causality, partially when a non-stationary process and a trend stationary process or a random walk with drift are included in the true process (He and Maekawa, 2001). For that reason, the study applies a VECM model to test for Granger causality when cointegration exists, and a VAR model to test for it if cointegration does not exist.

As we have introduced in the methodology chapter, if the cointegration does not exist, the study uses a standard VAR form to test for Granger causality, and the number of lags is determined by Akaike information criterion (AIC).

[37] The results have not been shown in the appendix, but are available on request.

$$\Delta y_{1t} = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta y_{2t-i} + \varepsilon_{1t} \qquad (4.2)$$

$$\Delta y_{2t} = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta y_{2t-i} + \varepsilon_{2t} \qquad (4.3)$$

in which δ_1 and δ_2 stand for speeds of adjustment. y_{1t} represents nominal GDP or real GDP and y_{2t} represents nominal interest rates. Failing to reject the H_0 : $\alpha_{21} = \alpha_{22} = \alpha_{23} = ... = a_{2k} = 0$ implies that nominal interest rates do not Granger cause real GDP or nominal GDP. Otherwise, failing to reject the $H_0 : \beta_{21} = \beta_{22} = \beta_{23} = ... = \beta_{2k} = 0$ implies that real GDP or nominal GDP does not Granger cause interest rates.

In the case of cointegration existing, an ECM model is used to test for the Granger causality:

$$\Delta y_{1t} = \alpha_0 + \delta_1 (y_{1t-1} - \gamma y_{2t-1}) + \sum_{i=1}^{k} \alpha_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta y_{2t-i} + \varepsilon_{1t} \qquad (4.4)$$

$$\Delta y_{2t} = \beta_0 + \delta_2 (y_{1t-1} - \gamma y_{2t-1}) + \sum_{i=1}^{k} \beta_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta y_{2t-i} + \varepsilon_{2t} \qquad (4.5)$$

in which δ_1 and δ_2 stand for speeds of adjustment. y_{1t} represents inflation and y_{2t} represents nominal interest rates. According to Engle and Granger (1987), the existence of the cointegration implies a causality among the set of variables as manifested by $|\delta_1|$ + $|\delta_2|$>0. Failing to reject the $H_0 : \alpha_{21} = \alpha_{22} = \alpha_{23} = ... = a_{2k} = 0$ implies that nominal interest rates do not Granger cause inflation. Otherwise, failing to reject the H_0 : $\beta_{21} = \beta_{22} = \beta_{23} = ... = \beta_{2k} = 0$ implies that inflation does not Grange cause interest rates. The table below shows the results from this.

4.5.1 Granger causality test with the short-term interest rate

Table 4-1 Granger causality test between real GDP, inflation, nominal GDP, and 3-month rates during 1960Q1-2008Q4

Countries	Real GDP does not GC 3-months Rate		3-months Rate does not GC Real GDP	
	F-statistic	P-value	F-statistic	P-value
U.S.	2.16983	0.0481**	7.13293	8.00E-07***
U.K.	3.80198	0.0007***	3.73638	0.0009***
Germany	3.51218	0.0005**	1.54471	0.1363
Japan	1.82735	0.0679*	1.11966	0.3525
Countries	inflation does not GC 3-months Treasury Bill Rate		3- months Treasury Bill Rate does not GC inflation	
	F-statistic	P-value	F-statistic	P-value
U.S.	1.750045	0.0736*	3.478707	0.0004***
U.K.	2.013505	0.0228**	2.419798	0.0053***
Germany	2.901599	0.0068***	1.796183	0.0907*
Japan	0.947518	0.4859	3.576735	0.0005***
Countries	nominal GDP does not GC 3-months Treasury Bill Rate		3-months Treasury Bill Rate does not GC nominal GDP	
	F-statistic	P-value	F-statistic	P-value
U.S.	3.32686	0.004***	7.02544	1.00E-06***
U.K.	2.27238	0.0248**	0.48078	0.8686
Germany	2.07798	0.0599*	1.42819	0.2084
Japan	1.20979	0.3069	1.28941	0.271

Note: the abbreviation for GR denotes nominal GDP, and GC denotes Granger Causality. * =10% significance level; ** =5% significance level; ***= 1% significance level. Germany test sample is from 1970Q1-2008Q4

From the table, it is clear that real GDP has a Granger cause to 3-months rates in four countries at the 10% significance level but, at the 5% significance level, the null hypothesis is not rejected in Japan, which implies real GDP does not Granger cause the 3-month Treasury bill rate at the 5% significance level in Japan, although real GDP does Granger cause to 3-months rate in U.S., U.K, and Germany at the 5% significance level. On the other hand, the null hypothesis that the 3-months rate does not Granger cause to real GDP in Germany and Japan is not rejected, although it could be rejected at the 5% significance level in the U.S. and U.K

The null hypothesis that inflation rate does not Granger cause 3-month rates in the U.S., U.K. and Germany is rejected at the 10% significance level, but it is not rejected in Japan. Meanwhile, the null hypothesis that the 3-month rate does not Granger cause inflation in the U.S., U.K., Germany and Japan at the 10% significance level is rejected, which implies that the 3-month Treasury bill rate does Granger cause inflation rate. The results show that the null hypothesis that nominal GDP does not Granger cause the 3-month rate is rejected in the U.S., U.K., and Germany at the 10% significance level, while it is accepted in Japan.

However, as to the Granger cause direction from the 3-month Treasury bill rate to nominal GDP, the null hypothesis is only rejected in the U.S., which means that short-term interest rate does not Granger cause to nominal GDP in the U.K., Germany and Japan.

In order to better understand the Granger causality results in each country, the researcher has constructed a summary table below:

Table 4-2 Summary of Granger causality test between real GDP, inflation, nominal GDP, and 3-month rates during 1960Q1-2008Q4

Countries	**3-months Rate does GC Real GDP**	**3-months Treasury Bill Rate does GC inflation**	**3-months Treasury Bill Rate does GC nominal GDP**
U.S.	YES	YES	YES
U.K.	YES	YES	NO
Germany	NO	NO(5% significance level) Yes(10%significance level)	NO
Japan	NO	YES	NO
	Real GDP does GC 3-months Rate	**Inflation does GC 3-months Treasury Bill Rate**	**nominal GDP does GC 3-months Treasury Bill Rate**
U.S.	YES	NO(5%significance level) Yes(10%significance level)	YES
U.K.	YES	YES	YES
Germany	YES	YES	NO(5% significance level) Yes(10%significance level)
Japan	NO(5%significance level) Yes(10%significance level)	NO	NO

Note: GC denotes Granger Causality. The results are based on the judgment at 5% significance level. Yes means does Granger cause. No means does not Granger cause. Germany test sample is from 1970Q1-2008Q4

In the summary of each column in the table, the researcher found that, in the U.S., real GDP and nominal GDP have a Granger cause to the 3-month Treasury bill rate, but inflation does not Granger cause the 3-month Treasury bill rate; meanwhile the 3-month Treasury rate does Granger cause real GDP, inflation and nominal GDP at the 5% significance level. As a result, there is a two-way causal direction between real GDP, nominal GDP and the 3-month Treasury bill rate, and just a one-way causal direction from the 3-month Treasury bill rate to inflation.

In the U.K., real GDP, inflation and nominal GDP does Granger cause the 3-month Treasury bill rate, and the 3-month Treasury bill rate does Granger cause real GDP, and inflation, but does not Granger cause nominal GDP. There is a puzzle here because, if the 3-month Treasury bill rate does Granger cause real GDP and inflation, it would be expected that the 3-month treasury rate would Granger cause nominal GDP. There are two-way causal directions between real GDP, inflation and the 3-month Treasury bill rate, but only one causality direction from nominal GDP to 3-month Treasury bill rate in the U.K., not the other way around.

In Germany, real GDP and inflation does Granger cause the 3-month money market rate, while the 3-month money market rate does not Granger cause real GDP. Further nominal GDP does Granger cause to 3-month market rate at 10% significance level, but the 3-month market rate does not Granger cause to nominal GDP.

In Japan, real GDP, inflation and nominal GDP does not Granger cause the 3-month Treasury bill rate, and the 3-month Treasury bill rate does not Granger cause real GDP and nominal GDP, but does Granger cause inflation.

Overall, the researcher concludes that real GDP is more likely to provide the future information for the 3-month Treasury bill rate in most countries except Japan, while the results that real GDP does not Granger cause the 3-month Treasury bill rate in Japan is reasonable, since the interest rate has been kept at a very low level for years and has not changed much; furthermore the 3-month Treasury bill rate fluctuated very little before the 1970s. On the other hand, the 3-month Treasury bill rate could provide the future real GDP information in the U.S. and U.K., but not in Germany and Japan.

The ability of the 3-month Treasury bill rate to provide future inflation information is better than the predictive power of inflation to interest rate. However, it is found that nominal GDP does Granger cause to the 3-month Treasury bill rate in more countries than the 3-month Treasury bill rate Granger causes the nominal GDP. In the U.S., U.K. and Germany, the nominal GDP could provide the future information for the short-term interest rate, but the short-term interest rate could not provide future information on nominal GDP in the U.K., Germany and Japan. Thus, it seems that the 3-month Treasury bill rate follows the nominal GDP and real GDP rather than leading the nominal GDP and real GDP as expected, and the 3-month Treasury bill rate could provide future inflation information rather than vice versa.

The study also applies the Granger causality test in the subsamples, and the results are presented in the Appendix table B4-6. The statistics shown in the table indicate that short-term interest rate does not Granger cause to nominal GDP in both subsamples with the only exception being the U.S. However, nominal GDP does not Granger cause to short-term interest rate in either subsample.

4.5.2 Granger causality test with the long-term interest rate

Table 4-3 Granger causality test between real GDP, inflation rate, nominal GDP, and 10-year government bond rates during 1960Q1-2008Q4

Countries	Real GDP does not GC 10-years Gov. Bond Rate		10-year Gov. Bond Rate does not GC Real GDP	
	F-statistic	P-value	F-statistic	P-value
U.S.	0.61449	0.6889	3.87017	2.40E-03***
U.K.	2.13485	0.0293**	2.88398	0.0035***
Germany	2.33163	0.0443**	3.41698	0.0057***
Japan	0.78066	0.6345	0.27166	0.9813
Countries	**inflation does not GC 10-year Gov. Rate**		**10-year Gov. Rate does not GC inflation**	
	F-statistic	P-value	F-statistic	P-value
U.S.	2.723022	0.0017***	2.330819	0.0073***
U.K.	2.301767	0.0068***	4.592669	0***
Germany	1.230493	0.2884	3.858595	0.0006***
Japan	0.818139	0.6559	0.708637	0.7719
Countries	**nominal GDP does not GC 10-year Gov. Bond Rate**		**10-year Gov. Bond Rate does not GC nominal GDP**	
	F-statistic	P-value	F-statistic	P-value
U.S.	1.35636	0.2431	2.55709	0.0292**
U.K.	2.87675	0.001***	1.41481	0.1583
Germany	1.57913	0.17	2.22141	0.0556*
Japan	1.09268	0.3669	0.82797	0.5317

Note: the abbreviation for GR denotes nominal GDP, and GC denotes Granger Causality. * =10% significance level; ** =5% significance level; ***= 1% significance level. Germany test sample is from 1970Q1

Table 4-4 Summary of Granger causality test between real GDP, inflation rate, nominal GDP, and 10-year government bond rates during 1960Q1-2008Q4

Countries	10-years Bond Rate does GC Real GDP	10-years Bond Rate does GC inflation	10-years Bond Rate does GC nominal GDP
U.S.	Yes	Yes	Yes
U.K.	Yes	Yes	No
Germany	Yes	Yes	No
Japan	No	No	No
	Real GDP does GC 10-years Bond Rate	**Inflation does GC 10-years Bond Rate**	**nominal GDP does GC 10-years Bond Rate**
U.S.	No	Yes	No
U.K.	Yes	Yes	Yes
Germany	Yes	No	No
Japan	No	No	No

Note: GC denotes Granger Causality. The results are based on the judgment at the 5% significance level. Yes means does Granger cause, No means does not Granger cause. Germany test sample is from 1970Q1

To summarize the table, it concludes that, in the U.S., real GDP and nominal GDP does not Granger cause the 10-year government bond rate, but inflation does Granger cause the 10-year government bond rate. On the other side, the 10-year government bond rate does Granger cause real GDP, inflation and nominal GDP.

In the U.K., real GDP, inflation and nominal GDP all Granger cause the 10-year government bond rate, while the 10-year government bond rate does Granger cause real GDP and inflation, but does not Granger cause nominal GDP. The results showing that the10-year government bond rate does Granger cause real GDP, inflation and nominal GDP are similar to those for the short-term interest rate. Combining the real GDP and inflation gives nominal GDP so, if the long-term interest rate does Granger cause real GDP and inflation, it should Granger cause to nominal GDP.

In Germany, real GDP and inflation does Granger cause the 10-year government bond rate, but nominal GDP does not Granger cause the 10-year government bond rate. The 10-year government bond rate does Granger cause to real GDP, but does not Granger cause inflation and nominal GDP.

In Japan, the 10-year government bond rate does not Granger cause real GDP, inflation and nominal GDP, while real GDP, inflation and nominal GDP do not Granger cause the 10-year government bond rate.

Comparing the Granger causality results of the short-term interest rate and long-term interest rate to real GDP, inflation, and nominal GDP, the researcher found that, in the U.S., U.K. and Japan, the Granger cause behavior of short-term interest rate and long-term interest rate are similar in most situations. Further to this, the researcher identifies that, in the graph of short-term interest rate and long-term interest rate, the two interest rates fluctuate closely together. As a result, the researcher intends to conclude that long-term interest rate follows the short-term interest rate.

4.6 Discussion and conclusion

In this chapter, only the simple Granger causality test is applied to find the link between nominal GDP and interest rates, incidentally providing the link between real GDP and interest rates, and inflation with interest rates. Although a simple Granger causality test only provides us with the "causality" relationship between the interest rates and nominal GDP, the more fundamental empirical results of the link between nominal GDP and interest rate will be shown in chapters 5 and 6.

The conclusion of this chapter can be divided into three parts. The first part summarises the relationship between nominal GDP and interest rate. The second part briefly concludes the link between real GDP and interest rate. Furthermore, the researcher outlines the results of the Granger causality test between the short-term interest rate and inflation.

Nominal GDP does Granger cause the 3-month Treasury bill rate in the U.S., U.K. and Germany, but the 3-month Treasury bill only Granger causes nominal GDP in the U.S. The Granger causality results imply that nominal GDP could provide future information on interest rate better than vice versa. The positive correlation between nominal GDP and the 3-month Treasury bill rate also suggests that increasing interest rates follow the high nominal GDP trend. Thus, it can be concluded that the short-term interest rate follows the trend of nominal GDP rather than leading the trend of nominal GDP. Zhou and Sornette (2004) found the strong evidence to support the following causality: Stock Market → Fed Reserve (Federal funds rate) → short-term yields → long-term yields. Our empirical findings are consistent with their result, as the causality link direction is nominal GDP → short-term interest rate → long-term yields.

Real GDP does Granger cause the 3-month Treasury bill rate in the U.S., U.K., Germany and Japan, but the 3-month Treasury bill rate Granger causes real GDP in the U.S. and U.K. This evidence enhances the notion that the short-term interest rate follows the real economic conditions rather than influencing the economic conditions.

The 3-month Treasury bill rate does Granger cause to inflation in the U.S., U.K., Germany and Japan, and inflation also Granger causes the 3-month Treasury bill rate in the U.S., U.K. and Germany, which implies that the connection between the 3-month Treasury bill rate and inflation is closer than that between short-term interest rate and real GDP or nominal GDP. It seems that the 3-month Treasury bill rate predicts the future inflation, which supports the view that central banks set the short-term interest rates to target inflation, but the short-term interest rate as the predictive variable to economic conditions, such as real GDP or nominal GDP, is not as good as the conventional theory had suggested.

It is also concluded that the link between the long-term interest rate and real GDP, inflation and nominal GDP is not as strong as the link with the short-term interest rate. However, the results still reveal that the long-term interest rate displays similar features to short-term interest rate in the link between nominal GDP, real GDP and inflation rate. Thus the researcher concludes that the long-term interest rate intend to follow the trend of short-term interest rate.

Appendix to chapter 4

Appendix 4.A: Data resource

Countries	Variables	Definition	Source
U.S.	Short-term interest rate	Monthly average 3-month Treasury bill secondary market rate discount basis	IFS
	Long-term interest rate	Market yield on U.S. Treasury securities at 10-year constant maturity, quoted on investment basis, monthly average data	
	inflation	Growth on the same period of the previous year, Consumer prices: all items, Quarterly	OECD
	Nominal GDP	The nominal GDP at market price, national currency, current prices, quarterly data, and non-seasonal adjustment	Thomas Datastream
	Real GDP	GDP VOL. 2000=100,Units: Index Number	IFS
	GDP-circulation credit	The sum of consumer credit, commercial and industrial loans from commercial banks and Government lending.	The Federal Reserve H.8 G.19 Z1.
	Total Domestic Credit	Total Financial Assets of Commercial Banks, Saving Institutions and Credit Unions	
	M2	Broad money (M2) nsa	The Federal Reserve H.6
U.K.	Short-term interest rate	Monthly average rate of discount, 3-month Treasury bills.	IFS
	Long-term interest rate	Quarterly average yield from British Government Securities, 10-year Nominal Par Yield	
	inflation	Growth on the same period of the previous year, Consumer prices: all items, Quarterly	OECD
	Nominal GDP	The nominal GDP at market price, national currency, current prices, quarterly data, and non-seasonal adjustment	ONS
	Real GDP	GDP VOL. 2000=100,Units: Index Number	IFS
	GDP-circulation credit	The sum of credit to householder sector and private non-financial corporation, and lending to financial transaction is credit to other financial corporation	Bank of England
	Total Domestic Credit	quarterly amounts outstanding of M4 lending (monetary financial institutions' sterling net lending to private sector) in sterling, non- seasonally adjusted	
	M4	Quarterly amounts outstanding of M4 (monetary financial institutions' sterling M4 liabilities to private sector) in sterling millions seasonally adjusted	Bank of England
Germany	Short-term interest rate	Money Market Rates , Units: Percent per Annum	IFS
	Long-term interest rate	Federal bond yield (outstanding listed federal securities with residual maturities of over 9 to 10 years). Data refer to unified Germany from July 1990 and West Germany prior to this date. Only bonds deliverable at the DTB (German Financial Futures Exchange) is included. Data refer to unified Germany from July 1990 and West Germany prior to this date. Quarterly average data	
	inflation	Growth on the same period of the previous year,	OECD

		Consumer prices: all items, Quarterly	
	Nominal GDP	The nominal GDP at market price, national currency, current prices, quarterly data, and non-seasonal adjustment	Thomas Datastream/ Deutsche Bundesbank
	Real GDP	GDP VOL. 2000=100,Units: Index Number	IFS
	GDP-circulation credit	Total credit minus financial circulation credit. The financial circulation credit is the sum of the lending to financial institutions, lending to housing enterprises, lending to holding companies, and mortgage loans to domestic enterprises and resident individuals	Deutsche Bundesbank
	Total Domestic Credit	loans to domestic enterprises and households	
	M3	Money supply-M3(contribution to Euro Basis from M0195) cur	Datastream
Japan	Short-term interest rate	3-month Treasury bill	IFS
	Long-term interest rate	Government Benchmarks, Bid, 10-Year, Yield, Average	
	inflation	Growth on the same period of the previous year, Consumer prices: all items, Quarterly	OECD
	Nominal GDP	The nominal GDP at market price, national currency, current prices, quarterly data, and non-seasonal adjustment	Bank of Japan
	Real GDP	GDP VOL. 2000=100,Units: Index Number	IFS
	Domestic Credit	Total credit minus financial circulation credit. Loans to the real estate sector, construction firms and non-bank financial institutions is the financial circulation credit	Bank of Japan
	Total Domestic Credit	the total credit as outstanding total credit including others, banking accounts and trust accounts from domestically licensed banks	
	Broad money	M2, average quarterly, sa	Datastream

Appendix 4.B: Unit root test

Table B 4-1Unit root test of nominal GDP growth rate

Countries	Time period	ZA	ADF		PP	
			t-Statistic	Prob.*	Adj. t-Stat	Prob.*
U.S.	1960Q1-2008Q4	-7.22383 at 1981:04	-1.77837	0.3904	-2.49415	0.1184
U.K.	1960Q1-2008Q4	-6.29006 at 1980:02	-1.73795	0.4106	-2.35092	0.1573
Germany	1970Q1-2008Q4	- 5.71156 at 1987:04	-2.85102	0.182	-5.1945	0.0002
Japan	1960Q1-2008Q4	-7.25137 at 1974:04	-2.03651	0.2711	-1.76632	0.3964

Assume the intercept in the equation

Table B 4-2Unit root test of real GDP growth rate

Countries	Time period	ZA	ADF		PP	
			t-Statistic	Prob.*	Adj. t-Stat	Prob.*
U.S.	1960Q1-2008Q4	-7.15042 at 1983:01	-3.41658	0.0116	-4.30827	0.0006
U.K.	1960Q1-2008Q3	-6.58469 at 1983:01	-3.57768	0.0071	-5.57997	0
Germany	1961Q1-2008Q4	-5.12460 at 1973:03	-2.38769	0.1468	-4.82479	0.0001
Japan	1960Q1-2008Q4	-6.40247 at 1970:04	-2.56503	0.1021	-3.40195	0.012

Assume the intercept in the equation

Table B 4-3Unit root test of 3-month Treasury Bill Rate

Countries	Time period	ZA	ADF		PP	
			t-Statistic	Prob.*	Adj. t-Stat	Prob.*
U.S.	1960Q1-2008Q4	-5.10500 at 1978:03	-1.85407	0.3535	-2.11067	0.2408
U.K.	1960Q1-2008Q4	-5.19482 at 1978:02	-1.98699	0.2925	-1.84213	0.3593
Germany	1960Q1-2008Q4	-4.99981 at 1969:03	-3.15075	0.0247	-3.1296	0.026
Japan	1960Q1-2008Q4	-5.41194 at 1993:01	-0.53583	0.8801	-1.05631	0.7326

Countries	Time period	ADF		PP	
		t-Statistic	Prob.*	Adj. t-Stat	Prob.*
U.S	1960Q1-1979Q3	-1.41487	0.5704	-0.89546	0.7848
	1979Q4-2008Q4	-1.22371	0.6625	-1.37018	0.5947
U.K	1960Q1-1992Q4	-2.14444	0.2279	-2.33001	0.1642
	1993Q1-2008Q4	-1.25209	0.6466	-1.9079	0.3268
Germany	1960Q1-1990Q3	-2.21575	0.2019	-2.80501	0.0605
	1990Q4-2008Q4	-1.55637	0.4996	-1.62165	0.4665
Japan	1960Q1-1990Q4	-2.27115	0.1831	-2.38393	0.1484
	1991Q1-2008Q4	-4.08463	0.0019	-4.61102	0.0003

Assume the intercept in the equation

Table B 4-4 Unit root of 10-year Gov. Bond Rate

Countries	Time period	ZA	ADF		PP	
			t-Statistic	Prob.*	Adj. t-Stat	Prob.*
U.S.	1960Q1-2008Q4	-5.35012 at 1979:04	-1.13335	0.7025	-1.4454	0.5592
U.K.	1960Q1-2008Q4	-6.13693 at 1973:03	-1.06832	0.7281	-1.20099	0.6741
Germany	1960Q1-2008Q4	-4.23883 at 1972:02	-0.7617	0.8269	-1.72367	0.4178
Japan	1966Q1-2008Q4	-4.58496 at 1973:01	-0.56298	0.8742	-0.91147	0.7827

Assume the intercept in the equation

Table B 4-5 Unit root of CPI growth rate

Countries	Time period	ZA	ADF		PP	
			t-Statistic	Prob.*	Adj. t-Stat	Prob.*
U.S.	1960Q1-2008Q4	-8.01090 at 1981:04	-1.71197	0.4236	-2.43283	0.1341
U.K.	1960Q1-2008Q4	-5.84958 at 1980:03	-2.37662	0.1497	-2.38785	0.1465
Germany	1960Q1-2008Q4	-4.73977 at 1970:01	-2.51839	0.1128	-2.29056	0.1761
Japan	1960Q1-2008Q4	-7.00810 at 1976:04	-2.00605	0.2841	-2.20643	0.2047

Assume the intercept in the equation
Model C Critical values at the 1%, 5% and 10% level are -5.57,-5.08 and -4.82, respectively (Zivot and Andrews, 1992)

Table B 4-6 Results of Granger Causality between nominal GDP and short-term interest rate in the subsamples

Countries	Time	H_0 : nominal GDP growth rate does not GC 3-months Treasury Bill Rate		H_0 : 3-months Treasury Bill Rate does not GC nominal GDP growth rate	
		F-statistic	P-value	F-statistic	P-value
U.S	1960Q1-1979Q3	1.40424	0.2279	2.05104	7.26E-02
	1979Q4-2008Q4	1.09794	0.3687	3.16758	0.0068
U.K	1960Q1-1992Q4	1.11252	0.3577	0.36791	0.9198
	1993Q1-2008Q4	0.46531	0.8017	0.19316	0.9648
Germany	1960Q1-1990Q3	1.31859	0.263	1.6482	0.1497
	1990Q4-2008Q4	1.7628	0.1222	2.30485	0.0455
Japan	1960Q1-1990Q4	0.61415	0.6084	0.58563	0.6267
	1991Q1-2008Q4	6.08356	0.001	1.39038	0.2536

Appendix 4.C: Cointegration test

Table C 4-1 Results of cointegration test

Countries	treasury on inflation	Null Hypothesis: has a unit root
U.S.	Fullbreak	-3.52144 at 1979:04
1960Q1-2008Q4	trend	-5.06033 at 1979:04
	constant	-2.91709 at 2000:02
U.K.	Fullbreak	-5.40384 at 1982:02
1960Q1-2008Q4	trend	-5.77133 at 1979:02
	constant	-4.17471 at 1977:02
Germany	Fullbreak	-5.07216 at 1979:04
1960Q1-2008Q4	trend	-5.58210 at 1979:04
	constant	-4.79437 at 1979:04
Japan	Fullbreak	-5.08307 at 1987:01
1960Q1-2008Q4	trend	-4.14252 at 1994:02
	constant	-3.78238 at 1993:02

Countries	bond on inflation	Null Hypothesis: has a unit root
U.S.	Fullbreak	-3.38067 at 1981:03
1960Q1-2008Q4	trend	-5.31567 at 1981:03
	constant	-2.73176 at 1982:03
U.K.	Fullbreak	-5.39007 at 1982:02
1960Q1-2008Q4	trend	-6.35338 at 1980:03
	constant	-4.65070 at 1999:04
Germany	Fullbreak	-5.09714 at 1997:03
1960Q1-2008Q4	trend	-4.93925 at 1999:02
	constant	-4.93330 at 1999:02
Japan	Fullbreak	-4.11021 at 1987:03
1960Q1-2008Q4	trend	-3.45905 at 1993:02
	constant	-3.60699 at 1993:02

Critical Values are 1% -5.47 and 5% -4.95(fullbreak), Critical Values are 1% -5.45 and 5% -4.99(trend), Critical Values are 1% -5.13 and 5% -4.61(constant)

Chapter 5

5 Empirical evidence on the relationship between money aggregates and nominal GDP in the U.S., U.K., Germany and Japan from 1960s to 2008

Abstract: In chapter 5, the main concern is to explore the relationship between money aggregates and nominal GDP in the short term, and also to provide extra evidence for the comparison of predictive power between interest rates and money aggregates for nominal GDP. In addition, this section gives empirical evidence of the link between money aggregates and real GDP. The money aggregates used in the tests are dependent on the intermediary monetary aggregates target in each country and also take account of data availability. The research firstly presents econometric evidence of the strength of the link between the nominal GDP and the money aggregate by simple regression, and more explicit stability tests point out the strength of this link. Secondly, the study employs Granger causality tests with the consideration of the cointegration to find whether the money aggregates could provide future information for nominal GDP. Moreover, this study applies a Vector Autoregression (VAR) model to discover how large the nominal GDP response is to money aggregate shocks, and what percentage of money aggregate accounts for nominal GDP variance. In order to remain consistent across the different econometric applications, the study selects the subjective structural beak data in each country, and tests the models for the entire sample and for the subsamples.

5.1 Introduction

The breakdown of consensus after the 2007/08 financial crisis

Monetary aggregates have been central to the conduct of monetary policy when the consensus that inflation was a monetary phenomenon was widely accepted after Friedman (1963) proposed it: "inflation is always and everywhere a monetary phenomenon." However, the route to using monetary aggregate to control inflation proved to be painful. The monetary aggregate did not react kindly to the efforts by central banks to control it. As the governor of the Bank of Canada at the time, Gerald Bouey, famously remarked, "We didn't abandon the monetary aggregates, they abandoned us". Therefore, Woodford, in his (2003) book "Interest and prices: foundations of a theory of monetary policy", re-examines the foundations of monetary economics, and shows how interest-rate policies can be used to achieve an inflation target in the absence of either commodity backing or control of a monetary aggregate. Furthermore, he shows how the tools of modern macroeconomic theory can be used to design an optimal inflation-targeting regime - one that balances stabilization goals with the pursuit of price stability in a way that is grounded in an explicit welfare analysis, and that takes account of the "New Classical" critique of traditional policy evaluation exercises. As we know, the influence emanating from the notion that interest rate is a proper intermediate target to control inflation has dominated in the last 20 years, but this consensus has been seriously challenged and has possibly declined since the 2007/08 financial crisis. The Granger causality tests in chapter 4 also show that short-term interest rate is not a reliable variable to predict future nominal GDP. As a result, the study will explore the link between nominal GDP and money aggregates in this chapter.

The 2007/08 financial crisis and subsequent economic recession has thrown doubt on current macroeconomic theory. Few economists predicted the crisis, and now, even after the crisis has happened, there is still no agreement among them on how serious the crisis could be. Most economists have joined the consensus that the crisis stems from an economic bubble, but neither of the mainstream macroeconomic schools have a theory on this bubble. Furthermore, the financial crisis has not only undermined the theories of New Classical and New Keynesian economics, but also the consensus that bonds them.

Since 2007, a series of banks and insurance companies have fallen into bankruptcy, which has caused a crisis of confidence and made banks reluctant to lend money amongst themselves. This triggered a financial crisis that almost halted global credit markets and needed unprecedented government intervention. The Bank of England had to inject £200 billion into the economy to jump-start growth, and prevent the risk of very low inflation after the financial crisis.[38] The Federal Reserve also carried out a large amount of “quantitative easing” twice in the U.S., referred to as “credit easing”. The Bank of Japan had already adopted “quantitative easing” during the period 2001 to

[38] When interest rates become close to zero, there is still a risk of very low inflation; banks can increase the quantity of money - in other words, inject billions into the economy to jump-start growth. This process is sometimes known as ‘quantitative easing’. (BOE)

2006. These processes of monetary policy point to the failure of interest rate as the intermediate target to influence output, so it spurred economists to rethink the current theory of macroeconomics.

The importance of the quantitative aggregate is recognized by the monetary authorities. Beck and Wieland (2007) developed a novel characterization of the ECB's monetary policy implement - what they call "monetary cross-checking" - and showed that it could generate large stabilization benefits in the event of persistent policy misperceptions regarding potential output. They point out that the European Central Bank has kept a separate and important role for the growth rate of money aggregates, contrary to the monetary policy strategies of the U.S. Federal Reserve and many inflation-targeting central banks, which assign no special role to monetary aggregates.

The monetary policy of the ECB 2004:

> *"In the ECB's strategy, monetary policy decisions are based on a comprehensive analysis of the risk to price stability. This analysis is organized on the basis of two complementary perspectives on the determination of price developments. The first perspective is aimed at assessing the short to medium-term determinants of price developments, with a focus on real activity and financial conditions in the economy. The second perspective refers to this as the monetary analysis, focusing on a longer-term horizon, and exploiting the long-run link between money and prices. The monetary analysis mainly serves as a means of cross-checking, from medium to long-term indications for monetary policy coming from the economic analysis. "*

The ECB singles out the monetary aggregate within the set of selected key indicators as the close relationship between money and inflation in the medium-to-long term. This view is also widely held by most economists: it states that, in the long term, money has little effect on real variables and depends mostly on prices, but it also holds that monetary disturbances can have large effects on real variables such as real GDP in the short term (Kydland and Prescott 1990). That is the traditional view about the link between money aggregates and economic condition variables.

A large number of researchers have studied this (Makin, 1982; Orphanides and Solow, 1990; McCandless and Weber, 1995; Gerlach and Svensson, 2003; Gaspar et al., 2001;

Barro and Grossman, 2008). The first set of studies has concentrated on the correlation between money and inflation, using a range of statistical methods. It normally claims that a very close co-movement between money growth and the trend in price in the long run exists. More recent studies, such as Estrella and Mishkin (1997), Stock and Watson (1999), Hendry (2001), Gerlach and Svensson (2000), King (2001), (Benati, 2005, King, 2001), produce conflicting and unstable regression results for the influence of money growth on inflation. A second set of literature has focused on the question of whether money could help to predict prices (Altimari, 2001, Neumann and Greiber). By using the forecasting technique, the evidence supports the proposal that the growth of money aggregate is likely to predict the trend of price. The last set of studies has tried to find the link between money and a series of fundamental economic variables such as real GDP. The most important was that by Friedman and Schwartz (1963). That is the traditional view about the link between money aggregate and economic condition variables. Although there is a continuing challenge to beliefs about the effect of money aggregates on the real economic conditions, the recent works still find the evidence to support the monetarism view. (Hendry and Ericsson, 1991; Meltzer, 1998; Amato and Swanson, 2001; Nelson, 2002)

Furthermore, a relatively large body of research focuses on the link between nominal GDP and money aggregates. The study in this section will also contribute to the existing literature by stressing the link between nominal GDP and other financial variables rather than real GDP. Because money, credit and interest rate are nominal variables, and nominal GDP is also measured in the nominal level, it is more reasonable to link variables through the same measurement. Further, we live in a nominal world and, although it is necessary to explore on an academic level the effect of monetary policy variables on the real GDP, it is more necessary to find out how the monetary policy variables could influence the economic conditions in the nominal measurement. In daily economic life, the public is more sensitive to nominal variables, such as price, money, and interest rate, and it is easier for the public to understand the nominal GDP growth in the current year rather than the real GDP growth. When individual customers or business corporations make decisions on consumption or investment, they normally base their choice on the current price or future nominal economic growth rather than real price or real economic growth. Therefore, although it is also important to divide changes in nominal GDP between prices and real output, the point is not relevant in the research here. The research aims to find the effect of monetary policy variables on the overall economic conditions that include price factor.

In this chapter, the study examines the practical feasibility of using monetary aggregate to target nominal gross domestic product (NGDP). The study measures the strength and stability of the link between the broad monetary aggregates and nominal GDP and compares the predictive power of money aggregates and short-term interest rate for nominal GDP. In section 5.5.2, the researcher presents the "causality" relationship between broad money aggregates and nominal GDP by employing the Granger causality test. The causality test also shows us the predictive power of money aggregate to future nominal GDP information. In addition, the most important features of how nominal GDP responds to money aggregates or short-term interest shock will be discussed with the VAR model in section 5.5.3.

5.2 Literature review on the relationship between nominal GDP and money

The use of money aggregates to target nominal GDP

Economists have long understood that the money aggregate, or its growth rate, can play an important role in the monetary policy process only if the fluctuations of money can constantly and reliably respond to the change in nominal income, inflation, or any other aspects of economic activity that the monetary authorities seek to influence. The same is certainly true for other financial variables (e.g. interest rate, measures of credit), which will be discussed in depth in chapters 4 and 6. In the case of money, a rich body of literature has developed to investigate in detail the relationship between money and income or prices. Some studies have focused on the requirement that there be a relationship between money and income (Friedman, 1991) and other researchers have sought to establish whether these requirements have been satisfied in specific places or at specific times. (McCallum, 1985).

The pioneer work by (Friedman and Schwartz, 1963) pointed out the importance of money supply to the fluctuation of the economy; furthermore, Sims (1972) suggested the unidirectional causality from money to nominal income in the postwar U.S. data. Based on quantitative monetary policy theory, McCallum (1988, 1990, and 1997) proposed a rule that targets nominal GDP directly, instead of separating real GDP and inflation. According to the McCallum rule, if the growth rate of nominal GDP does not reach the target growth rate of nominal GDP, the expansion of the monetary base will support the economy.

Feldstein and Stock (1993) concentrate on whether the link between monetary aggregate and nominal GDP is sufficiently stable, and then whether the money aggregate could be used as the monetary policy instrument to target nominal GDP. The study applies a simple regression to find whether the predictive power of monetary aggregate to nominal GDP is more than that of the interest rate. They also test the parameter stability with a series of recently developed statistical tests, and the results suggest that there is no evidence to indicate instability between M2 and nominal GDP during the period 1960 to 1992 in the U.S. However, the link between narrow monetary aggregate (M0) and nominal GDP is unstable. Feldstein and Stock take the evidence against the link between M2 and nominal GDP to show that it is not sufficiently stable to be used as the monetary policy.

Ball (1999) used a small closed-economy model to show that nominal GDP targeting can lead to instability. Richard Dennis (2001) extends Ball's model (1999) to find that nominal GDP targeting is unlikely to lead to instability if inflation expectation is allowed to be formed by the more general mixed expectations process. The instability was found to be generated by the specific emphasis on expected inflation; furthermore, it was shown that, in Ball's model, where exact targeting causes instability, moving to inexact targeting restores stability.

On the other hand, some researchers have found evidence against the stable link between money and income (Sims, 1972; Stock and Watson, 1987b; McCallum, 1991; Friedman and Kuttner, 1992;Hess et al., 1993; Friedman and Kuttner, 1993). Friedman and Kuttner (1992, 1993) showed that, based on the U.S. experience, the evidence did not indicate a close or consistent relationship between money and non-financial economic activity. They further extended the analysis to include the data from the 1980s, and found that the inclusion of the 1980s data roughly weakens the time series evidence that a stable relationship existed between money and nominal income in the prior period.

The deterioration of evidence supporting a relationship with either nominal or real income, or with price, appears not just for M1 but also for other monetary aggregates.

More recent work by Friedman (2005), however, showed the close relationship between money and nominal GDP. The study regarded three similar periods of rapid economic growth (the booms of the 1920s in the United States, the 1980s in Japan and the 1990s in the United States) as the equivalent of a controlled experiment to test the hypothesis of "The Great Contraction". The quantity of money is the counterpart of the experimenter's input. The performance of the economy and the level of the stock market are the counterpart of the experimenter's output. Results of the experiment showed that nominal GDP growth paralleled monetary growth, and the results strongly support the view that monetary policy should take much credit for the mildness of the recession following the collapse of the U.S. boom in the late 20th century.

5.3 Data and summary statistics

5.3.1 Money aggregates

U.S.: The Federal Reserve ceased publication of the M3 on 23rd March 2006, and has only published two money measurements, M0 and M2, since the spring of 2006. The explanation for this decision is that M3 did not provide any additional information about economic activity compared to M2; thus, M2 would be the monetary measurement that monetary policy-makers would focus on. M2 includes M1 plus balances that are generally similar to transaction accounts and that, for the most part, can be converted fairly readily to M1 with little or no loss of principal. Thus we use M2 in this research. Data source: The Federal Reserve H.6 Money Stock Measures

U.K.: There are only two official U.K. measures of money supply: M0 and M4. M0 denotes the wide monetary base or narrow money, and M4 is referred to as broad money or simply the money supply. Because M4 is a measure of the quantity of UK money supply, the M4 is the data used in this research.

M0: Cash outside Bank of England + Banks' operational deposits with Bank of England, which was discontinued in April 2006.

M4: Cash outside banks (i.e. in circulation with the public and non-bank firms) + private-sector retail bank and building society deposits + private-sector wholesale bank and building society deposits and Certificates of Deposit.

Germany: M3 is a monetary aggregate which the Bundesbank has set since 1970. From 2010, the Bundesbank began to officially announce a money supply target. M3 generally refers to the liability of commercial banks to the economy. M3 data are obtained from datastream, and are seasonally-adjusted data. We do not use non-seasonally-adjusted M3 data as the time period of this data is not long enough; thus, this research uses seasonally-adjusted data.

Japan: The Bank of Japan influences the volume of money to carry out monetary policy and M2 was the main monetary policy target during the 1970s and 1980s. The research has obtained M2, non-seasonal data from datastream. According to the Guide to Japan's Money Stock Statistics,
M2 = Cash currency in circulation + deposits deposited at domestically licensed banks, etc. ("Domestically licensed banks, etc." marks the same range of financial institutions stipulated as "M2+CDs depository institutions" in the former statistics)

All data are quarterly. Monthly data were aggregated to the quarterly level by averaging the data for the months within the quarter.

The figures contrast movement in money shown as a red line with nominal GDP growth rate shown as a blue line. In the U.S., the research displays M2 and M3, because M3 was the main monetary policy focus in the 1980s in the U.S.

5.3.2 Description of data

U.S. Four-quarter growth of (a) M2(red line) and nominal GDP (blue line) (b) M2 and real GDP, (c) M2 and CPI 1960:1- 2009:4

Figure 5-1 Annual nominal GDP growth rate and M2 growth rate

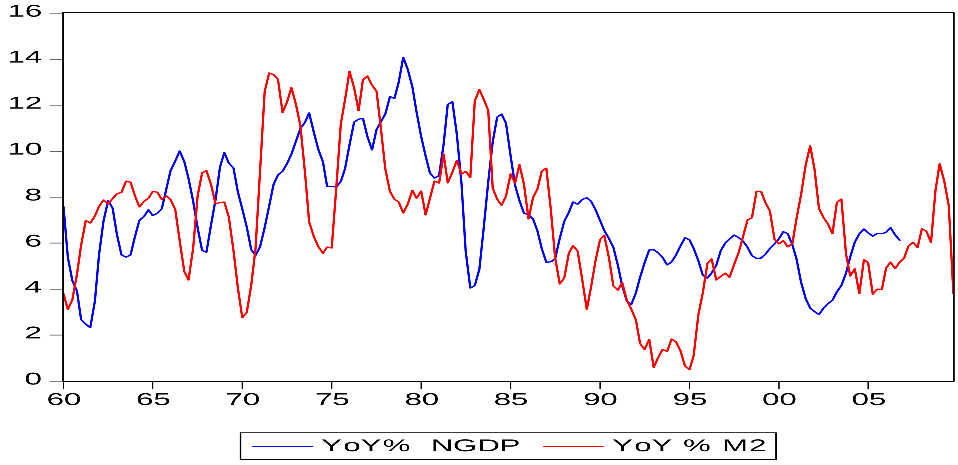


Figure 5-2 Annual real GDP growth rate and M2 growth rate

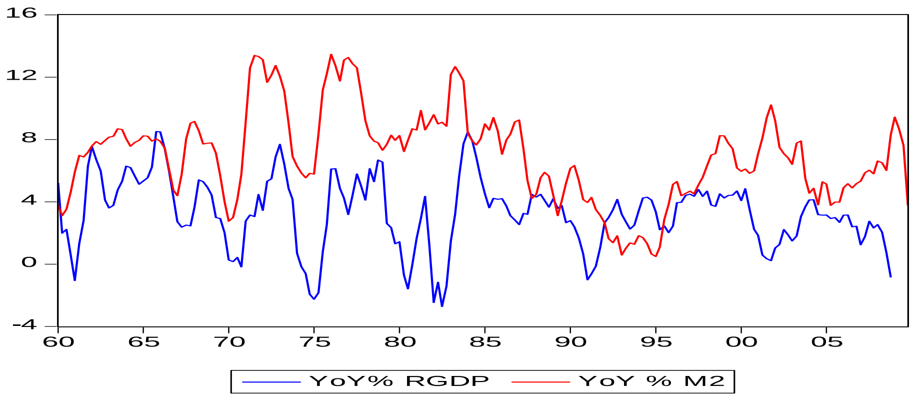
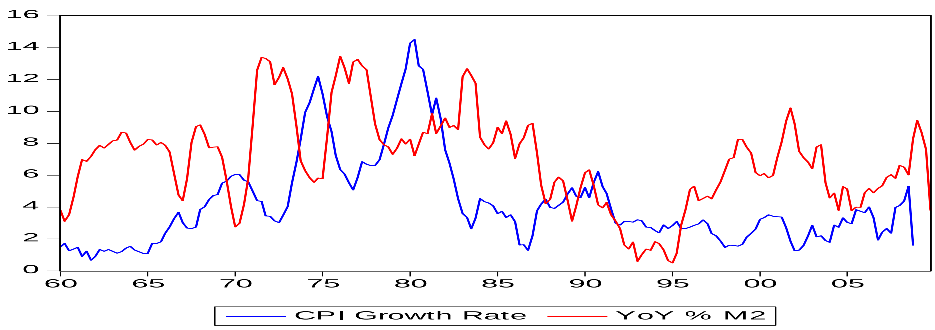


Figure 5-3 Annual CPI growth rate and M2 growth rate



M3 and nominal GDP, Real GDP and CPI growth rate is also spotted in the figure in the Appendix. From a simple inspection of the graphs, M2 seems to be closer to nominal GDP than M3. However, the figures also show that there is a strong link between M3 and nominal GDP than to real GDP and price growth rate.

