Changes in the Liquidity Effect Over Time: Evidence from Four Monetary Policy Regimes

Dawid Johannes van Lill

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by

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Abstract

This paper employs a time-varying parameter vector autoregressive (TVP-VAR) model to establish the nature of the relationship between central bank liabilities and the overnight policy rate. Four countries with different monetary policy regimes were considered. It was found that a clear negative relationship between these variables exists only in the case of one regime, namely the reserve regime. This result indicates that the introduction of new operational frameworks for central banks have challenged the traditional model of monetary policy implementation. A potential practical implication of the 'decoupling' of interest rates from reserves is that the central bank in the United States and Canada could potentially use their balance sheet alongside conventional interest rate policy. However, as there is practically no decoupling in South Africa, and very little evidence in Norway, such a policy recommendation would not apply.

1 Introduction

Monetary policy, post Bretton Woods, saw the emergence of the short-term interest rate as the primary policy instrument. However, in the wake of the financial crisis, balance sheets have, again, become part the monetary policy toolkit, now empowered to perform more than an automated role in policymaking. The present-day incarnation of balance sheet policy differs in character, though, from historically used balance sheet mechanisms. We now observe that under certain monetary policy regimes, balance sheet policies operate independently from movements in the central bank policy rate.[1] The independence of these monetary policy tools contests the conventional wisdom on the role of central bank balance sheets in policymaking (Borio and Disyatat, 2010). One of the implications is that balance sheets potentially could be used to extend the policy reach of central banks to promote financial stability.

To appreciate fully the changing role of balance sheets in policymaking one needs to look at the history of monetary policy implementation. Since the Second World War there has been a significant evolution in the way monetary policy is conducted. During this period central banks adopted several operational frameworks. Monetarism, which was dominant in monetary policy implementation from the early 1970s to the late 1980s, emphasised the ability of central banks to exert tight control over the money supply. This gave rise to use of several quantitative concepts[2] as preferred operational targets in this era. Operational targets of monetary policy[3] refer to some class of economic variable that the central bank can control using its monetary policy tools. Central banks utilise three tools toward this end, namely, reserve requirements, standing facilities and open market operations (Bindseil, 2004).

This monetarist view coincides with the textbook model of monetary policy implementation, which largely is shaped by the experience of the United States (US). According to this view, central banks actively practice their influence over the money supply in order to pursue their intermediate target[4] and ultimately economic objectives (Keister et al., 2008). However, since

[1] This comment might appear vague or even inaccurate for the first time reader on the topic, but the conditions under which this occurs will be identified further on in the text.

[2] Such as the monetary base, reserves of banks, total volume of open market operations, non-borrowed reserves, excess reserves, free reserves and borrowed reserves (Bindseil, 2004).

[3] We know that “there are essentially three main types of operational targets: (i) a short-term interest rate (pre-1914, and post 1990 the dominating type of operational target, and in between also playing at least implicitly an important role). (ii) A quantitative, reserve related concept - officially in the US the operational target in the period 1920-1983. (iii) A foreign exchange rate, for central banks which peg their own currency strictly to a foreign one” (Bindseil, 2005).

[4] According to Bindseil (2004) an “intermediate target is an economic variable that the central bank can control with a reasonable time lag and with a relative degree of precision, and which is in a relatively stable or at least predictable relationship with the final target of monetary policy, of which the intermediate target is a leading indicator”.

the early 1980s central banks have shifted their focus away from quantitative targets toward a short-term interest rate.[5]

This textbook narrative underlines the fundamental link between the balance sheets of central banks and monetary policy (Keister et al., 2008). In this framework, central banks can use the available monetary policy tools, generally open market operations, to make the short-term market interest rates effective. These operations entail a change in the level of reserves[6] to bring about changes in the interest rate (Disyatat, 2008; Kahn, 2010). The negative causal relationship between central bank reserves and the short-term interest rate is known as the "liquidity effect" (Kopchak, 2011).