U.K. Four-quarter growth of (a) M4(red line) and nominal GDP (blue line) (b) M4 and real GDP, (c) M4 and CPI 1960:1- 2009:3

Figure 5-4 Annual nominal GDP growth rate and M4 growth rate

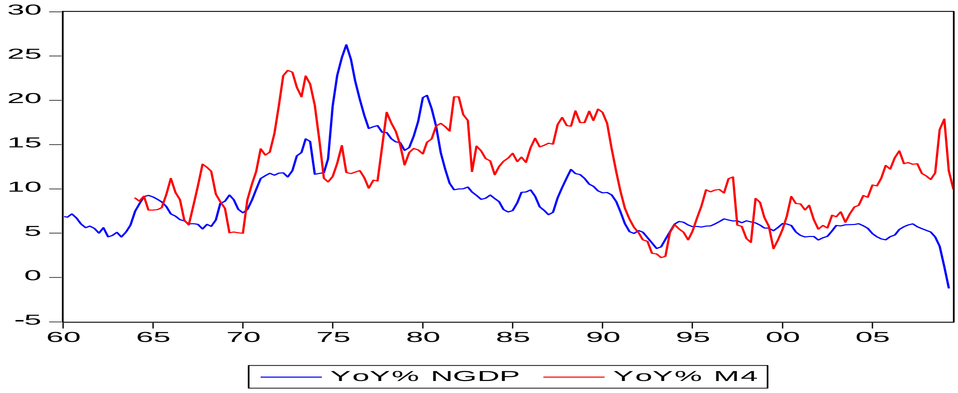


Figure 5-5 Annual real GDP growth rate and M4 growth rate

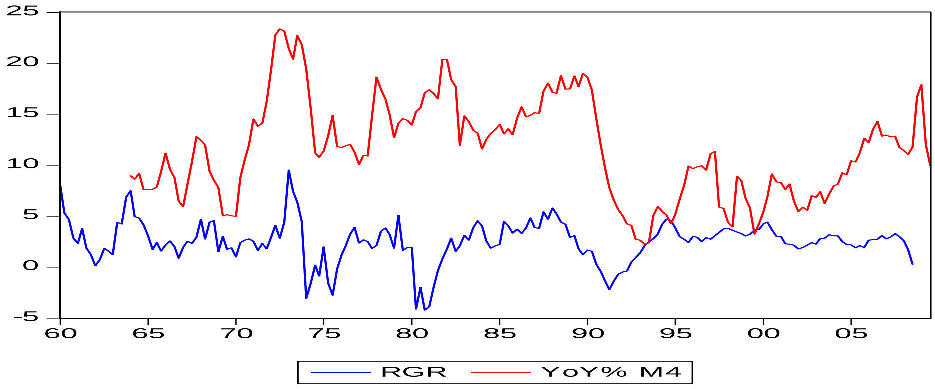
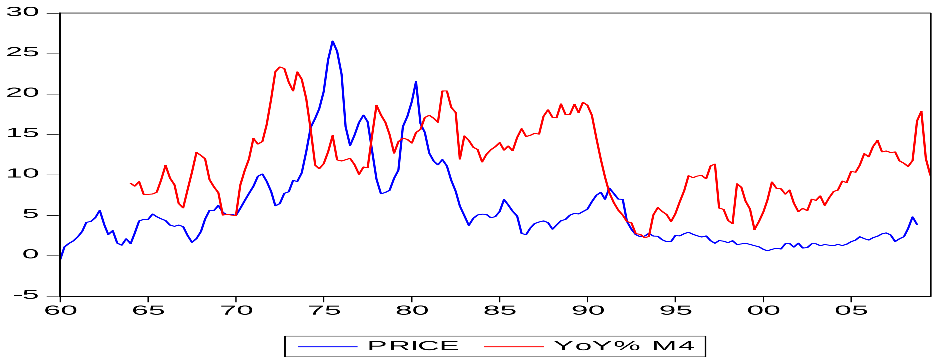


Figure 5-6 CPI growth rate and M4 growth rate



A visual assessment of the figure suggests that there is not a significant link between M4 and nominal GDP, real GDP, and price growth rate, which might be because M4 is too broad to contain much information that is not specific for estimation of nominal

GDP. Considering this problem, we also spot M0 with nominal GDP, real GDP and price growth rate in the Appendix FigureA5-2. It seems M0 is closer to nominal GDP than M4. Moreover, there is a stronger link between M0 and nominal GDP than real GDP and price growth rate.

Germany Four-quarter growth of (a) M3(red line) and nominal GDP (blue line) (b) M3 and real GDP, (c) M3 and CPI 1970:1- 2008:4

Figure 5-7 Annual nominal GDP growth rate and M3 growth rate

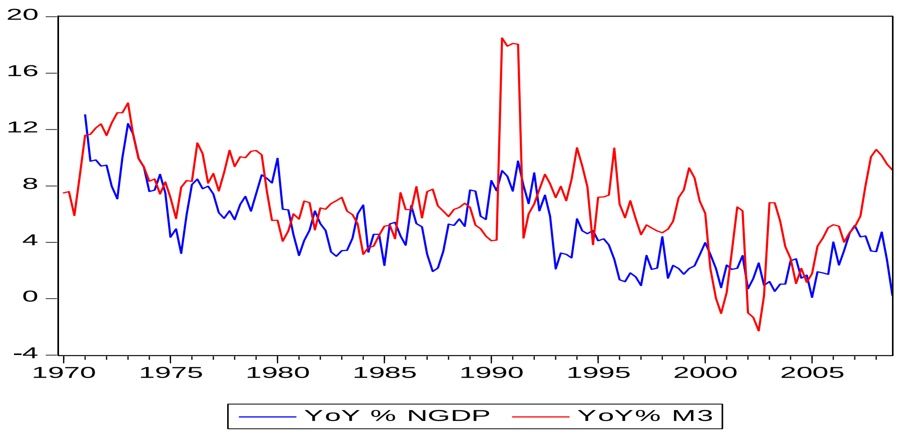


Figure 5-8 Annual real GDP growth rate and M3 growth rate

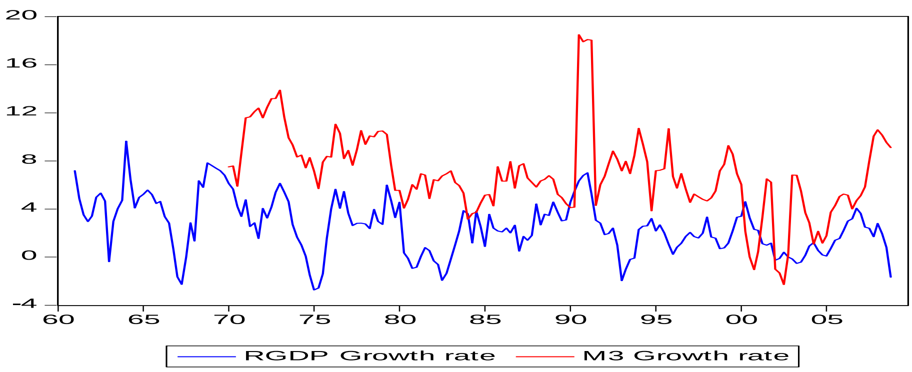
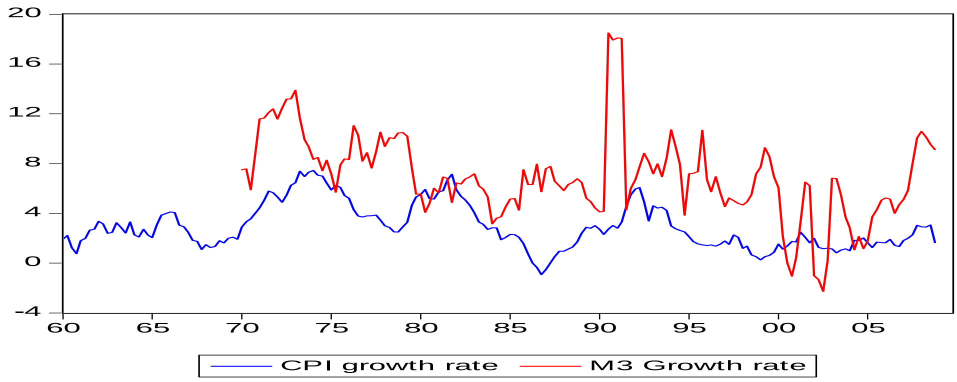


Figure 5-9 CPI growth rate and M3 growth rate



Japan Four-quarter growth of (a) M2(red line) and nominal GDP (blue line) (b) M2 and real GDP, (c) M2 and CPI 1960:1- 2008:4

Figure 5-10 Annual nominal GDP growth rate and M2 growth rate

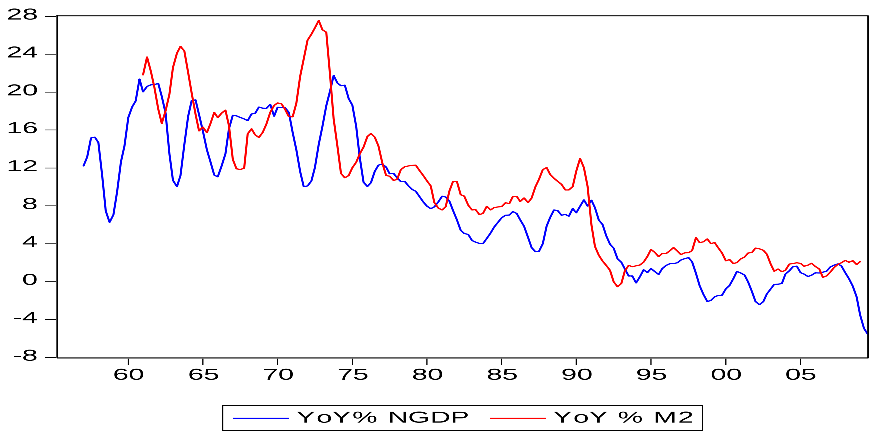


Figure 5-11 Annual real GDP growth rate and M2 growth rate

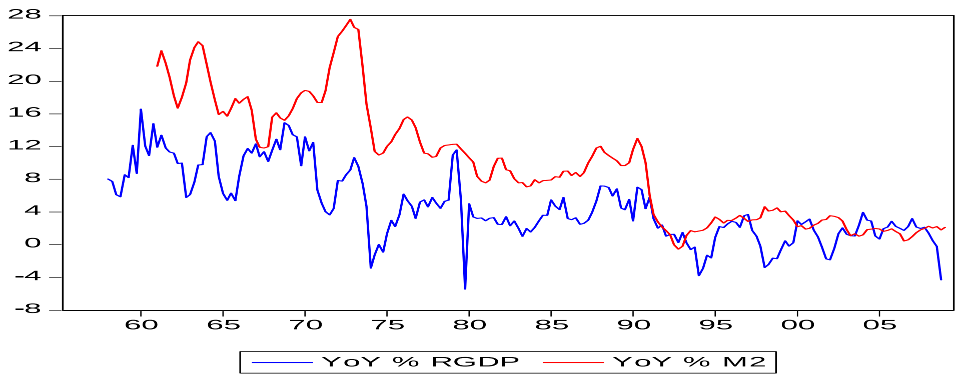
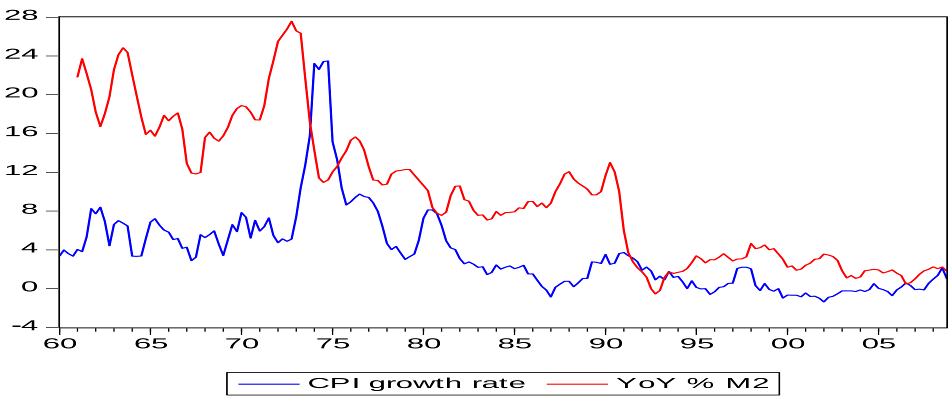


Figure 5-12 CPI growth rate and M2 growth rate



There is a stronger link between Money and nominal GDP than real GDP in Germany and Japan.

5.4 Main results

As is shown in the figures, the link between the annual growth rates in money aggregate and the nominal GDP appears closer than that with either the real GDP growth or CPI growth rate. Consequently, the research question proposed in the next section is whether money aggregate has more predictive content for future nominal GDP growth than interest rate and price growth in the cases of U.S., U.K., Germany and Japan. To answer this question, we apply a simple regression, and evaluate the predictive power based on the adjusted R square.

5.4.1 Results of single regression test in entire sample and subsamples

5.4.1.1 Strength of the link from money aggregates to nominal GDP

In the following tables, the study firstly shows econometric results on the predictive content of monetary aggregates for nominal GDP in each country from the entire sample. Each row in the tables represents a regression of nominal GDP growth on a constant and the explanatory variable at three lags. Nominal GDP, and money aggregate in the regression appear in quarterly, two-quarter, and four-quarter growth rate, and interest rate and price growth rate appear in first difference. The first column in the tables presents the $\overline{R}^2$'s from the regression of the quarterly growth of nominal GDP on the indicated regressors at three lags. The second and third columns provide the $\overline{R}^2$ by using two-quarter and four-quarter growth rate respectively in the regression.

Feldstein and Stock (1994) also conducted a similar regression with three lags for the U.S. in their paper "The use of monetary aggregate to target nominal GDP", however, the time period in their test is only from 1959:1 to 1992:2 and, furthermore, they carried out the test merely for the U.S. Therefore, this study not only extends the sample of countries, but also expands the time period. Few empirical works have emphasised the relationship between money aggregate and nominal GDP for the U.K., Germany and Japan, but this research can compare the relationship after including four countries together. Another main contribution is that the research expands the sample period over 40 years, from 1960 to 2008 (except for Germany, which begins in 1970). There are several changes of monetary policy regime and financial crises during this period[39]; thus, the long time period including several exogenous structural breaks provides us with the chance to test the stability of correlation between money aggregates and nominal GDP.

The results in the tables prove that the money aggregate has statistically significant predictive content for nominal GDP growth in all four countries over a long time period that includes several business cycles. This result is consistent with the finding in Feldstein and Stock (1994) that M2 is an important predictor for nominal GDP in the regression that includes M2, interest rate, and inflation growth.

The $\overline{R}^2$ suggests that money aggregates alone accounts for the large amount of predictive content for the nominal GDP. In the U.S. and U.K. the $\overline{R}^2$ is 0.338 and 0.233 respectively at four-quarter horizon. The $\overline{R}^2$ also suggests that money aggregate has more predictive power in Germany and Japan, at 0.51 and 0.812 respectively.

Generally, money aggregate is capable of predicting a larger amount of movements in nominal GDP at the four-quarter horizon than quarterly or two-quarter horizons in all

[39] Monetarism was popular during the late 1970s to 1980s, and then inflation target was widely accepted by most developed countries.
Financial crisis during this period: 1973 – 1973 oil crisis; 1987 – Black Monday the largest one-day percentage decline in stock market history; 1990 – Japanese asset price bubble collapsed ;1992–93 – Black Wednesday – speculative attacks on currencies in the European Exchange Rate Mechanism;1997–98 – 1997 Asian Financial Crisis; 2001 – Bursting of dot-com bubble – speculations concerning internet companies crashed ;2007–10 – Financial crisis of 2007–2010

four countries. The increase of $\overline{R}^2$ is substantial: for example, the improvement of $\overline{R}^2$ is from 0.284 to 0.529 in the U.S., 0.124 to 0.302 in the U.K., 0.185 to 0.583 in Germany and 0.668 to 0.829 in Japan in the regression which includes money aggregate in conjunction with price growth and interest rate.

In contrast, $\overline{R}^2$ in the regression with interest rate or price growth alone is comparably smaller, which indicates that interest rate or price growth has less predictive power than money aggregate. The range of $\overline{R}^2$ is only from 0.01 to 0.05 in four countries.

An additional question that should be considered is whether the inclusion of interest rates increases or eliminates the predictive power of money aggregate in the money-output relationship. (Sims 1972, 1980) If $\overline{R}^2$ increases substantially when adding interest rate, this suggests that interest rate would be a better variable than money. However, the results show that the inclusion of interest rate does not significantly increase the $\overline{R}^2$ in all four countries. From the tables, it can be seen that the inclusion of interest rate only raises around 1%-6% $\overline{R}^2$ in the U.K., Germany and Japan; thus, it appears that interest rate does not have predictive content for nominal GDP in these three countries, especially in Germany and Japan. In the U.S., interest rate seems be more important than in the other countries; for example, $\overline{R}^2$ increases to 0.530 at the four-quarter horizon, and $\overline{R}^2$ is 0.10 in the regression with interest rate alone at the four-quarter horizon. However, M2 in the U.S. is more statistically significant in the regression.

Table 5-1 Predictive content of M2 dependent variable: nominal GDP growth in the U.S. (1960:1-2006:4 quarterly)

Eq.	Regressors				$\overline{R}^2$	$\overline{R}^2(2)$	$\overline{R}^2(4)$
1	NGDP						
2	NGDP	M2			0.219	0.273	0.338
3	NGDP	PGR			0.061	0.074	0.003
4	NGDP	PGR	M2		0.239	0.310	0.412
5	NGDP	R-90			0.041	0.052	0.100
6	NGDP	R-90	M2		0.282	0.372	0.530
7	NGDP	PGR	R-90		0.031	0.050	0.106
8	NGDP	PGR	R-90	M2	0.284	0.376	0.529

Table 5-2 Predictive content of M4 dependent variable: nominal GDP growth in the U.K. (1960:1-2008:4 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M4			0.092	0.158	0.233
3	NGDP	PGR			0.025	0.042	0.060
4	NGDP	PGR	M4		0.127	0.221	0.306
5	NGDP	R-90			0.010	0.015	0.032
6	NGDP	R-90	M4		0.093	0.157	0.234
7	NGDP	PGR	R-90		0.030	0.047	0.070
8	NGDP	PGR	R-90	M4	0.124	0.216	0.302

Table 5-3 Predictive content of M2 dependent variable: nominal GDP growth in Germany (1970:1-2008:4 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M3			0.167	0.306	0.510
3	NGDP	PGR			0.011	0.034	0.061
4	NGDP	PGR	M3		0.185	0.344	0.572
5	NGDP	R-90			0.001	0.007	0.028
6	NGDP	R-90	M3		0.176	0.328	0.561
7	NGDP	PGR	R-90		0.006	0.029	0.058
8	NGDP	PGR	R-90	M3	0.185	0.347	0.583

Table 5-4 Predictive content of M2 dependent variable: nominal GDP growth in Japan (1960:1-2008:4 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M2			0.658	0.760	0.812
3	NGDP	PGR			0.017	0.029	0.044
4	NGDP	PGR	M2		0.667	0.775	0.829
5	NGDP	R-90			0.005	0.017	0.024
6	NGDP	R-90	M2		0.660	0.767	0.820
7	NGDP	PGR	R-90		0.014	0.029	0.042
8	NGDP	PGR	R-90	M2	0.668	0.776	0.829

5.4.1.2 Stability of the link between money aggregates and nominal GDP

In this section the study explores the stability of the link between money aggregate and nominal GDP. The results of the stability test could point to the strength of the link between nominal GDP and money aggregate as well. If the link between money aggregate and nominal GDP over the business cycle is stable, this suggests the money aggregate could be considered as a control variable to influence the economic conditions. If it is not stable, the study aims to test the regression in the subsample to discover whether the core findings in the section are robust or not.

If it were assumed that there was a known break date, then the straightforward method would be to apply the Chow-type test for the parameter stability. However, the possible break is based on historical knowledge and subjective decision. The break date occurrence is generally unknown in practice; therefore, the study also provides the results of CUSUM (the Cumulative Sum of the Recursive Residuals), and one-step forecast tests with the purpose of examining the parameter stability when the break date is unknown. The test results are described in the Appendix 5.B and a brief summary will be given here.

Although the research uses three types of stability test, the emphasis is on the Chow-type test. Considering there is not a well-recognized method which can automatically select a break date in the VAR model, this study applies the Granger causality test and VAR model in the following parts of the thesis. In order to be consistent for the break date in the tests, the research decides the break date based on historical events.

Results in the U.S.

The Federal Reserve came to regard the money aggregate growth target as having a dominant role in the monetary policy from October 6, 1979, the date on which the monetarist experiment started. This period ended in July 1982. During the period, M1 growth was first actively pursued and was then replaced by M2 growth, as the Federal Reserve found that M2-targeting was more relevant. As a result, this study considers 1979Q3 as the break quarter. Boivin and Giannoni (2002) also regard 1979Q3 as the break date in their VAR model after testing the stability of all the coefficients on the lags of a given variable using the Wald version of the Quandt likelihood-ratio test. This date is associated with the recessions during 1979 to 1982 and the procedure that the Federal Reserve changed, so it is reasonable. The Chow-test also confirms that there is a break in 1973Q3, and the resulting graph is shown in the Appendix 5.B.

The following tables show the summary statistics in the two subsamples in the U.S. The results suggest that M2 generally has more predictive content in the early sample, and the forecasting performance of M2 in the later sample deteriorates. For example, in the regression with lagged nominal GDP growth rate and lagged money, $\overline{R}^2$ falls from 0.475 to 0.121. On the other hand, it is worth noticing that the 3-month Treasury bill rate has increased the predictive content for nominal GDP in the later subsample. For instance, $\overline{R}^2$ rises from 0.029 to 0.179 in the regression model with only the lagged nominal GDP growth rate and lagged 3-month Treasury bill rate. In addition, the 3-month Treasury bill rate is added to the regression with M2 only in the later subsample, and $\overline{R}^2$ climbs from 0.121 to 0.402. If we examine the regression with lagged nominal GDP growth, 3-month Treasury bill rate, and M2, we will find that the change of $\overline{R}^2$ is modest, from 0.570 to 0.402. Considering M2 has less predictive content in the later subsample, it can be seen that the 3-month Treasury bill rate has more predictive power in the later subsample. Overall, it can be inferred that the interest rate has predictive content to nominal GDP in the later subsample, though it cannot compare with the predictive power of M2 and interest rate in the later subsample.

Table 5-5 Predictive content of M2 dependent variable: nominal GDP growth in the U.S. (1960:1-1979:3 quarterly)

Eq.	Regressors				$\overline{R}^2$	$\overline{R}^2(2)$	$\overline{R}^2(4)$
1	NGDP						
2	NGDP	M2			0.306	0.369	0.475
3	NGDP	PGR			0.024	0.050	0.077
4	NGDP	PGR	M2		0.311	0.403	0.565
5	NGDP	R-90			0.006	0.010	0.029
6	NGDP	R-90	M2		0.316	0.396	0.570
7	NGDP	PGR	R-90		0.005	0.012	0.050
8	NGDP	PGR	R-90	M2	0.311	0.404	0.583

Table 5-6 Predictive content of M2 dependent variable: nominal GDP growth in the U.S. (1979:4-2006:4 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M2			0.066	0.092	0.121
3	NGDP	PGR			0.025	0.021	0.015
4	NGDP	PGR	M2		0.074	0.108	0.183
5	NGDP	R-90			0.051	0.082	0.179
6	NGDP	R-90	M2		0.153	0.236	0.402
7	NGDP	PGR	R-90		0.041	0.075	0.181
8	NGDP	PGR	R-90	M2	0.148	0.230	0.397

Results in the U.K.

The regime of the U.K. monetary policy changed several times during the period between the floating of the exchange rate in 1972 and the beginning of the inflation target in 1992. In the early 1970s, monetary policy was secondary to income policy which the government regarded as acting against inflation. In the late 1970s, the monetarism experience swept through most developed countries, and money aggregate was first considered as a fitting control variable in the U.K. After the failure of the monetarism experience, monetary policy moved to the management of the exchange rate, and the United Kingdom became a member of the ERM (the Exchange Rate Mechanism) between 1990 and 1992.

With the collapse of the pound sterling on 16th September 1992, which forced Britain to leave the ERM, it was necessary to introduce a new monetary target. Following the lead of Canada and New Zealand, the inflation target was set up in 1992. In the meantime, the British economy went through a severe recession at the beginning of the 1990s which lasted until the end of 1992. Thus the research regards 1992Q3 as a break date.

If we compare the $\bar{R}^2$ in both subsamples, we can see that the predictive power of M4 for nominal GDP does not change much. M4 has the predictive content for nominal GDP in both subsamples. However, the predictive power is not as significant as that in the previous three countries. The 3-month Treasury bill rate also has little predictive power for nominal GDP in the U.K. in both subsamples. The findings in the subsample are consistent with those in the entire sample. M4 has more predictive power for nominal GDP than the interest rate does.

Table 5-7 Predictive content of M4 dependent variable: nominal GDP growth in the U.K. (1960:1-1992:3 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M4			0.014	0.031	0.233
3	NGDP	PGR			0.014	0.031	0.038
4	NGDP	PGR	M4		0.055	0.119	0.270
5	NGDP	R-90			0.006	0.009	0.033
6	NGDP	R-90	M4		0.015	0.033	0.234
7	NGDP	PGR	R-90		0.023	0.042	0.065
8	NGDP	PGR	R-90	M4	0.051	0.098	0.0302

Table 5-8 Predictive content of M4 dependent variable: nominal GDP growth in the U.K. (1992:4-2009:2 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M4			0.033	0.137	0.223
3	NGDP	PGR			0.100	0.030	0.051
4	NGDP	PGR	M4		0.114	0.183	0.286
5	NGDP	R-90			0.013	0.015	0.033
6	NGDP	R-90	M4		0.018	0.137	0.225
7	NGDP	PGR	R-90		0.086	0.036	0.065
8	NGDP	PGR	R-90	M4	0.103	0.178	0.282

Results in Germany

On October 3, 1990, East and West Germany were officially united. Although the data in Germany have been adjusted for the political and economic unification in 1990, there is still a question over the stability of relationship between the financial variables. It is possible that unification disturbed the operation of the economic system; thus, the study takes 1990Q3 as a break date.

The Chow test proves there is a break in 1990Q3, and CUSUM and one-step forecast suggest that the link between M3 and nominal GDP is not stable.

The tables present the statistical results in Germany. The results point out that M3 has significant predictive content both in the early subsample and later subsample, though the predictive content in the later subsample is not as notable as that in the early subsample. For example, $\bar{R}^2$ at the four-quarters in the regression with M3 only is 0.586 and 0.445 respectively.

The inclusion of interest rate does not eliminate the predictive power of M3 in Germany and, meanwhile, it increases the predictive content. However, the statistical results imply that the 3-month market rate does not provide future information on nominal GDP to a large extent. For example, the $\bar{R}^2$ in the regression with lagged interest rate alone is only 0.048 at two-quarter growth rate and 0.107 at four-quarter growth rate in the later subsample, which does not show a major difference with the early subsample.

To summarise, the conclusion that M3 has the main predictive content for nominal GDP in Germany is robust.

Table 5-9 Predictive content of M3 dependent variable: nominal GDP growth in Germany (1970:1-1990:3 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M3			0.218	0.401	0.586
3	NGDP	PGR			0.071	0.115	0.171
4	NGDP	PGR	M3		0.333	0.539	0.718
5	NGDP	R-90			0.070	0.120	0.022
6	NGDP	R-90	M3		0.257	0.443	0.659
7	NGDP	PGR	R-90		0.061	0.108	0.163
8	NGDP	PGR	R-90	M3	0.325	0.535	0.721

Table 5-10 Predictive content of M3 dependent variable: nominal GDP growth in Germany (1990:4-2008:4 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M3			0.146	0.263	0.445
3	NGDP	PGR			0.026	0.004	0.031
4	NGDP	PGR	M3		0.136	0.270	0.500
5	NGDP	R-90			0.027	0.048	0.107
6	NGDP	R-90	M3		0.177	0.325	0.574
7	NGDP	PGR	R-90		0.013	0.037	0.095
8	NGDP	PGR	R-90	M3	0.165	0.317	0.573

Results in Japan

After Japan established its status as the world's second-largest economy in the 1980s, the continuing rise of the stock market index and real estate prices made the Japanese economy overheat. The Japanese asset price bubble collapsed in 1989, when the Tokyo Stock Exchange also crashed. The period of Japanese asset price bubble normally refers to 1986 to 1991, so the sample is divided into two subsamples, which are from 1960:Q1-1990:Q4 and 1991:Q1 to 2008:Q4, reflecting the observation of a likely structural break in early 1991.

M2 still has extremely large predictive content for nominal GDP in Japan from 1961 to 1990. The range of $\overline{R}^2$'s at the four-quarter horizon in the regression with M2 alone, or with price growth and the 3-month Treasury bill rate is around 0.6 to 0.65, which indicates that inclusion of price growth or the 3-month Treasury bill rate does not significantly increase the predictive content for nominal GDP. In the regression with the 3-month Treasury bill alone, it is also revealed that short-term interest rate does not have the predictive content for nominal GDP during 1961 to 1990. The main findings in the entire sample are robust for the period during 1961 to 1990. However, the predictive power of M2 for nominal GDP in the later subsample decreases. The $\overline{R}^2$ at the four-quarter horizon is just 0.25 which is less than that in the early subsample, though 0.25 could not reject the predictive power of M2 in Japan. The 3-month Treasury bill rate has more predictive content for nominal GDP which is implied by the $\overline{R}^2$ in the regression with interest rate only; however, inclusion of the 3-month Treasury bill rate in the regression with M2 does not increase the predictive power for nominal GDP after 1990, so it cannot be assumed that interest rate is an appropriate control variable to predict future nominal GDP.

Table 5-11 Predictive content of M2 dependent variable: nominal GDP growth in Japan (1961:1-1990:4 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M2			0.360	0.520	0.600
3	NGDP	PGR			0.040	0.072	0.0956
4	NGDP	PGR	M2		0.388	0.564	0.647
5	NGDP	R-90			0.003	0.005	0.017
6	NGDP	R-90	M2		0.340	0.529	0.635
7	NGDP	PGR	R-90		0.035	0.059	0.092
8	NGDP	PGR	R-90	M2	0.364	0.549	0.644

Table 5-12 Predictive content of M2 dependent variable: nominal GDP growth in Japan (1991:1-2008:4 quarterly)

Eq.	Regressors				$\bar{R}^2$	$\bar{R}^2(2)$	$\bar{R}^2(4)$
1	NGDP						
2	NGDP	M2			0.004	0.059	0.251
3	NGDP	PGR			0.011	0.014	0.012
4	NGDP	PGR	M2		0.017	0.046	0.248
5	NGDP	R-90			0.025	0.071	0.171
6	NGDP	R-90	M2		0.012	0.079	0.251
7	NGDP	PGR	R-90		0.014	0.060	0.160
8	NGDP	PGR	R-90	M2	0.000	0.066	0.242

5.4.2 Results of Granger causality test in entire sample and subsamples

It is suggested from the results that money aggregate has more predictive content for nominal GDP based on the simple regression, and the study intends to apply the Granger causality test to shed light on the question of whether there is proof of unidirectional causality running from money aggregate to nominal GDP or whether the order is reversed.

Sims (1972) first developed a statistical technique for testing causality between two variables, and inferred that there is unidirectional causality from money to income using post-war U.S. data. Since then, many empirical researchers have concentrated on the causality test between money and income. Here the study focuses on the nominal GDP rather than nominal GNP.

According to the description of the methodology of the causality test in Chapter 3, the study firstly tests the cointegration between nominal GDP and money and finds that nominal GDP and money aggregate are cointegrated. The statistical results are presented in the Appendix 5.D. Because most researchers (Stock and Watson, 1987a, Amato and Swanson, 2001, Patinkin and Technology, 1965, Coenen et al., 2005, Green, April 26th 2009) have also been interested in the correlation between money and real GDP, or money and inflation, the study tests the hypothesis that there is a causality relationship between money and real GDP, or interest rate as well, and presents the results in the Appendix5.E. In the main part, the research only discusses the causality between money and nominal GDP, as this is the core interest of the research. The table 5-13 shows the statistical results. The hypothesis is that nominal GDP does not Granger cause money and vice versa. The hypothesis that nominal GDP does not Granger cause money is rejected in all four countries at the 5% significance level, but the hypothesis that money does not Granger cause nominal GDP could not be rejected in the U.S., U.K. and Japan at the 5% significance level, and also could not be rejected in Germany at the 10% significance level. Thus, it is found that the causality is unidirectional from money aggregate to nominal GDP in the U.S., U.K., Germany and Japan.

Table 5-13 Granger causality between money and nominal GDP

Countries	Time Period	nominal GDP does not GC[40] money		money does not GC nominal GDP	
		F-statistic	P-value	F-statistic	P-value
U.S.	1960Q1-2006Q4	1.8112	0.0993	3.836636	0.0013***
U.K.	1960Q1-2008Q4	0.763432	0.5997	6.632155	0***
Germany	1970Q1-2008Q4	1.290878	0.2711	2.027122	0.0784
Japan	1960Q1-2008Q4	1.615487	0.0986	3.375229	0.0003***

Granger Causality Test in subsamples

Since the time period is more than 30 years in all four countries, it is necessary to test the robustness of the Granger causality results. Therefore, this research uses the same structural break in each country as that in the simple regression, and tests the Granger causality in the subsample.

[40] GC means Granger Cause

This study has conducted the cointegration test between money and nominal GDP in the subsamples, and the results suggest that there is a cointegration relationship between money and nominal GDP in most of the subsamples across the four countries with only one exception - the late subsample in Germany. Detailed figures are shown in appendix G.

The summary of the Granger causality results is shown in the following table 5-14. The results in the two subsamples reveal that a unidirectional causality from money to nominal GDP is robust with only a few exceptions. The hypothesis that money does not Granger cause nominal GDP is rejected at the 5% significance level in all four countries in the early period subsample, and is also rejected at the 1% significance level in the U.S., U.K. and Germany in the later subsample. The hypothesis that money does not Granger cause nominal GDP is accepted in Japan in the later subsample. This might be because monetary policy has had little effect on economic conditions in Japan since the economy crashed in the late 1990s. On the other hand, the hypothesis that nominal GDP does not Granger cause money is accepted in most of the countries and both subsamples, with the only exception being the U.S. in the early period. As a result, the main empirical findings suggest that a stable unidirectional causality is from money to nominal GDP even with a structural break.

Table 5-14 Granger causality results

Subsample 1					
Countries	Time period	nominal GDP does not GC money		money does not GC nominal GDP	
		F-statistic	P-value	F-statistic	P-value
U.S.	1960Q1-1979Q3	2.578038	0.018**	4.197202	0.0005**
U.K.	1960Q1-1992Q3	1.161107	0.3325	2.513242	0.0205**
Germany	1970Q1-1990Q3	0.71135	0.5487	3.34945	0.0242**
Japan	1960Q1-1990Q4	2.143768	0.0546	2.657994	0.0194**
Subsample 2					
Countries	Time period	nominal GDP does not GC money		money does not GC nominal GDP	
		F-statistic	P-value	F-statistic	P-value
U.S.	1979Q4 -2006Q4	1.168872	0.3266	4.712548	0.0001***
U.K.	1992Q4-2008Q4	1.331667	0.2558	4.040096	0.0013***
Germany	1990Q4-2008Q4	0.20999	0.9571	5.99453	0.0001***
Japan	1991Q1-2008Q4	0.872347	0.5051	0.923123	0.4724

Discussion of empirical evidence of 4-countries VAR test during the period 1960s-2008Q4

The purpose of identifying the monetary shock is to evaluate the effectiveness of monetary policy on economic conditions. In general, there are two ways to capture money policy shock. The first one is called the historical approach, which was provided by Romer and Romer (1989). In their paper, Romer and Romer identify the dates on which monetary policy became restrictive, by using the minutes of the Federal Open Market Committee meetings. This method has its disadvantages, because only the restrictive shocks were chosen, and the expansive shocks were ignored. Besides, these dates only reflect a qualitative measurement.

The second method is to identify monetary shocks using the VAR model. The VAR model was first used in the works of Sim (1980, 1992) and extended by Bernanke (1986) and Bernanke and Blinder (1992). The VAR model is a linear stochastic system that can capture dynamic relationships between time series variables; thus, it is widely used in monetary policy analysis. This research applies the VAR model in an attempt to discover the effectiveness of money shock on nominal GDP.

In the following section, the research presents the empirical results, which stem from the reduced-form VAR model. The purpose of this part is to show the impact of broad money on nominal GDP, as previous opinion suggests that the impact of broad money falls on price and there is no impact on real GDP in the long term. This research intends to assess the overall impact of money on nominal GDP. A comparison between countries provides an important evaluation of the effectiveness of money on the economic conditions.

5.4.3 Results of VARs model

VAR model test with nominal variables in four countries during the period 1960Q1-2008Q4

A vector autoregression (VAR) is a system of ordinary least-squares regressions, in which each of a set of variables is regressed on lagged values of both itself and the other variables in the set. VAR model has been proved a convenient approach to summarise the dynamic behaviour among the variables, because the model can be used to simulate the response over time of any variable in the set to either an "own" disturbance (a disturbance to the equation for which the variable is the dependent variable) or a disturbance to any other variables in the system. (Bernanke, 1995)

The VAR model established here includes nominal GDP, price, interest rate, and money aggregate.[41] The research here assumes money aggregate to be an indicator of the stance of monetary policy, although short-term interest rate is normally regarded as that. Therefore, this means that the disturbance of money aggregate in the VAR model is identified as shocks to monetary policy, and the response of other variables to money aggregate shock is interpreted as the structural responses to an unanticipated change in monetary policy.

In the model $X_t \left[m_{t,} r_t \pi_t G_t\right]$, the variable is the nominal GDP (G_t), consumer price (π_t), the nominal short-term interest rate (r_t) and broad money (m_t), in that order. Nominal GDP and money in VAR model appear as annual growth rate, while consumer price growth rate and the 3-month Treasury bill rate appear as the first difference. The VAR model involves four equations: nominal GDP as a function of past value of nominal GDP, consumer price growth, interest rate and money; consumer price growth as a function of past value of nominal GDP, consumer price growth, interest rate and money; and similar for the interest rate and money equations. Each equation is estimated by ordinary least squares regression. The equations are shown below:

$$\begin{aligned}
\Delta y_t &= \alpha_1 + \sum_{j=1}^{6} \beta_j^1 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^1 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^1 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^1 \Delta m_{t-j} \\
\Delta r_t &= \alpha_2 + \sum_{j=1}^{6} \beta_j^2 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^2 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^2 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^2 \Delta m_{t-j} \\
\Delta p_t &= \alpha_3 + \sum_{j=1}^{6} \beta_j^3 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^3 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^3 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^3 \Delta m_{t-j} \\
\Delta m_t &= \alpha_4 + \sum_{j=1}^{6} \beta_j^4 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^4 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^4 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^4 \Delta m_{t-j}
\end{aligned} \qquad (5.1)$$

[41] Clearly, this VAR provides a very simple description of the economy, but it contains at least the minimum set of variables that are crucial for any discussion of monetary policy.

Generally, the number of lagged values to include in each equation can be determined by a number of different methods. The Akaike (AIC) or BIC information criteria are frequently used to select the length of lags. The results show that six is appropriate for the lag length in most countries after running the VAR model. Considering that the VAR model in monetary transmission literature takes six lags, such as Bernanke (1992), this research runs the VAR model at a six-lag length. The sample period of the estimated country VAR model for the U.S., U.K., Germany and Japan is from 1960Q1 to 2008Q4 except Germany. Because the nominal GDP data obtained for Germany are from 1970Q1, the time period starts from 1970Q1. The data are quarterly, non-seasonally-adjusted. The results are similar when we start the estimation a few years earlier or later, or use different lags.

The difference from the previous models in the literature is the use of nominal GDP instead of the real GDP, which provides us with a new angle from which to examine how nominal GDP responds to money aggregate shock. Nominal GDP and consumer price are included to represent the economic activity and price.

The VARs model identified is using Cholesky decomposition, with the order being nominal GDP, price, the nominal interest rate, and money. As the reduced–form errors are typically correlated, the Cholesky decomposition isolates the underlying structural errors by recursive orthogonalization, with the innovation in the first equation untransformed, the innovation in the second equation taken as orthogonal to the first, and so on. The ordering was based on the speed at which the variable responds to shocks. It was assumed that output was the least responsive, followed by price, short interest rate, and money.

Given the long planning procedures involved in setting economic output and prices, these variables are supposed to not respond to simultaneous shocks to financial variables. The assumption is that the monetary authorities set the money aggregate with information on the contemporaneous performance of slowly-moving output and price, but without a complete picture of the actions of quickly-changing financial variables. Although this research did not test all possible alternative orderings, the results were not significantly different from the complete re-ordering of money, nominal interest rate, price, and nominal GDP.

5.4.3.1 The main impulse response results in the entire sample

As an illustration, the shock is identified through a standard Cholesky-decomposition. The figures 5.14, 5.16, 5.17 show the dynamic accumulated impulse response of the nominal GDP, price and short-term interest rate to an unanticipated tightening of money shocks, for each country, along with 95 per cent confidence bands.

The impact of money innovation on nominal GDP

The patterns of nominal GDP response to money shock are all statistically significant and positive in all four countries, which were implied by the accumulated impulse response. It is clear that the impact of money on nominal GDP increases in the first few quarters, and the maximum impact reached after the 4-quarters initial money shock, where 1% of money-tightening leads to around 0.3% of nominal GDP increase, then gradually returns to the baseline in the U.S. and Germany. The magnitude of impact of money on nominal GDP is largely positive in Japan, where 1% of money-tightening leads to around 0.7% of nominal GDP increase after 8 quarters; however, in the U.K. the impact is negative in the first few quarters, and then becomes positive after 4 quarters. Although the positive effect of money on nominal GDP in the U.K. is not apparent based on the impulse response, the feature of accumulated impulse response suggests that money has a positive impact on nominal GDP in these four developed countries. More detailed figures are displayed in Appendix F.

Figure 5-13 Impulse response of Cholesky One S. D. money innovation on nominal GDP

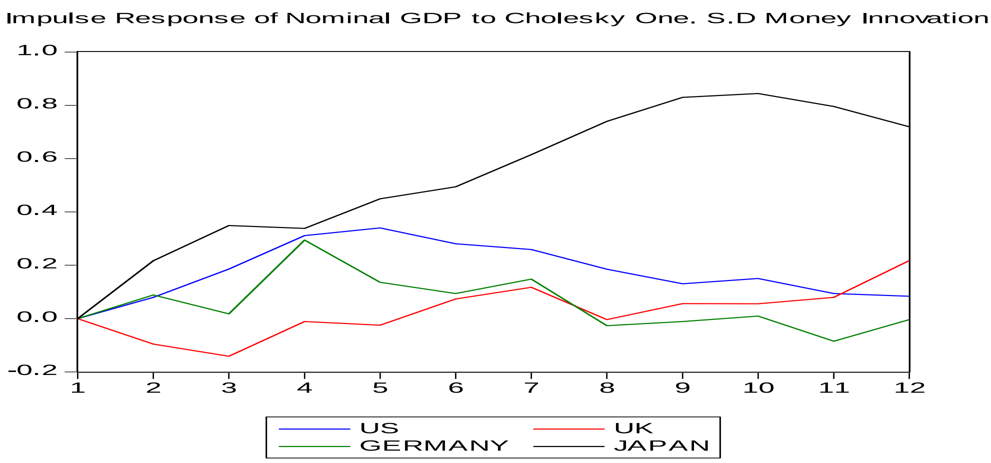
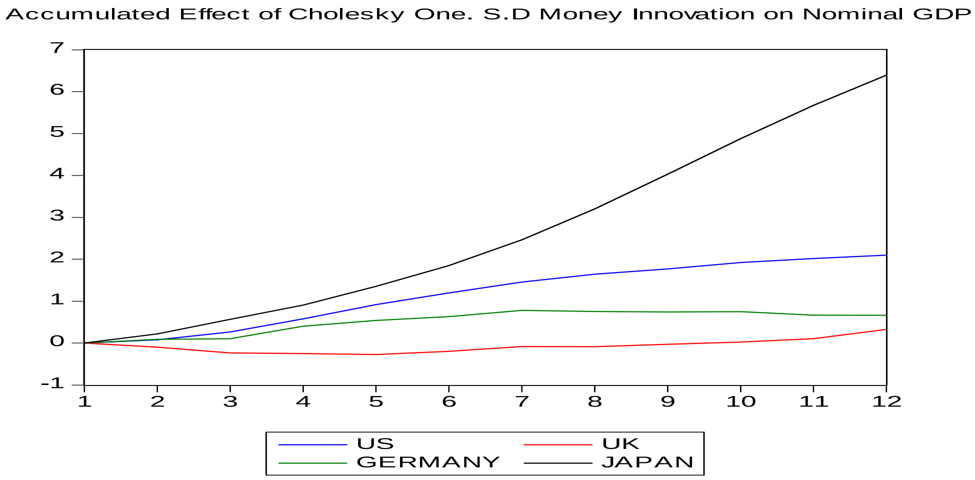


Figure 5-14 Accumulated effect of Cholesky One S.D. money innovation on nominal GDP



The impulse response of money innovation on interest rate

As the figure shows, the accumulated response of interest rate to money shock in the U.S., U.K., Germany and Japan is positive. In the U.S., Germany and U.K., one percentage point of money supply increase leads to a 0.2% interest rate increase, and the magnitude of impulse response of interest rate to money shock is smaller in Japan. Normally, the interest rates are expected to decrease if the money supply increases, so the results drew the liquidity puzzle in the figure. Liquidity puzzle refers to an expansionary monetary policy shock where interest rate increases rather than decreases.