A substantial body of empirical work has sought to identify a clear and stable link between several components of central bank balance sheets and key policy interest rates (Friedman and Kuttner, 2010). The results have been mixed. Some authors have found significant liquidity effects for the US economy in the 1980s and early 1990s.[7] However, when the analysis is extended beyond this timeframe one finds that the relationship fades. This has important implications for the understanding of how monetary policy implementation works in the 21st century. Theoretical models of monetary policy implementation stress the negative relationship that exists between liquidity and interest rates, but in modern central bank practice, we do not necessarily see clear evidence of this.

Several explanations have been posited to explain the disappearance of this liquidity effect in recent years. The implementation of new operational frameworks at central banks is often the reason that is put forward for the fading out of this effect. It has been suggested that because of innovations in conducting of monetary policy that interest rates and reserves have been decoupled, which means that various levels of reserves can exist for a given interest rate. The independent movement of these policy targets has been referred to as the "decoupling principle" (Borio and Disyatat, 2010). This has far-reaching implications for the future conduct of monetary policy, as it provides the central bank with a tool that may be used to pursue additional economic objectives.

The objective of this paper is to establish the empirical validity of the decoupling principle by analysing the relationship between short-term nominal interest rates and selected central bank balance sheet variables in four countries, each with different operational frameworks. Several empirical methods were used in order to assess the nature of the liquidity effect in

[5] Some central banks, such as the Bank of England have never adopted quantitative targets and have always relied on the use of a short-term interbank rate (Bindseil, 2004).

[6] Reserves take the form of both bank deposits and vault cash held at the central bank.

[7] Studies primarily have focused on the United States.

the selected sample of countries. First, a simple rolling regression was used to illustrate the potential liquidity effect in each country over time. Second, an identified VAR was used to determine the effect of a shock to different quantity concepts on the relevant policy interest rate for different subsamples. Third, a time-varying parameter VAR (TVP-VAR) with stochastic volatility was constructed, which combines the time-varying properties of the rolling regression and the structural nature of a VAR analysis.

Empirical evidence from the different methods employed point to an identifiable decoupling principle for Canada and the US with the adoption of new monetary policy regimes. The result for the US aligns with comparable empirical research conducted using regime switching methods. In the case of South Africa and Norway there is no evidence of a decoupling. This result aligns with the regime employed by the South African Reserve Bank. However, the Norges Bank followed a floor regime in recent years, which means that a decoupling should be observable.

The article is structured as follows. Section 2 contains a literature review on the liquidity effect. This review provides a context for the rest of the discussion in the article. Section 3 provides a discussion on the different operational frameworks of modern central banks. This section also endeavours to undertake a descriptive analysis of the decoupling principle in the sample of countries. Section 4 provides empirical evidence of the decoupling principle. Section 5 concludes.

2 The Liquidity Effect

According to the traditional/textbook view of monetary policy implementation, central banks conduct open market operations[8] in order to steer the short-term market interest rates toward the bank's policy interest rate target (Friedman and Kuttner, 2010; Ihrig and Meade, 2015). The mechanism underlying monetary policy conduct within this framework is often illustrated with the aid of a graph, as in Figure 1. The explanation turns on the interaction of a negatively sloped money demand curve, m_t^d, with a perfectly inelastic money supply curve, m_t^s. The money supply curve is vertical because the central bank is a monopoly supplier of money or reserves (Ihrig and Meade, 2015). In this model m_t is the log of nominal money, d indicates demand and s, supply. These money demand and supply functions are usually expressed analytically, in addition to the graphical presentation. The following money demand and supply relations,

[8]This is achieved by buying or selling reserves/quantity aggregates to depository institutions (i.e. expansion or contraction of the money supply)

similar to those found in Pagan and Robertson (1995), will prove useful for exposition. These equations are:

$$m_t^d = \alpha_1 + \alpha_2 r_t + \varepsilon_t^d \tag{1}$$

$$m_t^s = \beta_1 + \beta_2 r_t + \varepsilon_t^s \tag{2}$$

where r is a short-term non-negative nominal interest rate and ε_t^d and ε_t^d are mutually uncorrelated demand and supply shocks. In equilibrium, $m_t^d = m_t^s$. Shifting either the m_t^s or m_t^d curves within this framework will bring about changes in the level of the interest rate and/or level of money in the economy. One could ask, what would happen in the case where $\beta_1 \uparrow \Rightarrow m^s \uparrow$ (as in the case of expansionary monetary policy)? An increase in β_1 would result in a decrease in r_t if $\alpha_2 < 0$ and $\beta_2 \leq -\alpha_2$ because $dr/d\beta_1 = (\alpha_2 - \beta_2)^{-1}$. Since m_t^d is downward sloping (i.e. $\alpha_2 < 0$) and it is assumed that $\beta_2 = 0$, it implies that m_t^s is perfectly inelastic.[9] The changes induced are illustrated in Figure 1; one can see that increasing the money supply[10] drives down the nominal interest rate.[11] The negative response of the interest rate to an increase in the money supply is referred to as the "liquidity effect" (Friedman, 1972).[12] Because central banks retain a monopoly over the supply of outside money, the existence of this effect allows them to tightly control the short-term interest rate through adjustments in m_t^s.

The negative relationship between m_t^d and r_t is a crucial component in this monetary policy narrative, and has resulted in a substantial body of work to investigate the empirical validity of the claim (Friedman and Kuttner, 2010). Although some of the earliest attempts to capture this negative relationship were unsuccessful (Litterman and Weiss, 1984; Sims, 1986; Mishkin, 1986), several articles (Reichenstein, 1987; Thornton, 1988; Sims, 1992; Leeper and Gordon, 1992; Gali, 1992; Bernanke and Blinder, 1992; Christiano and Eichenbaum, 1992), find evidence of a link between short-term interest rates and various monetary aggregates (in particular the monetary base, M1 and M2).[13] Leeper and Gordon (1992)'s results had a large impact on the liquidity effect discourse. They found a statistically significant liquidity effect, but it was highly

[9] The shape of the supply curve in this model is assumed to be vertical, although some Post-Keynesian authors have suggested that a horizontal supply curve is more realistic.

[10] Shifting the m_t^s curve to the right

[11] Once the demand for money reaches the elastic portion of the curve, changes in the money supply will not bring about significant changes in the interest rate. This is normally referred to in the literature as a "liquidity trap" (Hicks, 1937)

[12] Friedman (1968) described this mechanism in his famous presidential address: "Let the Fed set out to keep interest rates down. How will it try to do so? By buying securities. This raises their prices and lowers their yields. In the process, it also increases the quantity of reserves available to banks, hence the amount of bank credit, and, ultimately the total quantity of money. That is why central bankers in particular, and the financial community more broadly, generally believe that an increase in the quantity of money tends to lower interest rates".

[13] The monetary base is defined as the sum of vault cash, currency in circulation and the reserves deposited by private banks with the central bank (Bindseil, 2005).