Figure 5-15 Impulse response of Cholesky One S.D. money innovation on interest rate

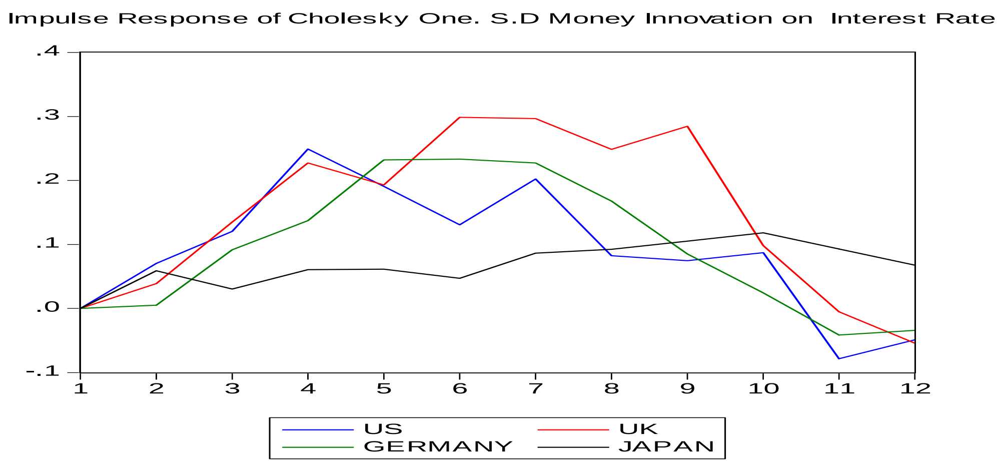
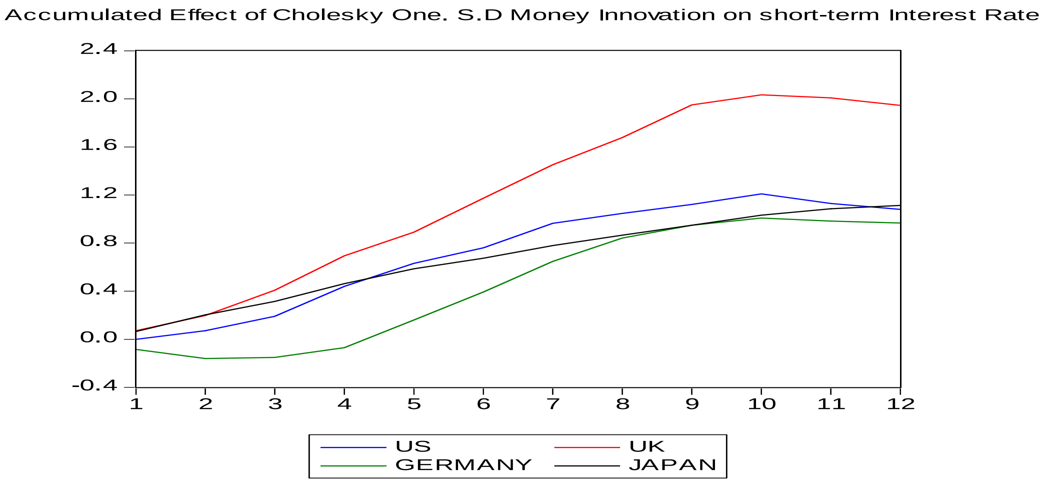


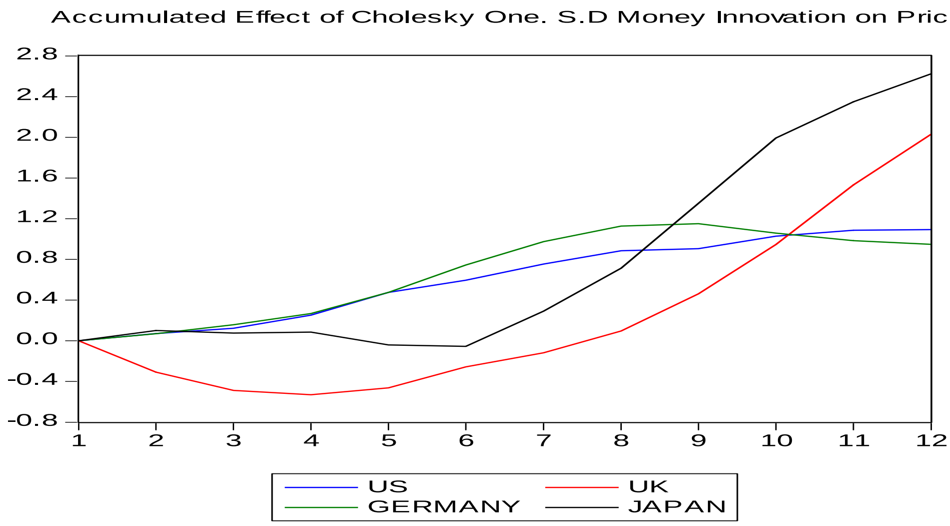
Figure 5-16 Accumulated effect of Cholesky One S.D. money innovation on short-term interest rate



The pattern of money innovation on price

The accumulated response of price to broad money shock in all four countries is positive. Price does not immediately respond to money shock, and displays the feature of price stickiness. After 8 quarters of initial shock, the impact becomes apparent. The impulse response table can be found in Appendix F.

Figure 5-17 Accumulated effect of Cholesky One S. D. money innovation on price

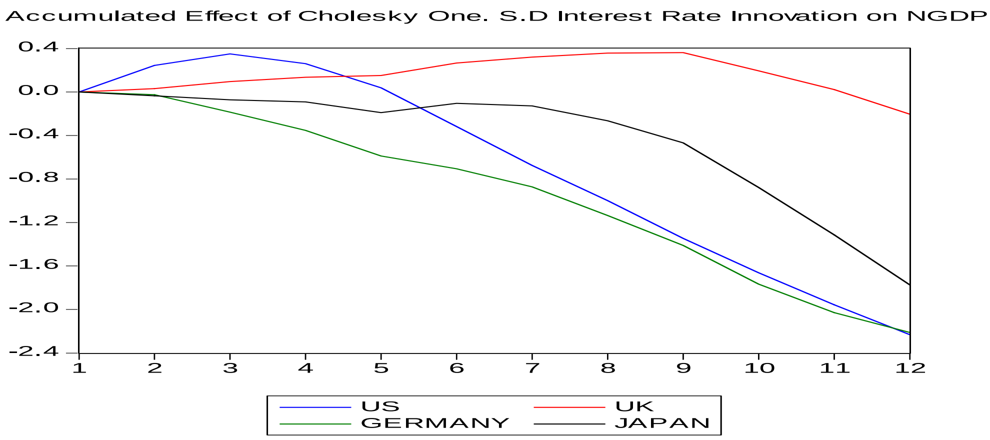


The impact of interest rate innovation on nominal GDP

In the figure, the accumulated effect implies that interest rate shock has a negative effect on nominal GDP, though the interest rate shock does not cause the immediate negative effect. In the each country, a shock of short-term interest rate leads to a gradual decrease in nominal GDP, and the impulse response fluctuates. The negative response is eventually stable after 12 quarters initial shock, which implies that the impact of interest rate innovation on nominal GDP is constant.

The table in Appendix 5.C summarises the response of nominal GDP to short-term interest rate shock at half, one, two and three years of shock. In the U.S. and Germany, the magnitude of response is similar, where the nominal GDP growth rate fell 0.22% after the 100 basis-point rise of the 3-month Treasury bill rate at 5 quarters. Although the magnitude of response in Japan is similar to that in the U.S. and Germany, the speed of impulse response is much slower. It is surprising that the impulse response of nominal GDP to interest rate shock is positive in the first 2 years, even though it becomes negative after 3 years in the U.K., and the magnitude of impulse response is relatively small.

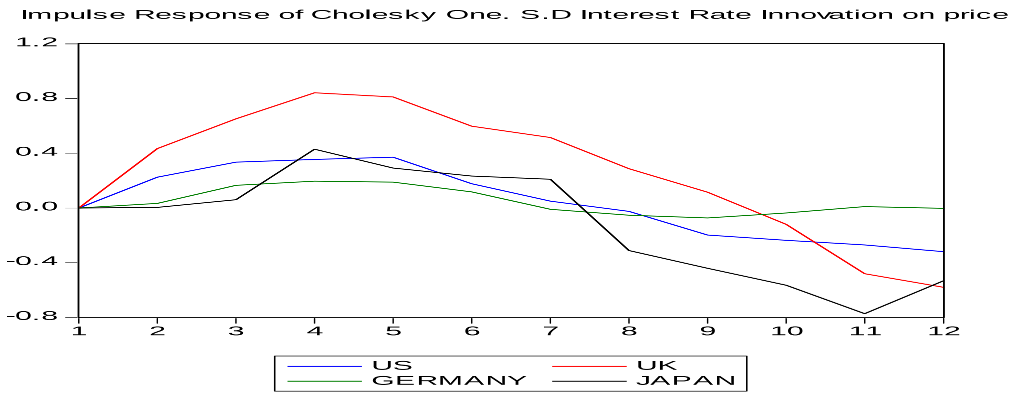
Figure 5-18 Accumulated effect of Cholesky One S.D. interest rate innovation on nominal GDP



The impact of interest rate innovation on price

The impulse response reaches its maximum point after increasing in the first 4 quarters, and then gradually decreases to the baseline. This pattern of impulse response sketches the price puzzle, where interest rate-tightening causes the increasing price rather than the decreasing price. The price puzzle was first provided by Sim (1992) and labelled by Eichenbaum (1992).

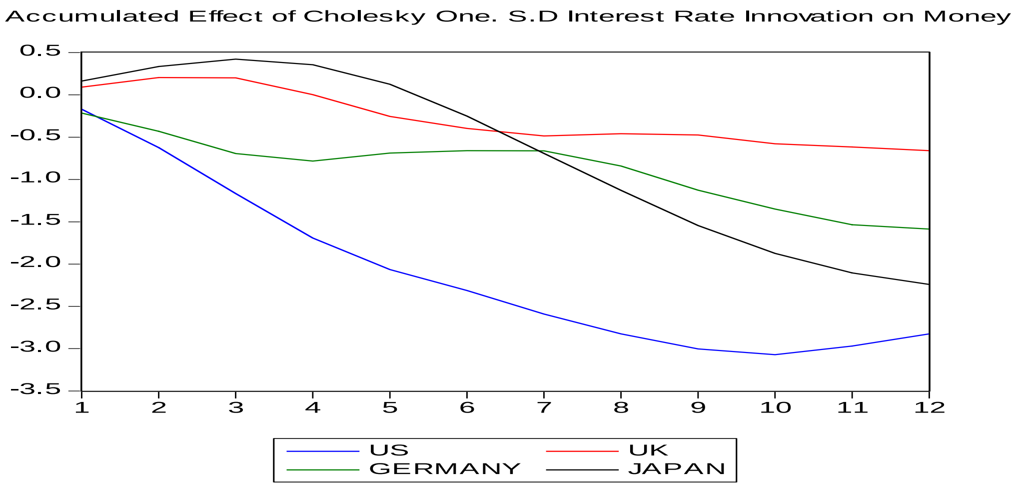
Figure 5-19 Impulse response of Cholesky One S.D. interest rate innovation on price



The impact of interest rate innovation on money

The pattern of money response to interest rate shock shows a decrease across all four countries, which implies that, when the interest rate increases, the money supply decreases in all countries. One percentage point of interest rate shock leads to 0.26%-0.55% of money supply decrease after 4 to 5 quarters initial shock. The magnitude of impulse response in the U.S. is the largest.

Figure 5-20 Accumulated effect of Cholesky One S.D. interest rate innovation on money

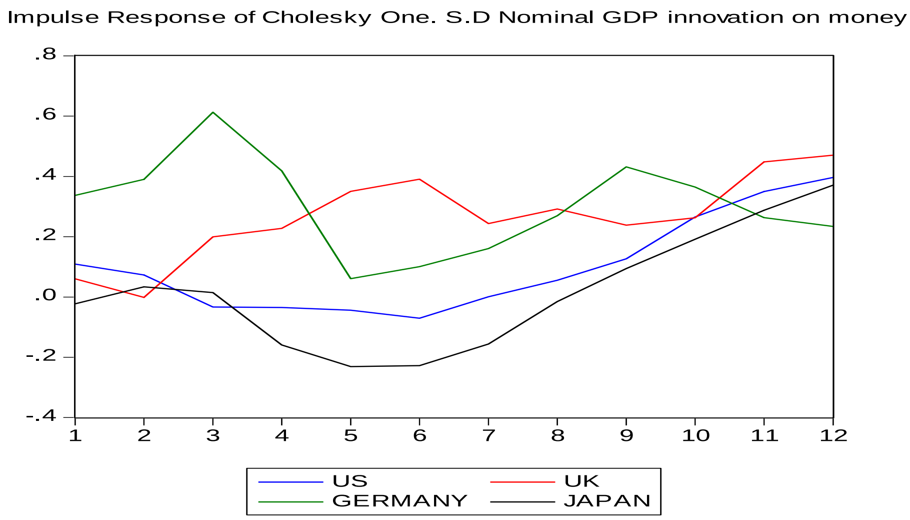


In accordance with its interest in discovering how money aggregate and interest rate respond to nominal GDP shock, this research also provides the impulse response of money and interest rate to nominal GDP shock.

The pattern of nominal GDP innovation on money

Based on inspection, it seems there is no constant pattern of money response to nominal GDP shock. The impulse response is negative in the U.S. and Japan and positive in the U.K. and Germany after the initial shock. The magnitude of response is also completely different in each country. Thus, there is no constant pattern of money response to nominal GDP in the four countries.

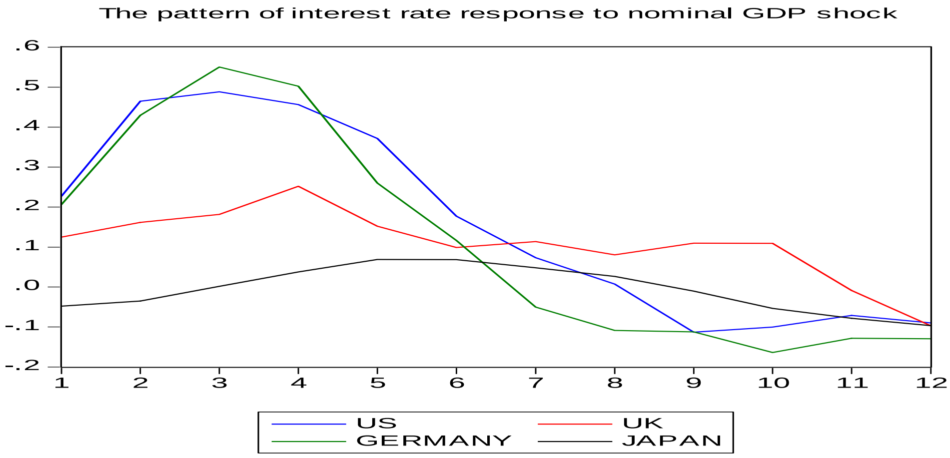
Figure 5-21 Impulse response of Cholesky One S.D. nominal GDP innovation on money



The pattern of nominal GDP innovation on interest rate

Judd and Motley (1993) have suggested that, when nominal GDP growth exceeds the target by one percentage point, policy-makers should raise the short-term interest rate by 0.2 per cent, or 20 basis points. Here, the test shows the percentage of interest rate response to a 1% increase in GDP. The pattern of interest rate response to nominal GDP shock is positive across all the countries, although the magnitudes are different. The maximum impulse response was reached after 3 to 4 quarters in the U.S., U.K. and Germany, while the magnitude of impulse response in Japan is small. The interest rate increased by 0.4% to 0.5% in the U.S. and Germany, and increased around by 0.2% in the U.K., however, it increased by less than 0.1% in Japan, after a 1% increase in nominal GDP.

Figure 5-22 Impulse response of Cholesky One S.D. nominal GDP innovation on interest rate



Overall we find that the impulse response of nominal GDP is positive to broad money shock and is negative to interest rate shock across all the countries, which implies that money supply has a positive effect on nominal GDP, and interest rate has a negative effect on nominal GDP. However, there is no constant pattern of money aggregate response to nominal GDP shock, which might signal only that nominal GDP could not be the monetary policy target. In the 4-variable VARs model, the price puzzle and liquidity puzzle still exist. In order to acquire more details on these variables' interaction, we apply the variance decomposition.

5.4.3.2 Variance decomposition in the entire sample

In this section, we try to provide an outline of what percentage of shocks contributes to nominal GDP, price, money and the 3-month Treasury bill rate for the U.S., U.K., Germany and Japan.

The table below shows that M2 and interest rate account for between 9% and 10% respectively of nominal GDP in the U.S., but money and the 3-month Treasury bill rate account for little of nominal GDP in the U.K. and Germany. In Japan, M2 contributes nearly 20% of nominal GDP, which implies that M2 is a very important factor for influencing nominal GDP, while the 3-month Treasury bill rate gives little explanation for nominal GDP in Japan. Overall, money has more explanatory power than interest rate for nominal GDP based on variance decomposition in four countries.

Table 5-15 Variance decomposition for VAR model

Variance Decomposition for VAR of Nominal GDP					
		U.S.	U. K	Germany	Japan
Period	Nominal GDP				
2		96.43257	94.892	98.34189	98.28249
4		92.34622	89.45719	90.74785	94.28474
8		77.39462	82.83877	86.85351	75.22181
	CPI				
2		0.027745	4.885219	1.324961	0.120251
4		1.617766	10.15809	5.415622	0.415033
8		2.636892	16.53785	5.388302	4.450835
	3-months Rate				
2		3.199173	0.021302	0.02484	0.039436
4		2.194131	0.07213	1.396041	0.054742
8		10.56956	0.209566	4.688412	0.476689
	Money				
2		0.340509	0.201477	0.308311	1.557822
4		3.841884	0.312586	2.440482	5.245481
8		9.398932	0.413811	3.069778	19.85066

5.4.3.3 Test of four-countries VARs model in subsamples

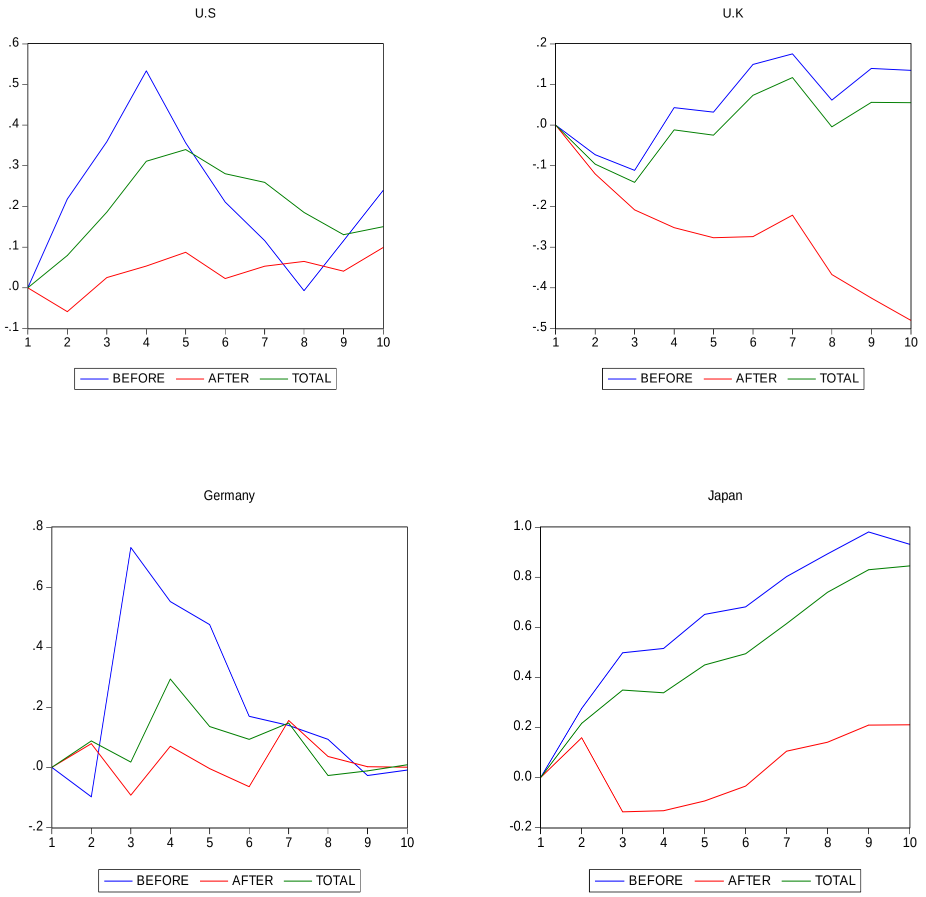
The stability of parameters in estimated macroeconomic correlation has been examined in a quantity of recent papers. The most specific evidence was provided by Stock and Watson (1996). They suggested that there is widespread instability in the bivariate relationship among 76 macroeconomic variables. However, mixed outcomes have been obtained in the VAR context.[42] Given that the sample of the test covers a long period, and includes some monetary policy regime change periods, it is necessary to test the robustness of VAR results in the subsample. The sample is divided by using the same break date as used in the simple regression test in order to retain consistency.

The study firstly focuses on the response of nominal GDP to money shock. It compares the impulse response for both longer and shorter sample periods. The trend of impulse

[42] Bernanke, Gertler, and Watson (1997) find evidence of instability in a monetary VAR, while Bernanke and Mihov (1998) and Christiano, Eichenbaum, and Evans (1999) reach the opposite conclusion.

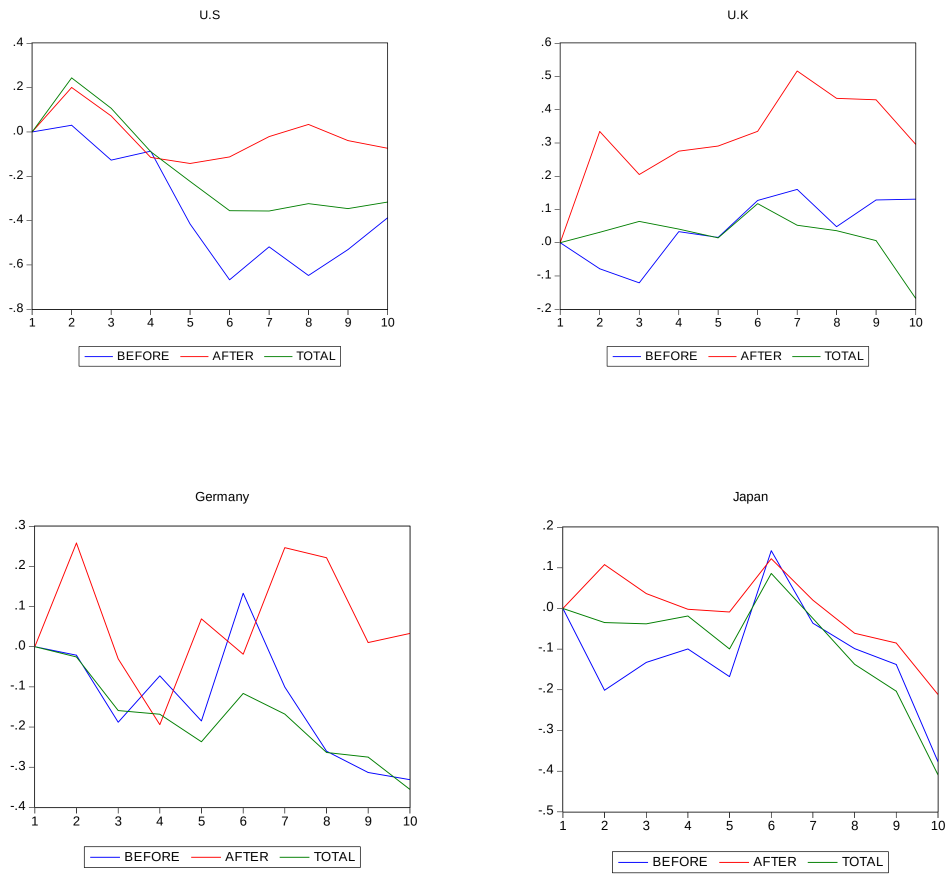
response over time is consistent, although the magnitude of impulse response is different. The nominal GDP positively responds to money aggregate shock in most periods. However, the only exception is in the later period in the U.K. It is obvious that the magnitude of nominal GDP to money shock is larger in the early time period, and becomes smaller in the later period. This phenomenon may reflect the monetary policy regime change from money supply control to inflation-targeting in these countries. The results are robust, compared to before and after the subsample, but generally money aggregate shock has a positive effect on nominal GDP.

Figure 5-23 The impulse response of nominal GDP to money shock before and after structural break, and in the entire sample in the U.S., U.K., Germany and Japan



The figures 5-24 draws the nominal GDP response to interest rate shock. From the figures, it is hard to find a consistent pattern of nominal GDP response to interest rate shock across all four countries. In the U.S. and Japan, nominal GDP negatively responds to interest rate shock, but in the U.K. and Germany there is no consistent pattern of impulse response.

Figure 5-24 The impulse response of nominal GDP to interest rate shock, before and after structural break, in the entire sample in the U.S., U.K., Germany and Japan



5.4.3.4 Variance decomposition in subsamples

The table5-16 explains the variance decomposition in the subsamples. It reveals that money aggregates account for a considerable part of nominal GDP in the early period in the U.S., Germany and Japan, but do not in the U.K. This might be because M4 is too broad to capture nominal GDP fluctuations in the early period. Money aggregates account for larger proportion of nominal GDP more than short-term interest rate does in Germany and Japan in the early period sample. In the U.S., m2 also accounts for around 13% of nominal GDP in the early period. However, money aggregates only slightly account for nominal GDP in the later period in the U.S., Germany and Japan, but M4 increases the explanatory power in the U.K. in the later period. Short-term interest rate accounts for small part of nominal GDP in the U.K., Germany and Japan in the early period, and also has little power of explanation for nominal GDP in the U.S. Japan and Germany in the later period.

As a result, the ability of money aggregates to explain nominal GDP decreases in the last twenty years, but the short-term interest rate has little power of explanation for nominal GDP over the last 30 years in Germany and Japan. Besides, more than 70% of nominal GDP contributed by itself in the later period, which implies that nominal GDP is an exogenous variable, or there are factors influencing nominal GDP that have not been included.

Table 5-16 Variance decomposition in subsamples

Variance Decomposition for VAR of Nominal GDP in the early period					
		U.S.	U. K	Germany	Japan
Period	Nominal GDP				
2		96.92693	93.3912	99.60571	97.15788
4		81.75983	86.69764	71.20617	90.4912
8		55.10798	78.4458	63.7428	73.51772
	CPI				
2		0.581434	6.479237	0.001011	0.026085
4		3.389923	12.83552	6.264823	1.33868
8		4.360021	20.23704	7.615521	1.619476
	3-months Rate				
2		0.047842	0.03991	0.016958	0.980162
4		0.754642	0.313342	1.035181	0.843161
8		27.29035	0.951662	3.741527	1.037623
	Money				
2		2.443799	0.089653	0.37632	1.835875
4		14.0956	0.1535	21.49382	7.326956
8		13.24165	0.365496	24.90015	23.82519
Variance Decomposition for VAR of Nominal GDP in the later period					
		U.S.	U,K	Germany	Japan
Period	Nominal GDP				
2		96.31867	87.19396	95.57395	97.5895
4		93.27536	64.6026	92.44209	88.18708
8		90.79346	53.03749	88.11514	77.00417
	CPI				
2		0.959263	1.136604	0.302267	0.888171
4		4.700634	21.03883	3.33832	9.83327
8		6.155095	22.5728	5.371977	20.13939
	3-months Rate				
2		2.505689	10.12281	3.770507	0.479517
4		1.810608	8.677039	3.551249	0.344386
8		2.470227	14.99728	5.315964	0.68324
	Money				
2		0.216376	1.54662	0.353274	1.042814
4		0.213399	5.68153	0.668346	1.635268
8		0.581217	9.39243	1.196914	2.1732

5.5 Discussion and conclusion

In this chapter, the study tests the possibility of using money aggregate to target nominal GDP by employing three approaches. The three approaches are designed to explore the strength and stability of predictive power of money aggregates for nominal GDP in the U.S., U.K., Germany and Japan. Additionally, the study intends to reveal the pattern of nominal GDP response to money aggregates and short-term interest rate shock with an attempt to provide the statistical evidence. The study firstly summarises the predictive power of money to nominal GDP according to the results of a simple regression, then outlines the Granger causality results between money aggregate and nominal GDP in four countries, and lastly discusses the results of VAR model with 4 variables, which are nominal GDP, CPI annual growth rate, short-term interest rate, and money.

The general conclusion is that money aggregate is a useful predictor of nominal GDP, even introducing the short-term interest rate does not decrease the predictive power for nominal GDP. The further Granger causality tests show that a unidirectional causality from money aggregate to nominal GDP exists in most of the countries in both entire sample and subsamples and the VAR model implies the positive response of nominal GDP to money aggregates shock, though the magnitude is different. The detailed conclusions will now be presented.

The simple comparison of $\overline{R}^2$ suggests that interest rate has little predictive power for nominal GDP comparing to money aggregate in the entire sample. In the U.S., M2 has less predictive power in the later subsample, while the predictive power of the 3-month Treasury bill rate for nominal GDP increases in the later subsample. In the U.K., the predictive power of M4 for nominal GDP is stable, and the slight predictive power of interest rate to nominal GDP is also stable. In Germany, M3 is a sufficiently predictive power in both early and later subsamples, while short-term interest rate is not an important predictor of nominal GDP in both subsamples. In Japan, the predictive power of M2 for nominal GDP decreases in the later subsample and, similarly in other countries, interest rate does not have significant predictive power of nominal GDP. Overall, although money aggregate has more predictive power for nominal GDP than interest rate and price growth in all countries, the predictive link between money aggregate and nominal GDP is not stable in the U.S. and Japan.

The simple Granger causality test shows that a unidirectional causality from money aggregates to nominal GDP occurs in most of the countries in the entire sample. Additionally, the early subsample test results suggest that money aggregate unidirectionally Granger causes nominal GDP in the U.K., Germany and Japan, with a two-way Granger causality between money and nominal GDP in the U.S. The results in the later subsample also show a unidirectional Granger cause from money to nominal GDP in the U.S., U.K. and Germany. However, there is no Granger cause link between M2 and nominal GDP in Japan. A unidirectional Granger causality link indicates that money could provide future nominal GDP information better than conversely. Thus, according to the main Granger causality results in the entire sample and subsamples, it could be concluded that money aggregate is a possible variable to target nominal GDP.

The impulse response evidence based on the simple VAR model tells us that the money aggregate has a positive effect on nominal GDP in the entire sample, although the magnitude of nominal GDP response to money aggregate shock differs. The most significant response is in Japan, where there is around a 0.7% increase of nominal GDP after 1% of money aggregate-tightening, although the impulse response is only 0.3% in the U.S. and Germany, and is not significant in the U.K. Comparing the impulse responses before and after the structural break in each country reveals that the magnitude of impulse response of nominal GDP to money aggregate shock is larger in the earlier period, and the impulse response is positive before and after the structural break.

Nominal GDP response to interest rate shock is negative in the U.S., Germany and Japan, as is theoretically expected, but is positive in the U.K. for the first several quarters in the entire sample test. More importantly, the study finds that positive effect of interest rate innovation on nominal GDP after the break in each four countries. Therefore the pattern of nominal GDP response to interest rate shock is uncertain. In the subsample test, the VAR models also find no constant pattern of impulse response of nominal GDP to interest rate shock before and after the structural break in each country.

Thus, based on the impulse response, it is concluded that money aggregate might be a more appropriate variable to target nominal GDP than short-term interest rate.

In order to find out which factor influences nominal GDP the most, the study provides the variance decomposition results. The results suggest that money aggregates shock accounts for nominal GDP by a similar percentage as interest rate shock does in the U.S., U.K. and Germany, however, M2 accounts for nominal GDP more than interest rate does in Japan in the entire sample. In the earlier period, money aggregates innovation accounts for a notably larger amount of nominal GDP than interest rate does in Germany and Japan, but not in the U.S. and U.K. In the later period, money and interest rate shock all account for little nominal GDP except in the U.K., which implies the possibility that an unknown factor that influences nominal GDP is not included in the model. The study will continue with the search for this factor in the next chapter.

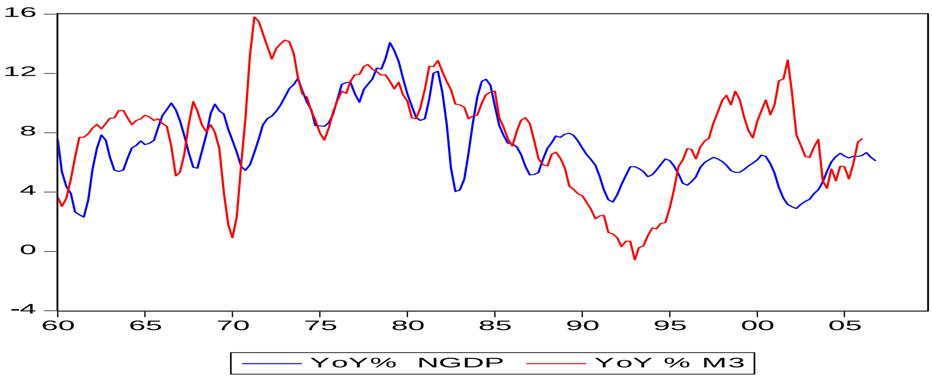
Generally, in line with the results of simple regression, Granger causality, and impulse response, money aggregate has more predictive power for nominal GDP than interest rate, although variance decomposition does not provide supporting evidence. On the other hand, variance decomposition implies that some factors that influence nominal GDP may not have been included. Looking to the next chapter, the research will shed some light on the link between GDP-circulation credit and nominal GDP.

Appendix to chapter 5

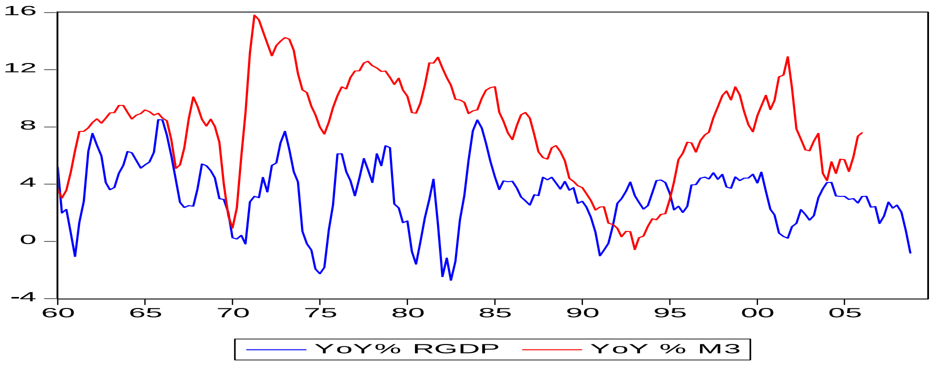
Appendix 5.A M3, nominal GDP, real GDP, CPI growth rate in the U.S.

Figure A 5-1 U.S. Four-quarter growth of (a) M3 (red line) and nominal GDP (blue line) (b) M3 and real GDP, (c) M3 and CPI 1960:1- 2009:4

(a) Annual Nominal GDP growth and M3



(b) Annual Real GDP growth and M3



(c) CPI growth and M3

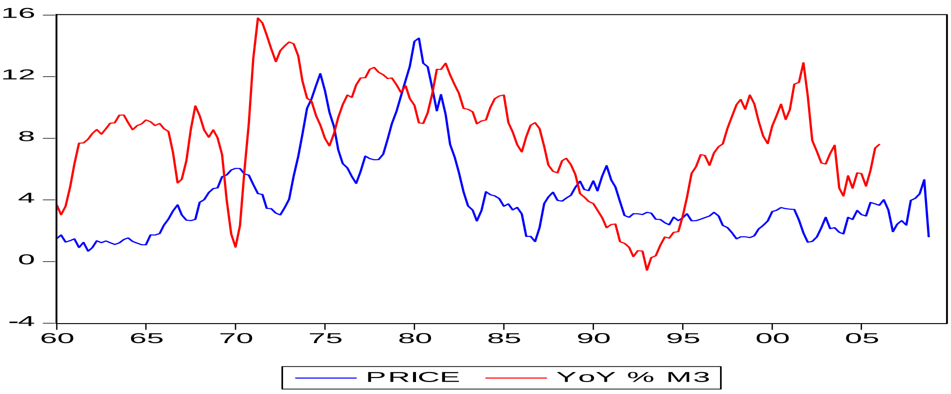
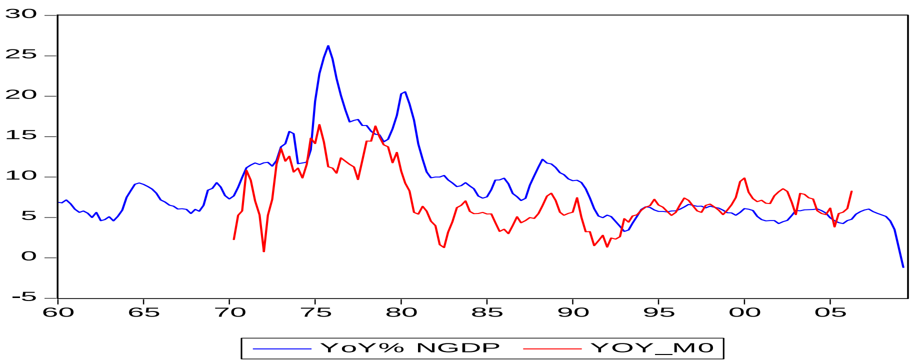
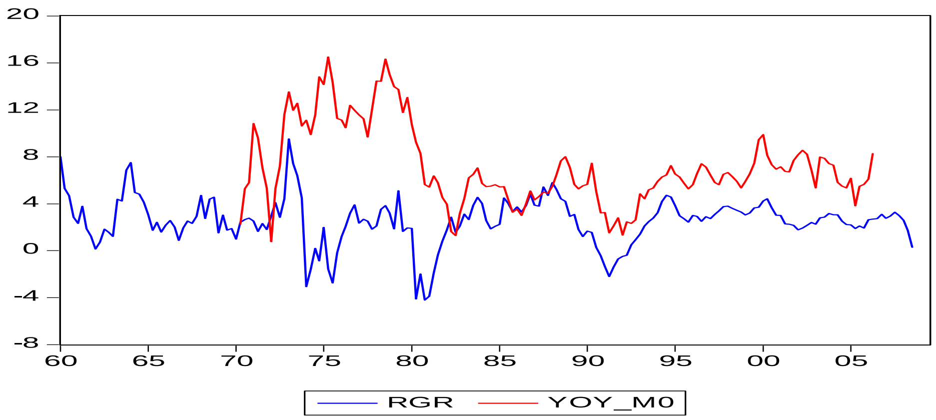


Figure A 5-2 U.K. Four-quarter growth of (a) M4(red line) and nominal GDP(blue line) (b) M4 and real GDP, (c) M4 and CPI 1960:1- 2009:3

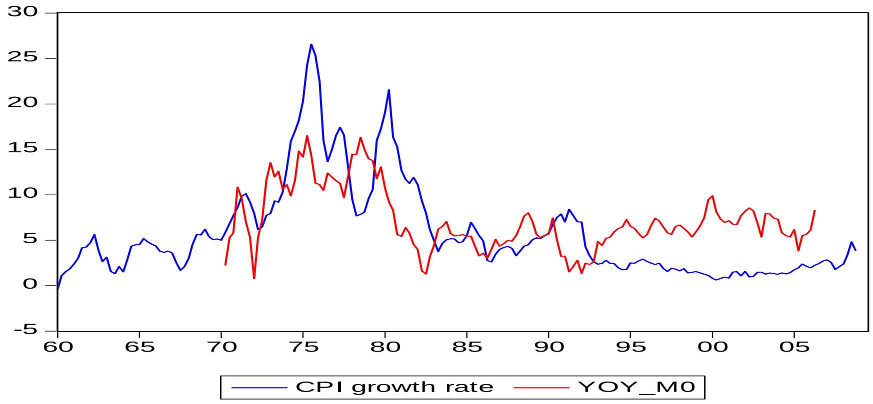
(a) Annual Nominal GDP growth and M0



(b)Annual Real GDP growth and M0



(c) CPI growth and M0



Appendix 5.B Chow breakpoint test

Table B 5-1 Chow breakpoint test for structural break. (dependent variable: nominal GDP growth)

Countries	Eq.	Regressor			Break	Chow Test	
						F-Statistic	P-Value
U.S.	1	M2				12.021***	0.00
	2	M2	PGR	R-90	1979:03	4.996***	0.00
U.K.	1	M4				31.38534	0.00
	2	M4	PGR	R-90	1992:04	13.28969	0.00
Germany	1	M3				14.987	0.00
	2	M3	PGR	R-90	1990:03	10.35286	0.00
Japan	1	M2				22.22657	0.00
	2	M2	PGR	R-90	1990:04	16.21684	0.00

Appendix 5.C Unit root test for money aggregates

Table C 5-1 Unit Root results of money aggregates

Countries	Time period	ZA	ADF		PP	
			t-Statistic	Prob.*	Adj. t-Stat	Prob.*
U.S.	1960Q1-2008Q4	-4.96843 at 1987:02	-0.974	0.294	-3.034	0.033
U.K.	1960Q1-2008Q3	-3.33761 at 1986:04	-2.14736	0.2266	-2.58878	0.0972
Germany	1961Q1-2008Q4	-5.88322 at 1996:01	-1.84396	0.0622	-3.04215	0.0025
Japan	1960Q1-2008Q4	-3.44116 at 1971:01	-1.7292	0.0794	-1.63519	0.0962

Model C Critical values at the 1%, 5% and 10% level are -5.57,-5.08 and -4.82, respectively (Zivot and Andrews, 1992)

Appendix 5.D Cointegration test

Table D 5-1Cointegration test in the entire sample

Null Hypothesis: has a unit root			nominal GDP and money
Countries	Fullbreak	trend	constant
US	-3.96619 at 1993:03	-3.76942 at 1993:03	-3.57738 at 1993:03
U.K.	-2.95812 at 2005:02	-3.22684 at 1976:02	-3.22684 at 1976:02
Canada	-2.54702 at 1987:04	-3.49091 at 1990:02	-2.61261 at 1998:03
Germany	-3.80015 at 1967:02	-4.70272 at 1990:04	-4.27585 at 2001:04
Japan	-2.95991 at 1989:04	-3.49252 at 2000:03	-2.95287 at 2000:02

Table D 5-2Cointegration test in the subsamples

Null Hypothesis: has a unit root				nominal GDP and money
Countries	Time period	Fullbreak	trend	constant
US	1960Q1-1979Q3	-4.23096 at 1976:02	-3.65618 at 1973:02	-3.52 at 1969:04
U.K.	1960Q1-1992Q3	-3.05342 at 1979:01	-3.30126 at 1979:01	-2.99713 at 1978:01
Germany	1960Q1-1990Q3	-3.10258 at 1990:03	-4.68613 at 1982:01	-3.10258 at 1990:03
Japan	1960Q1-1990Q4	-3.96081 at 1981:04	-3.10317 at 1975:04	-3.96081 at 1981:04

Null Hypothesis: has a unit root				nominal GDP and money
Countries	Time period	Fullbreak	trend	constant
US	1979Q4 - 2008Q4	-2.98732 at 1993:03	-2.53059 at 2002:03	-2.93559 at 1993:03
U.K.	1992Q4-2008Q4	-2.95812 at 2005:02	-3.02914 at 2003:03	-1.47890 at 2006:03
Germany	1990Q4-2008Q4	-5.41218 at 1995:02	-5.02264 at 1996:02	-5.03975 at 1995:02
Japan	1991Q1-2008Q4	-3.34158 at 2000:02	-5.12623 at 1996:04	- 3.35039 at 2000:04

Critical Values are 1% -5.47 and 5% -4.95 (fullbreak), Critical Values are 1% -5.45 and 5% -4.99(trend) Critical Values are 1% -5.13 and 5% -4.61(constant)

Appendix 5.E Granger causality test

Table E 5-1 Granger Causality Test

Countries	Real GDP does not GC money		money does not GC Real GDP	
	F-statistic	P-value	F-statistic	P-value
U.S.	3.582688	0.0022	1.885695	0.0856
U.K.	0.963312	0.4903	1.180904	0.299
Germany	1.603464	0.1613	1.298269	0.2666
Japan	1.853372	0.0552	3.133932	0.0011
Countries	inflation does not GC money		money does not GC inflation	
	F-statistic	P-value	F-statistic	P-value
U.S.	2.64029	0.01783	1.08817	0.37137
U.K.	2.01425	0.0565	2.69954	0.0114
Germany	2.88476	0.0009	1.33232	0.1999
Japan	1.14	0.33	3.49661	9.00E-05
Countries	3-month Treasury bill rate does not GC money		money does not GC 3-month Treasury bill rate	
	F-statistic	P-value	F-statistic	P-value
U.S.	7.7367	2.20E-07	1.09523	0.36715
U.K.	1.09708	0.3676	2.00764	0.0573
Germany	0.70168	0.6486	0.323	0.9243
Japan	2.07032	0.02	1.16564	0.3118

Appendix 5.F Impulse response results

Table F 5-1Impulse response of nominal GDP to money shock in 4- variable VAR model

Period	U.S.	U.K.	Germany	Japan
1	0	0	0	0
2	0.079468	-0.095764	0.088759	0.216709
3	0.186092	-0.14099	0.017604	0.349144
4	0.310924	-0.011498	0.294435	0.338279
5	0.340041	-0.024686	0.136264	0.449437
6	0.280516	0.073412	0.093748	0.49427
7	0.259085	0.117347	0.148035	0.61475
8	0.18536	-0.004392	-0.02652	0.739839
9	0.130144	0.056172	-0.011324	0.829828
10	0.149996	0.055382	0.009148	0.844914
11	0.093975	0.0794119	-0.084805	0.795789
12	0.083283	0.21766	-0.0036619	0.719609

Table F 5-2Accumulated impulse response of nominal GDP to money shock in 4- variable VAR model

Period	U.S.	U.K.	Germany	Japan
1	0	0	0	0
2	0.079468	-0.0932570	0.091063	0.202157
3	0.265559	-0.229248	0.126794	0.532096
4	0.576483	-0.237748	0.438588	0.856156
5	0.916524	-0.261336	0.601076	1.268712
6	1.19704	-0.179619	0.707534	1.769322
7	1.456125	-0.058766	0.873816	2.360327
8	1.641485	-0.060511	0.877681	3.045847000
9	1.771628	-0.00404	0.897979	3.802835
10	1.921624	0.039048	0.947845	4.525177
11	2.015599	0.105677	0.893526	5.19346
12	2.098882	0.306363	0.910857	5.781953

Table F 5-3Impulse response of price to money shock in 4- variable VAR model

Period	U.S.	U.K.	Germany	Japan
1	0	0	0	0
2	0.07083	-0.3078	0.069645	0.100686
3	0.053076	-0.181441	0.086455	-0.025573
4	0.12764	-0.040947	0.111638	0.010333
5	0.223451	0.068374	0.207581	-0.127497
6	0.120196	0.203998	0.268101	-0.013404
7	0.160012	0.13876	0.230592	0.346418
8	0.128613	0.213982	0.152626	0.422067
9	0.02223	0.366907	0.023628	0.637006
10	0.121157	0.483583	-0.09196	0.641931
11	0.059006	0.586483	-0.074035	0.3565
12	0.0060010	0.499944	-0.036408	0.275729

Table F 5-4Impulse response of nominal GDP to interest rate shock in 4- variable VAR model

Period	U.S.	U.K.	Germany	Japan
1	0	0	0	0
2	0.243582	0.031138	-0.025194	-0.03448
3	0.106311	0.063921	-0.159089	-0.037839
4	-0.089225	0.040966	-0.168317	-0.018326
5	-0.223606	0.014266	-0.236525	-0.099505
6	-0.355405	0.117321	-0.116225	0.086509
7	-0.357066	0.052663	-0.167631	-0.024547
8	-0.324032	0.036399	-0.263452	-0.137098
9	-0.346119	0.006163	-0.275107	-0.203548
10	-0.316635	-0.167733	-0.3556	-0.409491
11	-0.294475	-0.173613	-0.26098	-0.436073
12	-0.274943	-0.226462	-0.182853	-0.460405

Table F 5-5 Impulse response of price to interest rate shock in 4- variable VAR model

Period	U.S.	U.K.	Germany	Japan
1	0	0	0	0
2	0.224465	0.433552	0.034173	0.004747
3	0.334564	0.652037	0.165876	0.059863
4	0.354852	0.841704	0.195356	0.429938
5	0.371428	0.811901	0.188725	0.291305
6	0.176942	0.597317	0.117734	0.232877
7	0.049598	0.514092	-0.009922	0.210668
8	-0.02598	0.286386	-0.052549	-0.311068
9	-0.197894	0.114561	-0.073186	-0.441189
10	-0.236143	-0.120168	-0.036524	-0.565007
11	-0.270249	-0.480568	0.009712	-0.773329
12	-0.318809	-0.58018	-0.003108	-0.5322

Table F 5-6 Impulse response of money to interest rate shock in 4- variable VAR model

Period	U.S.	U.K.	Germany	Japan
1	-0.169445	0.09085	-0.216324	0.16102
2	-0.454497	0.113599	-0.215064	0.175067
3	-0.544479	-0.003976	-0.262418	0.085497
4	-0.522846	-0.197946	-0.090165	-0.066083
5	-0.37319	-0.258224	0.096708	-0.229932
6	-0.249201	-0.142699	0.025548	-0.377394
7	-0.277273	-0.086965	-0.001804	-0.440527
8	-0.234002	0.024403	-0.179514	-0.437156
9	-0.178992	-0.013739	-0.283543	-0.416066
10	-0.067367	-0.103973	-0.223627	-0.327873
11	0.10301	-0.036360	-0.186603	-0.232444
12	0.144047	-0.04494	-0.049409	-0.135765

Note: The time period is 1960Q1-2008Q4 in the U.S., U.K., and Japan, and 1970Q1-2008Q4 in Germany

Chapter 6

6 Empirical evidence on the relationship between credit and nominal GDP in the U.S., U.K., Germany and Japan from 1960s to 2008

Abstract: Over the past twenty years a considerable amount of literature has focused on the interest rate or money aggregate as the monetary policy instruments.(Friedman and Schwartz,1963; Friedman, 1970; Bernanke and Blinder, 1988; McCALLUM, 1988; Bernanke and Blinder, 1992; Henderson and McKibbin, 1993; Taylor, 1993, 1995,1998; Bernanke and Gertler, 1995; Bernanke et al., 2001; Friedman, 2000; Friedman, 2005) However, there is a need to explore the topic from the credit viewpoint. The central banks have paid much closer attention to credit variables since the 2007/08 financial crisis, as the crisis made the central banks realize the limitations of using interest rate as the monetary policy instrument. In this chapter, the central hypothesis to be examined is that the GDP-circulation credit[43] could be a variable in targeting nominal GDP. The credit can be disaggregated to real GDP effective transactions and to financial speculation transactions that were first proposed by Werner (1993, 1994, 2003, and 2005). In order to test the hypothesis, the empirical test employs the general-to-specific (GETS) model, the "causality" test and the VAR model. Though the results obtained from different econometric models are not entirely consistent, the role of credit variable in the effect on nominal GDP should be reconsidered, because the positive evidence of using GDP-circulation credit to target nominal GDP is found in the GETS model, the "causality" test and VAR model.

6.1 Introduction

In the last twenty years, the widely accepted argument has been that a low inflation level benefits economic growth and the models often simply assume that the impact on the economic conditions could be reflected by fluctuations in interest rate. (Svensson 1997, 1999, 2000, 2002; Bernanke and Mishkin, 1997, Bernanke et al., 2001) Therefore, the central banks' monetary policy has turned to target inflation via changes in short-

[43] Richard. A .Werner (1991, 1993, 2003, 2004, and 2005) has defined the concept of the GDP-circulation credit as the credit used for the real economic activities, but not for the financial speculations.

term interest rates. Despite the generalised use of short-term interest rates, the interaction with the real economy is becoming increasingly complex, especially with the advent of several serious financial crises which have hit the economy since the 1990s. After experiencing the financial crisis of 2007/08, the central banks have realised that the financial market has become more and more complex, and have acknowledged the limitations of using the interest rate as the sole instrument in affecting the flow of credit.

During the crisis of 2007/08, the fears of a lack of liquidity swamped the financial markets after Lehman Brothers went bankrupt in the summer of 2008; this suddenly caused the financial credit markets to freeze, with the central banks across the world reducing their short-term interest rates. Even with this stimulus, bank lending is continuing to fall because financial institutions are unwilling to lend to consumers or other institutions, and the criteria of credit standard has tightened.[44] To combat the situation, the central banks have had to inject billions of credit into the markets.[45] In fact, the policy-makers take into account a wide range of information on conditions in financial markets to monitor and attempt to respond to various sorts of financial development. The policy-makers no longer only watch the interest rate in the market, but also look at the credit conditions in the market. [46]

[44] "The total dollar amount of new loans declined in three of the four months the government has reported this data. Just three of the 19 largest TARP (Troubled Asset Relief Program) banks increased lending from October to February and the total dollar amount of new loans declined in three of the four months." Source: "Bank Lending Keeps Dropping" April 20, 2009 WSJ
Total lending by banks and building societies fell by £2.5 billion ($3.91 billion), a smaller drop than the £3.2 billion decline recorded the previous month, BOE monthly report, Trends in Lending September 20 2010.

[45] The Troubled Asset Relief Program, commonly referred to as TARP or RCP, is a program of the United States government to purchase assets and equity from financial institutions to strengthen its financial sector which was signed into law by U.S. President George W. Bush on October 3, 2008. TARP allows the United States Department of the Treasury to purchase or insure up to $700 Billion of "troubled assets", in which the $250 billion was used to purchase the assets and then either sell them or hold the assets and collect the 'coupons'. The initial $250 billion can be increased to $350 billion upon the President's certification to Congress that such an increase is necessary. The remaining $350 billion may be released to the Treasury upon a written report to Congress from the Treasury with details of its plan for the money. Summary of the Emergency Economic Stabilization Act of 2008 United States Senate Committee on Banking, Housing and Urban Affairs. (Retrieved October 2, 2008)
"To promote a stronger pace of economic recovery and to help ensure that inflation, over time, is at levels consistent with its mandate, the Committee decided today to expand its holdings of securities. The Committee will maintain its existing policy of reinvesting principal payments from its securities holdings. In addition, the Committee intends to purchase a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011, a pace of about $75 billion per month." FOMC Statement November 3rd 2010

46 The Bank of England (BOE) started to publish the trends in lending since April 2009 and the Federal Reserve also took the step of publishing the monthly Report on Credit and Liquidity Programs and the Balance Sheet after the crisis happened in the summer of 2007

Moreover, the approach of using monetary aggregates as the monetary policy instrument variables has not been popular in the developed countries in the last twenty years because of the instability of the money aggregate function and the continuing decline in the velocity of money aggregate. Therefore, the weakness of interest rate or money aggregate as the instrument variables to target the real economy stimulates the research to seek a new monetary policy instrument variable.

In chapters 4 and 5, the research also finds that the fluctuations of short-term interest rate tend to follow the trend of nominal GDP rather than leading the change of nominal GDP, so the short-term interest rate is not an appropriate indictor for nominal GDP. Furthermore, the short-term interest rate has less predictive power than money aggregates to target nominal GDP. However, chapter 5 indicates there is a factor that might influence nominal GDP, but it is not included in the model. As a result, the interest in using credit variables to target nominal GDP is raised after discussing these weaknesses of traditional approaches, based on interest rates and money aggregates.

According to Fry (1998), the central banks in the developing economies try to control domestic credit expansion to monitor economic growth. This differs from developed economies, where the central banks tend to use indirect ways, such as the interest rate. There is a long tradition of using direct controls on the supply of credit in the developing countries, and not only in special cases. An example would be the setting of credit supply targets in China. The fact that the continuing high economic growth is accompanied by the growth in credit supply from central banks in the rapid expansion stage of the economy throws up the question of whether credit has a direct effect on economic growth. If the answer to this question is yes, then it is necessary to ask whether it is possible to use the credit supply as the monetary policy intermediate target.

In previous research, this issue has been addressed in theoretical terms in the credit channels. Two credit channels have been identified: a balance sheet channel and a bank lending channel. The first one has suggested that lending is linked to observable features of the financial health of the borrowing firms, while the second one identifies the lending flow as originating from within the banking system. Although the credit view attempts to provide a macroeconomic framework that credit affects the economy through the credit channels, the operation of credit channels also incorporates the interest rate to achieve the effect on the economy.

A substantial part of the credit view focuses on the credit rationing argument. Stiglitz and Weiss (1981) have proposed the concept of credit rationing. They showed that credit markets will be rationed as long as information is asymmetric between borrowers and lenders. Because the credit rationing argument emphasises the microeconomic foundation, it is difficult to explain the link between credit and the macroeconomic condition solely through the finding in itself. As Werner (2005) argued the credit rationing argument does not explain why other sources of funding can not be a substitute for bank credit.

Monetary policy analysis has a long tradition of using macroeconomic models to perform the quantitative analysis. Later, modern macroeconomists built up models that included the microeconomic assumptions concerning the consumers, firms, and policy-makers. The DSGE (Dynamic Stochastic General Equilibrium) model is one of these. The DSGE model specifies particular assumptions, and attempts to explain the aggregate economic conditions, such as economic growth, the effect of monetary policy and fiscal policy. The general DSGE model considers the behaviour of householders, firms and the monetary authority, and assumes a general equilibrium between these parties. In the traditional DSGE model, there are no banks and no financial institutions. Recently, a few studies have started to focus on the role of banking in the DSGE model(Atta-Mensah and Dib, 2008, Gerali et al., 2008, Gerali et al.). In addition, they found that credit accounts for substantial fractions of output in the short term and medium term.

It has been the trend to emphasize the role of credit and financial intermediation for macroeconomic fluctuations and monetary policy transmission over the past two years(Goodfriend and McCallum, 2007, Cúrdia and Woodford, 2009, Mishkin, 2010). In particular, the development of the literature of non-price aspects of credit restriction has contributed to policy strategy in the economic downturns(Bernanke, 1983). After the financial crisis, the researchers have especially recognized that the available flow of credit between financial intermediates and business sectors and households could put extraordinary restrictions on spending. However, the core macroeconomic models used in most central banks around the world only have a constricted role for the balance sheet of the financial intermediation. The various studies have considered the effect of asset price movements, but credit supplies were not well-captured in the models (Mishkin, 2010). It was even suggested in the literature review of monetary transmission that credit did not play an important role in the models that central banks used or in the academic research. (Kohn, 2009)

> "It is fair to say, however, that the core macroeconomic modelling framework used at the Federal Reserve and other central banks around the world has included, at best, only a limited role for the balance sheets of households and firms, credit provision, and financial intermediation. The features suggested by the literature on the role of credit in the transmission of policy have not yet become prominent ingredients in models used at central banks or in much academic research." (Kohn, 2009)

However, there are encouraging signs in that a large number of recent studies have added credit creation and banking sectors to the conventional monetary policy models because of a burgeoning realization that the supply constraints on credit provision significantly affect spending(Goodfriend and McCallum, 2007, Canzoneri et al., 2008, Christiano et al., 2010).

Johnson (2010) argued that the Fed was failing to seize the opportunities to reform the financial system, and thought the central banks had not solved the issue of "too big to fail"- the notion that big banks will be bailed out if their failure represents a systemic risk. However, the differing opinions on the bailout of the banking sectors indicate the importance of the banking sectors in the economy. The importance of banking in the economy causes the central banks to fear allowing the banks to go bankrupt, and credit creation is a unique feature of the banking sectors. Thus, the financial crisis of 20007/08 pointed out the obvious significance of the credit supply.

Although there is a trend toward considering the banking sectors in the models used by the central banks, it is fair to say that this is only supplementary to the current economic models. In order to understand the prominent role of credit creation by the banking sectors, a more powerful model may be required in order to explain the role of credit.

Werner (1992, 1997, and 2005) shows that Japanese nominal GDP growth in the 1970s, 1980s and 1990s can be explained by a credit disaggregated model that was derived from the quantity equation and empirically supported by a downward reduction of a general model including alternative explanations (M2, interest rates). In his framework, the GDP-circulation credit could be the variable to target, in order to achieve a particular nominal GDP. A few studies have explored the disaggregation of credit. Gertler and Gilchrist (1993, 1994) distinguished between loans to small and large firms; Kashyap and Stein (1995, 2000) considered the lending from small banks and large banks separately. However, their intention was to find evidence to support the credit channels. Werner's GDP-circulation credit model (1997, 2005) differed from the previous ones in that he used a new way to disaggregate the credit, and he also used this new GDP-circulation credit to target nominal GDP.

Our research follows the approach that Werner (2005) took in disaggregating the credit, and attempts to ascertain whether Werner's empirical findings (1992, 1997, 2005), that GDP-circulation credit is an appropriate variable to target nominal GDP in Japan, could be generalised to other industrial countries. In Werner's model, the credit flow from the banking system would be disaggregated to distinguish between the credit linked to real GDP-effective transaction and the flow to the financial market for speculation. The loans to the asset market in each country, as part of the credit flow into the financial markets, are intended for speculation, which does not directly link to the real economy. However, the credit flow into the real economy does affect real GDP (Werner 1997, 2003, 2005). Based on this theory, credit for transactions that contribute to GDP might be more correlated to economic growth than total credit.

This empirical research enriches the studies on targeting nominal income, and intends to provide empirical evidence for the arguments that nominal GDP is a considerable targeting rule. Meanwhile, it also presents a new angle to consider the role of GDP-circulation credit, and expands the literature on the importance of credit in economic activities. Nowadays in particular, the credit aggregates or GDP-circulation credit data are seriously examined by central banks all over the world; thus this research will be useful for monetary policy-making.

Before proceeding to the literature review, it is first necessary to briefly summarise the trend of central banks beginning to focus on the credit data after the 2007/08 financial crisis.

The trend towards publishing more credit information after the 2007/08 financial credit crisis

As part of its mission to maintain monetary and financial stability, the Bank of England realised the need to understand trends and developments in credit conditions. Thus, Bank of England monthly publications, established by the Bank of England in late 2008, present the Bank's assessment of the latest trends in lending to the U.K. economy.[47] The trend in lending provides more timely data covering aspects of lending to the UK corporate and household sectors; for the purposes of analysis, the lending data are divided into lending to UK businesses, consumer credit and mortgage lending. Therefore, the lending to businesses, consumer credit and mortgage lending are important financial variables that the Bank of England now emphasises more than before.

It is not a coincidence that the Federal Reserve has also begun publishing a monthly report on "Credit and Liquidity Programs and the Balance Sheet" since the 2008 financial crisis. The Federal Reserve clearly pointed out that the preparation of this report is part of its efforts to strengthen transparency about the range of programs faced and tools that have been utilised in response to the financial crisis and to ensure proper accountability to Congress and the public. Most of the programs during the financial crisis are credit arrangement, [48] thus the importance of the credit effect on economic conditions cannot be ignored.

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47 The Bank of England started to publish "the trends of lending" since the later 2008. This report presents the Bank's assessment of the latest trends in lending to the UK economy and draws mainly on long-established official data sources, such as the existing monetary and financial statistics collected by the Bank of England. Source: Bank of England.
http://www.bankofengland.co.uk/publications/other/monetary/trendsinlending.htm

48 The Federal Reserve responded aggressively to the financial crisis that emerged in the summer of 2007. The tools described in this section can be divided into three groups. The first set of tools, which are closely tied to the central bank's traditional role as the lender of last resort, involve the provision of short-term liquidity to banks and other depository institutions and other financial institutions. A second set of tools involve the provision of liquidity directly to borrowers and investors in key credit markets. The CPFF, AMLF, MMIFF, and the Term Asset-Backed Securities Loan Facility (TALF) fall into this category. All of the programs are described in detail elsewhere on this website. As a third set of instruments, the Federal Reserve has expanded its traditional tool of open market operations to support

Within the European Union, the Eurosystem publishes a survey on bank lending for the Euro area. The survey addresses issues such as credit standards for approving loans as well as credit terms and conditions applied to enterprises and households. It also asks for an assessment of the conditions affecting credit demand. The purpose of the survey is to help the Governing Council of the European Central Bank (ECB) to assess monetary and economic developments as an input into monetary policy decisions. [49] Credit information has already become a matter of key concern to central banks, although it has been highlighted as much as interest rate over the past twenty years. However, changes have been more noticeable since the 2007/08 financial crisis, and a greater emphasis has been put on credit information by central banks.

6.2 Literature review on the relationship between credit and economic conditions

In this part, the main area of study to be reviewed concerns the link between credit and economy. Kohn (2009) suggested the research on the credit channel in the financial sector consider the role of asset price in the monetary policy transmission, because in neoclassical models, asset price will effect the investment and spending decisions by wealth effects. However, these models fail to capture the interactions among asset price, credit, and economic condition, which has been the important feature in the current economic situation. The research briefly reassesses some theories on credit, such as credit rationing and the DSGE model heavily used in this area. However, it starts by investigating the credit channels.

6.2.1 The credit channel

After the failure of monetarism, researchers began to realise that the traditional monetary view has some impractical assumptions and cannot completely explain the real economy. According to Bernanke (1993, 1995), the traditional monetary view is too narrow to capture all the responses of the real economy to monetary policy change. Additionally, the timing of the real economy does not respond very well to interest rate

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the functioning of credit markets through the purchase of longer-term securities for the Federal Reserve's portfolio. Source: The Federal Reserve's response to the crisis. http://www.federalreserve.gov/monetarypolicy/bst_crisisresponse.htm

[49] Source: Bank of European available: http://www.ecb.int/stats/money/surveys/lend/html/index.en.html

shock. As a result, the credit channel provides an alternative monetary policy transmission channel based on the assumption of imperfect information in the financial markets. In the credit channel view, the monetary policy could influence not only the money price-interest rate, but also money volume-credit; thus, the aggregate demand of loans would be affected.

According to Bernanke (1993), there are three merits in understanding the existence of the credit channel of money transmission mechanism. First, it is the channel that could improve the measurement of magnitude and timing of the monetary policy's impact on the real economy. Second, credit could be the variable that is useful to indicate a monetary policy, especially in extreme financial circumstances, such as a credit crisis. Lastly, it could be helpful in assessing whether banks are crucial in the modern financial markets.

The simplest empirical implication of the bank-centric credit view is to find the closely correlated link between bank loan and economic output. This view argues that constraint of real quantity on lending would affect investment and, hence, the real economy. Bernanke (1992) pointed out a strong correlation between loans and unemployment, GNP and other key macroeconomic indicators. However, empirical studies set out to find more complicated links between bank loan and the real economic output. Bernanke and Gertler (1995) and Gertler and Gilchrist (1993) proposed the concept of the external finance premium (EFP). The EFP acts as a difference between the opportunity cost of internal funds and the cost of external funds. The size of the EFP reflects two aspects: the asymmetric information in the credit market and a borrower's net worth relative to the size of the loan. Thus, there are two forms of credit channel, namely the banking lending channel (the narrow credit channel) and the balance sheet channel (the broad credit channel). There is also a third channel called the bank capital channel, which emphasises the banks' capital. This feature of credit channel is ignored by the previous two channels. (Thakor 1996; Furfine 2000; Van den Heuvel 2002, 2006, 2007; Sunirand 2003; Gambacorta and Mistrulli, 2004; Engler 2005)

6.2.1.1 The banking lending channel

The banking lending channel, also referred to as the narrow credit channel, relies on credit market frictions. The original concept of bank lending goes back to Roosa (1951) and became the centre of academic interest in Bernanke and Blinder's (1988) influential paper. The fundamental insight to be gained from the bank lending channel is that monetary authorities could influence the volume of bank loans in the market through the requirement of reserveable demand deposits; furthermore, a decline in loan supply would decrease the aggregate spending. These statements have three assumptions. First, monetary authorities should be able to affect the bank reserve and hence the supply of bank loans in the financial market through open-market operations or other monetary instruments. Second, the banks might not easily find substitutes to replace the loss of deposits, and should not be able to offset the influence from monetary authorities. Third, there should not be perfect substitutes for bank loans for a significant subset of borrowers. A considerable number of borrowers heavily rely on bank loans, and therefore a reduction in the bank supply would depress aggregate spending. These assumptions clearly depend on the regulation in markets and the structure of the financial systems (Fernando Barran 1996).

Bernanke, Kashyap and Stein are the major contributors to the bank lending channel research. Their work has provided support, through empirical evidence, for the bank lending channel. Bernanke and Blinder (1992) have used Granger Causality tests and a vector autoregressions approach to find a strong correlation between real output and short-term interest rate. They explained this empirical evidence as support for the effectiveness of monetary policy and demonstrated that monetary policy is effective through the credit channel. McMillan (1996) also researched the credit channel in the U.S. for the period 1973-1994, and found results that are consistent with the Bernanke-Blinder model.

Kashyap, Stein and Wilcox (1993) found evidence for the effectiveness of credit on real output after proving that the tightening of monetary policy leads to a change in a firm's external financing. For example, a bank loan fall would lead to a commercial paper issuance increase, which suggests that a contractionary policy could reduce the loan supply; additionally, the shift in loan supply would influence investment, even controlling interest rates and output. Barran, Coudert, and Mojon (1996) suggested that the credit channel could also be effective in European countries. Hallsten (1999) also found evidence to confirm this correlation in Sweden. Further to this, Van Ees et al. (1999) found that the loan supply was largely influenced when an amount restriction was withdrawn in the Netherlands by testing the shift of banks' balance sheets to monetary policy shock for the period 1957-1991.

Lown and Morgan (2000) provided a different angle to test the credit channel, which is to examine the change of bank lending standards to monetary policy shock. They used the vector autoregressions (VARs) approach to find that lending standards has predictive power for both loan supply and real output. This empirical evidence strongly supported the view that that the shock to bank lending is important; however, it could be concluded that the bank lending channel is a central channel of monetary policy transmission.

Because the bank lending channel implies that effects would be different across firms or industries, some studies put an emphasis on whether the bank size affects the operation of the credit channel. Most of these studies confirm that the different size of banks or different bank types has a direct effect on the operation of the credit channel. Kashyap and Stein (1997) studied the balance sheet data from U.S. banks for the period 1976-1993. They found that monetary policy had a more significant effect on banks which had a less liquid balance sheet. De Bondt (1999) used data from bank balance sheets for the period 1990-1998 to explore whether banks with high liquidity or low liquidity responded to monetary policy differently. The findings suggested that the empirical evidence supports the fact that banking lending channels exist across Europe, but not in the United Kingdom.

Kishan and Opiela (2000) grouped the banks according to asset size and capital leverage ratio, and tested the bank loan change after monetary policy shock in the U.S. during 1980-1995. They concluded that small banks respond to policy shock more significantly than the rest, but that there is not much difference over different capitalization ratios.

Altunbas et al. (2002) used data on bank balance sheets to assess the response of banks of different asset size and capital strength to the change in monetary policy. Their results suggested that undercapitalized banks responded more significantly, which supports the notion that a bank lending channel is in operation.

Ford et al. (2003) examined whether the response to monetary policy shock was different across firm size and bank size in Japan for the period 1965-1995. They found evidence to support the presence of a bank lending channel in Japan until the end of 1984, but no evidence to confirm that after 1985.

De Haan (2003) also found similar results on the bank lending channel in the Netherlands, with more significant effects for small, less capitalized and less liquid banks and more loan contractions to businesses than to home owners.

Gambacorta and Mistrulli (2004), using data from Italian banks, established that capitalization does matter to the response of lending to shocks, which supports the existence of banking lending channels. These findings provide the credibility of bank lending channels in the monetary transmission mechanism.

Empirical evidence does not always support the existence of credit channels. Fuerst (1995) and Fisher (1996) found that real effect through credit channels is very small in the United States. Favero (1999) used data from balance sheets in France, Germany, Italy and Spain, but did not find any evidence to support the existence of credit channels during the episode of tightening monetary policy in 1992 for these four countries. Yuan and Zimmermann (1999) found an insignificant importance of monetary policy in a credit crunch model in Canada, but they suggested that loan regulation had important real effects. Kakes et al. (2001) differentiate between company loans and household lending in Germany, and found that banks respond to a monetary tightening by changing their securities holdings rather than reducing the loans portfolio, thus weakening the shock of monetary policy.

6.2.1.2 The balance sheet channel

The central notion of the balance sheet channel is that monetary policy affects the aggregate demand by influencing borrowers' balance sheets. An increase in the interest rate would lead to a fall of asset prices, which decreases the value of a borrower's collateral. The deduction of net worth would reduce the firms' willingness to borrow, therefore resulting in a decrease in investment and hence a shrinkage of the real economy.

Asset value plays an important part in the balance sheet channel. In the frictionless credit market, the investment decision would not be affected by the fall in value of a borrowers' collateral; however, in the presence of agency costs and information asymmetry, deduction of collateral value would raise the external finance premium, which in turn shrinks investment and consumption. Thus the effect of the interest rate on the real economy may be exaggerated through the balance sheet channel.

Gertler and Gilchrist (1993) found that monetary policy has a large effect on small firms which have little access to external funding, because small firms have more bankruptcy costs and comparatively small net worth. They also discovered that, after monetary policy tightening, bank lending to large firms rises, whilst lending to small firms declines. Bernanke and Gertler (1995) applied coverage ratio to the estimation of borrowers' financial position, and showed a relatively close correlation between coverage ratio and federal fund rate, which pointed out the strong link between monetary policy and the financial position of firms.

The banking lending channel and the balance sheet channel are actually the additional channels to the interest rates channel, because of the effect of credit through the interest rate in influencing the total demand. Therefore, interest rate as monetary policy should have a greater effect once the researchers recognize credit channels, but empirically this is not supported. In chapters 4 and 5, the study did not find any obvious empirical evidence to support the predictive power of interest rate to nominal GDP. Thus, the puzzle increases.

In the disequilibrium economics view, the interest rate-money price, which is proposed as being capable of clearing the financial market in an equilibrium model, might not be a good indicator for output (Korliras 1975; Charemza and Quandt, 1982; Quandt, 1983; Van Brabant, 1990; Werner, 2005). Some economists agree that the quantity is more important, particularly in the credit market. The credit rationing view outlines the underlying importance of credit quantity.

6.2.2 Credit rationing

(Jaffee and Russell, 1976) developed a model of loan markets to explain the rationing of credit. Stiglitz and Weiss (1981) proposed the existence of credit rationing in financial markets. The interest rate cannot by itself equalize demand and supply, and credit rationing plays an important role in allocating loan supply. Contrary to the traditional view, an increase in interest rate might attract risky customers while driving away the banks' more risk-averse customers; thus, even when there is an excess demand for loans, instead of raising the interest rate, banks will lend to those who are most likely to repay, while denying those who might not. The credit rationing theory is based on the micro-level analysis. Though credit rationing theory has pointed out the importance of quantity of credit, it only explains the credit arrangement at the micro-level, but does not provide the macroeconomic framework for credit's role in the economy (Werner, 2005)

6.2.3 Discussion of macro-models - DSGE (Dynamic Stochastic General Equilibrium) models

A "General equilibrium" model has the assumption that the market will be clear across the different sectors, and the "stochastic" indicates the unexpected shocks that hit the economy. "Dynamic" general equilibrium, unlike the static general model, explicitly captures the evolution across the steady state.

In practice, several central banks have developed the DSGE models for implementation (Murchison and Rennison, 2006; Harrison et al. 2005; Medina and Soto 2006; Adolfson et al. 2007(Lees, 2009). For example, they have been implemented in the Bank of England, the Bank of Canada and Bank of New Zealand. In academia, the DSGE model is mainly implemented in the New Keynesian School and the RBC school. Firstly, RBC theory builds on the neoclassical growth model to examine the real shocks to the economy, based on the assumption of flexible price. The starting paper by Kydland and Prescott (1982) showed the DSGE model in RBC theory. Furthermore, the RBC school found that, if it added the New Keynesian School features of introducing sticky price and imperfect competition in the DSGE model, the explanatory power of the model increased; meanwhile, the New Keynesians found there were advantages in using the DSGE model. Goodfriend and King (1997) named this combination NNS (new neoclassical synthesis), and Rotemberg and Woodford (1997, 2003) label themselves neo-Wicksellian

The disadvantage of DSGE model

Narayana Kocherlakota, the President of the Federal Reserve Bank of Minneapolis, has pointed out the DSGE models were not useful for analyzing the financial crisis of 2007/08. Nevertheless, he argued that these models have room for improvement, and there is a consensus to include the financial market frictions and price stickiness in the DSGE model. Atta-Mensah and Dib (2008) incorporate the financial intermediates in the DSGE model, and attempt to examine the role of bank lending as a transmission mechanism of monetary policy shocks. Their findings suggested that exogenous credit shocks account for substantial fractions of output, inflation, and nominal interest rates fluctuations in the short and medium terms. Although the trend towards considering the role of credit in the macroeconomic models has been popular since the financial crisis of 2007/08, there is still insufficient research focusing on credit, especially in the banking sectors. Moreover, the DSGE model also has its limits as an analytical tool.

Solow (2010) said, in the statement "Building a science of Economics for the Real World"[50],

> "The DSGE model has nothing useful to say about anti-recession policy because it has built into its essentially implausible assumptions the "conclusion" that there is nothing for macroeconomic policy to do. I think we have just seen how untrue this is for an economy attached to a highly-leveraged, weakly-regulated financial system." (Solow 2010)

6.2.4 **The use of GDP-circulation credit to target nominal GDP**

The discussion of the previous studies in relation to credit reveals that both theoretical and empirical research admits the important role of credit in the economy. In particular, since the financial crisis of 2007/08, adding the credit variable to the existing models has been the trend of recent researches although credit is a supplementary variable for interest rate rather than a predominant variable in these models. We need a framework

[50] Prepared Statement "Building a Science of Economics for the Real World" July 20, 2010. House Committee on Science and Technology Subcommittee on Investigations and Oversight. Robert Solow Professor Emeritus, MIT

in which credit has a powerful role in the economy; therefore, Werner's GDP-circulation credit model will be introduced in the following part.

The theory model

Werner modifies the traditional quantity equation of money (Fisher, 1911), with the starting point of replacing credit with money, and then disaggregating credit. The following formulations attempt to explain this in more detail:

$$M \times V = P \times Q \qquad (6.1)$$

According to the definition of the equation, the money supply in circulation (M) multiplied by the velocity (V) must be identical to the vector of prices (P) multiplied by the quantity of all transactions (Q). Variable (Q) stands for the output measured in volume that is real GDP (Y). Variable (P) refers to price level that is the GDP deflator and, sometimes, CPI can be used as a proxy for this. Thus, the right-hand side of the equation is identical to the nominal GDP. On the left-hand side of the equation, velocity of money multiplied by the money supply is equal to the total effective money supply.

Theoretically, the disaggregated transaction data could be used in the equation. The only issue is whether the appropriate disaggregated data could be found to proxy the theoretical breakdown in empirical work. On the other hand, GDP is the sum total of all final consumer goods and services produced; thus, any transactions in property market, stock market and bond market are not included in the calculation of GDP. In short, financial transactions are not included. (Howells and Mariscal, 1992) used aggregate monthly data on inter-bank and inter-branch payments provided by the Association of Payments Clearing System (APACS) in the U.K. They found that the increase in financial transactions during the 1980s explained the apparent decline in the income velocity of the traditional quantity equation in the U.K. Thus, it is necessary to remove financial transactions from the right-hand side of the equation.

Werner (1992, 1997, and 2005) has tried to disaggregate both sides: on the left hand, it is disaggregated into the money used for transactions that are part of GDP ($M_r V_r$) and those that are not (called $M_f V_f$) ; and on the right hand, it can be divided into the value of transactions that are part of GDP ($P_r Q_r = P_r Y$) , and those that are not $P_r Q_r$:

$$MV = M_r V_r + M_f V_f \qquad (6.2)$$

$$PQ = P_r Q_r + P_f Q_f \qquad (6.3)$$

Because $P_r Q_r$ was defined as the value of all GDP-based transactions, the following equation would hold, where P_r stand for the GDP deflator and $P_r Y$ stands for nominal GDP

$$M_r V_r = P_r Y \qquad (6.4)$$

With $V_r = (P_r Y) / M_r$ =constant

Werner (2005) provided the theory that the amount of money used for GDP effective transactions during any period of time ($M_r V_r$) must be equal to nominal GDP, with a stable 'real' velocity of money (V_r). Meanwhile, the amount of money used for non-GDP transitions will be equal to the value of the non-GDP transaction. The following core question concerns which variable could represent money used in transaction. If it is not easy, empirically, to catalogue money aggregates in GDP effective transactions and non-GDP transactions. Werner (2005) claims that it makes sense to bring credit into the equation, as a credit variable may better capture the quantity of money used in transactions.

Why is GDP-circulation credit?

The growth of money supply and the growth of velocity are identical to the growth of nominal GDP. Using credit instead of money in the quantity equation is advantageous. One reason for the failure of monetarism is that money aggregates are hard to measure with economic activities. The central banks have tried M_0, M_2 and M_3 to capture the economic transactions, but all these measurements are insufficient for indicating future economic conditions because the money aggregate is not one to one with economic transactions, and the innovations in the financial market make the flow of money supply more complicated. It is hard to tell the difference between the amount that is flowing into the real economy sectors and that which is flowing into financial speculation. On the other hand, the nature of credit aggregates determines the credit link to each economic transaction, regardless of whether it is for real economic effect transactions or for financial speculations. As a result, the connection between credit and economic performance must be clearly distinguished by the initial use of credit flow. The loan amount could be disaggregated between the credit used for real economic activities and that used for financial transactions.

Werner (1997, 2002, and 2005) also proposed that banks are a special case compared to other financial institutions because banks can create credit out of nothing. Werner advised that banks act as the settlement system for all non-cash transactions; thus, banks can write the figures into their books and the customer's account book. In Werner's view, credit is created through bank lending, and almost every dollar circulating in the economy that is used for transactions is created by loans; therefore the nature of money is credit. These summaries were derived after exhaustive analysis of the Japanese economic performance. He argued that credit growth is the essential factor which leads to economic growth. For that reason, bank credit channels should dominate in the monetary policy transmission mechanism rather than other channels. The difference between the bank lending channel, the bank capital channel and the credit creation channel (Werner1997, 2003, 2005) is that the role of the bank in credit creation is claimed to be unique.

Thus the study defines C_r as the credit for the real sector and C_f as the credit for speculative lending for the financial sector in the economy. Therefore, C_r could have a causal link with nominal GDP, as the following equation points out:

$$C_r \times V_r = P \times Q = \text{Nominal}GDP \qquad (6.5)$$

On the other hand, the loan for speculative rather than productive operation is C_f. As the previous equation used C_r, Werner (2005) also writes the equation as:

$$C_f \times V_f = P_f \times Q_f \qquad (6.6)$$

The large amount of credit to financial transaction may lead to bubbles in the financial market and price rises in real estimates; thus, P_f describes the inflation of the asset price. Based on Werner's modified equation, it indicates that GDP-circulation credit has a link with the nominal GDP. Therefore, the hypothesis in the research is whether GDP-circulation credit is a good indicator variable to nominal GDP.

Growth and the disaggregated quantity equation

The research is normally interested in dynamic situations, so economic growth rate will take place in the most cases. As a result, Werner (2005) modifies the equation into a different way, and instead of describing in the absolute value, the percentage growth rate was used. This step is also called logarithmic differentiation:

$$\Delta(MV) = \Delta(PQ) \qquad (6.7)$$

The economic growth takes place by definition. The net changes in economic transactions over the observed period equal the growth of the amount of money in circulation. Considering that the velocity of money is constant, the equation could be written in:

$$\Delta MV = \Delta(PQ) \qquad (6.8)$$

This simply restates that only an increase in the amount of money used for GDP effective transaction could result in an increase in the value of transactions (the economic growth) Furthermore, it divides both the change in the value of transactions and the change in the amount of money used for the transactions into those that are part of the GDP definition (ΔM_r and ΔQ_r) and those that are not (ΔM_f and ΔQ_f)

$$\Delta MV = \Delta M_r V_r + \Delta M_f V_f \qquad (6.9)$$

$$\Delta(PQ) = \Delta(P_r Q_r) + \Delta(P_f Q_f) \qquad (6.10)$$

At the same time, equations (9) and (10) must also hold:

$$\Delta M_r V_r = \Delta(P_r Q_r) = \Delta(P_r Y) \qquad (6.11)$$

$$\Delta M_f V_f = \Delta(P_f Q_f) \qquad (6.12)$$

We can say that the rise (fall) in the amount of money used for GDP-based transactions is equal to the rise (fall) in nominal GDP. Similarly, the rise (fall) in the amount of money used for non-GDP transactions is equal to the change in the value of non-GDP transactions.

As it was pointed out, in the previous part, that the GDP-circulation credit is more empirically convenient for replacing money in the equation, so the credit nature of money causing growth in the loan supply will reflect the growth rate of the money supply, with the assumption of constant velocity of credit to real transaction.

For the growth:

$$\Delta CV = \Delta(PQ) \qquad (6.13)$$

$$\Delta CV = \Delta C_r V_r + \Delta C_f V_f \qquad (6.14)$$

$$\Delta(PQ) == \Delta(P_r Q_r) + \Delta(P_f Q_f) \qquad (6.15)$$

At the same time,

$$\Delta C_r V_r = \Delta(P_r Q_r) = \Delta(P_r Y) \qquad (6.16)$$

$$\Delta C_f V_f = \Delta(P_f Q_f) \qquad (6.17)$$

6.3 Methodology

6.3.1 Data description and summary statistics

Definition of credit in the U.S.

Total credit: The most important variables defined in this part are the GDP-circulation credit, financial circulation credit and total credit. The credit data are not provided directly by the Federal Reserve, but can be inferred. We regard the total financial assets of commercial banks, saving institutions and credit unions as the total credit, which was obtained from the flow of funds accounts. The table codes are L.109, L.114 and L.115, and can be downloaded from the Federal Reserve website.[51]

The GDP-circulation credit is defined as the sum of consumer credit, commercial and industrial loans from commercial banks and government lending. Consumer credit nominally links to individual consumption, along with the commercial and industrial loans from commercial banks. Government lending is mainly for business investments. Thus these three parts constitute GDP-circulation credit. Because the Federal Reserve does not supply business loans information from saving institutions and credit unions, it is further considered that the amount of business loans from both institutions is small compared to that of commercial banks. Therefore this definition is reasonable as it only includes commercial and industrial loans from commercial banks, although commercial and industrial loans from commercial banks do not cover all business loans from financial institutions. Consumer credit and commercial and industrial loans from commercial banks can be taken directly from tables G.19 and H.8 given by the Federal Reserve. Government lending is identified as the sum of open-market paper, Treasury securities, Agency and GSE-backed Securities and Municipal Securities held by commercial banks, saving Institutions and Credit Unions, which is also from the flow of funds. After defining the total credit and GDP-circulation credit, what remains becomes the financial circulation credit.

C_t [52]= Total Financial Assets of Commercial Banks, Saving Institutions and Credit Unions

C_r = Consumer credit + Commercial and Industrial loans from commercial banks + Government Lending

Government lending = Open market paper + Treasury securities + Agency and GSE-backed Securities + Municipal Securities (Commercial banks, saving Institutions and Credit Unions)

[51] http://www.federalreserve.gov/econresdata/releases/statisticsdata.htm

[52] C_t : Total Credit; C_r : Credit to real GDP effective transaction; C_f : Financial circulation credit

C_f = Total Credit - GDP-circulation credit

According to this definition, the available period of GDP-circulation credit rums from 1960Q1 to 2008Q4 in the U.S.

Definition of credit in the U.K.

Credit data are obtained from the Monetary & Financial Statistics table of the Bank of England. The total credit in the U.K. is quarterly amounts outstanding of M4 lending (monetary financial institutions' sterling net lending to private sector) in sterling, non-seasonally-adjusted (the code is LPQVQKQ). Monetary financial institutions under the ESA95[53] classification refers to those institutions in the UK financial sector (other than the central bank) which are principally engaged in financial intermediation, and whose business is both to receive deposits and, for their own account, to grant loans and/or make investments in all kinds of securities. The time period of total credit is from 1963Q1 to 2008Q4.

The M4 lending is equal to lending to the household sector, private non-financial corporations and other financial corporations. It generally regards the lending to the householder sector as the lending to individual consumers, and private non-financial corporations as the lending to business, so the credit to real GDP-effective transaction is the sum of credit to the householder sector and private non-financial corporation (the code is LPQAVHF), and lending to financial transactions is credit to other financial corporations[54] (the code is LPQAVHE).