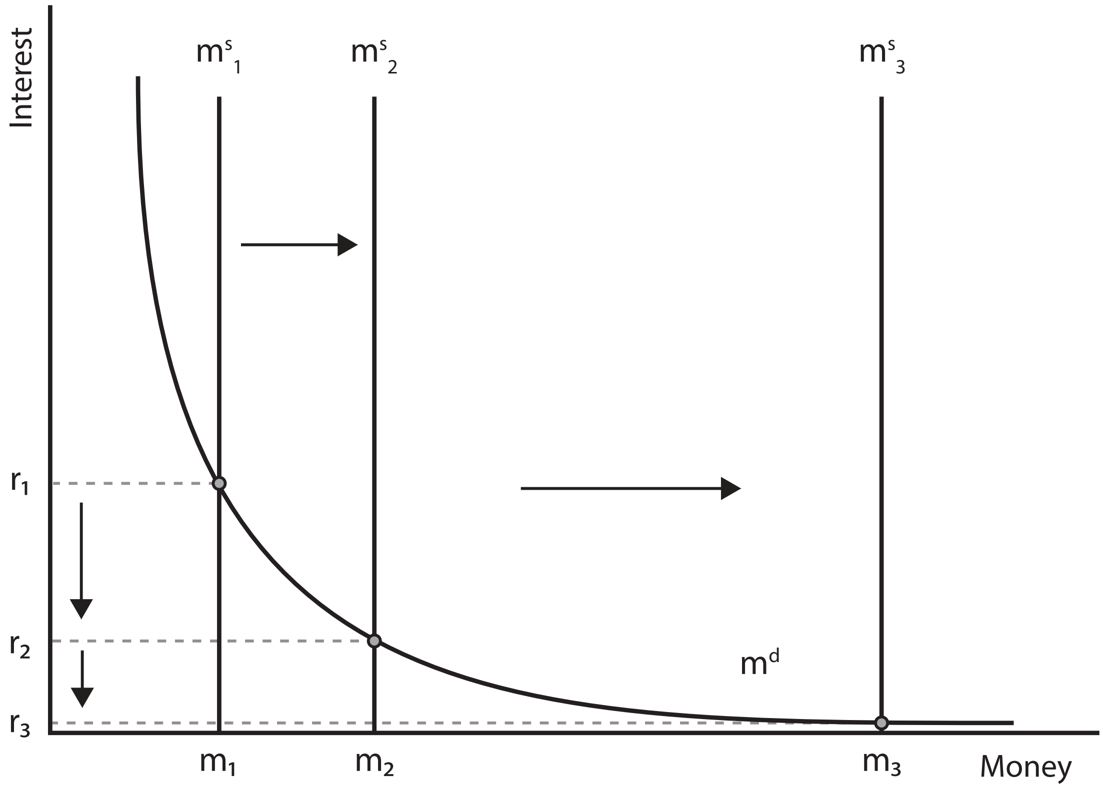


Figure 1: This figure presents expansionary monetary policy in the traditional model of central bank interest rate setting. Changes in the m^s curve cause a move along the m^d curve. A rightward shift in m^s increases the quantity of money and depresses the level of the nominal non-negative short-term interest rate

dependent on the subsample used. In addition, the size of the innovation in money aggregates required to induce a change in the interest rate was implausibly large. This failure to provide robust and economically significant estimates of the liquidity effect is referred to as the "liquidity puzzle"[14] (Leeper and Gordon, 1992).

Several authors have argued that the fragility of Leeper and Gordon (1992)'s results were due to incorrect model specification - specifically, the use of monetary aggregates as explanatory variables. Christiano et al. (1994) argue that bank reserves could serve as a more appropriate independent variable. They constructed a vector autoregressive (VAR) model[15] and estimated the response of the short-term interest rate to shocks on non-borrowed bank reserves[16]. With this model, they established a significant and persistent liquidity effect. This outcome led Gordon

[14]There are four 'puzzles' in empirical macroeconomics. In other words, situations in which the data does not fit the underlying theory. The four puzzles are, the price, liquidity, exchange rate and forward discount bias puzzle (Vinayagathasan, 2014).

[15]This is the standard method used for estimating the magnitude and significance of the liquidity effect in the literature.

[16]Non-borrowed reserves are equal to total reserves minus borrowed reserves, where borrowed reserves are loans/credit extended to depository institutions (which is normally located on the asset side of the central bank's balance sheet).

and Leeper (1994), among others, to reconsider their methodology and variable selection. They found that after including a measure of reserves in their model identification, they were able to find strong evidence for a liquidity effect. Pagan and Robertson (1994) tried to evaluate the econometric methods used to obtain these results and found that due to improperly motivated identification strategies, evidence from these studies is weak at best. They devote the majority of their analysis and criticism to the article of Gordon and Leeper (1994).

The conflicting evidence in the literature led Strongin (1995) to examine the operational procedures of the US Federal Reserve. Strongin (1995) found that the lion's share of changes to the supply of reserves are made to prevent the market rate from deviating too far from the policy rate. These actions taken by the central bank are known as liquidity management operations.[17] In other words, it was becoming more difficult to isolate the exogenous policy actions of the Federal Reserve, and central banks in general, as the fine-tuning of liquidity management operations became more frequent and efficient. Strongin's (1995) strategy to identify supply shocks entailed constructing a new reserve measure. He generated this variable by dividing non-borrowed reserves by total reserves. Redefining the independent variable in this fashion revealed a significant and persistent liquidity effect (Strongin, 1995). Bernanke and Mihov (1998) extended the model of Strongin (1995) to allow for different operating procedures. They present a preferred just-identified biweekly model and found a highly significant liquidity effect.

During the mid-1990s various central banks moved away from "quantity-based operating procedures, toward a focus on explicit interest rate targets" (Friedman and Kuttner, 2010). This change meant that the policy interest rate would no longer be endogenously determined through exogenous movements in the supply of reserves. Instead, central banks would rely on the announcement of an explicit policy interest rate and a credible commitment to maintaining it. The introduction of new monetary policy regimes whittled down the remaining evidence of the liquidity effect. The only line of research to yield any significant liquidity effect during the late 1990s was that of James Hamilton (1996; 1997; 1998), who advocated the use of high-frequency data.

Hamilton contributes to the literature by applying an unanticipated shock to the forecasting error of the Federal Reserve, instead of the actual level of reserves, on the last day of the maintenance period.[18] The choice of a forecasting error as an explanatory variable starts at the level of liquidity management operations. These operations entail making reserves available

[17] These operations entail the provision and withdrawal of liquidity available to private banks. Repurchase and reverse repurchase agreements traditionally are conducted to alter liquidity levels.

[18] The maintenance period is a timeframe during which depository institutions must maintain a specified level of funds.

each day for depositing institutions. The amount of reserves needed is unknown, so the central bank attempts to forecast the demand for reserves. Deviations from this forecast are supposed to alter the position of the economy along the demand for money, m_t^d, curve (i.e. supplying more/less than required in the market shifts the short-term market interest rate). Applying shocks to this variable replicates the liquidity effect. However, to affect a quantifiable movement in the interest rate required a tremendous shock to the level of reserves (which left some to question the economic significance of the result).

Thornton (2005; 2006; 2010) provides a critique on the work of Hamilton. He agrees with the finding of a liquidity effect, using data at a daily frequency, but emphasises that the effect is “statistically significant but quantitatively unimportant" (Thornton, 2006). These findings are reinforced by the work of Carpenter and Demiralp (2006a,b), who used a methodology similar to that of Hamilton (1997), estimating the liquidity effect with high-frequency data. The effect is significant but trivial, with a 1 billion dollar shock to non-borrowed reserves on the final day of the maintenance period delivering a 3.5 basis point movement in the interest rate (Carpenter and Demiralp, 2006b). This indicates that “the change in balances necessary for even a 25-basis point change in the funds rate would lead to implausibly large open market operations” (Carpenter and Demiralp, 2006b).

The most recent strand of liquidity effect literature acknowledges the decrease of the effect over time. Judson and Klee (2010) indicate, for example, that the liquidity effect has “attenuated considerably with time”. They test their hypothesis by looking at high-frequency data in a sample ranging from 1995 to 2007. They posit that successive changes in policy practice, especially in the 1990s, have resulted in the disappearance of the observed liquidity effect.