C_t = M4 lending (monetary financial institutions' sterling net lending to private sector

C_r = Lending to private non-financial corporations + household sector

C_f = Lending to other financial corporations

[53] UK national accounts economic sector reporting categories in conformity with the European system of national and regional accounts (ESA 95)

[54] Financial corporations other than monetary financial institutions include all financial limited and unlimited liability partnerships resident on the UK mainland and which are engaged principally in financial activities. These are also known as financial quasi corporations: Insurance brokers, loan brokers & financial planning consultants, salvage administrators and loss adjusters.

The problem with credit to real transaction data in the U.K. is that credit to household sector consists of three parts: net secured lending to individuals, net unsecured lending to individuals and net lending to unincorporated businesses and non-profit institutions serving households. The net secured lending to individuals is most likely to be mortgage credit, which it would be better to include in the financial circulation credit. However, the net secured lending data are only available from 1986Q1 so, if this lending involves financial transactions, it will influence the consistency of the data.

According to this definition, the available period of GDP-circulation credit rums from 1963Q1 to 2008Q4 in the U.K.

Definition of credit in Germany

The credit to real transaction and financial transaction is not directly provided by the Bundesbank, but it can be inferred. According to the credit definition (Werner 2005), the total credit could be estimated as the total amount of loans to domestic enterprises and households (PQA350). The credit to financial transaction is the credit that is not part of GDP, so it should include the credit to speculation, real estimate market etc. In Germany, it has been described as the lending to financial institutions (PQ3026), lending to housing enterprises (PQ3185), lending to holding companies (PQ3189), and mortgage loans to domestic enterprises and resident individuals (PQ3013). The credit to real transaction would be the total amount of credit minus the financial circulation credit.

C_t = Loans to domestic enterprises and households

C_f = Lending to financial institutions + Lending to housing enterprises + Lending to holding companies + Mortgage loans to domestic enterprises and resident individuals

C_r = Total credit – Financial circulation credit

This study looks at the series and found that the data on lending to housing enterprises and lending to holding companies began from 1980Q4, which will have caused the structural decrease of credit to real transaction during 1980Q4 - 1981Q3. Thus, in order to achieve a smoother growth rate, this study uses the definition of credit to financial transaction being equal to lending to financial institutions and mortgagee loans to domestic enterprises and resident individuals during the period 1980Q4 - 1981Q3, thus giving a smoother growth rate of GDP-circulation credit.

According to this definition, the period of GDP-circulation credit in Germany is shorter than that in the U.S., and U.K., running from 1970Q1 to 2008Q4.

Definition of credit in Japan

Credit data have been obtained from the Bank of Japan. The study describes the total credit as outstanding total credit including, among others, banking accounts and trust accounts from domestically-licensed banks. The definition of financial circulation credit is the same as that of Werner (2005). "Financial and real estate transaction are the main type of transactions that are not part of GDP. Transactions of this kind, which are not due to shifts of already existing purchasing power, but based on bank borrowing (and therefore on a net addition in purchasing power) are mainly conducted by the real estate and construction sector and the non-bank financial institutions. Loans to the real estate sector, construction firms and non-bank financial institutions (which mainly served as conduit for real estate loans) as speculative credit creation is used for real estate transactions" (Werner, 2005). Therefore, it is obvious that the total credit minus financial circulation credit is GDP-circulation credit.

The credit data have a structural break in 1992Q2, as the calculation of statistical methods changed; thus the study uses the overlap credit data to acquire a smoother growth rate.

C_t = Total credit including Others, Banking Accounts and Trust Accounts from Domestically Licensed Banks

C_f = Construction + Finance and Insurance + Real Estate, Banking Account and Trust Accounts from Domestically-Licensed Banks

C_r = Total credit – financial circulation credit

According to the available data in Japan, the period of GDP-circulation credit runs from 1970Q1 to 2008Q4.

Figure 6-1 Ratio of GDP-circulation credit to total credit and ratio of financial circulation credit to total credit

In the figure, the year is on the x-axis, and the annual percentage change of GDP-circulation credit is on the y-axis. [55]

The research firstly shows the ratio of credit to real transaction to total credit and ratio of credit to financial speculation to total credit in each country. As the figures show, the

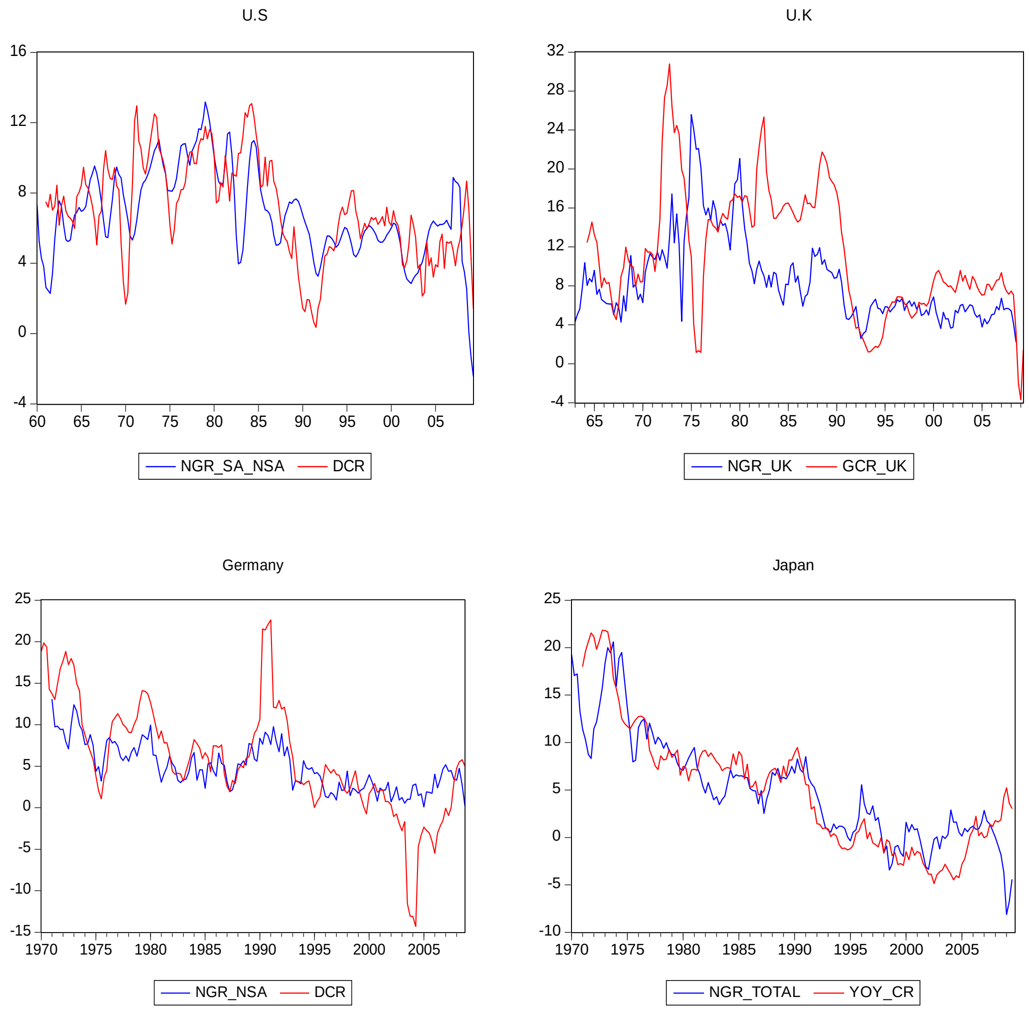
[55] RATIO_REAL = GDP-circulation credit/ total credit, RATIO_FINANCE= financial circulation credit/ total credit

ratio of credit to real transaction gradually decreases and the ratio of financial speculation to total credit steadily increases as time goes by. In the U.S. and Germany, the ratio of GDP-circulation credit to total credit has even fallen to below 35%, and the financial circulation credit shows a noticeable increase after 1990 in the U.S., U.K. and Germany but not in Japan. As we know, Japan has experienced a collapse in the real estate market since the 1990s, so the fact that the credit to financial transaction does not increase dramatically is reasonable. These pieces of evidence point out a trend that credit for financial speculation has increased more than credit for real transactions in the U.S., U.K. and Germany over the last twenty years.

Figure 6-2 Ratio of GDP-circulation credit to nominal GDP and ratio of credit to financial transaction to nominal GDP

As the figures show, the ratio of credit to financial transaction to nominal GDP increased considerably after the 1990s in the U.S., U.K. and Germany. The percentage increase from below 50% to around 80% of nominal GDP signals that the volume of financial circulation credit in the economy expanded significantly. The ratio of credit to real transaction to nominal GDP is more stable, except in the U.K. [56]

Figure 6-3 Growth rate of nominal GDP and GDP-circulation credit growth rate



Inspection reveals that the correlated movement of the nominal GDP growth rate and credit to real transaction is closer in the U.S. and Japan than in the U.K. and Germany. Furthermore, as can be seen from the figure, there are two abnormal increases or decreases in credit growth in Germany, namely in 1990Q2-1991Q1, and 2003Q3-2004Q2. The researcher examined the data in detail and found that the data of lending to housing enterprises and lending to domestic enterprises and resident individuals both suddenly increased in 1990Q2, and mortgage loans to domestic enterprises and resident individuals rose sharply in 2003Q3. These sudden increases caused the abnormal increase of credit to real transaction in 1990Q2, and decrease in 2003Q3. The study has

[56]Ratio_Cr_NGDP=Cr/NGDP_moving_sum; Ratio_Cf_NGDP=Cf/NGDP_moving_sum

used 1990Q3 as the structural break in the tests, thus the influence from structural break would be eliminated in the subsample test. However, further research needs the overlap data, and the results would be more accurate.

6.3.2 Modelling

General-to-Specific model

`The LSE methodology[57] has been the leading approach for pursuing econometrics in the last three decades. One of its main contributions is the concept of general-to-specific modelling, which contains the correct regressors which capture the essential features of the underlying data set; then, the standard procedures are used to reduce insignificant regressors. Eventually, only the significant variables remain. An important characteristic of this model is that the research has less chance of choosing a particularly preferred variable at the beginning. This approach is an inductive method; thus, it prefers the determinants of structure of data rather than the researcher's assumption.

Granger Causality test

In this part, the researcher uses two approaches to test the causality between nominal GDP and GDP-circulation credit. The first one is to use the VARs model to test Granger causality when two variables are not cointegrated, and to apply VECM model to test Granger causality if two variables are cointegrated. The second one is to compare the robustness of regression of credit on nominal GDP and nominal GDP on credit: whichever direction is more stable will imply the direction of causality between those two variables. The later causality test approach is suggested by Mizon (1995).

VARs Model analysis

The VARs is identified using Cholesky decomposition, with the order being nominal GDP, price, the nominal short-term interest rate, money and GDP-circulation credit. The first differences of variables are taken in the VARs model, and the ordering was chosen on the basis of the speed with which the variables respond to shocks, with output assumed to be the least responsive, followed by price, then short-term rates. As the study has mentioned, in the VARs model including monetary aggregate etc, output and

[57] Hendry (1993), for an overview

price are assumed not to react to the contemporaneous shocks. In the extended VARs, lending aggregates are assumed to reflect contemporaneous shocks to output and price. The alternative ordering does not change the results; furthermore, in particular, the positive effect of credit on output is found in any orderings. The lag length is six, enabling a comparison of the results with those in the 4-variable VARs model

6.4 Empirical Results in the U.S., U.K., Germany and Japan

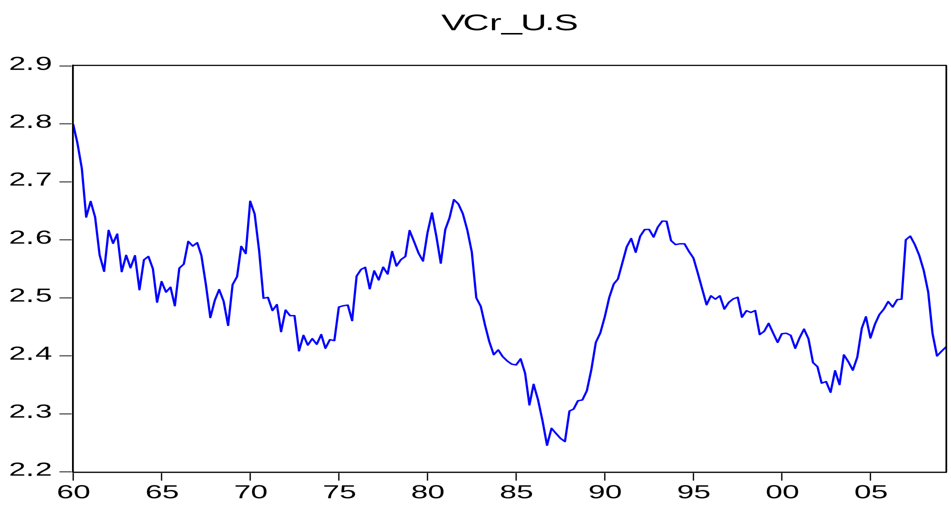
6.4.1 Velocity of GDP-circulation credit

Velocity of GDP-circulation credit in the U.S.

According to the equation, the velocity of credit to real economic activities is defined as the ratio of nominal GDP and the amount of GDP-circulation credit. The basic assumption of the model is a constant velocity. It shows the velocity of GDP-circulation credit in the U.S. in the figure, and then tests whether the velocity of credit to real transaction is constant.

VCr_U.S. = Annual nominal GDP/ Credit to real activities

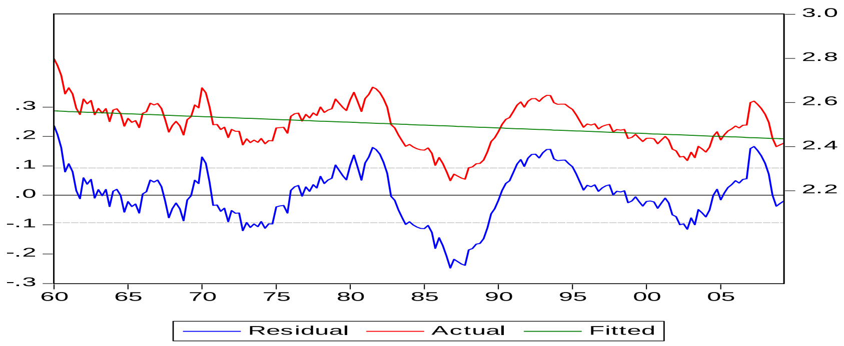
Figure 6-4 Velocity of GDP-circulation credit in the U.S.



Testing the trend of velocity of GDP-circulation credit in the U.S.:

$V_t = \alpha + \beta * Trend + \varepsilon_t$

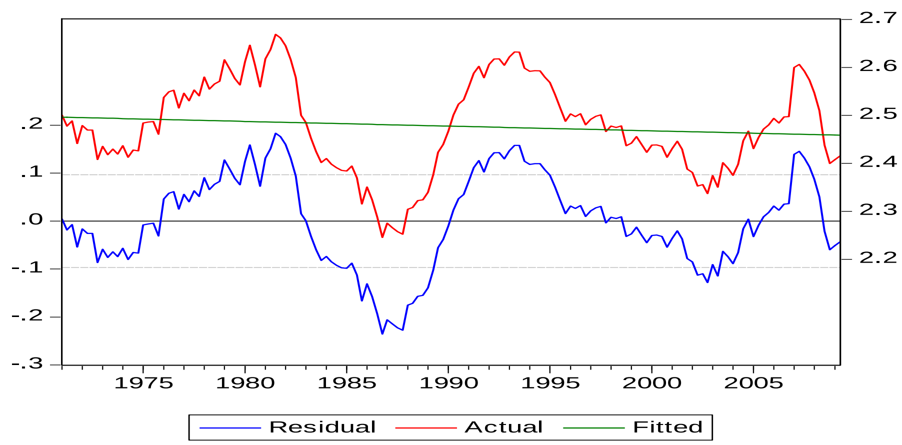
Figure 6-5 Trend in velocity in the U.S during 1960Q1-2008Q4



Non-seasonally-adjusted nominal GDP data end in 2006Q3, so the study uses the seasonally-adjusted nominal GDP after that. The difference in growth rate between non-seasonally and seasonally-adjusted data is small, because the logarithm difference was taken to make the growth rate. A combination of non-seasonal and seasonal data would not significantly influence the results.

The trend test based on the period 1960Q1 to 2009Q2 rejects the null hypothesis that there is no trend, which means that velocity of GDP-circulation credit has a trend; however, we can see that the trend is very flat in the figure6-5, so we apply the trend test for the period 1971Q1 to 2009Q2.

Figure 6-6 Trend in velocity in the U.S during 1971Q1- 2009Q2



The null hypothesis is that there is no trend, so the hypothesis is accepted. No trend is found in the velocity of GDP-circulation credit during the period 1971Q1 to 2009Q2.

As a result, it cannot be concluded without hesitation that there is a trend in velocity of GDP-circulation credit. The possibility that a trend in GDP-circulation credit might be largely based on the time period is plausible.

Stationarity test for velocity of GDP-circulation credit in the U.S.

The study tests whether the velocity of GDP-circulation credit is stationary in the U.S., with the purpose of investigating the constant property of velocity as well. The null hypothesis is that velocity is not stationary and has a unit root. The null hypothesis is rejected at the 1% significance level including intercept or intercept and trend; thus, the velocity of credit to real GDP effective in the U.S. is stationary. The results are displayed in the Appendix B. Table B 6-2. Therefore, the velocity of GDP-circulation credit does not change much in the long term, and it seems to randomly fluctuate around a constant level in the U.S.

Velocity of GDP-circulation credit in the U.K.

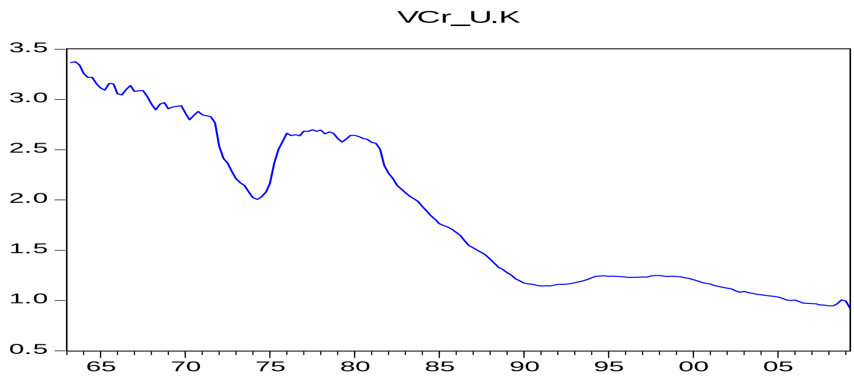
The equation is velocity of GDP-circulation credit = NGDP/GDP-circulation credit.

The velocity of GDP-circulation credit in the U.K. is shown in the figure below, and inspection reveals an obviously decreasing trend. This result runs counter to the assumption that velocity of credit to real transaction is constant but, as mentioned, GDP-circulation credit includes the credit to the household sector. The data on credit to the household sector obtained from Bank of England only started from 1980. The inclusion of the credit to household sector might cause the decreased trend of velocity in the U.K. after 1980. Meanwhile, the credit to household sector contains mortgage credit; so, if mortgage credit increased dramatically after 1986 following the prosperity of the real estate market, this will have resulted in the decrease of velocity of credit to real activities. In order to gain an insight into credit in the U.K., the research also calculates the ratio of total bank assets to nominal GDP, [58] which is shown in the figure 6-9. As the figure illustrates, the portion of total bank credit in the nominal GDP significantly increased during the last two decades, from 1.4 times nominal GDP at the starting point to 2.4 times nominal GDP at the peak time. The amount of credit from banks largely

[58] Total bank asset is monthly amounts outstanding of UK resident banks (excl, Central Bank) sterling assets total (in sterling millions) not seasonally adjusted. Because the BOE changed the method to calculate the total bank asset at 1997 Q2, so the research only show the ratio during 1997Q3 to 2009Q4, in order to avoid the structural break.

expanded, which may have raised the amount of credit to the household sector as well, but it is possible that part of the credit to the household sector was used for speculations in the housing market. Considering these factors, the limitations of the data might be part of the reason for the decline in the trend of velocity of GDP-circulation credit in the U.K.

Figure 6-7 Velocity of GDP-circulation credit in the U.K. 1963Q1- 2008Q4



Testing the trend of velocity of GDP-circulation credit in the U.K.

$$V_t = \alpha + \beta * Trend + \varepsilon_t$$

Figure 6-8 Trend in the velocity in the U.K during 1963Q1- 2008Q4

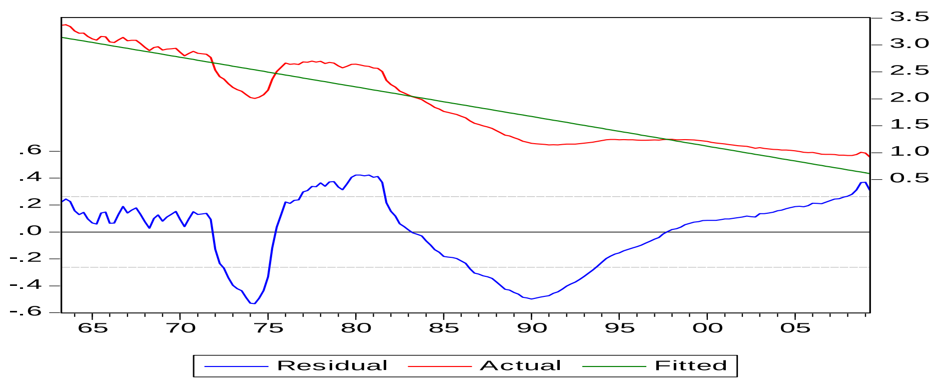
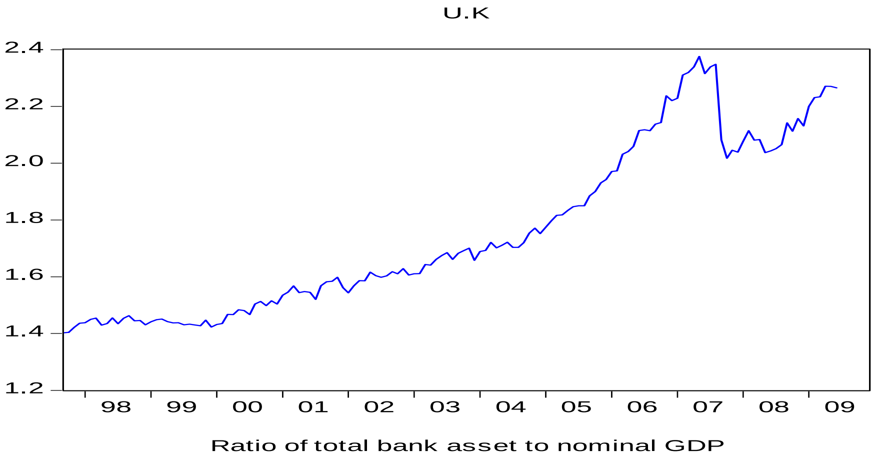


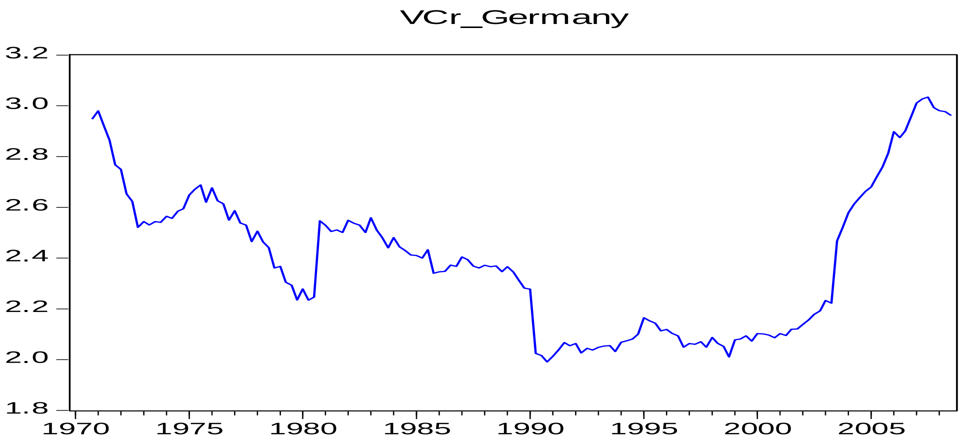
Figure 6-9 Ratio of total bank asset to nominal GDP during 1997M9-2009M6



Velocity of GDP-circulation credit in Germany

The velocity of GDP-circulation credit = NGDP/GDP-circulation credit, as shown in the figure above. The velocity in Germany seems to be constant, and the researcher will test the trend of velocity of GDP-circulation credit.

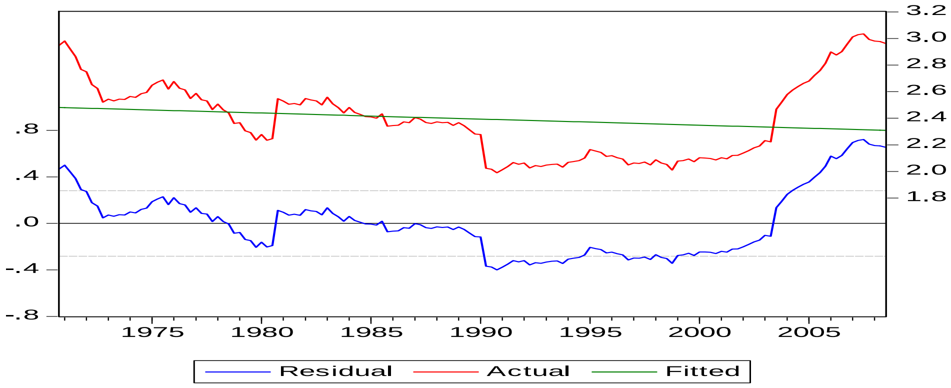
Figure 6-10 Velocity of GDP-circulation credit in Germany during 1970Q1-2008Q4



Testing the trend of velocity of GDP-circulation credit in Germany

$V_t = \alpha + \beta * Trend + \varepsilon_t$

Figure 6-11 Trend in the velocity in Germany during 1970Q1- 2008Q4



The null hypothesis that the velocity of credit to real transaction is constant is rejected at the 1% significance level, which suggests that velocity of credit to real transaction in Germany is not constant. But it can be seen from the figure that the trend of velocity in Germany is not significant, and the null hypothesis could not be rejected at the 5% significance level. Further, there is a structural break in 1990Q2 and 2003Q3, which lead the decrease of velocity in 1990Q2 and increase of velocity in 2003Q3. Thus, strictly speaking, the velocity of credit to real transaction is constant at the 5% significance level

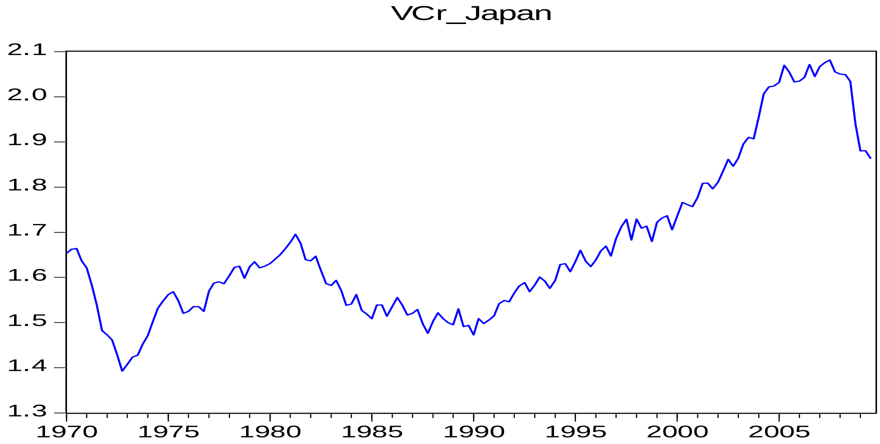
Velocity of GDP-circulation credit in Japan

The velocity of GDP-circulation credit = NGDP/GDP-circulation credit. The credit data contain a structural break in 1992Q2; so, if the study uses the original credit data to calculate the velocity of credit to real transaction, it would also have a break in 1992Q2, meaning that the velocity would not be smooth. [59] In order to have smooth credit volume data, this study uses the growth rate of GDP-circulation credit to create a new series Cr_{t+4} = growth rate of credit to real * Cr_t, so the series C_r is the estimation based on the old definition.

The velocity in Japan seems to have a slightly increasing trend, as indicated by the figure, and the researcher tested the trend of velocity of GDP-circulation credit.

[59] The velocity of credit to real GDP effective transaction with the structural break is shown in the Appendix

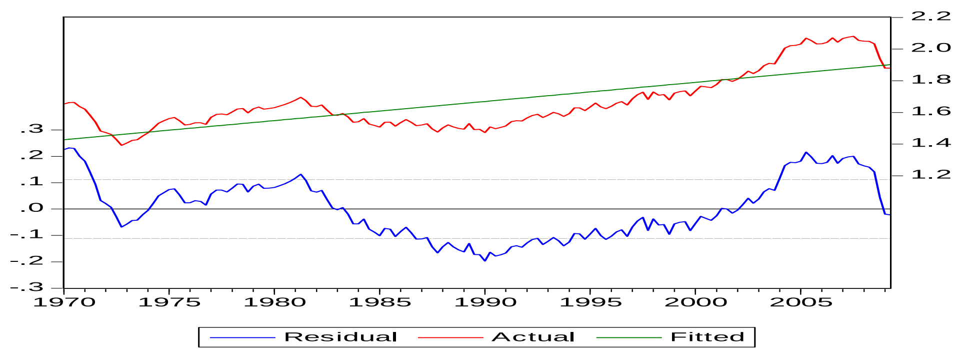
Figure 6-12 Velocity of GDP-circulation credit in Japan (modified) during 1970Q1-2009Q3



Testing the trend of velocity of GDP-circulation credit in Japan

$V_t = \alpha + \beta * Trend + \varepsilon_t$

Figure 6-13 Trend in the velocity in Japan during 1970Q1- 2009Q3



The null hypothesis that the velocity of credit to real transaction is constant is rejected at the 5% significance level, which suggests that velocity of credit to real transaction in Japan is not constant.

To summarise the test on the velocity of GDP-circulation credit in the four countries, the obvious conclusion is that the velocity of GDP-circulation credit is not constant if only based on the trend test results. However, if one takes account of the insignificant trend in the velocity of credit to real economic transactions in the U.S., Germany and Japan, and on the other hand, the continuously falling trend in the velocity of money aggregates in the U.S., the U.K. (Bordo et al., 1997) and in Japan (Werner 2005), the velocity of credit to real economic transactions is more stable than velocity of money aggregates in the U.S., the U.K. and Japan. The more stable velocity of GDP-circulation credit makes C_r easier and more reliable for policy- makers to consider than money aggregates.

6.4.2 Empirical results of general-to-specific model (GETS)

The subprime mortgage crisis in 2007 caused central banks in these four countries to expand the money supply, and the quantity of money supply dramatically increased. The Federal Reserve, Bank of England and Bank of Japan announced the adoption of quantitative easing after the crisis. Thus, considering the sensitivity of the general-to-specific model, in order to avoid the special case of the 2007 financial crisis having a statistical effect on the modelling results, the study tests the general-to-specific model in the sample period end at 2007Q4.

The general-to-specific model

The parsimonious form could be applied based on the general-to-specific modelling strategy (Hendry 1979, 1986). Through stepwise regression, the insignificant variables are eliminated in each step, and only significant variables, which have more explanatory power for the dependent variable, are left in the parsimonious form. This GETS model includes short-term interest rate, money, total credit, and GDP-circulation credit at the beginning, and the intention is to find which variable might best explain nominal GDP. Because the study uses different money aggregates in each country, it is not fair to compare the results across countries. However, the choice of money aggregates in each country depends on the monetary policy rule and the availability of data, so it would provide us with a better understanding of which monetary policy variable in each country best explains the nominal GDP. The model implied in the research is formulated as follows, and has general lag structure, with four lags.

$$g_t = \alpha + \sum_{k=0}^{4} \beta_k g_{t-k-1} + \sum_{k=0}^{4} \delta_k gcr_{t-k} + \sum_{k=0}^{4} \varphi_k gm_{t-k} + \sum_{k=0}^{4} \eta_k i_{t-k} + \varepsilon_t \qquad (6.18)$$

g_t: Annual growth rate of nominal GDP

gcr_{t-k} : Growth rate of GDP-circulation credit

gm_{t-k} : Growth rate of money

i_{t-k} : Interest rate

ε_t : Error

Results of general-to-specific model results in the U.S. 1960Q1-2007Q4

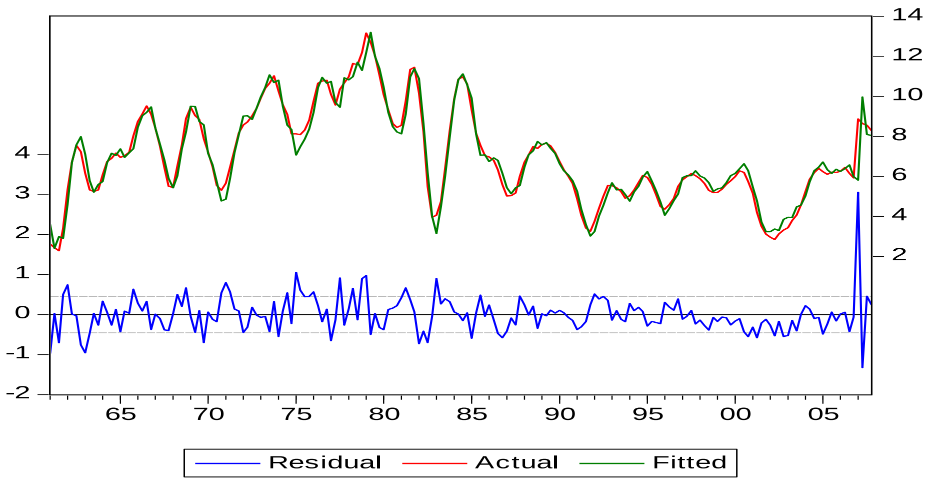
Quarterly data are used in the equation and, after the single specification selection, the final parsimonious model is:

$$g = 0.3955 + 1.3821g_{-1} - 0.5065g_{-2} + 0.0717gm + 0.1448i - 0.0729i_{-4}$$

t-stat (3.2415) (24.0915) (-8.8802) (5.0050) (5.8110) (-2.9907)

Adj. R^2=0.9525, F-statistic=429.2628, DW-Statistic=2.0666

Figure 6-14 Nominal GDP, actual and fitted, residual in the U.S. during 1960Q1-2007Q4



The t-statistic is significant at the 1% level. The adjusted R^2 is fairly high, which suggests that the final equation could well explain the dependent variable. The green line gives the predictive value of the equation model, while the red line presents the actual values of the time series. The difference represents the residual term. The figure 6-14 displays that the parsimonious equation well describes the dependent variable (nominal GDP). The money and interest rate seem to outperform the credit aggregate in predicting the changes in nominal GDP in the U.S.; however, the coefficient of interest rate is positive and the coefficient of nominal GDP at two lags is negative, which contradicts the traditional wisdom. The error correction mechanism might have caused this. The multicollinearity among variables may cause the signs of expected coefficient being opposite to those estimated and central banks' behaviour could also result in this (Asteriou and Hall, 2007). This is because, when central banks overshoot or undershoot the intermediate target in the previous year, they will undo the target in the next year. More statistical results are shown in the Appendix B.

The Chow test (with F-statistic 1.313136 and p-value 0.1950) showed that there is no break in 1979Q3 in the general-to-specific model, but the study still tests the two subsamples, and finds no significant difference between the statistical results.[60] The nominal GDP growth rate at current could be explained by itself in two lags, money growth at current or one lag behind, and interest rate at current and two lags.

Results of general-to-specific model in the U.K. from 1963Q1 to 2007Q4

$$g = 0.5209 + 0.8775g_{-1} + 0.2223g_{-3} - 0.2261g_{-4} + 0.0485gcr_{-3}$$

t-stat (1.5298) (15.3859) (2.5669) (-3.0394) (2.0437)

Adj. R^2=0.8471, F-statistic=237.8057, DW-Statistic=1.8203

[60] **From 1960Q1- 1979Q3:** $g_t = 0.0980 + 1.4204g_{-1} - 0.5493g_{-2} + 0.1142gm + 0.1368i$

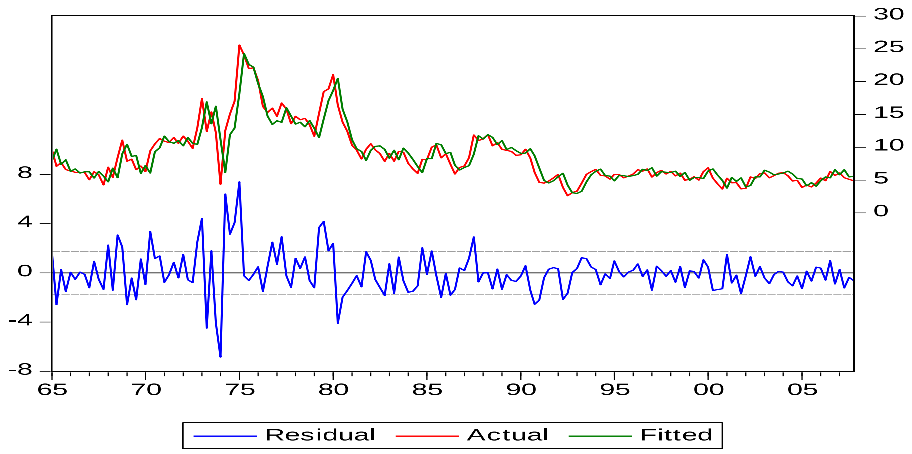
Adj. R^2=0.9622, F-statistic=497.7563, DW-Statistic=1.8205

From 1979Q4- 2009Q2

$$g = 0.5147 + 1.4076g_{-1} - 0.5363g_{-2} + 0.0520gm_{-1} + 0.1824i - 0.0946i_{-2}$$

Adj. R^2=0.9503, F-statistic=429.2628, DW-Statistic=2.06

Figure 6-15 Nominal GDP, actual and fitted, residual in the U.K. 1963Q1 to 2007Q4



Results of general-to-specific model in the U.K. from 1963Q1 to 2007Q4

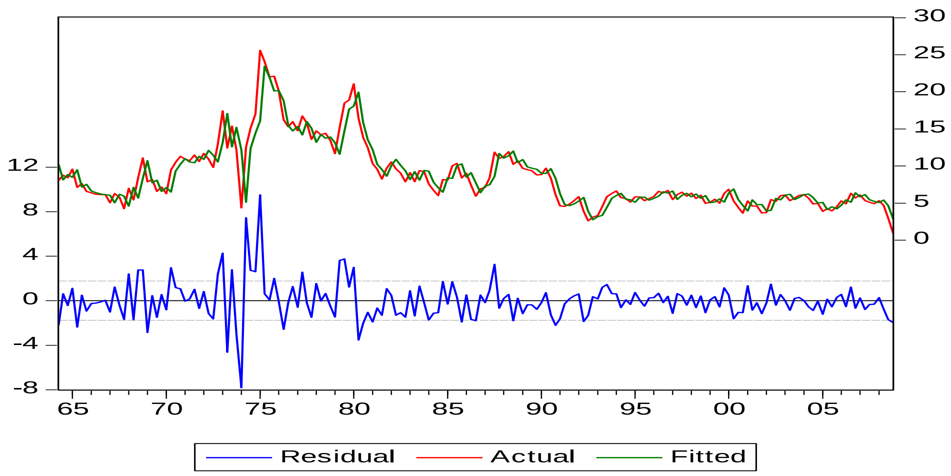
After the selection in each reduced equation, the final parsimonious model in the U.K. is

$g = 0.3014 + 0.8967 g_{-1} + 0.0470 gcr$

t-stat (0.9210) (27.2709) (2.0310)

Adj. R^2=0.8416, F-statistic=473.6958, DW-Statistic=2.02

Figure 6-16 Nominal GDP, actual and fitted, residual in the U.K. 1963Q1 to 2008Q4



The t-statistic is significant at the 1% level. The adjusted R^2 is quite high and the DW-statistic is also near 2.0. This shows that the credit to real GDP-effective transaction could give a good explanation of nominal GDP. The result of the general-to-specific model implies that GDP-circulation credit outperforms the M4 and interest rate to predict nominal GDP in the U.K. More statistical results are shown in the Appendix C.

Applying the Chow-test for the final equation, the results (with F-statistic 0.726493, p-value 0.5374) signal that there is no break at 1992Q4 in the U.K. The stability of the final parsimonious model shows the credibility of the power of credit to real transaction in predicting the nominal GDP.

Results of general-to-specific model in Germany 1970Q1- 2007Q4

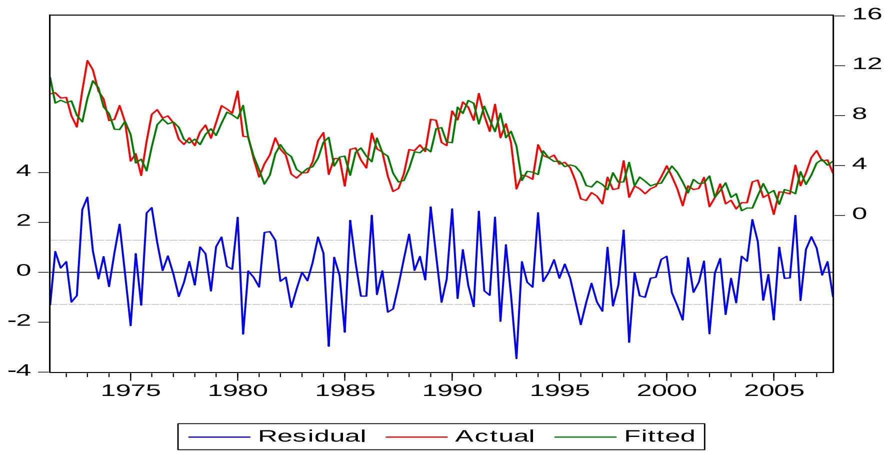
After the selection in each reduced equation, the final parsimonious model in Germany is:

$$g = 1.0812 + 0.6741 g_{-1} + 0.09093 gcr$$

t-stat (4.5254) (11.3811) (3.7627)

Adj. R^2=0.7742, F-statistic=251.3322, DW-Statistic=2.0998

Figure 6-17 Nominal GDP, actual and fitted, residual in Germany 1970Q1- 2007Q4



The statistics of adjusted R^2, F-statistic and DW-statistic all indicate that the final equation describes the dependent variable well. Based on the final equation, GDP-circulation credit explains the nominal GDP better than M3 and interest rate. More statistical results are shown in the Appendix D. The study applies the Chow-test to find whether there is a break in the final equation, and the results show that there is a break in 1990Q3. Therefore the study tests the general-to-specific model in the subsamples.

The results of general-to-specific model in subsamples

Time Period: 1970Q1- 1990Q3

$g = 1.0861 + 0.4444g_{-1} + 0.1181gcr_{-1} + 0.1890gm_{-2}$

t-stat (2.28) (5.1203) (3.5606) (2.6447)

Adj. R^2=0.7264, F-statistic=65.502, DW-Statistic=1.7981

The GDP-circulation credit and M3 remain in the final equation, and credit is better than M3 for explaining the nominal GDP according to the t-statistic in the first subsample in Germany.

Time period: 1990Q4-2007Q4

$g = 0.1934 + 0.5348g_{-1} + 0.1268gm + 0.1029gm_{-3} + 1.6329i_{-1} - 2.7318i_{-2} + 1.4481i_{-3}$

t-stat (0.7534) (7.0461) (3.3875) (2.9044) (4.2332) (-4.0380) (3.7297)

Adj. R^2=0.8083, F-statistic=48.7938, DW-Statistic=2.23

In the later period in Germany, M3 and interest rate outperform GDP-circulation credit in predicting the nominal GDP. Interest rate current, 1 and 2 lags behind all remain, which indicates that the interest rate increases the predictive power for nominal GDP.

Overall, GDP-circulation credit outperform other variables to predict nominal GDP in the early period and in the entire sample, but interest rate and M2 become more important in influencing nominal GDP after 1990Q3.

Results of general-to-specific model in Japan from 1970Q1- 2007Q4

After the selection in each reduced equation, the final parsimonious model in Japan is

$g = -0.4484 + 0.7171g_{-1} + 0.2420gm_{-4}$

t-stat (-2.6214) (15.6471.) (5.8637)

Adj. R^2=0.9477, F-statistic=1316.162, DW-Statistic=1.8095

The statistics of adjusted R^2, F-statistic and DW-statistic all indicate that the final equation describes the dependent variable well. Based on the final equation, M2 explains the nominal GDP better than interest rate and GDP-circulation credit. The study applies the Chow-test to find whether there is a break in the final equation, and the results show that there is no break in 1990Q4. More statistical results are shown in the Appendix E. This result is different from the one Werner (2003) obtained. The reason might be that GDP-circulation credit used in this thesis include trust account and bank account, but Werner (2003) only includes credit from bank account.