Several other viewpoints are considered as to why this effect has decreased. Kopchak (2011) makes the argument, similar to the one advocated by Strongin (1995), that the difficulty in isolating the exogenous policy actions of the Federal Reserve, and central banks in general, has increased with time, as fine-tuning of liquidity management operations becomes more frequent and efficient. Furthermore, the forecasting ability of central banks has improved greatly with the introduction of modern account monitoring technology (Judson and Klee, 2010). Another argument is that the liquidity effect may have waned in developed economies because of the growing importance of non-bank lending institutions in the setting of market interest rates. This evolution has been facilitated by the “relaxation of legal and regulatory restrictions” in financial markets (Friedman and Kuttner, 2010). Innovations in the financial sector certainly have a role to play in the ongoing liquidity puzzle. However, it seems that the main contribution comes from the changes in monetary policy implementation.

Finally, the liquidity effect may have disappeared because of the shift in monetary policy implementation toward the announcement of a target policy rate. According to Guthrie and Wright (2000) the central bank announcement of a certain policy rate, rather than open market operations, is responsible for the conduct of monetary policy. They refer to these announcements as "open mouth operations". Borio (1997) reaches a similar conclusion about the importance of policy signals, in a study conducted on monetary policy implementation in industrialised countries. A verbalised credible commitment by central banks to counter any deviations from the policy rate focuses the expectations of financial actors around the specified target. In this way market rates may change without any liquidity operations ever taking place (Borio, 1997). The vital point in this discussion is that it appears that in recent years, changes in reserves have played an increasingly insignificant role in the implementation of monetary policy. The discussion in the next section provides insight into some of the operational frameworks that are currently used. Four countries, each with a different operational framework, are considered.

3 Changes in Monetary Policy Implementation

The discussion in the preceding section has alluded to the changing nature of monetary policy in the post-war era. This section provides some additional background information as well as a context for the discussion of the most popular operating procedures that central banks currently employ. During the 1950s through to the late 1960s, traditional Keynesianism dominated the policy space. However, the 1970s saw the rise of monetarism and with it the targeting of monetary aggregates by several central banks. A monetary target was the obvious choice for monetarists, as the tools of monetary policy enable central banks to "determine the total amount of money in existence or to alter that amount" (Friedman, 1959, p. 24). This meant adopting a precise level of reserve/money quantity as the operational target for the central bank, with the intermediate target being a monetary aggregate, for example M1. The money multiplier was at the heart of the transmission mechanism by which an adjustment in a reserve or money quantity would bring about changes in a specified monetary aggregate (Bindseil, 2004). By controlling this monetary aggregate, the central bank could exert pressure on inflation and other key economic indicators.

In the early 1980s, several central banks adopted a new operational target, a short-term policy interest rate. The shift toward a new policy instrument paradigm was heavily influenced by William Poole's (1970) seminal work on the instrument problem.[19] Poole utilised a stochastic

[19]Poole should be referring to operational targets, as neither the interest rate nor money/reserve quantities are policy instruments. This has been the source of much confusion in the literature.

IS-LM model to illustrate that the policy interest rate was the superior policy instrument with which to negate the impact of a large shock to the monetary sector (Poole, 1970). In the wake of this paper, three dominant monetary policy regimes emerged.[20] These regimes all use the announcement of the policy rate as the primary policy tool (Guthrie and Wright, 2000). The main difference between regimes is the mechanism by which interest rates are made effective. These regimes are discussed next, in turn.

In the traditional model of monetary policy, as propounded in Section 2, interest rates are determined endogenously through manipulation of the money/reserve supply. However, since the early 1990s, central bank operations have been approached in a slightly different manner. Two broad/stylised operational frameworks emerged. First, the reserve regime, which retains some of the components of the traditional model. The reserve regime relies on the use of reserve requirements (which usually must be met on an average basis over a specified maintenance period) and a publicly announced policy rate (Whitesell, 2006). Either this policy rate or the rate that the central bank charges can then be targeted (Brink and Kock, 2009).