If the downward reduction is checked at the 10% significance level, the parsimonious model becomes:

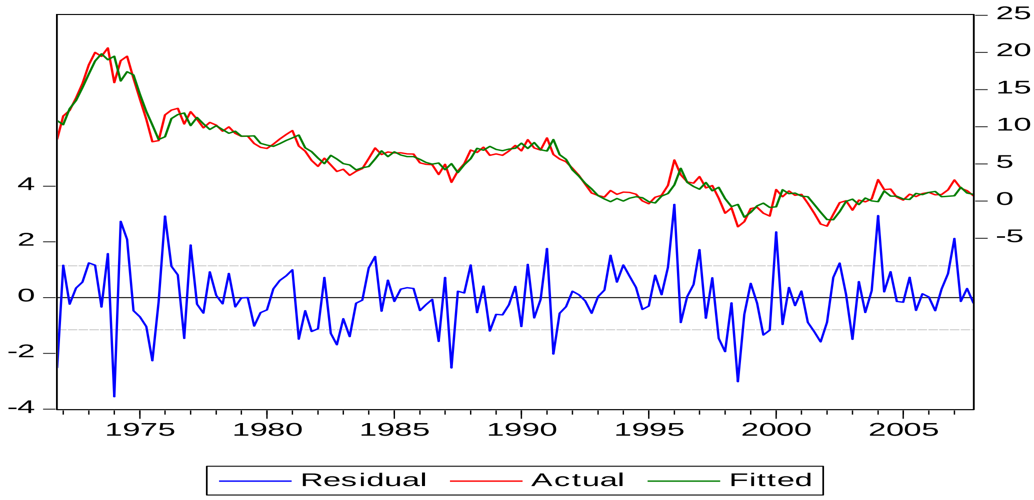
$$g = -0.4128 + 0.6903g_{-1} + 0.2346gm_{-4} + 0.1821gcr - 0.1282gcr_{-3}$$

t-stat (-2.0569) (14.2998) (4.5660) (3.0768) (- 1.7552)

Adj. R^2=0.9520, F-statistic=714.0067, DW-Statistic=1.9969

As we can see, the adjusted R^2 is near 1, and the DW-statistic is near 2, which indicate that the equation also describes nominal GDP growth rate well. And, when the structural beak test is applied, the result suggests there is no structural break at 1990Q4, which indicates that the equation is credible. The parsimonious model has no noticeable problems and appears to be a valid model of the nominal GDP growth rate. The following figure shows the actual and fitted curves for nominal GDP growth rate.

Figure 6-18 Nominal GDP, actual and fitted, residual in Japan 1970Q1- 2007Q4



Diagnostic Tests

Histogram and normality test of the error terms

The basic assumption of the OLS estimator is that the errors have a normal distribution conditional on the regressors. If the residuals are normally distributed, the histogram should be bell-shaped and the Jarque-Bera statistic should not be significant. The results are shown in Appendix, and the null hypothesis of normally distributed errors is significantly rejected in the U.S. and the U.K.; although also rejected in Germany and Japan, the statistical results are less significant.

Breusch-Godfrey LM test for autocorrelation

Only when the serial autocorrelation of error terms is small does the OLS estimation generate the efficient estimates for the standard deviations of the coefficients. Too high an autoregression lessens the credibility of all hypothesis tests. The null hypothesis in the Breusch-Godfrey LM test for autoregression is that there is no autoregression. The statistical results are shown in Tables B6-4, C6-3, D6-3 and E6-3. The test is performed with one or two lags, and the null hypothesis is accepted with very high securities in the U.K., Germany and Japan. Although the null hypothesis is accepted at 5% significance level in the U.S., it could be rejected at 10% significance level. These results indicate that the explanatory power of credit to real-GDP transaction for nominal GDP is reliable in the U.K., Germany, and Japan, but the explanatory power of interest rate for nominal GDP in the U.S. is reduced.

Test for Heteroskedasticity

An autocorrelation heteroskedasticity of the error terms leads to a reduction in the power of hypothesis tests. The phenomenon of heteroskedasticity occurs when the variance of the error terms is not constant for all observations. The figures 6-14, 6-15, 6-17 and 6-18 represent a graphical assessment of residuals; in addition, the study will carry out more formal tests for heteroscedasticity using the Breusch-Pagan-Godfrey test. The Breusch-Pagan-Godfrey test is a Lagrange multiplier test of the null hypothesis of no heteroskedasticity. The null hypothesis that there is no heteroskedasticity is accepted in the U.S. and Germany, but rejected in the U.K. and Japan. The results are shown in the tables B6-5, C6-4, D6-4, and E6-4.

Conclusions on the general-to-specific model

The review of normality test, autocorrelation test and heteroskedasticity test for the error terms reveals the risk of GETS model, thereby indicating the need to employ the other approaches. However, the GETS model still provides some useful indications. It can be inferred that the credit to real transaction is a better explanatory variable of nominal GDP growth rate compared to interest rate, apart from in the U.S. GDP-circulation credit is the only variable that remains at the 1% significance level to explain the nominal GDP growth even better than the money aggregate in the U.K. and Germany. In Japan, the GDP-circulation credit is also left at the 10% significance level. It is obvious that credit outperforms the short-term interest rate in describing the nominal GDP growth in most of the four countries analysed. Therefore, the quantity variables (money aggregates, GDP-circulation credit) outperform the price variable (interest rate) in the prediction of nominal GDP based on both simple regressions and multiple equation analysis. However, as we know, the limits of simple regression inspire further studies.

6.4.3 Empirical results of the Granger Causality test

To assess the causal relationship between credit and nominal GDP in the four countries, Granger causality tests are adopted in this section. The study estimates the causality by employing conventional methods involving a single country data set, which includes a cointegration test and the use of error correction models (ECMs) for the Granger causality test to confirm whether the two variables could provide future information to each other.

The results of the unit root test

This study uses annual growth rate of GDP-circulation credit and nominal GDP. The period is the same length as that in the previous part. The credit data take the year-over-year growth rate.

Granger and Newbold (1974) have indicated that the Granger causality test suggested by Granger (1969) would lead to spurious results if the time series data set is non-stationary. In order to be sure that the credit data set in each country is stationary, the study examines the stationarity of GDP-circulation credit by the use of ADF (Dickey and Fuller, 1981), the PP test (Phillips and Perron, 1988) and the Zivot and Andrews (1992) test. The results shown in the appendix reveal that credit is non-stationary in the first-differencing level in the U.S. and the U.K. according to the ADF and PP critical value, but the stationary property is found based on the Zivot and Andrews approach. Furthermore, in Germany and Japan, the stationary property is also found according to all three tests. In order to keep the property of GDP-circulation credit consistent, the study regards the GDP-circulation credit as stationary in the first-differencing level.

The results of Cointegration test

Engle and Granger (1987) have defined X and Y as being cointegrated if the linear combination of X and Y is stationary but each variable is not stationary. Engel and Granger (1987) also claimed that, if two variables are non-stationary but cointegrated, the traditional Granger causality test will be invalid. An error correction model (ECM) should be established to test the existence of a causal correlation. Conversely, the traditional VARs model of Granger causality test should be used when these two variables are not cointegrated. Therefore, the cointegration test of Gregory and Hansen will be applied before testing for a causal relationship between nominal GDP and GDP-circulation credit. (Gregory and Hansen, 1996) model to test the bivariate cointegration between GDP-circulation credit and nominal GDP has incorporated the structural break compared to other popular cointegration test methods. The results are presented in Appendix 6.F. The study also tests the cointegration between the credit to real transaction and nominal GDP in the subsamples. According to the critical value provided by Gregory and Hansen, the null hypothesis, that there is no cointegration between the GDP-circulation credit and nominal GDP, fails to be rejected at the 5% significance level in the U.S., Japan and Germany, and fails to be rejected at the 10% significance level in U.K. in the entire sample. This implies that there is a cointegration between GDP-circulation credit and nominal GDP in the U.S. and U.K., Germany and Japan in the entire sample. The results in the subsamples point out a cointegration between GDP-circulation credit and nominal GDP in the U.S. and Japan, but not in Germany and U.K. in the earlier sample. No cointegration relationships are found across countries in the later period. The statistical values can be seen in the Appendix.6.F

Granger causality results in the entire sample

Because there is a cointegration between nominal GDP and GDP-circulation credit, the study applies a VECM model to test Granger causality in the U.S., Germany and Japan, and a standard Granger causality test in the U.K. The results are summarised in the table below. As the statistics indicate, the null hypothesis that nominal GDP does not Granger cause to credit to real transaction is rejected in U.S., U.K. at the 1% significance level, and is also rejected in Germany at the 10% significance level, but fails to be rejected in Japan. On the other hand, the hypothesis that GDP-circulation credit does not Granger cause to nominal GDP fails to be rejected in the U.K. and Germany, and is only accepted at the 10% significance level in Japan and the 1% significance level in the U.S. Compared to two directions of causality, it is more likely that nominal GDP provides the future credit to real credit information in the U.S., U.K. and Germany than vice versa, but not in the case of Japan. In Japan, there is unidirectional causality from credit to real transaction to nominal GDP, which is consistent with the results found by Werner (2005).

Table 6-1 Summary of Granger causality tests in the entire sample

Countries	Period	nominal GDP does not GC credit		credit does not GC nominal GDP	
		F-statistic	P-value	F-statistic	P-value
U.S.	1960Q1-2008Q4	9.48989	0***	3.456004	0.0017***
U.K.	1963Q1-2008Q4	3.00562	0.0083***	1.5473	0.1661
Germany	1970Q1-2008Q4	1.901302	0.085*	1.332387	0.247
Japan	1970Q1-2008Q4	1.722206	0.12	2.057477	0.062*

Note: *** significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Granger causality results in subsamples

The causality results for the two subsamples are reported in the table. During the earlier period, the results are similar to those in the entire sample. The statistics point out that the hypothesis that nominal GDP does not Granger cause to credit is rejected at the 5% significance level in the U.S. and Germany, and at the 10% significance level in the U.K., but is still accepted in Japan in the earlier period. From the causality direction from credit to nominal GDP, the null hypothesis that credit does not Granger cause to nominal GDP is rejected at the 5% significance level in the U.S. and the 10% significance level in Japan, but is accepted in the U.K. and Germany. Overall the results from the earlier period are consistent with those in the entire sample.

In period 2, the results shown in the table indicate that the null hypothesis that nominal GDP does not Granger cause to GDP-circulation credit fails to be rejected in all four countries and, from the other direction, that GDP-circulation credit does not Granger cause to nominal GDP fails to be rejected at 5% significance level across countries as well. The implication is that there is no causality between nominal GDP and credit to real transaction in the later period, which suggests that the relationship between these two variables has become weaker in recent years. This may also be because structural change makes data less accurate in proxying C_r.

Considering the evidence that there is no cointegration between GDP-circulation credit with nominal GDP in the later period, the implication is that there is no long-run and short-run relationship between these two variables. Furthermore, no Granger causality link between the variables is found in the later period. It can be pointed out that the link between GDP-circulation credit and nominal GDP has weakened in recent years, based on the cointegration tests and Granger causality test.

Table 6-2 Summary of Granger causality tests in subsamples

subsample 1					
Countries	Time period	nominal GDP does not GC credit		credit does not GC nominal GDP	
		F-statistic	P-value	F-statistic	P-value
U.S.	1960Q1-1979Q3	4.578274	0.0007***	2.880417	0.0155**
U.K.	1963Q1-1992Q3	1.96317	0.0786*	1.02893	0.4115
Germany	1970Q1-1990Q3	2.72502	0.0158**	1.61835	0.1468
Japan	1970Q1-1990Q4	0.905236	0.4967	2.189998	0.0549*
subsample 2					
Countries	Time period	nominal GDP does not GC credit		credit does not GC nominal GDP	
		F-statistic	P-value	F-statistic	P-value
U.S.	1979Q4 - 2008Q4	0.42147	0.8329	2.02774	0.0806*
U.K.	1992Q4-2008Q4	1.74765	0.1399	1.0129	0.4194
Germany	1990Q4-2008Q4	1.47117	0.2121	0.37929	0.8611
Japan	1991Q1-2008Q4	0.78069	0.5675	0.56232	0.7284

Note: *** significant at 1% level, ** significant at 5% level, and * significant at 10% level.

6.4.4 Comparison of robustness to structural break

Hendry and Mizon (1978) suggested running two equations of y on x and x on y, and then testing for structural breaks. The more robust equation with regard to structural breaks has the superior 'causality' direction. Therefore, regressions of nominal GDP on credit C_r and of credit C_r on nominal GDP were tested for the behaviour of parameter constancy during a period when a structural break is likely to have occurred. Parameter constancy tests of both regressions during this period will yield strong evidence concerning their relative merits and, thus, the direction of causation (Werner 2005).

According to Hendry and Mizon (1978), this type of causation test delivers even stronger causation evidence than the traditional Granger causality test.

The Chow Breakpoint test was employed, comparing the parameter constancy of the two subsample regressions. A simple regression was conducted in both directions (credit on GDP vs GDP on credit) in order to assess which relationship would break down (parameter instability) due to the regime shift. The hypotheses were as follows:

Hypotheses: H_0: No structural break

H_1: Structural break

As already discussed, the Chow (1996) F test statistic is given by:

$$F = \frac{(RSS_r - RSS_{ur})/k}{(RSS_{ur})/(n_1 + n_2 - 2k)} \qquad F_{\{k,(n_1+n_2-2k)\}} \qquad (6.19)$$

With k = number of estimated parameters

RSS_r = restricted residual sum of squares (imposing that subsamples are not different)

RSS_{ur} = unrestricted residual sum of squares = $RSS_1 + RSS_2$ with df = ($n_1 + n_2 - 2k$)

n_1, n_2 = size of the subsamples

The results are reported in the table6-3 below. As can be seen, the null hypothesis that there is no structural break is rejected in both directions in the U.S. and U.K., but the regression of credit on nominal GDP performs worse than vice versa after comparing the computed F value, which indicates that GDP-circulation credit as the explanatory variable to nominal GDP is better than nominal GDP as the explanatory variable for GDP-circulation credit. In Japan, the null hypothesis that there is no structural break is accepted in the regression of nominal GDP on GDP-circulation credit, but rejected in the regression of GDP-circulation credit on nominal GDP. This result supports the strong causality from GDP-circulation credit to nominal GDP in Japan. The only exception is in Germany where, according to the computed F statistic, the conclusion could be causality from nominal GDP to GDP-circulation credit. However, the study conducts the one-step forecast test to exam the stability, and the results show causality from GDP-circulation credit to nominal GDP and not vice versa in Germany.

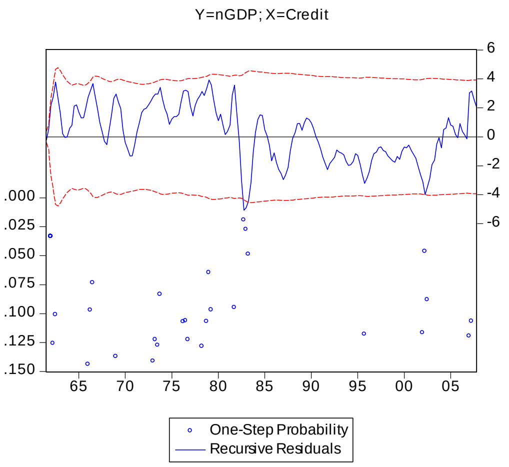
Then recursive estimation was conducted, namely the one-step forecast. These are presented in the figures6-19 below. As the figures show, the regression with credit as the explanatory variable is more stable than the regression of credit on nominal GDP. The parameter is more stable, which implies that credit as an explanatory variable of nominal GDP is better. This means the causality is more likely to occur from credit to nominal GDP and not inversely, particularly in Germany.

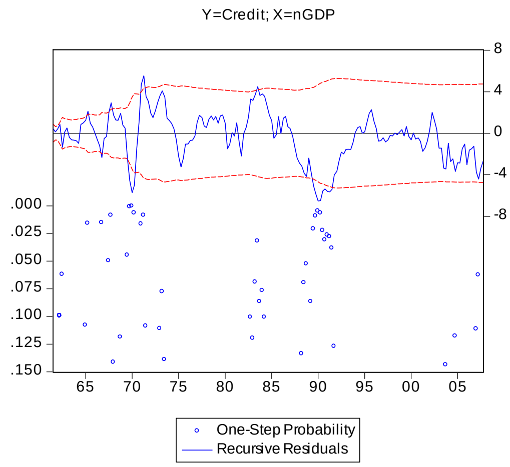
Table 6-3 Comparing the robustness for structural break

U.S.	Y=nGDP X= C_r	Y= C_r X=nGDP
Sample period	Coeff	Coeff
1960Q1-2007Q4	0.4471	0.6505
Chow Breakpoint Test : 1979Q3 F-statistic F(2,184)	5.1444 *	6.5983*
U.K.		
Sample period	Coeff	Coeff
1963Q1-2007Q4	0.2881	0.5669
Chow Breakpoint Test: 1992Q3 F-statistic F(2,171)	21.0827 *	29.2339*
Germany		
Sample period	Coeff	Coeff
1970Q1-2007Q4	0.3080	1.8661
Chow Breakpoint Test: 1990Q3 F-statistic F(2,144)	13.8185 *	0.8113
Japan		
Sample period	Coeff	Coeff
1970Q1-2007Q4	0.7374	1.0681
Chow Breakpoint Test: 1990Q4 F-statistic F(2,144)	0.1237	28.8073*

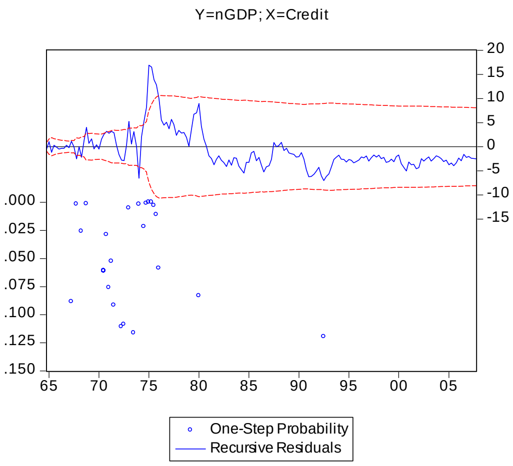
Figure 6-19 One-Step forecast test for parameter stability

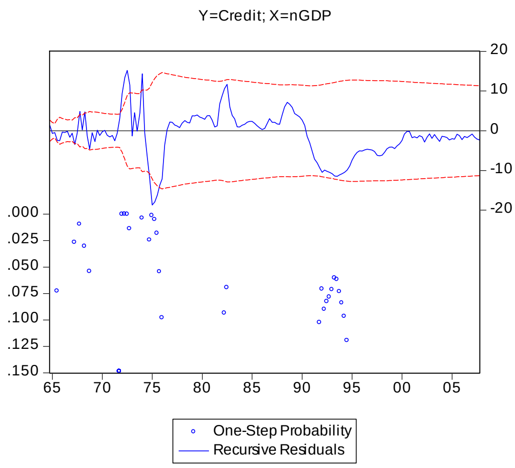
U.S.



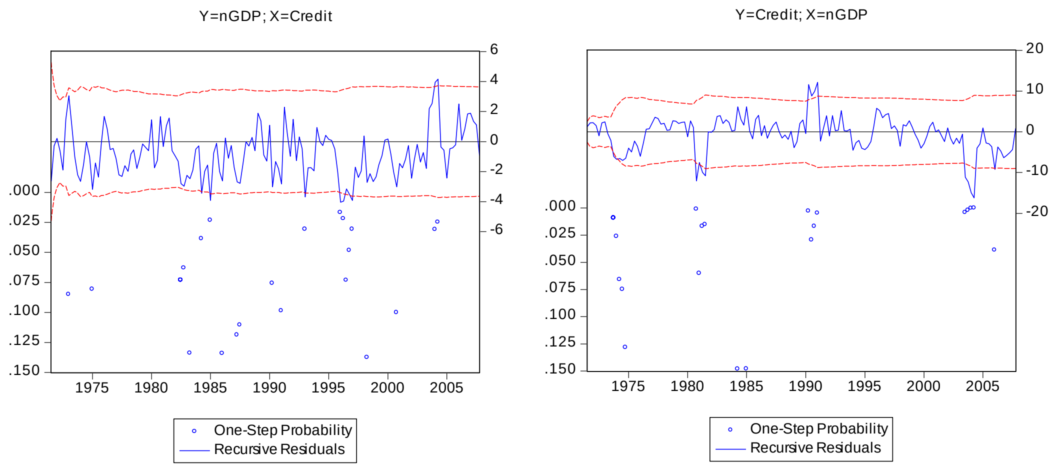


U.K.

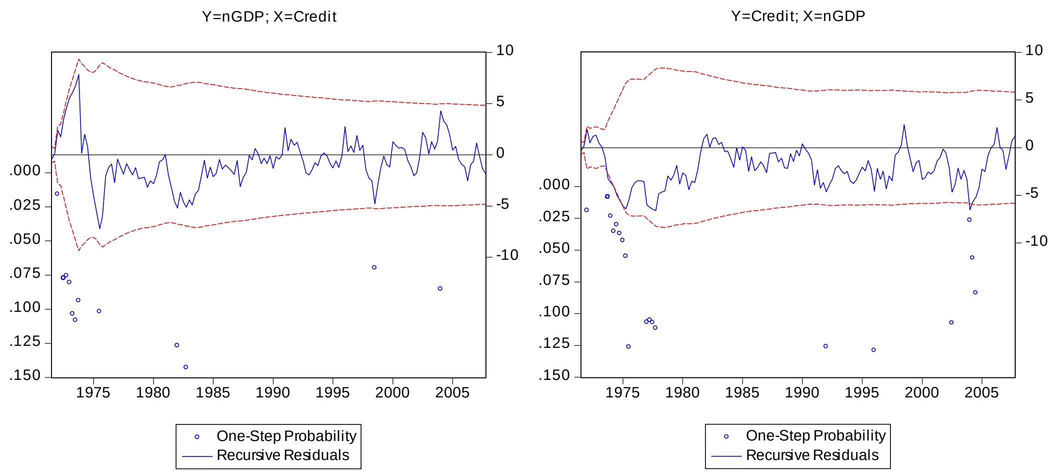




Germany



Japan



Conclusion of "causality" test

There is no strong consistent causality conclusion between GDP-circulation credit and nominal GDP based on both tests. In the Granger causality test, the causality between nominal GDP and GDP-circulation credit is mixed in the entire sample. GDP-circulation credit Granger cause to nominal GDP in the U.S. and Japan, but not in the U.K. and Germany. Considering the structural break in the Granger causality test, the causality results in the early sample are the same as those in the entire sample. However, in the later sample, the credit to real economic transactions does not Granger cause to nominal GDP, and there is no causality in the direction from nominal GDP to GDP-circulation credit either at 5% significance level. Through comparing the robustness to structural break, the causality direction from credit to nominal GDP is slight stronger in the U.S and U.K., and one way causality direction from GDP-circulation credit to nominal GDP in Japan. Considering that the comparison of robustness to structural break provides a stronger causality link than the Granger causality test (Mizon, 1995), it can be concluded that credit to real economic transactions has slightly better causality to nominal GDP than vice versa.

6.4.5 Results of VARs model

Since Christopher Sim (1980) provided the simple VAR model that captures rich dynamics in multiple time series, the VAR model has become a credible and coherent approach to interpreting and forecasting time series because it places minimal restrictions on how monetary shocks affect the economy, which leads to a lack of consensus about the working of the monetary transmission channel – this is a distinct advantage. The choice of the VAR approach to test the effect of GDP-circulation credit on nominal GDP is inspired by the explicit simultaneity between monetary policy and macroeconomic developments; that is, the dependence of monetary policy on other economic variables (the policy reaction function), as well as the dependence of economic variables on monetary policy.

It is important to apply nominal GDP as the measure of economic activity in the VAR model, because the effect of financial variables on nominal GDP is what this study intends to explore. The VAR model extends to include GDP-circulation credit which consists of nominal GDP, price, interest rate, money and credit to real economic activities. The model is expanded to be $X_t\left[c_t m_{t,} r_t \pi_t G_t\right]$; the variables are the nominal GDP (G_t), consumer price (π_t), the nominal short-term interest rate (r_t), broad money (m_t), and credit to GDP-effective transaction in that order. Nominal GDP, money aggregates, and GDP-circulation credit in the VAR model appear as annual growth rate, while consumer price growth rate and 3-month Treasury bill rate appear as the first difference. The study assumes credit to real GDP-effective transaction to be the monetary policy. As a result, the disturbance of GDP-circulation credit is assumed to be the shock to monetary policy, and the response of other variables to GDP-circulation credit is explained as the structural response to an unanticipated change in monetary policy.

The VAR involves five equations: nominal GDP as a function of the past value of nominal GDP, consumer price growth, interest rate, money and credit; consumer price growth as a function of the past value of nominal GDP, consumer price growth, interest rate and money and credit; and similar for the interest rate, money and credit equations. Each equation is estimated by ordinary least squares regression. The equations are shown below:

$$
\begin{aligned}
\Delta y_t &= \alpha_1 + \sum_{j=1}^{6} \beta_j^1 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^1 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^1 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^1 \Delta m_{t-j} + \sum_{j=1}^{6} \delta_j^1 \Delta c_{t-j} \\
\Delta r_t &= \alpha_2 + \sum_{j=1}^{6} \beta_j^2 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^2 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^2 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^2 \Delta m_{t-j} + \sum_{j=1}^{6} \delta_j^2 \Delta c_{t-j} \\
\Delta p_t &= \alpha_3 + \sum_{j=1}^{6} \beta_j^3 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^3 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^3 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^3 \Delta m_{t-j} + \sum_{j=1}^{6} \delta_j^3 \Delta c_{t-j} \qquad (6.20) \\
\Delta m_t &= \alpha_4 + \sum_{j=1}^{6} \beta_j^4 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^4 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^4 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^4 \Delta m_{t-j} + \sum_{j=1}^{6} \delta_j^4 \Delta c_{t-j} \\
\Delta c_t &= \alpha_5 + \sum_{j=1}^{6} \beta_j^5 \Delta y_{t-j} + \sum_{j=1}^{6} \delta_j^5 \Delta r_{t-j} + \sum_{j=1}^{6} \gamma_j^5 \Delta p_{t-j} + \sum_{j=1}^{6} \lambda_j^5 \Delta m_{t-j} + \sum_{j=1}^{6} \delta_j^5 \Delta c_{t-j}
\end{aligned}
$$

The number of lagged values is also six, which is consistent with the lag length in the VAR model with four variables in chapter 5. Because of the differing availability of credit data, the sample period in each country is a little different from those in the four-variable VAR model. The time period is from 1961Q1-2008Q4 in the U.S., 1963Q1-2008Q4 in the U.K., 1970Q1-2008Q4 in Germany, and 1970Q1-2008Q4 in Japan. The data is quarterly, and non-seasonally adjusted. The results are similar when we start the estimation a few years earlier or later, or use different lags.

Given the long planning procedures involved in setting economic output and prices, these variables are supposed to not respond to simultaneous shocks to financial variables. It is assumed that the monetary authorities set the credit data with information on the contemporaneous performance of slowly-moving output and price, but without a complete picture of the actions of quickly-changing financial variables. Though the research did not test all possible alternative orderings, the results were not significantly different from the complete re-ordering of credit, money, nominal interest rate, price and nominal GDP.

The main impulse response results in the entire sample

The impact of GDP-circulation credit innovation on nominal GDP

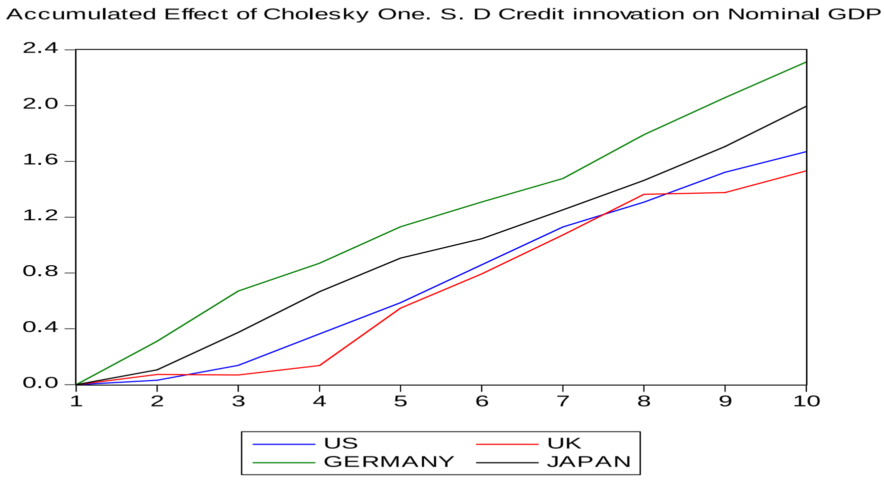
The results from the 5-variables model are illustrated through the model's impulse response function reported in the following figure[61]. An unexpected rise in GDP-circulation credit causes a statistically significant rise in nominal GDP, which still remains positive after 8-10 quarters. The maximum magnitude of impulse response is normally reached at around 4-5 quarters after the initial shock. The nominal GDP growth rate is estimated to increase by 0.27-0.3% after a 1% rise of GDP-circulation credit in the U.S., Germany and Japan although, in the U.K., the nominal GDP growth rate rose by 0.41% after the initial shock. Turning to the accumulated impulse response in the following figure, the incredibly consistent positive effect of GDP-circulation credit on nominal GDP in each country indicates that the GDP-circulation credit is an appropriate variable to target nominal GDP.

Table 6-4 Impulse response of nominal GDP to credit shock in 5-variable VAR model

Period	U.S.	U.K.	Germany	Japan
1	0	0	0	0
2	0.030675	0.072488	0.310994	0.106224
3	0.107294	-0.003806	0.359346	0.267681
4	0.225481	0.0672	0.199243	0.292517
5	0.222875	0.412405	0.260657	0.239654
6	0.271691	0.244138	0.177931	0.138962
7	0.270706	0.279718	0.168939	0.207071
8	0.178601	0.291075	0.314003	0.21026
9	0.213279	0.012398	0.26562	0.243196
10	0.149058	0.155396	0.254483	0.289175

[61] Detailed results for this VAR model reported in the Appendix 6.G

Figure 6-20 Accumulated effect of Cholesky One. S.D. GDP-circulation credit innovation on nominal GDP

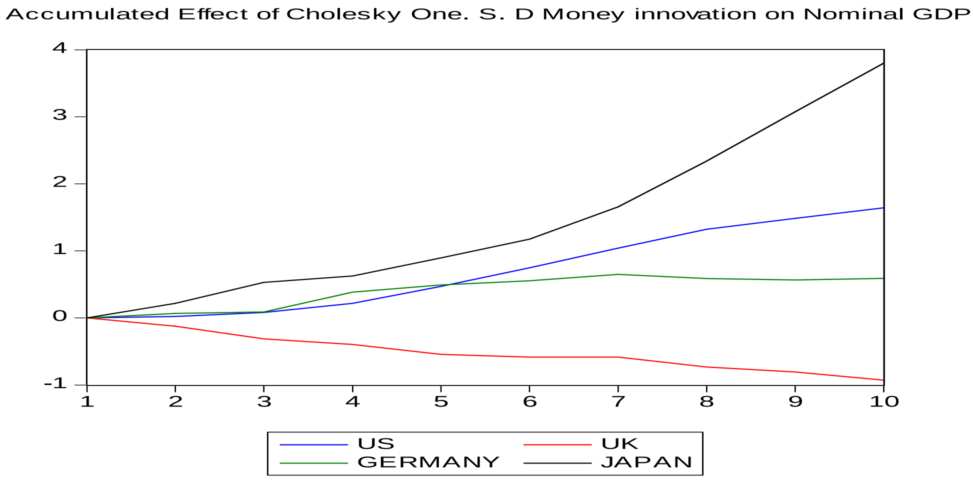


Note: Horizontal axis indicates time period (quarterly), and vertical axis indicates the accumulated percentage change of nominal GDP to GDP-circulation credit innovation

The impact of money aggregate innovation on nominal GDP

The patterns of nominal GDP response to money shock in a 5-variables VAR model do not change much compared to those in a 4-variables VAR model. The significant positive impulse response of nominal GDP to money aggregate shock occurs in Japan, with moderate positive impulse responses in the U.S. and Germany; however, the impulse response became negative in the U.K. Including GDP-circulation credit in the VAR model eliminated a small positive effect of money innovation on nominal GDP. In contrast to the consistent pattern of impulse response of nominal GDP to credit innovation, the impulse response of nominal GDP to money aggregate shock is not steady across the countries, which indicates that GDP-circulation credit rather than money aggregate is appropriate for targeting nominal GDP based on the VAR model.

Figure 6-21 Accumulated effect of Cholesky One. S.D. money aggregates innovation on nominal GDP



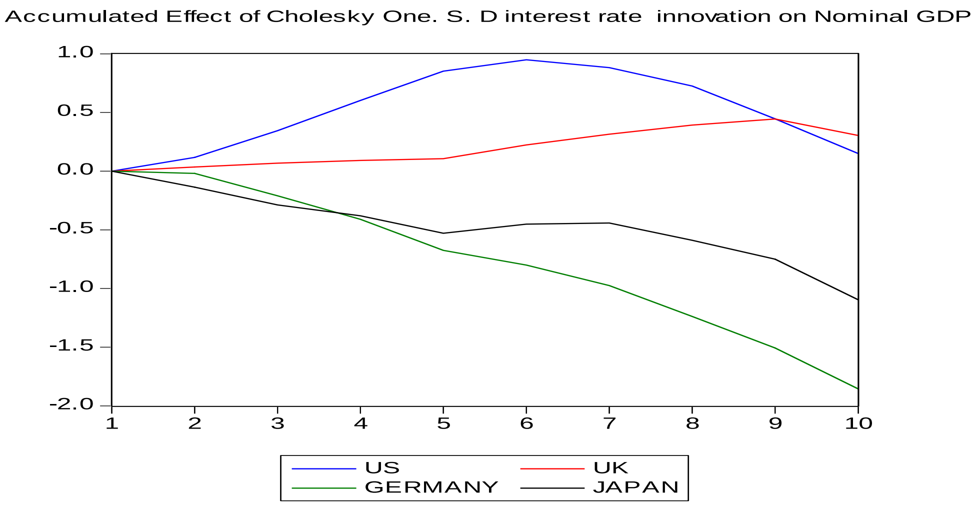
Note: Horizontal axis indicates time period (quarterly), and vertical axis indicates the accumulated percentage change of nominal GDP to money aggregates innovation

The impact of interest rate innovation on nominal GDP

In the figure above, the accumulated effect implies that interest rate shock has a negative effect on nominal GDP in Germany and Japan, but not in the U.S. and U.K. Moreover, a positive effect of interest rates on nominal GDP at early periods in the U.S. and nearly zero effect on nominal GDP in the U.K. are found; this conflicts with theoretical expectations. In the standard theory, real GDP and inflation rate will decrease when interest rates are increased; thus the nominal GDP should respond negatively to rising interest rates in the theory.

The figures in the Appendix 6.G summarise the response of nominal GDP to interest rate shock. They show that the negative response decreases to around 0.2% level at 8 quarters after the 100 basis point cut of 3-month Treasury bill rate in the U.S., Germany and Japan, but no effect is found in the U.K. Considering the small magnitude of impulse response of nominal GDP to interest rate shock also found in 4-variables VAR in the U.K., no interest rate variable remains in the general-to-specific model and no Granger causality direction is found from interest rate to nominal GDP, which raises doubts about the ability of interest rate to target nominal GDP in the U.K.

Figure 6-22 Accumulated effect of Cholesky One. S.D. interest rate innovation on nominal GDP

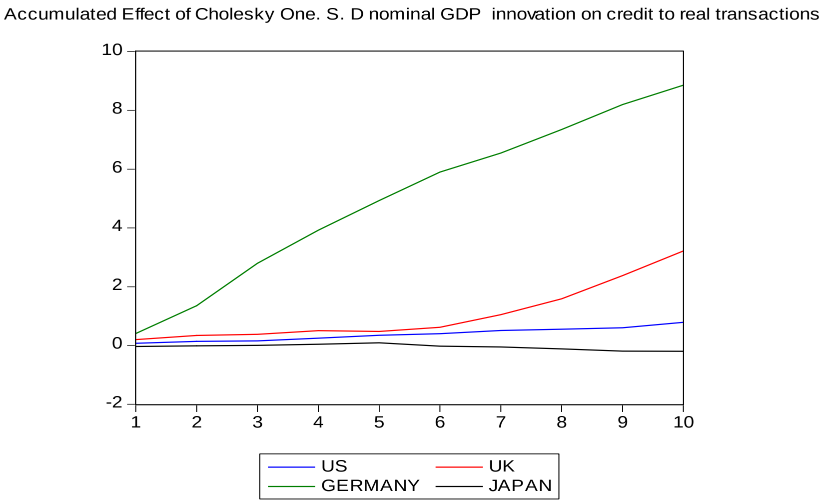


Note: Horizontal axis indicates time period (quarterly), and vertical axis indicates the accumulated percentage change of nominal GDP to short-term interest rate innovation

The study amalgamates the figures of accumulated response of nominal GDP innovation on GDP-circulation credit and money together. Inspection reveals that there is no constant pattern of money or GDP-circulation credit response to nominal GDP shock. The impulse response of nominal GDP innovation on money aggregate is negative in the U.S. and Japan and positive in the U.K. and Germany after the initial shock. The magnitude of response is also completely different in each country. The nominal GDP innovation has little effect on credit to real transaction in the U.S., U.K. and Germany during the first 6 quarters, while there is a large significant effect in Japan.

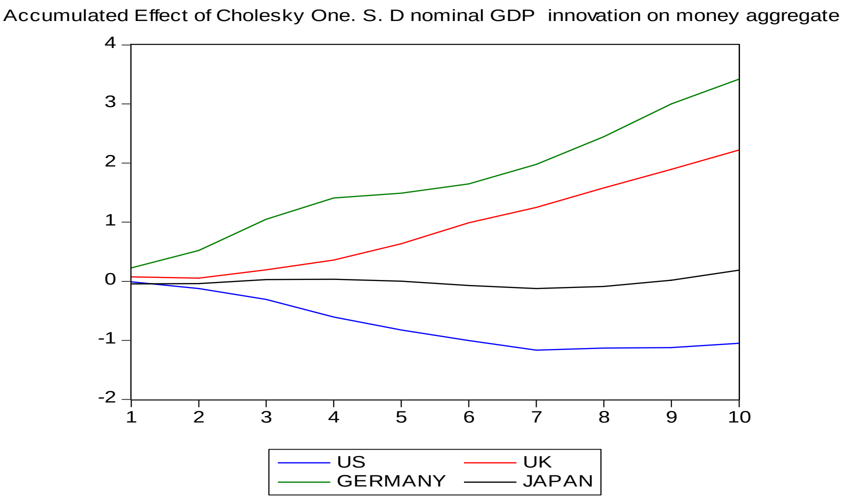
Based on the inconsistent impact of nominal GDP innovation on money and GDP-circulation credit, no evidence is found to support the view that money supply or the volume of GDP-circulation credit follows the trend of nominal GDP across countries.

Figure 6-23 Accumulated effect of nominal GDP innovation on GDP-circulation credit



Note: Horizontal axis indicates time period (quarterly), and vertical axis indicates the accumulated percentage change of GDP-circulation credit to nominal GDP innovation

Figure 6-24 Accumulated effect of nominal GDP innovation on money aggregates

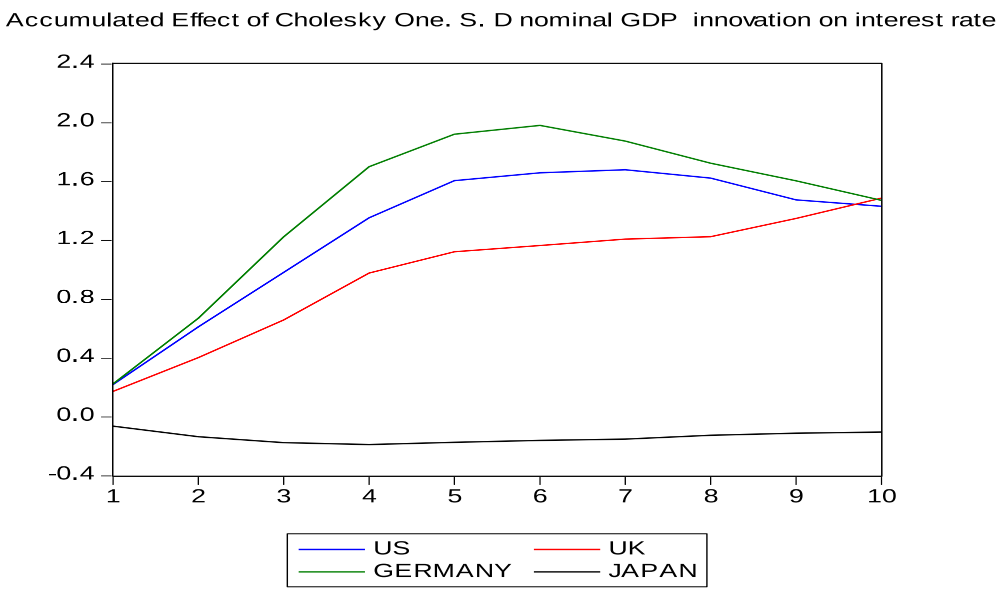


Note: Horizontal axis indicates time period (quarterly), and vertical axis indicates the accumulated percentage change of money aggregates to nominal GDP innovation

In contrast to the inconsistent pattern of impulse response of money and credit to nominal GDP shock, the pattern of impulse response of interest rate to nominal GDP shock is much more consistent. The positive impulse response in the U.S., U.K. and Germany is shown in the figure above; moreover, the ultimate accumulated responses in the U.S., U.K. and Germany become very close after 10 quarters, which implies that the change in interest rate might endogenously follow the trend of nominal GDP. Although there was virtually no impulse response of interest rate to nominal GDP shock in Japan, as we know, this was possibly due to the failure of using interest rates as the monetary policy and the fact that low interest rates have been retained for a long period in Japan.

Impulse responses reach their maximum after 3 to 4 quarters in the U.S.., U.K. and Germany, with an interest rate increase of 0.4% in Germany, and a rise of around 0.2% in the U.S. and U.K. after 1% of nominal GDP increase. This result is also found in the 4-variable VAR model.

Figure 6-25 Accumulated effect of nominal GDP innovation on interest rates



Note: Horizontal axis indicates time period (quarterly), and vertical axis indicates the accumulated percentage change of interest rate to nominal GDP innovation

Variance Decomposition in the entire sample

Table 6-5 Variance decomposition for VAR of nominal GDP in the U.S. U.K. Germany and Japan

Variance Decomposition for VAR of Nominal GDP					
		U.S.	U, K	Germany	Japan
Period	Nominal GDP				
2		96.70425	95.0439	95.00074	96.32682
4		86.84588	89.43553	84.54849	88.3422
8		70.19269	80.94266	78.01647	63.06932
	CPI				
2		0.753195	4.468336	0.988894	0.169777
4		3.505323	9.811269	4.577756	0.384035
8		7.140383	14.77569	4.493794	7.689187
	3-months Rate				
2		2.309107	0.027199	0.015382	0.851083
4		5.845567	0.031041	1.922576	1.511209
8		6.178464	0.248347	5.247191	2.029597
	Money				
2		0.075441	0.344019	0.16839	2.138514
4		1.003187	0.616916	2.30098	4.671035
8		8.740679	0.819461	2.395384	20.43458
	Credit				
2		0.158005	0.116544	3.826589	0.513807
4		2.80004	0.105241	6.650198	5.09152
8		7.747787	3.213849	9.847167	6.777313

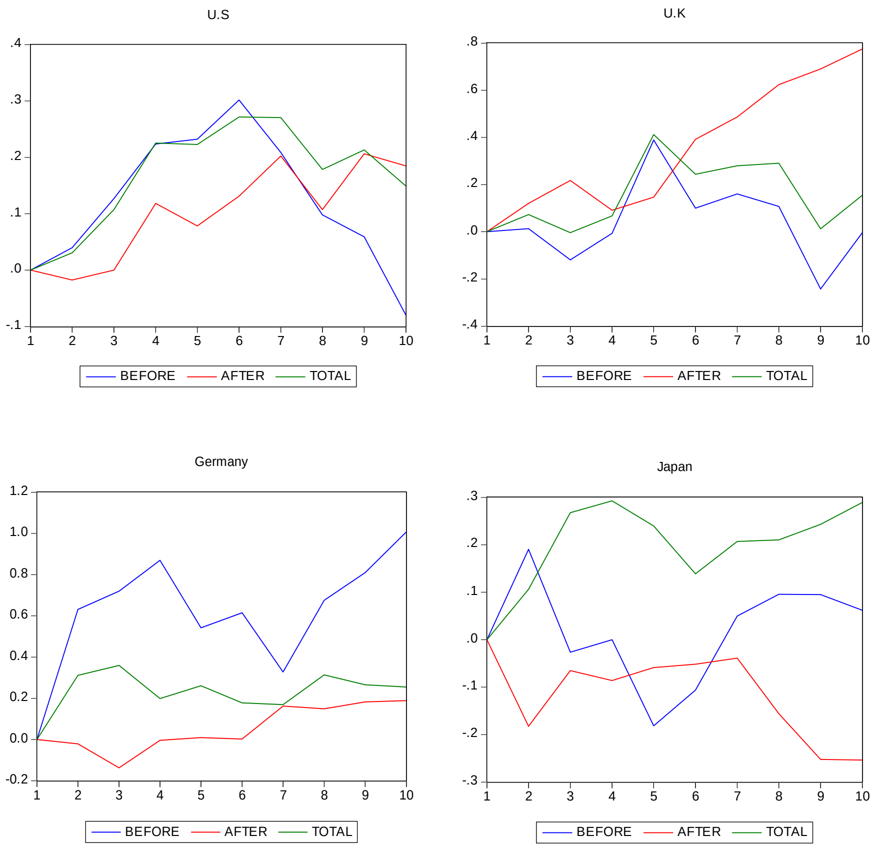
Turning to the results of variance decomposition shown in the table below, it can be seen that GDP-circulation credit has more explanatory power for nominal GDP than money and interest rate in Germany and the U.K., and 3-month Treasury bill rate and money account slightly for nominal GDP in both countries. In the case of the U.S., 3-month Treasury bill rate, money and credit play fairly equal roles in accounting for nominal GDP; however, in Japan, M2 outperforms interest rate and credit to account for nominal GDP. In Japan, credit still accounts more than interest rate for nominal GDP. Overall GDP-circulation credit does account for nominal GDP, and the performance is better than interest rate across countries. If we compare that with money aggregate, it is hard to conclude which variable is better than the other. The study also tests the variance decomposition in subsamples. As the results of variance decomposition in subsamples, showing what percentages of short-term interest rate, money aggregate and GDP-circulation credit account for nominal GDP, are not consistent when comparing before and after the structural break, the study provides the results in the Appendix 6.H for reference only.

Tests in subsamples

The main concern of this chapter is the effect of GDP-circulation credit innovation on nominal GDP, so the study only discusses the impulse response of credit innovation on nominal GDP and variance decomposition in subsamples. The impulse responses of nominal GDP to money aggregates innovation or interest rate innovation have been given in chapter 5, so they are not discussed here.

As the figure below shows, there is no consistent pattern of impulse response of credit innovation on nominal GDP in each country before and after the structural break. Nevertheless, the impulse response of nominal GDP to GDP-circulation credit shock is generally larger before structural break than after besides in the U.K., which indicates that the GDP-circulation credit is more useful to influence the nominal GDP before the structural break. Most of the effects of GDP-circulation credit innovation on nominal GDP are positive, although in different magnitudes. Thus, the results of the subsample test suggest the instability of impulse response of nominal GDP to GDP-circulation credit innovation, although impulse response is consistently positive.

Figure 6-26 The Impulse response of nominal GDP to GDP-circulation credit shock before, after and in the entire sample in the U.S., U.K., Germany and Japan



Note: Horizontal axis indicates time period (quarterly), and vertical axis indicates the accumulated percentage change of nominal GDP to GDP-circulation credit innovation before, after and in the entire sample

6.5 Discussion and conclusion

Werner (1992, 1997, 2005) shows that Japanese nominal GDP growth can be explained by a credit disaggregated model that was derived from a downward reduction of a general model including alternative explanations (M2, interest rates). The tests in this chapter were designed to accomplish two goals. The first was to discover whether the empirical finding that GDP-circulation credit is an appropriate variable to target nominal GDP, provided by Werner (1997, 2005), could be generalised to other developed countries, such as the U.S., U.K. and Germany. The second goal of the empirical tests in this chapter was to discover the quantitative effect of GDP-circulation credit innovation on nominal GDP. A significant feature of the credit used in this chapter is that the researcher develops a new type of credit flow that is capable of distinguishing the bank credit flow to the real sector and credit to financial-sector firms (such as those in the real estate sectors, financial intuitions, mortgage credit). In order to realise the two aims, the study not only applies the general-to-specific model, but also extends to the use of the "causality" tests and VAR model. The general-to-specific model could show us which variable (interest rate, money aggregates and GDP-circulation credit) best explains the nominal GDP, and further "causality" tests give the causality link between GDP-circulation credit and nominal GDP. The implementation of the VAR model reveals what percentage of nominal GDP responds to a 1% increase in GDP-circulation credit, and also shows the pattern of nominal GDP response to money policy variables (interest rates, money aggregates and GDP-circulation credit). The empirical findings obtained are displayed below.

The findings can be summarised as follows:

(a) The assumption that velocity of GDP-circulation credit is constant could not be proved by a strict trend test. However the stationary feature of GDP-circulation credit is found in the U.S., Germany and Japan. Thus it could not be concluded that the GDP-circulation credit is constant, but the velocity somehow fluctuates around one level.

(b) One of the mainstream intermediary targets, bank credit growth, appears to be a good explanatory variable for nominal GDP according to the general-to-specific model. Besides the U.S., GDP-circulation credit remains after a step-by-step deduction of the general-to-specific model in the U.K., Germany and Japan, although the significance level is 10% in Japan. However, the money aggregate also seems to be a positive variable to explain nominal GDP. In the U.S., M2 and short-term interest rate remain to explain nominal GDP. In Germany, M3 and interest rate are also left in the later period. In Japan, only M2 is left if the significance level is 1%. Thus, overall GDP-circulation credit and money aggregates are both variables that could be used to target nominal GDP, if based only on the results of the general-to-specific model.

(c) Although the two approaches of "causality" tests provide inconsistent results, the causality conclusion is mainly based on the comparison of robustness with

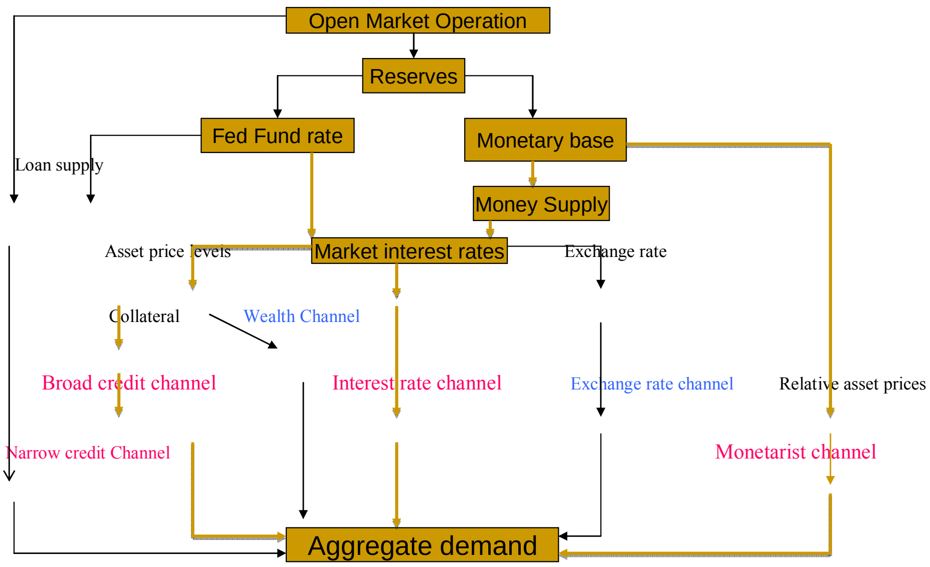
(d) The most important results of the VAR model show that the positive impact of GDP-circulation credit expansion on nominal GDP is qualitatively similar in four countries, which indicates that the GDP-circulation credit could be a good intermediate variable to target nominal GDP. Generally, a 1% increase in GDP-circulation credit will lead to approximately 0.2% of nominal GDP boost. This evidence strongly supports the notion that the GDP-circulation credit is an appropriate variable to influence nominal GDP. The additional findings are that the interest rate is more likely to follow nominal GDP stimulation, but GDP-circulation credit and money aggregates do not, according to the inconsistent pattern of credit and money aggregate response to nominal GDP innovation and the consistent pattern of interest rate to nominal GDP innovation.

The findings obtained are encouraging. GDP-circulation credit exhibits a close short-term correlation and causation to nominal GDP growth, though there are conflicts in the empirical results. The main empirical results are strong enough to point out the positive correlation between the GDP-circulation credit and nominal GDP, and the limitations of this empirical research may have caused the conflicting results in the empirical tests.

Appendix 6.A Map of monetary policy transmission

Figure A 6-1 Map of Monetary Policy transmission

- **Map of Monetary policy transmission**



Monetary Policy Transmission (Kenneth N. Kuttner and Patricia C. Mosser 2002)

Appendix 6.B Trend test, stationary test and GETS model test in the U.S.

Table B 6-1 Trend Test for Velocity of GDP-circulation credit in the U.S.

Dependent Variable: VCr_U.S.				
Method: Least Squares				
Sample: 1960Q1 2009Q2				
Included observations: 198				
	Coefficient	Std. Error	t-Statistic	Prob.
PERIOD	-0.000642	0.000116	-5.534775	0.0000
C	2.562532	0.013313	192.4802	0.0000
Dependent Variable: VCr_U.S.				
Method: Least Squares				
Sample: 1971Q1 2009Q2				
Included observations: 154				
	Coefficient	Std. Error	t-Statistic	Prob.
PERIOD	-0.000245	0.000175	-1.401942	0.1630
C	2.507424	0.022647	110.7177	0.0000

Table B 6-2 Stationary Test for Velocity of GDP-circulation credit in the U.S.

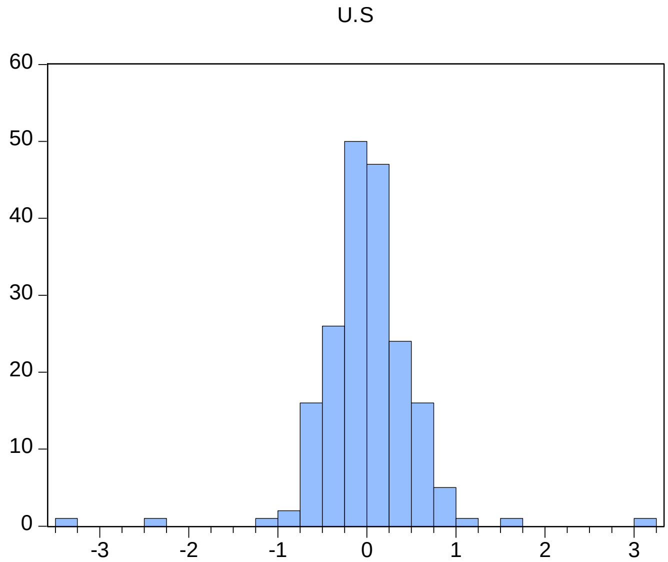
Null Hypothesis: VCR_US has a unit root				
Exogenous: Constant				
Lag Length: 14 (Automatic based on SIC, MAXLAG=14)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-3.670547	0.0053
Test critical values:	1% level		-3.466176	
	5% level		-2.877186	
	10% level		-2.575189	
Null Hypothesis: VCR_US has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 14 (Automatic based on SIC, MAXLAG=14)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.204524	0.0054
Test critical values:	1% level		-4.008987	
	5% level		-3.434569	
	10% level		-3.141237	

Table B 6-3 The Test of General-to-Specific Models in the U.S.

Dependent Variable: NGR_SA_NSA				
Method: Least Squares				
Sample (adjusted): 1961Q1 2007Q4				
Included observations: 188 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_SA_NSA(-1)	1.382122	0.057370	24.09149	0.0000
NGR_SA_NSA(-2)	-0.506545	0.057042	-8.880156	0.0000
DTREASURY	0.144826	0.024923	5.811027	0.0000
DTREASURY(-4)	-0.072871	0.024366	-2.990656	0.0032
DM2_NSA	0.071745	0.014335	5.004966	0.0000
C	0.395501	0.122014	3.241452	0.0014
R-squared	0.964060	Mean dependent var		7.016864

Adjusted R-squared	0.963073	S.D. dependent var	2.330936
S.E. of regression	0.447923	Akaike info criterion	1.263004
Sum squared resid	36.51557	Schwarz criterion	1.366294
Log likelihood	-112.7223	Hannan-Quinn criter.	1.304853
F-statistic	976.4047	Durbin-Watson stat	1.774452
Prob(F-statistic)	0.000000		

Figure B 6-1 Histogram and Normality Test of the Error Terms in the U.S.



Series: Residuals	
Sample 1961Q1 2008Q4	
Observations 192	
Mean	-7.40e-17
Median	-0.001824
Maximum	3.073006
Minimum	-3.352832
Std. Dev.	0.544636
Skewness	-0.534636
Kurtosis	15.69789
Jarque-Bera	1299.038
Probability	0.000000

Table B 6-4 Breusch-Godfrey LM Test for Autocorrelation in the U.S.

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	3.523743	Prob. F(1,181)	0.0621
Obs*R-squared	3.590127	Prob. Chi-Square(1)	0.0581

Table B 6-5 Test for Heteroskedasticity in the U.S.

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.619463	Prob. F(5,182)	0.6851
Obs*R-squared	3.145885	Prob. Chi-Square(5)	0.6775
Scaled explained SS	19.73760	Prob. Chi-Square(5)	0.0014

Table B 6-6 Test for Structural break in GETS model in the U.S.

Chow Breakpoint Test: 1979Q3			
Null Hypothesis: No breaks at specified breakpoints			
Varying regressors: All equation variables			
Equation Sample: 1961Q4 2009Q2			
F-statistic	1.313136	Prob. F(16,159)	0.1950
Log likelihood ratio	23.70486	Prob. Chi-Square(16)	0.0962
Wald Statistic	21.01018	Prob. Chi-Square(16)	0.1781

Table B 6-7 The Results of GETS Model in the U.S. in the Early Subsample

Dependent Variable: NGR_SA_NSA		
Method: Least Squares		
Sample: 1960Q1 1979Q3		

Included observations: 79				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_SA_NSA(-1)	1.420452	0.090769	15.64913	0.0000
NGR_SA_NSA(-2)	-0.549260	0.085521	-6.422530	0.0000
DM2_NSA	0.114202	0.025543	4.470934	0.0000
DTREASURY	0.136761	0.050294	2.719247	0.0081
C	0.098076	0.248562	0.394572	0.6943
R-squared	0.964165	Mean dependent var		8.004892
Adjusted R-squared	0.962228	S.D. dependent var		2.408958
S.E. of regression	0.468181	Akaike info criterion		1.381276
Sum squared resid	16.22031	Schwarz criterion		1.531241
Log likelihood	-49.56040	Hannan-Quinn criter.		1.441357
F-statistic	497.7563	Durbin-Watson stat		1.820459
Prob(F-statistic)	0.000000			

Table B 6-8 The Results of GETS Model in the U.S. in the later Subsample

Dependent Variable: NGR_SA_NSA				
Method: Least Squares				
Sample: 1979Q4 2007Q4				
Included observations: 113				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_SA_NSA(-1)	1.407645	0.070845	19.86950	0.0000
NGR_SA_NSA(-2)	-0.536354	0.065403	-8.200782	0.0000
DTREASURY	0.182353	0.031557	5.778478	0.0000
DTREASURY(-2)	-0.094570	0.033167	-2.851313	0.0052
DM2_NSA	0.052022	0.019801	2.627191	0.0099
C	0.514730	0.167987	3.064101	0.0028
R-squared	0.952514	Mean dependent var		6.260480
Adjusted R-squared	0.950295	S.D. dependent var		1.987732
S.E. of regression	0.443155	Akaike info criterion		1.261843
Sum squared resid	21.01336	Schwarz criterion		1.406660
Log likelihood	-65.29411	Hannan-Quinn criter.		1.320608
F-statistic	429.2628	Durbin-Watson stat		2.066555
Prob(F-statistic)	0.000000			

Appendix 6.C Trend test and GETS model test in the U.K.

Table C 6-1 Trend Test for Velocity of Credit to Real-GDP Effective Transactions in the U.K.

Dependent Variable: VCr_U.K.				
Method: Least Squares				
Sample (adjusted): 1963Q2 2008Q4				
Included observations: 183 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
PERIOD	-0.013882	0.000366	-37.90747	0.0000
C	3.178693	0.039169	81.15401	0.0000

Table C 6-2 The Test of General-to-Specific Models in the U.K. end in 2008Q4

Dependent Variable: NGR_NSA_ONS				
Method: Least Squares				
Sample (adjusted): 1964Q2 2008Q4				
Included observations: 179 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_NSA_ONS(-1)	0.896781	0.032884	27.27093	0.0000
GCREDIT_REAL	0.047055	0.023168	2.030980	0.0438
C	0.301440	0.327264	0.921092	0.3583
R-squared	0.843332	Mean dependent var		8.577487
Adjusted R-squared	0.841551	S.D. dependent var		4.432839
S.E. of regression	1.764519	Akaike info criterion		3.990251
Sum squared resid	547.9808	Schwarz criterion		4.043671
Log likelihood	-354.1275	Hannan-Quinn criter.		4.011912
F-statistic	473.6958	Durbin-Watson stat		2.025315
Prob(F-statistic)	0.000000			

Figure C 6-1 Histogram and Normality Test of the Error Terms in the U.K. end in 2008Q4

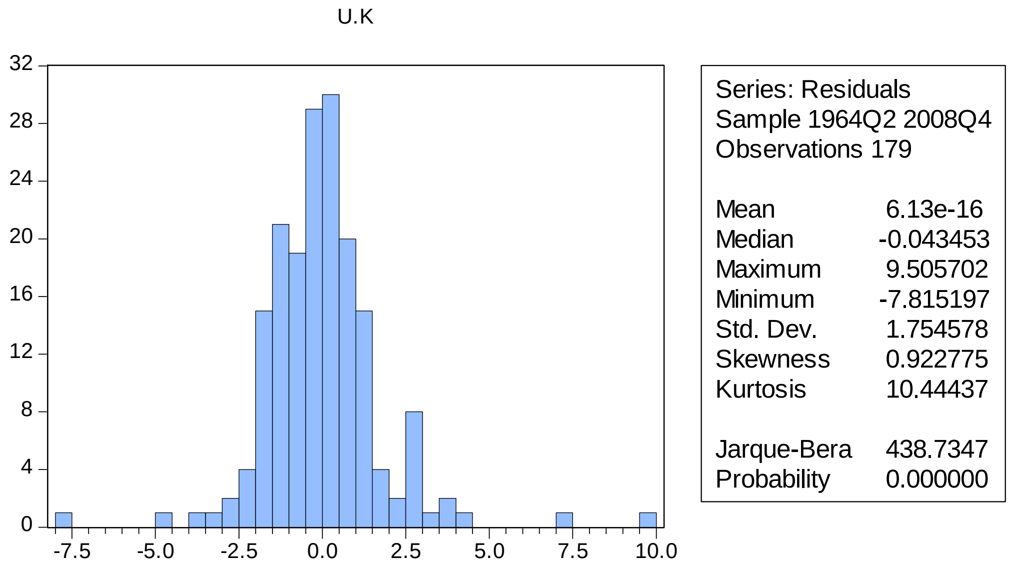


Table C 6-3 Breusch-Godfrey LM Test for Autocorrelation in the U.K. end in 2008Q4

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.093223	Prob. F(1,175)	0.7605
Obs*R-squared	0.095303	Prob. Chi-Square(1)	0.7575

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.048153	Prob. F(2,174)	0.9530
Obs*R-squared	0.099019	Prob. Chi-Square(2)	0.9517

Table C 6-4 Test for Heteroskedasticity in the U.K. end in 2008Q4

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	6.328942	Prob. F(2,176)	0.0022
Obs*R-squared	12.00989	Prob. Chi-Square(2)	0.0025
Scaled explained SS	54.82790	Prob. Chi-Square(2)	0.0000

Table C 6-5 The Test of General-to-Specific Models in the U.K. end in 2007Q4

Dependent Variable: NGR_NSA_ONS				
Method: Least Squares				
Sample (adjusted): 1965Q1 2007Q4				
Included observations: 172 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_NSA_ONS(-1)	0.877522	0.057034	15.38591	0.0000
NGR_NSA_ONS(-3)	0.222372	0.086630	2.566918	0.0111
NGR_NSA_ONS(-4)	-0.226132	0.074401	-3.039390	0.0028
GCREDIT_REAL(-3)	0.048564	0.023763	2.043732	0.0426
C	0.520916	0.340500	1.529857	0.1279
R-squared	0.850656	Mean dependent var		8.699223
Adjusted R-squared	0.847079	S.D. dependent var		4.445133
S.E. of regression	1.738276	Akaike info criterion		3.972303
Sum squared resid	504.6076	Schwarz criterion		4.063800
Log likelihood	-336.6181	Hannan-Quinn criter.		4.009426
F-statistic	237.8057	Durbin-Watson stat		1.820350
Prob(F-statistic)	0.000000			

Figure C 6-2 Histogram and Normality Test of the Error Terms in the U.K. end in 2007Q4

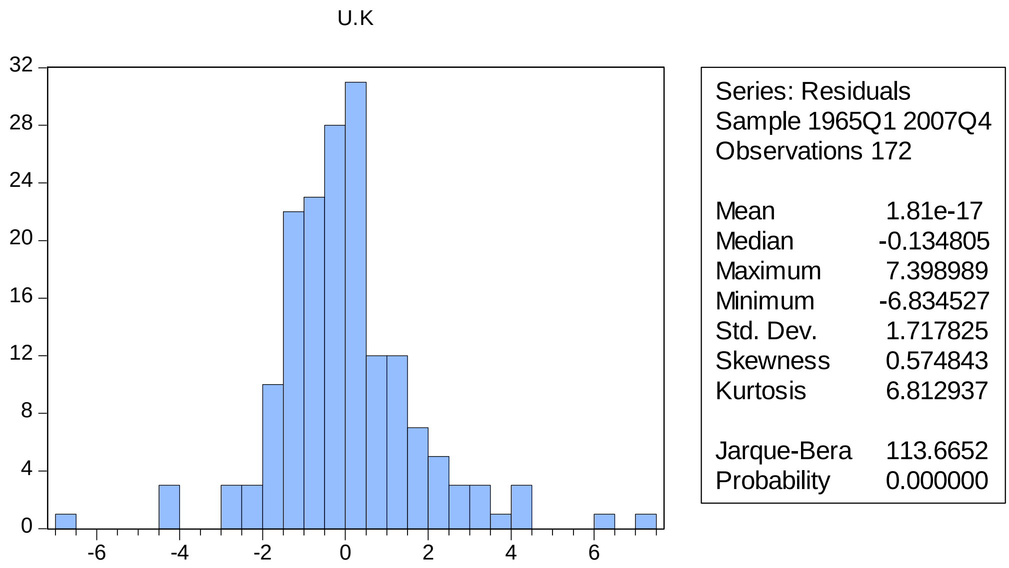


Table C 6-6 Breusch-Godfrey LM Test for Autocorrelation in the U.K. end in 2007Q4

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	2.666736	Prob. F(1,166)	0.1044
Obs*R-squared	2.719437	Prob. Chi-Square(1)	0.0991

Table C 6-7 Test for Heteroskedasticity in the U.K. end in 2007Q4

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	9.115582	Prob. F(4,167)	0.0000
Obs*R-squared	30.82399	Prob. Chi-Square(4)	0.0000
Scaled explained SS	84.45600	Prob. Chi-Square(4)	0.0000

Table C 6-8 Test for Structural break in GETS model in the U.K.

Chow Breakpoint Test: 1992Q4				
Null Hypothesis: No breaks at specified breakpoints				
Varying regressors: All equation variables				
Equation Sample: 1964Q2 2008Q4				
F-statistic	0.726493		Prob. F(3,175)	0.5374
Log likelihood ratio	2.240281		Prob. Chi-Square(3)	0.5241
Wald Statistic	2.179478		Prob. Chi-Square(3)	0.5360

Appendix 6.D Trend test and GETS model test in Germany.

Table D 6-1 Trend Test for Velocity of Credit to Real-GDP Effective Transactions in Germany

Dependent Variable: VR_Germany				
Method: Least Squares				
Sample (adjusted): 1970Q4 2008Q3				
Included observations: 152 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
PERIOD	-0.001142	0.000520	-2.196232	0.0296
C	2.518276	0.060382	41.70545	0.0000
R-squared	0.031154	Mean dependent var		2.395496
Adjusted R-squared	0.024695	S.D. dependent var		0.284863
S.E. of regression	0.281324	Akaike info criterion		0.314451
Sum squared resid	11.87148	Schwarz criterion		0.354239
Log likelihood	-21.89829	Hannan-Quinn criter.		0.330614
F-statistic	4.823436	Durbin-Watson stat		0.033521
Prob(F-statistic)	0.029611			

Table D 6-2 The Test of General-to-Specific Models in Germany

Dependent Variable: NGR_NSA				
Method: Least Squares				
Sample (adjusted): 1971Q2 2007Q4				
Included observations: 147 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_NSA(-1)	0.674134	0.059233	11.38111	0.0000
DCREDIT_REAL	0.090932	0.024167	3.762664	0.0002
C	1.081256	0.239005	4.523994	0.0000
R-squared	0.777319	Mean dependent var		4.888673
Adjusted R-squared	0.774226	S.D. dependent var		2.711265
S.E. of regression	1.288276	Akaike info criterion		3.364684
Sum squared resid	238.9903	Schwarz criterion		3.425713
Log likelihood	-244.3043	Hannan-Quinn criter.		3.389481
F-statistic	251.3322	Durbin-Watson stat		2.099773
Prob(F-statistic)	0.000000			

Figure D 6-1 Histogram and Normality Test of the Error Terms in Germany

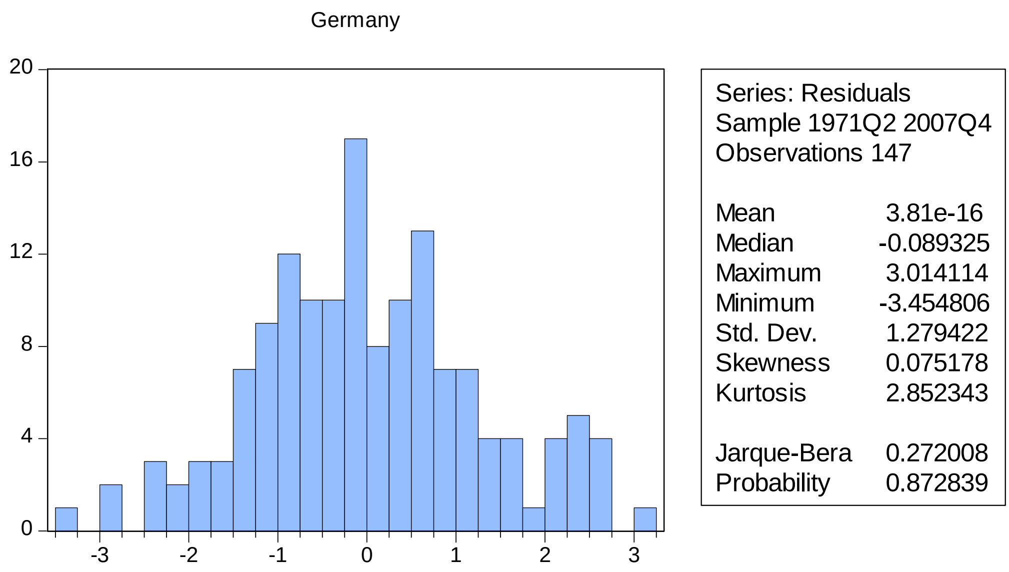


Table D 6-3 Breusch-Godfrey LM Test for Autocorrelation in Germany

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.692692	Prob. F(1,143)	0.4066
Obs*R-squared	0.708635	Prob. Chi-Square(1)	0.3999

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.507104	Prob. F(2,142)	0.6033
Obs*R-squared	1.042474	Prob. Chi-Square(2)	0.5938

Table D 6-4 Test for Heteroskedasticity in Germany

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.445498	Prob. F(2,144)	0.6414
Obs*R-squared	0.903965	Prob. Chi-Square(2)	0.6364
Scaled explained SS	0.803403	Prob. Chi-Square(2)	0.6692

Table D 6-5 Test for Structural break in GETS model in Germany

Chow Breakpoint Test: 1990Q3				
Null Hypothesis: No breaks at specified breakpoints				
Varying regressors: All equation variables				
Equation Sample: 1971Q2 2007Q4				
F-statistic	3.038008		Prob. F(3,141)	0.0312
Log likelihood ratio	9.207386		Prob. Chi-Square(3)	0.0267
Wald Statistic	9.114024		Prob. Chi-Square(3)	0.0278

Table D 6-6 The Test of General-to-Specific Models in Germany in the Early Subsample

Dependent Variable: NGR_NSA				
Method: Least Squares				
Sample (adjusted): 1971Q2 1990Q3				
Included observations: 78 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_NSA(-1)	0.444475	0.086805	5.120385	0.0000
DCREDIT_REAL	0.118124	0.033175	3.560606	0.0007
DM3(-2)	0.189629	0.071702	2.644681	0.0100
C	1.086175	0.476385	2.280034	0.0255
R-squared	0.726441	Mean dependent var		6.332384
Adjusted R-squared	0.715350	S.D. dependent var		2.301933
S.E. of regression	1.228141	Akaike info criterion		3.298800
Sum squared resid	111.6164	Schwarz criterion		3.419657
Log likelihood	-124.6532	Hannan-Quinn criter.		3.347181
F-statistic	65.50267	Durbin-Watson stat		1.798179
Prob(F-statistic)	0.000000			

Table D 6-7 Table D 6-8 The Test of General-to-Specific Models in Germany in the later Subsample

Dependent Variable: NGR_NSA				
Method: Least Squares				
Sample: 1990Q4 2007Q4				
Included observations: 69				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_NSA(-1)	0.534791	0.075899	7.046114	0.0000
DTREASURY(-1)	1.632934	0.385745	4.233202	0.0001
DTREASURY(-2)	-2.731810	0.676525	-4.038004	0.0002
DTREASURY(-3)	1.448110	0.388255	3.729788	0.0004
DM3	0.126795	0.037430	3.387510	0.0012
DM3(-3)	0.102908	0.035431	2.904416	0.0051
C	0.193382	0.256676	0.753408	0.4541
R-squared	0.825236	Mean dependent var		3.256652
Adjusted R-squared	0.808323	S.D. dependent var		2.165465
S.E. of regression	0.948061	Akaike info criterion		2.827131
Sum squared resid	55.72682	Schwarz criterion		3.053779
Log likelihood	-90.53601	Hannan-Quinn criter.		2.917050
F-statistic	48.79388	Durbin-Watson stat		2.234397
Prob(F-statistic)	0.000000			

Appendix 6.E Trend test and GETS model test in Japan

Trend test for velocity of GDP-circulation credit and GETS model test in Japan

Table E 6-1 Trend Test for Velocity of Credit to Real-GDP Effective Transactions in Japan

Dependent Variable: VR_Japan				
Method: Least Squares				
Sample: 1970Q1 2008Q4				
Included observations: 156				
	Coefficient	Std. Error	t-Statistic	Prob.
PERIOD	0.003031	0.000199	15.19714	0.0000
C	1.339536	0.023064	58.07892	0.0000

Table E 6-2 The Test of General-to-Specific Models in Japan

Dependent Variable: NGR_TOTAL				
Method: Least Squares				
Sample (adjusted): 1971Q1 2007Q4				
Included observations: 148 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_TOTAL(-1)	0.717127	0.045831	15.64713	0.0000
DM2_IMF_NSA(-4)	0.242033	0.041276	5.863755	0.0000
C	-0.448445	0.171074	-2.621351	0.0097
R-squared	0.947791	Mean dependent var		5.257401
Adjusted R-squared	0.947071	S.D. dependent var		5.227557
S.E. of regression	1.202664	Akaike info criterion		3.227017
Sum squared resid	209.7280	Schwarz criterion		3.287771
Log likelihood	-235.7992	Hannan-Quinn criter.		3.251701
F-statistic	1316.162	Durbin-Watson stat		1.809516
Prob(F-statistic)	0.000000			

Figure E 6-1 Histogram and Normality Test of the Error Terms in Japan

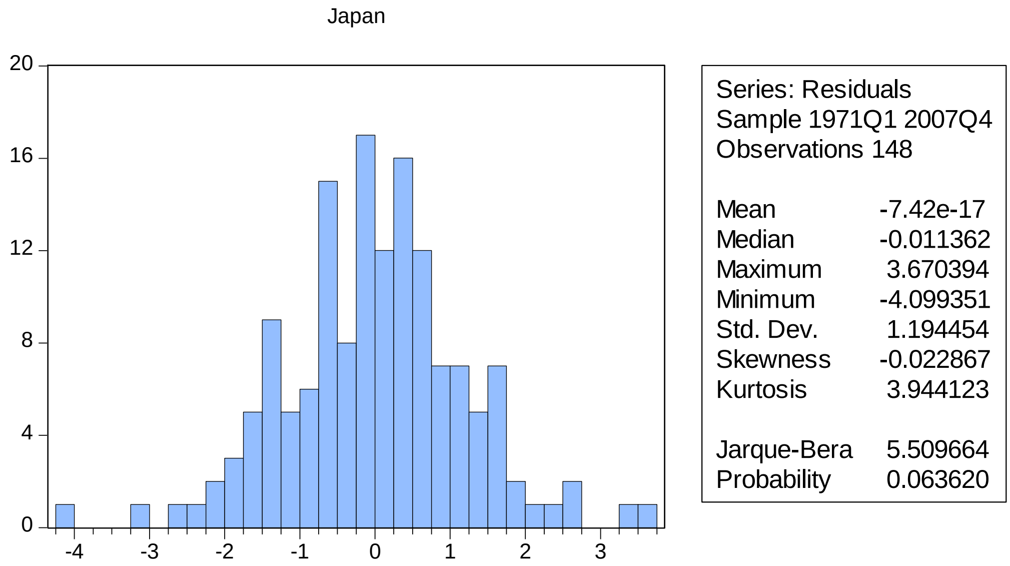


Table E 6-3 Breusch-Godfrey LM Test for Autocorrelation in Japan

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.518340	Prob. F(1,144)	0.2199
Obs*R-squared	1.544234	Prob. Chi-Square(1)	0.2140

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.938108	Prob. F(2,143)	0.1477
Obs*R-squared	3.905875	Prob. Chi-Square(2)	0.1419

Table E 6-4 Test for Heteroskedasticity in Japan

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	4.833178	Prob. F(2,145)	0.0093
Obs*R-squared	9.249722	Prob. Chi-Square(2)	0.0098
Scaled explained SS	13.06975	Prob. Chi-Square(2)	0.0015

Table E 6-5 Test for Structural break in GETS model in Japan

Chow Breakpoint Test: 1990Q4				
Null Hypothesis: No breaks at specified breakpoints				
Varying regressors: All equation variables				
Equation Sample: 1971Q1 2007Q4				
F-statistic	1.749498		Prob. F(3,142)	0.1596
Log likelihood ratio	5.371592		Prob. Chi-Square(3)	0.1465
Wald Statistic	5.248494		Prob. Chi-Square(3)	0.1545

Velocity of GDP-circulation credit in Japan (non-modified)

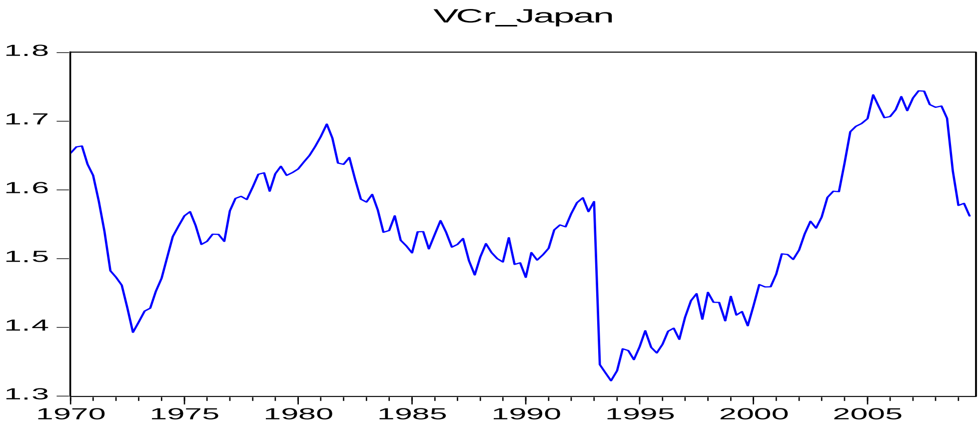


Table E 6-6 The Test of General-to-Specific Models in Japan(rejected the null hypothesis at 10% significance level)

Dependent Variable: NGR_TOTAL				
Method: Least Squares				
Sample (adjusted): 1971Q4 2007Q4				
Included observations: 145 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
NGR_TOTAL(-1)	0.690270	0.048271	14.29983	0.0000
DM2_IMF_NSA(-4)	0.234655	0.051391	4.566058	0.0000
DCR	0.182074	0.059177	3.076755	0.0025
DCR(-3)	-0.128188	0.073035	-1.755157	0.0814
C	-0.413708	0.201124	-2.056980	0.0415
R-squared	0.953271	Mean dependent var		5.156357
Adjusted R-squared	0.951936	S.D. dependent var		5.231136
S.E. of regression	1.146844	Akaike info criterion		3.145779
Sum squared resid	184.1352	Schwarz criterion		3.248425
Log likelihood	-223.0690	Hannan-Quinn criter.		3.187488
F-statistic	714.0067	Durbin-Watson stat		1.996934
Prob(F-statistic)	0.000000			

Figure E 6-2 Histogram and Normality Test of the Error Terms in Japan (reject at 10% significance level)

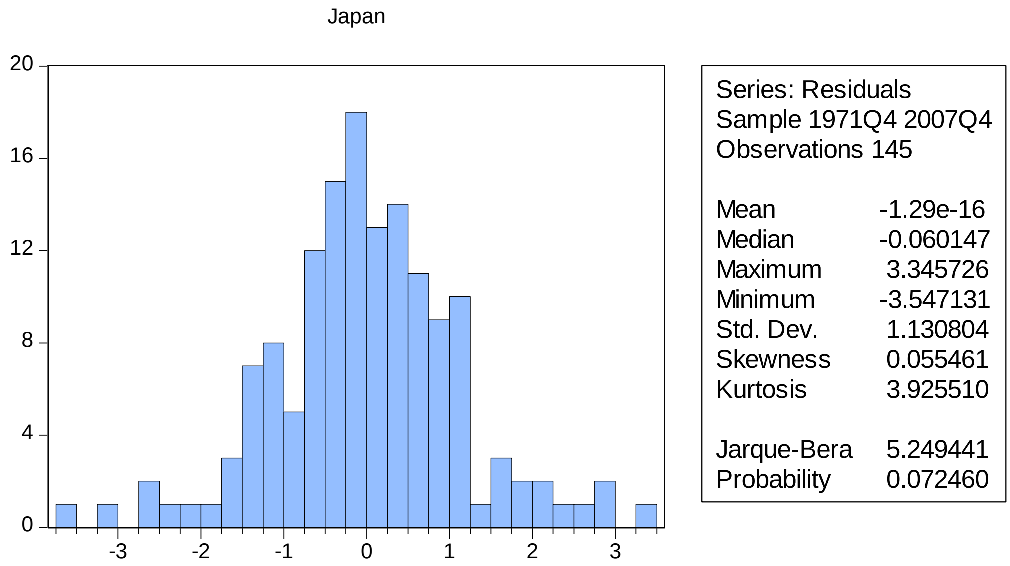


Table E 6-7 Breusch-Godfrey LM Test for Autocorrelation in Japan (reject at 10% significance level)

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.050909	Prob. F(1,139)	0.8218
Obs*R-squared	0.053087	Prob. Chi-Square(1)	0.8178

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.402440	Prob. F(2,138)	0.6695
Obs*R-squared	0.840803	Prob. Chi-Square(2)	0.6568

Table E 6-8 Test for Heteroskedasticity in Japan (reject at 10% significance level)

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	2.172695	Prob. F(4,140)	0.0751
Obs*R-squared	8.475059	Prob. Chi-Square(4)	0.0756
Scaled explained SS	11.55672	Prob. Chi-Square(4)	0.0210

Table E 6-9 Test for Structural break in GETS model in Japan (reject at 10% significance level)

Chow Breakpoint Test: 1990Q4				
Null Hypothesis: No breaks at specified breakpoints				
Varying regressors: All equation variables				
Equation Sample: 1971Q4 2007Q4				
F-statistic	1.330973		Prob. F(5,135)	0.2548
Log likelihood ratio	6.977225		Prob. Chi-Square(5)	0.2223
Wald Statistic	6.654866		Prob. Chi-Square(5)	0.2476

Appendix 6.F Unit root test and cointegration test

Table F 6-1 Unit Root Test for GDP-circulation credit

Countries	Time period	ZA	ADF		PP	
			t-Statistic	Prob.*	Adj. t-Stat	Prob.*
U.S.	1960Q1-2008Q4	-4.93351 at 1986:04	-2.00112	0.2863	-2.39211	0.1453
U.K.	1964Q2-2008Q3	-4.95164 at 1990:02	-1.19497	0.2119	-1.34434	0.1653
Germany	1961Q1-2008Q4	-3.47196 at 1989:02	-6.01284	0	-6.96016	0
Japan	1960Q1-2008Q4	-4.75865 at 2001:03	-2.29267	0.0216	-2.23049	0.0252

Table F 6-2 Cointegration test results (nominal GDP growth rate and GDP-circulation credit)

Full time period			
Countries	Fullbreak	trend	constant
US	-4.78865 at 1988:04	-5.03378 at 1988:01	-4.69140 at 1988:04
U.K.	- 4.88809 at 1981:02	-4.70327 at 1981:01	-4.32105 at 1979:01
Germany	-6.58379 at 1982:04	6.64335 at 1992:01	-6.64040 at 1982:04
Japan	- 7.47630 at 1971:04	-5.86593 at 1972: 01	-7.47287 at 1971:04

Table F 6-3

Countries	Time period	Fullbreak	trend	constant
US	1960Q1-1979Q3	-5.25798 at 1970:01	-5.31053 at 1971:04	-5.36756 at 1971:04
U.K.	1960Q1-1992Q3	-4.17596 at 1974:02	-3.68862 at 1971:01	-3.58784 at 1981:01
Germany	1971Q1-1990Q3	3.38358 at 1982:01	-3.37604 at 1980:02	-3.37118 at 1982:01
Japan	1960Q1-1990Q4	-6.93280 at 1975:01	-5.10957 at 1975:03	-6.11605 at 1971:04

Null Hypothesis: has a unit root				
Countries	Time period	Fullbreak	trend	constant
US	1979Q4 -2008Q4	-3.22558 at 1987:01	-3.29141 at 1987:01	- 3.20093 at 1987:01
U.K.	1992Q4-2008Q4	-2.36741 at 1995:03	-1.99161 at 1999:02	-2.36866 at 1995:03
Germany	1990Q4-2008Q4	-4.69252 at 1994:04	-4.56514 at 1996:01	-4.42826 at 1996:01
Japan	1991Q1-2008Q4	-3.86534 at 20006:02	5.13367 at 2006:02	-3.83176 at 2006:02

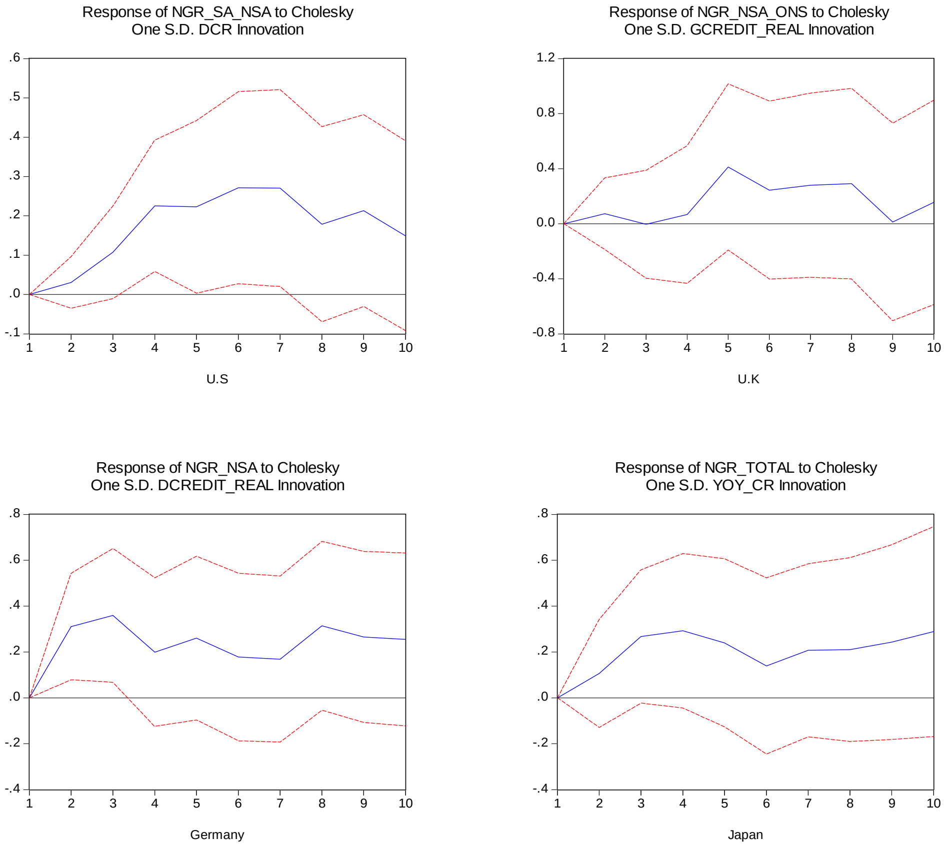
Critical Values are 1% -5.47 and 5% -4.95 10% -4.82 (fullbreak)

Critical Values are 1% -5.45 and 5% -4.99 10% -4.58(trend)

Critical Values are 1% -5.13 and 5% -4.6110% -4.11 (constant)

Appendix 6.G Impulse response

Figure G 6-1 Impulse response of nominal GDP to GDP-circulation credit shock



Notes: The blue solid lines are the dynamic response of each variable while the red dotted lines are the 95% confidence interval. The time period: 1961Q1-2008Q4 in the U.S., 1963Q1- 2008Q4 in the U.K., 1970Q1-2008Q4 in Germany, and 1970Q1-2008Q4 in Japan

Figure G 6-2

Impulse response of nominal GDP to money aggregates shock

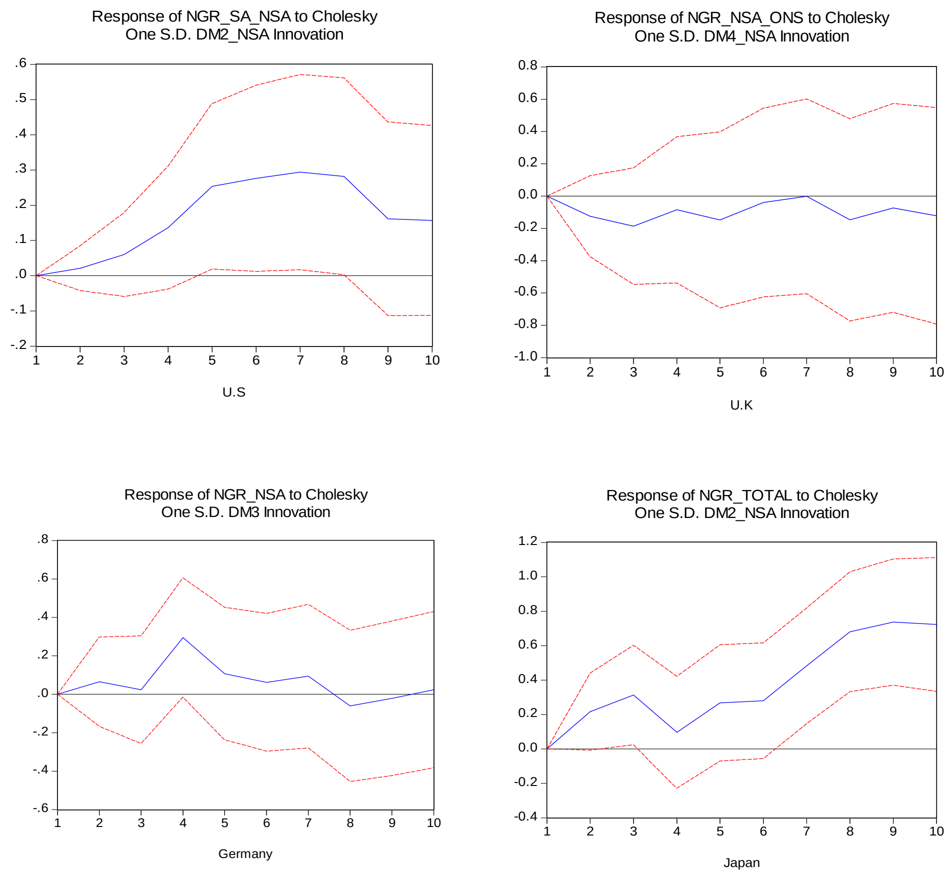


Table G 6-1Table Impulse response of nominal GDP to money shock

Period	U.S	U.K	Germany	Japan
1	0	0	0	0
2	0.021196	-0.124541	0.065239	0.216709
3	0.06014	-0.186283	0.023842	0.313453
4	0.136421	-0.084991	0.29505	0.096803
5	0.253559	-0.14785	0.107205	0.267737
6	0.276531	-0.040257	0.062074	0.279951
7	0.294006	-0.001376	0.094057	0.483456
8	0.28196	-0.147301	-0.060658	0.680929
9	0.161444	-0.073052	-0.020728	0.736957
10	0.156857	-0.122503	0.024272	0.723169

Notes: The blue solid lines are the dynamic response of each variable while the red dotted lines are the 95% confidence interval. The time period: 1961Q1-2008Q4 in the U.S., 1963Q1- 2008Q4 in the U.K., 1970Q1-2008Q4 in Germany, and 1970Q1-2008Q4 in Japan

Figure G 6-3 Impulse response of nominal GDP to interest rate shock

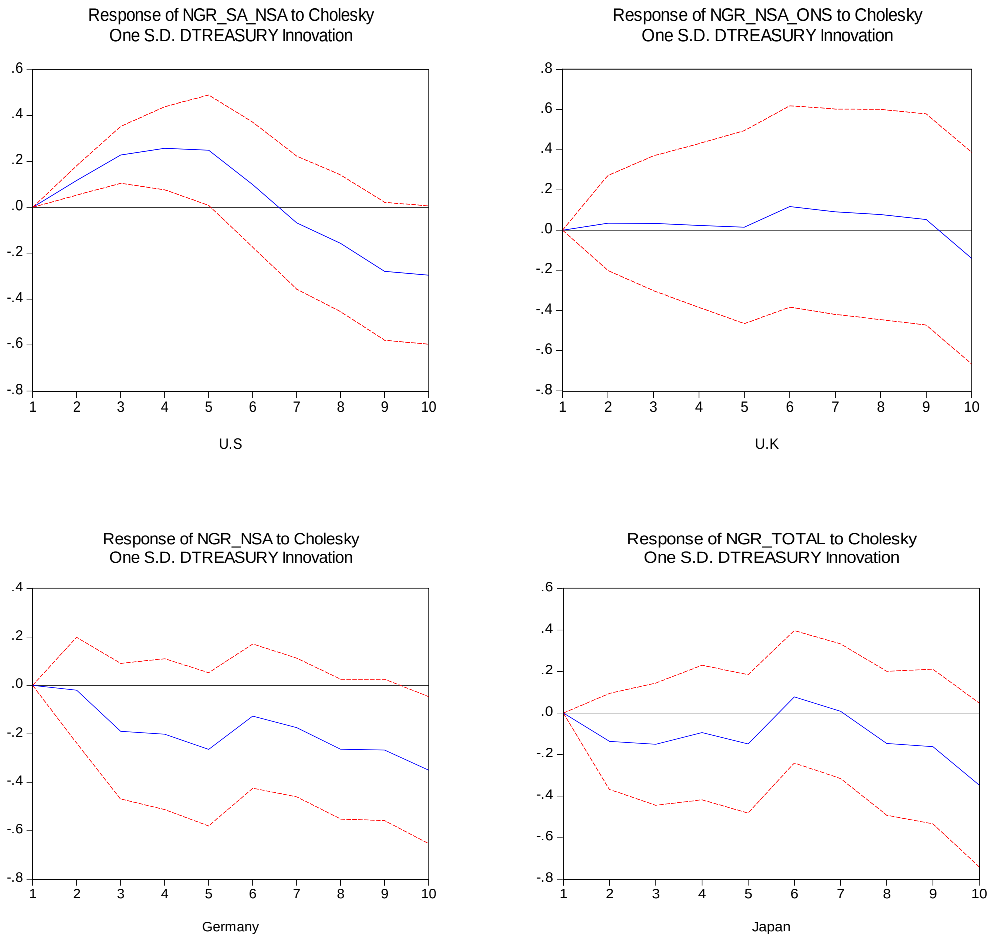


Figure G 6-4 Impulse response of money to GDP-circulation credit shock

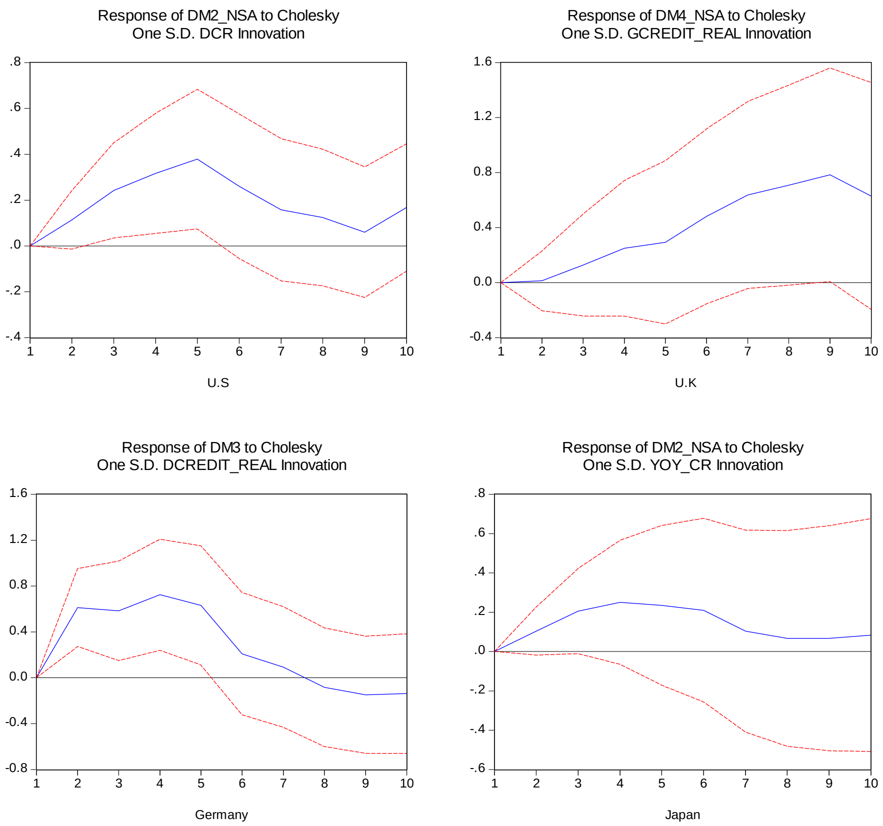


Figure G 6-5 Impulse response of interest rate to GDP-circulation credit shock

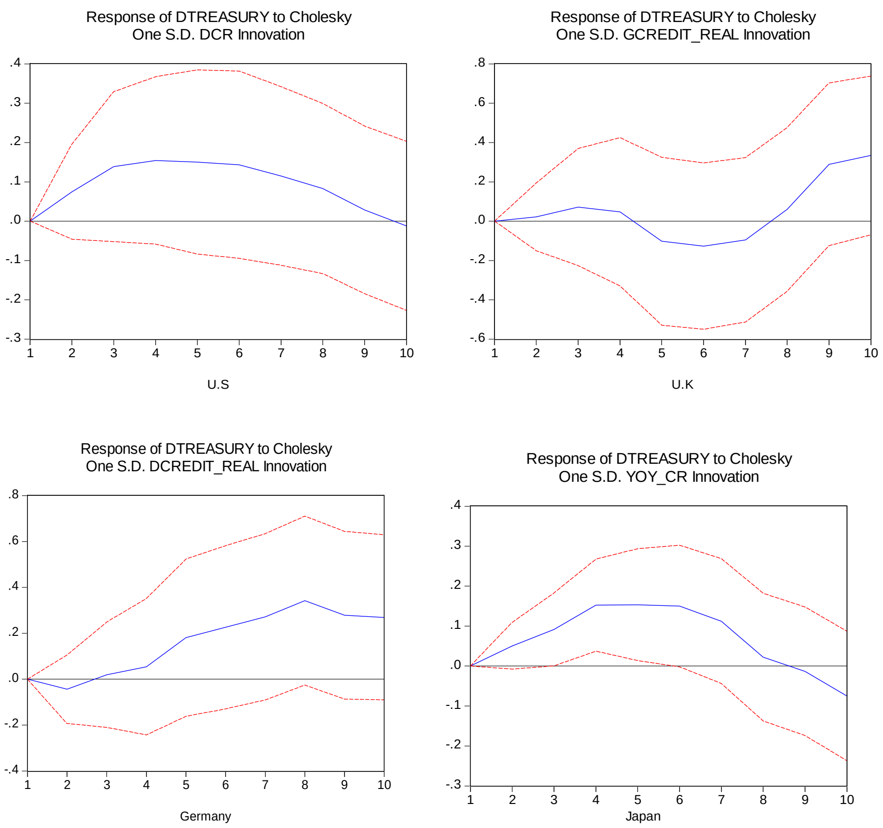


Figure G 6-6 Impulse response of GDP-circulation credit to nominal GDP shock

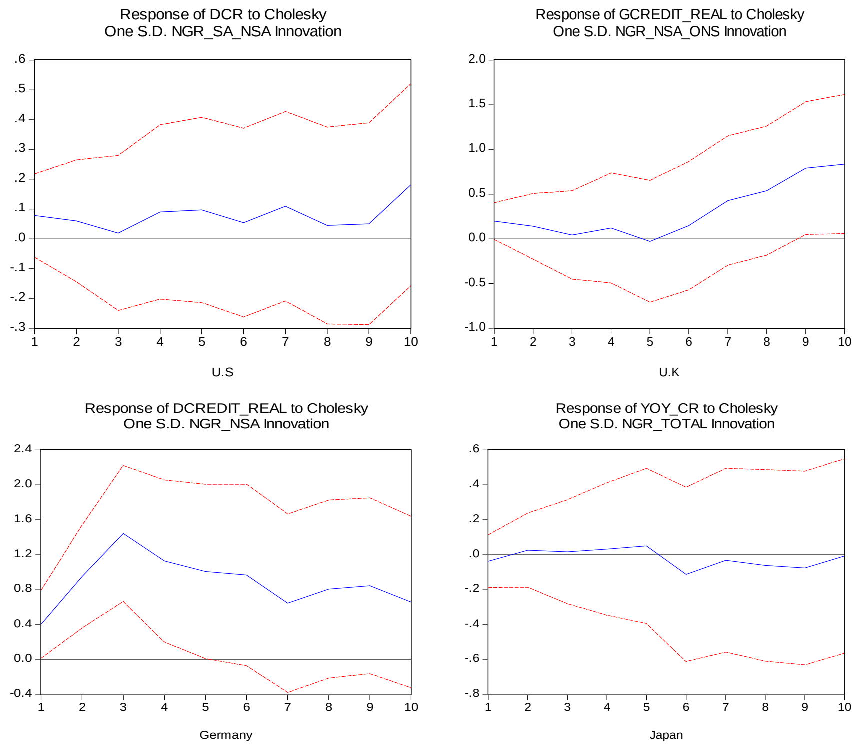
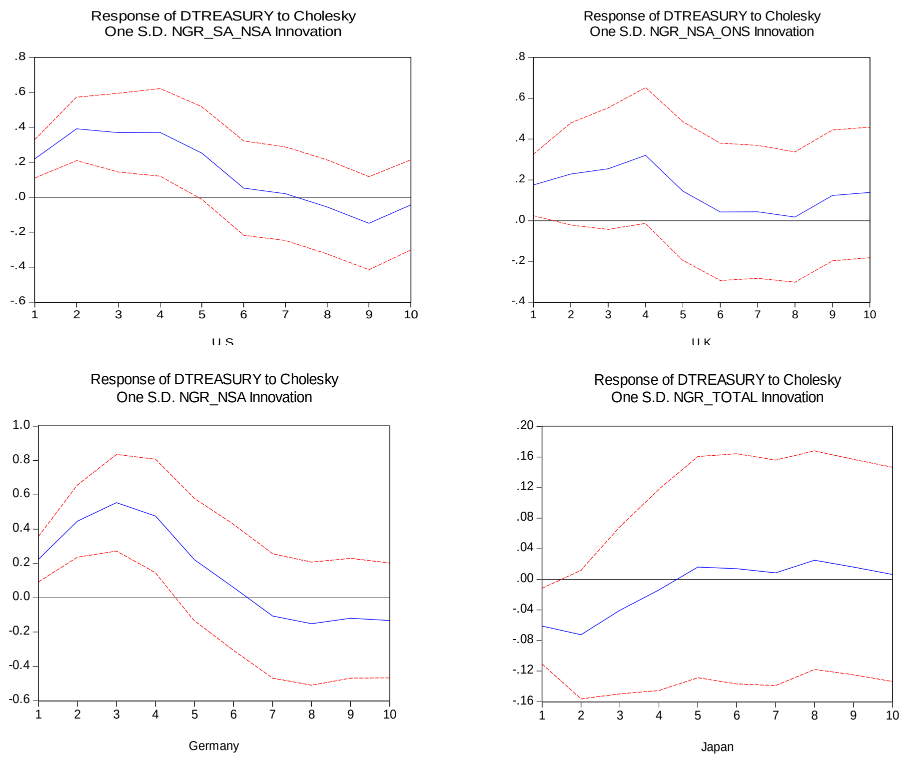


Figure G 6-7Impulse response of interest rate to nominal GDP shock



Notes: The blue solid lines are the dynamic response of each variable while the red dotted lines are the 95% confidence interval. The time period: 1961Q1-2008Q4 in the U.S., 1963Q1- 2008Q4 in the U.K., 1970Q1-2008Q4 in Germany, and 1970Q1-2008Q4 in Japan

Appendix 6.H variance decomposition in the subsamples

Table H 6-1 Variance Decomposition for VAR of Nominal GDP in the subsamples

Variance Decomposition for VAR of Nominal GDP in the early period					
		U.S.	U, K	Germany	Japan
Period	Nominal GDP				
2		98.42248	93.79998	83.81919	72.22654
4		86.80826	86.33032	43.81575	46.30183
8		48.12127	77.18486	31.25319	24.7776
	CPI				
2		0.792967	6.06336	0.352768	0.046576
4		1.095069	13.23261	5.888523	6.23944
8		8.458288	20.76078	9.241094	4.626551
	3-months Rate				
2		0.28866	0.024786	0.037843	8.524778
4		2.50022	0.16461	2.053972	5.429891
8		24.34992	0.601472	3.761642	6.988301
	Money				
2		0.043892	0.109335	0.017168	16.79056
4		3.028558	0.174878	17.00374	39.84051
8		7.328382	0.362868	18.69973	61.98011
	credit				
2		0.451999	0.002539	15.77303	2.411544
4		6.567892	0.097591	31.23802	2.188333
8		11.74214	1.090014	37.04434	1.62744
Variance Decomposition for VAR of Nominal GDP in the later period					
		U.S.	U.K	Germany	Japan
Period	Nominal GDP				
2		95.5316	86.28445	95.34585	96.26964
4		85.24496	63.35529	89.43364	85.15935
8		77.90699	39.44692	84.70013	70.88665
	CPI				
2		1.313585	2.542899	0.637663	1.536087
4		5.163861	20.28788	3.573173	8.568264
8		6.82208	26.2664	5.683849	20.66106
	3-months Rate				
2		3.096144	6.963796	3.151502	0.001803

4		8.954368	5.845467	5.370745	0.997994
8		12.62271	12.99049	6.149908	1.591988
	Money				
2		0.011455	2.684256	0.84169	1.39015
4		0.053828	7.680107	0.975106	4.543649
8		0.105607	10.50185	1.704041	5.385915
	credit				
2		0.047216	1.524601	0.023298	0.802316
4		0.582982	2.831258	0.64734	0.730746
8		2.542611	10.79434	1.762071	1.474388

Chapter 7

7 Conclusion

Almost every month a considerable amount of time in financial news is spent reporting on the monetary policy of the Federal Reserve or other central banks' actions across the world. This happens because money and banking issues are widespread, and the monetary policy will affect the most important aspects of daily life. The interest rate policy has been the main focus of attention of central banks in the last two decades. However, we can see that changes occurred after the financial crisis of 2007/08. Money and credit measures in the conduct of policy have been emphasised, since the limitations of interest rate policy made the policymakers in central banks start to use "quantitative easing" (QE) to stimulate the economy. This shift also reflected the realization that the monetary policy needs to respond to the considerable underlying development in the financial market. The creation of new instruments, changes in the features of current financial instruments, and the indistinct characteristics of financial instruments all possibly distort the effect of interest rate on the economy.

There is a gap in the understanding of credit's effect on the economy in theory and practice. Therefore, this study explores the relationship between credit and nominal GDP in detail, and further examines the link between interest rate and nominal GDP, and money aggregates and nominal GDP. The simple regression, the Granger causality test, GETS model and VAR model are applied. This study is the first to analyse the use of GDP-circulation credit to target nominal GDP in the U.S., U.K. and Germany, although this kind of work has been done by Werner (1997, 2003) in Japan; however, our study greatly extends the time period, broadens the range of countries and employs more complex econometric approaches.

The study examines an essential set of issues raised in the introduction chapter, and proceeds to generalize conclusions regarding the use of financial variables (short-term interest rate, money and GDP-circulation credit) to influence nominal GDP. In chapter 4, the simple Granger causality test is employed to find the link between nominal GDP and interest rates, additionally providing the link between real GDP and interest rates and inflation and interest rates in the U.S., U.K., Germany and Japan. In chapter 5, the comparison of $\overline{R^2}$ in the regression reveals the strength and stability of the predictive power of money aggregates for nominal GDP in the U.S., U.K., Germany and Japan; then, the Granger causality test outlines the "causality" correlation between money aggregate and nominal GDP in four countries and, lastly, the VAR model with four variables, which are nominal GDP, CPI annual growth rate, short-term interest rate, and money, presents how nominal GDP responds to money aggregate shock and interest rate shock. In chapter 6, an important contribution of the study involves building a new type of GDP-circulation credit in the U.S., U.K., Germany and Japan. The GDP-circulation credit distinguishes the bank credit flow into the real economy sector and financial sector, and then the study mostly focuses on the link between GDP-circulation credit and nominal GDP. The general-to-specific model is used in an attempt to discover which variable (interest rate, money aggregates, or GDP-circulation credit) has the most explanatory power for nominal GDP, and further "causality" tests give the causality link between GDP-circulation credit and nominal GDP. The implementation of the VAR model reveals what percentage of nominal GDP responds to a 1% increase in GDP-circulation credit, and also shows the pattern of nominal GDP response to money policy variables (interest rates, money aggregates and GDP-circulation credit).

7.1 Summary of findings

7.1.1 Results on the link between interest rates and nominal GDP

Regarding the link between nominal GDP and interest rates, the results of the Granger causality test indicate that nominal GDP does Granger cause the 3-month Treasury bill rate in the U.S., U.K. and Germany, but the 3-month Treasury bill does not Granger cause nominal GDP in the U.K., Germany and Japan. The causality from nominal GDP to short-term interest rates in three of the four countries indicates that nominal GDP could provide more future information on interest rate than vice versa. The positive correlation between nominal GDP and the 3-month Treasury bill rate also suggests that increasing interest rates tend to follow rather than lead the trend of nominal GDP.

In the VAR model, nominal GDP negatively responds to interest rate shock in the U.S., Germany and Japan, as the theory expects, but positively responds in the U.K. for the first several quarters in the entire sample test. Additionally, the magnitude of impulse response of nominal GDP to short-term interest rate shock is substantially different, especially in the U.K. and Japan. The nominal GDP growth rate fell by around 0.22% after a 1% increase of 3-month Treasury bill rate in the U.S. and Germany, but only decreased by less than 0.1% after the initial shock in the U.K. and Japan. As a result, the pattern of nominal GDP response to interest rate shock is uncertain. In the subsample test, the VAR models also find no constant patterns of impulse response of nominal GDP to interest rate shock before and after the structural break in each country. Thus, short-term interest rate does not display a robustly stable and constant correlation with nominal GDP based on the results of the Granger causality test and VAR model.

On the other hand, the impulse response of interest rate to nominal GDP shock is positive during a 2-year period. The results show that short-term interest rate increased by 0.4% to 0.5% in the U.S. and Germany, and increased by around 0.2% in the U.K.; however, it only increased by less than 0.1% in Japan, after a 1% rise in nominal GDP. Considering that interest rates have been kept at a low level for the last two decades, the result in Japan is reasonable. Judd and Motley (1993) proposed that, when nominal GDP growth exceeds the target by one percentage point, policymakers should raise the short-term interest rate by 0.2%. Hence, the results confirm the pattern that short-term interest rate tends to positively follow the growth of the economy.

Because most studies have investigated the relationship between interest rates and real GDP (Goodfriend, 1991; Taylor, 1993, Woodford, 2003), so our study also provides the "causality" relationship between short-term interest rate and real GDP as a reference. Real GDP does Granger cause the 3-month Treasury bill rate in the U.S., U.K., Germany and Japan, but the 3-month Treasury bill rate only Granger causes real GDP in the U.S. and U.K., which enhances the view that the real economic conditions influence the determination of short-term interest rate. The current interest rate does not reflect the future economic conditions as much as some academics believe.

The result of the Granger causality test shows the relatively close link between the 3-month Treasury bill rate and inflation, which is closer than the link between short-term interest rate and real GDP, or short-term interest rate and nominal GDP. This result is compatible with (Lee, 1992). The 3-month Treasury bill rate does Granger cause inflation in the U.S., U.K., Germany and Japan; meanwhile, inflation also Granger causes the 3-month Treasury bill rate in the U.S., U.K. and Germany. It seems that the

3-month Treasury bill rate predicts the future inflation, which supports the view that central banks set the short-term interest rates to target inflation; however, the short-term interest rate as the predictive variable to economic conditions, such as real GDP or nominal GDP, is not as good as the conventional theory had suggested.

The study also conducted the Granger causality test on 10-year Government bond rate and real GDP, inflation and nominal GDP in the U.S., U.K., Germany and Japan. Firstly, the study finds that 10-year Government bond rate does not Granger cause nominal GDP in the U.K., Germany and Japan, which is consistent with the results of the Granger causality test for the link between 3-month Treasury bill rate and nominal GDP. An absence of "causality" from 10-year Government bond rate to nominal GDP in three of the four countries enhances the view that interest rates do not predict the future economic information very well. Secondly, the 10-year Government bond rate does Granger cause inflation in the U.S., U.K. and Germany. This result gives us two indications. Firstly, the short-term interest might be closely related to long-term interest rate. Secondly, interest rates might have predictive power for the future inflation information.

Overall, the results of the Granger causality test point out that interest rates, be the short-term or long-term, do not predict future nominal GDP in most of the countries very well, and causality from interest rates to inflation is found in the U.S., U.K., Germany and Japan.

7.1.2 Results on the link between money aggregates and nominal GDP

Regarding the link between money aggregates and nominal GDP, the conclusion based on the simple regression, "causality" test, and the VAR model is that money is a useful predictor of nominal GDP, and even introducing the short-term interest rate does not decrease the predictive power for nominal GDP. A unidirectional causality from money to nominal GDP exists in the U.S., U.K. Germany and Japan. The VAR model implies the positive response of nominal GDP to money shock. More detailed summaries are presented in the following paragraphs.

The simple comparison of $\overline{R}^2$ suggests that interest rate has little predictive power for nominal GDP comparing to money aggregates in the entire sample, and introducing the interest rate into the regression does not decrease the predictive ability of money aggregates to nominal GDP in the U.S., U.K., Germany and Japan. This is consistent with the result obtained by (Feldstein and Stock, 1994). In the U.S., M2 has more predictive power in the early subsample, while the predictive power of the 3-month Treasury bill rate for nominal GDP is enhanced in the later subsample. In the U.K., the predictive power of M4 for nominal GDP is stable, with little predictive power of interest rate for nominal GDP. In Germany, M3 seems the most important and stable variable to predict nominal GDP, while 3-month market rate is not. In Japan, M2 also has the most predictive power for nominal GDP, although the predictive power decreases in the later subsample. 3-month Treasury bill rate does not have significant predictive power for nominal GDP. In general, money aggregates have more predictive power for nominal GDP than interest rate and price growth in all countries, although the predictive link between money aggregates and nominal GDP is not stable in the U.S. and Japan.

The Granger causality test shows that a unidirectional causality from money aggregates to nominal GDP exists in the U.S., U.K., Germany and Japan in the entire sample. Furthermore, the test results from the early subsample suggest a unidirectional Granger causality from money aggregates to nominal GDP in the U.K., Germany and Japan, with a two-way Granger causality between money and nominal GDP in the U.S. The results from the later subsample present a unidirectional Granger causality to nominal GDP in the U.S., U.K. and Germany; however, no Granger causality exists between M2 and nominal GDP in Japan. Taken as a whole, a stable unidirectional Granger causality from money aggregates to nominal GDP in three out of four countries points out that money could provide future nominal GDP information better than conversely. Moreover, after comparing the results of Granger causality, money aggregates are demonstrably more appropriate than interest rates to provide future nominal GDP information.

Friedman and Kuttner (1992) argued that there was no evidence to suggest that movements in money include any information about subsequent fluctuations in income or prices. Moreover, if there is no evidence to show that money and income are cointegrated, even if the money were used as the intermediate target of monetary policy, there would be no empirical grounds for it. However, our empirical results show that, if the broader cointegration test is accepted, there is strong evidence to indicate a long-run and short-run relationship between money and nominal GDP.

The results of the VAR model present the positive effect of money aggregates shock on nominal GDP in the U.S., U.K., Germany and Japan, although the magnitude of nominal GDP response to money shock is different. The most significant response is in Japan, where there is around a 0.7% increase of nominal GDP after 1% of money aggregate-tightening, while the impulse response rises to 0.3% in the U.S. and Germany, and is not significant in the U.K. The impulse response of nominal GDP to money aggregates shock is found to be larger in the earlier period after comparing before and after the structural break in each country.

The variance decomposition test attempts to show which factor mostly influences nominal GDP, and the results suggest that money shock and interest rate shock account for a similar percentage of nominal GDP in the U.S., U.K. and Germany; however, in Japan M2 accounts for nominal GDP more than interest rate does. Money shock accounts for a considerably larger amount of nominal GDP than interest rate in Germany and Japan in the early period; however, in the later period, money shock and interest rate shock both account for only a small amount of nominal GDP in the U.S., Germany and Japan. Neither money nor interest rate greatly account for nominal GDP, implying the possibility that an unknown variable, which could explain nominal GDP, is missing.

The results of comparing $\overline{R^2}$ in both the simple regression and Granger causality test imply that money has more predictive power than interest rate for nominal GDP in the U.S., U.K., Germany and Japan. The impulse response of nominal GDP to money shock is positive; however, the magnitude of impulse response in each country is different. The most significant impulse response of nominal GDP is in Japan, which confirms that money is the most important factor to influence nominal GDP in Japan. The results of variance decomposition do not find the supportive evidence that interest rate and money account for a large amount of nominal GDP in each country, which suggests that some factors that influence nominal GDP may not have been included.

7.1.3 Results on the link between GDP-circulation credit and nominal GDP

Empirical evidence from the study reported here as well as from earlier studies (Werner, 2003) indicates that GDP-circulation credit could be considered as an optional variable to target nominal GDP in the U.S., U.K., Germany and Japan.

Firstly, the assumption that velocity of GDP-circulation credit is constant could not be proved by a trend test. On the other hand, the stationary feature of GDP-circulation credit is found in the U.S., Germany and Japan. As a result, the assumption that velocity of GDP-circulation credit is constant could not be demonstrated, but the stationary feature of velocity suggests that velocity of GDP-circulation credit fluctuates around a certain level.

After a step-by-step deduction of the general-to-specific model test, GDP-circulation credit remains in the U.K., Germany and Japan, although the significance level is 10% in Japan. Thus bank credit appears to be a good explanatory variable for nominal GDP, apart from in the U.S., according to the general-to-specific model. On the other hand, money aggregates are also left in the general-to-specific model in the U.S. and Japan at 1% significance level in the entire sample, but the interest rates are not left in the model in the U.K., Germany and Japan. Therefore, the quantitative variables (GDP-circulation credit and money) have more power than the price variable (interest rate) to explain the nominal GDP.

The conclusion of causality between credit to real GDP effectiveness transaction and nominal GDP is made based on the comparison of robustness with structural break, because the comparison of robustness with structural break provides the stronger causality link than the Granger causality test. After comparing the robustness to structural break of regression of credit on nominal GDP and vice versa, it can be found that the causality direction is from credit to nominal GDP rather than the other way around in the U.S., U.K. and Japan. The Granger causality test in the entire sample based on the VAR or VECM model shows that the hypothesis that GDP-circulation credit does not Granger cause nominal GDP is rejected only in the U.S. and Japan. The

Granger causality relationship between nominal GDP and GDP-circulation credit is not stable after testing it in the subsample. The results of Granger causality in the earlier period are the same as those in the entire sample, in which credit to real GDP-effective transaction does Granger cause nominal GDP in the U.S. and Japan. Furthermore, in the later period it seems there is no strong causality between nominal GDP and GDP-circulation credit. Thus, at least, GDP-circulation credit does have a causality link to the nominal GDP in the U.S. and Japan in both tests.

The most encouraging findings are that the impulse response of nominal GDP to GDP-circulation credit shock is constantly positive in each country, and the most impressive finding is that the magnitude of impulse response of nominal GDP to GDP-circulation credit shock is qualitatively similar in the U.S., U.K., Germany and Japan. This evidence strongly supports the notion that the GDP-circulation credit could be an appropriate intermediate variable to influence nominal GDP. Generally, it was found that a 1% increase in GDP-circulation credit will cause a rise of approximately 0.2% of nominal GDP in the U.S., U.K., Germany and Japan.

The other findings from the VAR model are that the interest rate is more likely to follow nominal GDP stimulation rather than lead the trend of nominal GDP, but GDP-circulation credit and money aggregates do not, according to the inconsistent pattern of GDP-circulation credit and money aggregates, respond to nominal GDP innovation and the consistent pattern of interest rate to nominal GDP innovation.

The findings of impulse response obtained from the VAR model suggest that GDP-circulation credit exhibits a close short-term correlation and causation to nominal GDP growth, though the variance decomposition results do not give this indication. Some facts found in the general-to-specific model, “causality” test and VAR model support the positive correlation between the GDP-circulation credit and nominal GDP, and GDP-circulation credit could be regarded as a suitable variable to influence nominal GDP.

After summing up the findings in the thesis, we can answer the three questions proposed in the abstract. Firstly, quantitative variables (money and GDP-circulation credit) could be considered appropriate variables to target nominal GDP, but the price variable (short-term interest rate) could not. The unidirectional causality from money to nominal GDP suggests that money aggregates could provide future nominal GDP information, and constant positive impulse response of nominal GDP to GDP-circulation credit shock in each country also supports the view that GDP-circulation credit could be an appropriate variable to affect nominal GDP. The results from the VAR model do not strongly support the notion that money aggregates have a constant positive effect on nominal GDP, and the Granger causality test does not support the existence of a strong causality relationship from GDP-circulation credit and nominal GDP. However, the study at least finds some positive evidence to indicate the predictive power of quantitative variables (money and GDP-circulation credit) for nominal GDP. On the other hand, the study does not find the evidence to support the idea that interest rate is an appropriate variable to influence nominal GDP, as no constantly close relationship between interest rate and nominal GDP is found in simple regression, GETS model, "causality" test and the VAR model.

Secondly, it seems that quantitative variables (money and GDP-circulation credit) are better than the price variable (short-term interest rate) to influence nominal GDP. The comparing of $\overline{R^2}$ in the simple regression points out that the money aggregates have more predictive power than short-term interest rate for nominal GDP. Furthermore, the results from the general-to-specific model show that GDP-circulation credit remains in the U.K., Germany and Japan, while M2 and 3-month Treasury bill rate is left only in the U.S. after step-by-step deduction. Thus, it could be concluded that money aggregates and GDP-circulation credit have more explanatory power than short-term interest rate for nominal GDP.

Last but not least, there is no conclusive evidence to support GDP-circulation credit is better than money aggregates to explain nominal GDP. In the GETS model and VAR model, the GDP-circulation credit displays more explanatory power to nominal GDP than money aggregates do. The results of impulse response show that the GDP-circulation credit exhibit more accurate features than money aggregates to target nominal GDP, because the nominal GDP response to GDP-circulation credit shock is more constant across the four countries than that to money shock. In the meantime, GDP-circulation credit remains in the GETS model in the U.K., Germany and Japan, but money aggregates do not remain in these three countries. However, considering the results of the "causality test", money aggregates provide the future nominal GDP information better than GDP-circulation credit does. The result of Granger causality test shows that money aggregates do Granger cause nominal GDP and the result is robust in the entire sample and subsamples test, but GDP-circulation credit does not. Meanwhile Granger causality test does not confirm GDP-circulation credit does Granger cause nominal GDP. Therefore, based on the GETS model, Granger casualty test, and VAR model, we cannot conclude that GDP-circulation credit does better than money aggregates to explain nominal GDP.

7.2 Contribution

Monetary policy

This study enriches the empirical monetary policy research, and adds some knowledge to the understanding of a modified 'credit view' of the transmission of monetary policy in the U.S., U.K., Germany and Japan. The empirical results in these countries could be helpful for the monetary policymakers to gain a deeper understanding of the effect of financial variables (short-term interest rate, money and credit) on economic output.

Although many studies have focused on the relationship between monetary policy variables (interest rates or money aggregates) and economic conditions, most studies used real GDP or industrial production to represent economic conditions because these studies intended to remove the price factor from the economic conditions, and only examine the link between monetary policy variables (short-term interest rate or money) and economy in real measurement. However, Orphanides (1999), McCallum and Nelson (1999), and other earlier researchers argued that uncertainty in real-time output gap and uncertain persistent inflation make the monetary policy rules that respond to nominal output growth perform well. On the other hand, few empirical studies have paid attention to the link between financial variables and nominal output; thus, it is obvious that our study fills this gap by providing the empirical evidence on this aspect. Furthermore, our empirical study enriches the empirical works on the link between monetary policy (short-term interest rates or money aggregates) and economic conditions.

GDP-circulation credit

Until recently, academic studies had started to rethink the importance of credit for economic conditions, and more researchers had begun to explore the link between GDP-circulation credit and economy (Fisman and Love, 2003; Büyükkarabacak and Krause, 2009; Büyükkarabacak and Valev, 2010). Werner (1997, 2003, and 2005) provided the concept that credit could be divided into two parts: one for real GDP effective transactions, and the other one for financial speculation. Werner (2003, 2005) had already tested the link between this kind of GDP-circulation credit and economic output in Japan, but this empirical study is the first to test the empirical relationship between GDP-circulation credit and nominal GDP in the U.S., U.K. and Germany. Additionally, our study employs more econometric models to examine the relationship. This way of analysing the GDP-circulation credit and credit to financial speculation in the U.S., U.K. and Germany will be helpful for the reference of further empirical work. Meanwhile, the empirical results support the view that credit could be regarded as a monetary policy variable because a constantly positive relationship between GDP-circulation credit and nominal GDP in the U.S., U.K., Germany and Japan is found. These results are encouraging, especially since academics have started to reconsider the importance of the role of credit in the implementation of monetary policy after the financial crisis of 2007/08.

7.3 The weakness of empirical tests

The limitations of the data

There are several limitations of the credit data in the research. Firstly, there is the issue induced by the definition of discrepancy. Because the central banks in the four countries studied did not provide the direct credit data that flow into real GDP effective transactions, and because they normally only present the credit to different industries or from different types of banks, the author calculated the credit data according to the definition first given by Werner (1997). Therefore, it is hard to avoid inconsistency in the data across countries. Secondly, there is the question of the definition of data breaks over the period. As we know, the time period is more than 30 years in each country, and the definition of the credit component has changed; for example, in Germany the lending to housing enterprises and lending to holding companies started in 1980Q4, so the definition of break in the data might have influenced the results. Thirdly, although the study has been careful to design the GDP-circulation credit, it is still hard to demonstrate the accuracy of the credit used. For example, in the U.K., the credit to householders was regarded as part of GDP-circulation credit; however, some of the credit to householders has been used for speculation in the housing market in the last 10 years, so there may have been an overemphasis on GDP-circulation credit. These limitations will have influenced the empirical results, so further work needs to be undertaken. This study only provides the first attempt to employ empirical research on using GDP-circulation credit to target nominal GDP. More attention to credit research and more credit data could be revealed by the central banks. More research on the effect of credit on economic conditions would help us to better understand the functioning of the economy.

The limitation of the econometrics models: Granger causality, VAR model, structural break

The drawback of Granger causality

The major problem with the Granger causality test is that the right-hand variables are not orthogonal, which is at least one of the reasons why Sims (1980) and Litterman and Weiss (1985) pay attention to the VAR with orthogonal residuals: the percentage of the variance of the forecasted variable attributable to alternative right-hand-side variables at different horizons.

The disadvantages of the Granger causality test lie generally in the following aspects: the causality tests are sensitive to the lag length selection, the particular form of test employed, the method of detrending non-stationary time series and the increasing criticism of the insufficiency of theoretical considerations. Considering these disadvantages of the Granger causality test, it is necessary to employ other approaches to explore the link between financial variables and nominal GDP. In chapters 5 and 6, the research will employ more econometric models and extend to examine the link between money aggregates or GDP-circulation credit and nominal GDP.

Problems with VARs model

The disadvantage of the VAR model has been discussed in chapter 3. However, we still need to summarise the problems of the VAR model in the context of our study. Firstly, the order of VAR model has been chosen according to the assumption that nominal GDP has a contemporaneous effect on all other variables and only the lag of the GDP-circulation credit can have any effect on other variables. Although the change of order does not significantly influence the results, the assumption imposes a restriction on the VAR model. Secondly, in contrast to the structural VAR model, the theory-free background of the VAR model makes the coefficients of the VAR model hard to explain. Thirdly, in order to remain consistent and compare the results among the countries, the length of lag is chosen as six in both VAR models, with four or five variables in each country. Thus, the choice of lag length might not be the best in the VAR model in each country. Fourthly, in the VAR model in the thesis, it is assumed that short-term interest rate, money aggregates and GDP-circulation credit as monetary policy indicators, and "price puzzle" and "liquidity puzzle" are still found. The choice of monetary policy indicator is subject to prior theories, thus enduring the Lucas critique as well.

Structural break

Structural break is an important issue in the empirical test of monetary transmission mechanism because a change of monetary policy regime or exogenous economic shocks such as oil or financial crises would cause the alteration of the link between financial variables (interest rates, money and credit) and economic conditions. Consequently, the structural break must be considered, otherwise the results would be distorted. On the other hand, it is not easy to find the same structural break in the different econometric models in each country, because there is not a widely accepted method that could automatically choose a structural break date in the VAR model, and the structural break dates found in the Gregory Hansen cointegration test with break in the intercept, trend or both intercept and trend are different. As a result, the study decides to choose a subjective structural break in each country based on the change in economic conditions in each country. Although using a subjective structural break in each country brings consistency across the models in each country, the study cannot ignore the problems that subjective structural breaks present.

As we know, numerous changes of monetary policy regime or financial crises have occurred in the last four decades in the U.S., U.K., Germany and Japan, but only one structural break is considered in our study. The choice of break date in each country will certainly have influenced the empirical results and, furthermore, the date is assumed to be known subject to the critique that one could manipulate data by selecting a particular date. Considering these factors, it is not easy to find a way to avoid both the subjective judgement and inconsistent structural breaks chosen by different models. How to consider the structural break in the VAR model is an ongoing topic, and needs to be explored in future works.

Lucas critique

Lucas critique is summarized as follows:

> *"Given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models."* ----Lucas (1976)

The Lucas critique indicates that the difficulty to establish macroeconomic models is problem of rational expectation. The parameter of the model will change after the market behaviour is adjusted to changing expectation of monetary policy. As a result, my study is subjective to Lucas critique as well, because if monetary authorities suggest that they will attempt to control some types of credit, the financial intuitions or individual investors might find alternative credit resource to avoid the regulation on the credit. The Lucas critique advises that it is better to take into account individual behaviour in macroeconomic models, when aiming to predict the effect of monetary policy. Therefore, further research might need to consider individual behaviour when modelling the importance of credit. However, my study can only discuss the general thoughts on this limitation, and more research is need in the future.

7.4 Outlook for future research

Overall, the empirical findings confirm the role of credit in affecting economic conditions and, furthermore, give support to the implementation of nominal GDP targeting in practice. Regarding the previous scepticism about the use of money aggregates as the intermediate target, the research also finds the predictive power of money aggregates for nominal GDP. The critique for quantitative variables (money aggregates or credit) as intermediate targets is attributed to the deregulation of financial markets, and now the same factor seems to cast doubts on the short-term interest rate as the effective intermediate target. Our study did not find supportive evidence that short-term interest rate is an appropriate variable to target nominal GDP.

One interesting field of future empirical work would be to estimate more accurate GDP-circulation credit that is used for real GDP effective transactions and for financial speculation. Meanwhile, it is necessary to utilize more sophisticated econometric models to discover the link between quantitative variables (money aggregates or GDP-circulation credit) and economic output. We look forward to future studies that re-examine our conclusion with broader or improved econometric models, and even more GDP-circulation credit data. Our contribution has been to provide the preliminary support to target nominal GDP in practice through quantitative variables (money aggregates or GDP-circulation credit) rather than the price variable (short-term interest rates). The recent financial crisis across the world also highlights the importance of quantitative variables (money aggregates or credit) to the economic output beyond our previous expectations.

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