In the case of a policy target, the central bank determines the level that it would like the overnight rate to be, based on prevailing economic conditions, and it then uses liquidity management operations to steer the rate toward this target. According to Ennis and Keister (2008), "central banks aim to adjust the total supply of reserve balances so that it equals demand at exactly the target rate of interest". This requires an estimation of the demand for reserves[21]. Errors in forecasting demand are thought to lead to movements away from the target rate. If central banks are not able to consistently hit the target, the credibility of the communication mechanism of the bank is questioned (Ennis and Keister, 2008). In the case where the rate is the one that the central bank charges, the central bank creates a "shortage of bank reserves in the money market through levying a cash reserve requirement and draining liquidity through open-market operations, and then refinances the shortage by lending funds to banks at its policy interest rate" (Brink and Kock, 2009). This approach is usually followed by developing countries with less active interbank markets.

Second, some advanced economies employ a corridor or floor interest rate regime. In this regime the central banks often use interest rate targets. The most noticeable difference between corridor/floor and reserve regimes is the use of standing facilities. Some reserve regimes may employ a penalty rate or overnight lending facilities that act as an upper bound to the interest rate. However, in corridor and floor regimes, interest is paid on reserves through a deposit

[20]The three regimes of monetary policy implementation are the reserve, corridor and floor regimes

[21]One of the sources of demand, apart from reasons of statutory compliance (i.e. the reserve requirement), is the usage of reserves to facilitate large inter-bank settlements (Brink and Kock, 2009).

facility. This means that there is a lower bound placed on the interest rate. The mechanics of both these regimes is described in Section 3.3.1 and Section 3.3.2, respectively.

3.1 Reserve Regimes

Reserve regimes rely on the use of a reserve requirement and liquidity management operations to make the announced interest rate effective. The reserve requirement is usually greater than the working (settlement) balances of private banks (Borio, 1997). The reserve regime, in comparison with corridor/floor regimes, most closely resembles the traditional framework of monetary policy implementation, where "changes in reserve supply systematically result in movements in the relevant interest rate" (Friedman and Kuttner, 2010). However, liquidity management operations in this regime play a purely "technical and supportive role" and they "neither impinge upon, nor contain any information relevant to, the overall stance of policy" (Borio and Disyatat, 2010). The question is whether the market for bank reserves is insulated from these operations. This is emphasised by Borio and Disyatat (2010) as one of the preconditions for decoupling the interest rate from the level of reserves. Central banks need to "engage in offsetting transactions that 'sterilise' the impact of the operations on the amount of reserve balances" (Borio and Disyatat, 2010)[22]. When the market for reserves is insulated from the interest rate, two changes to the traditional framework seem plausible.

First, central banks are either operating on the (almost) perfectly elastic or inelastic portion of the m_t^d curve and the argument in favour of negative interest rate elasticity becomes tenable (Friedman and Kuttner, 2010). Figure 2 depicts this alteration, demonstrating the inability of reserve changes to induce proportional shifts in the interest rate once m_t^d becomes sufficiently horizontal. Essentially, interest rates are unresponsive to changes in reserves, as found in the liquidity effect literature for the USA.

Second, substantial interest rate changes do not necessarily require any movement in the supply of reserves. The announcement of the policy interest rate allows central banks to set their rate (or target) instantaneously and precludes the use reserves that may be used to shift the interest rate. In Figure 3 the entire m^d schedule shifts outward in response to the announcement of a higher policy rate and private banks react to the policy stance signal of the central bank. Woodford (2000) argues that "there need not be a stable relation between this overnight interest rate and the size of the monetary base in order for the central bank to effectively control overnight interest rates". This notion that interest rate movements happen regardless of

[22]Another way to decouple would be to ensure that changing reserve holdings have no impact on the policy rate. This would be achieved by, for example, implementing a policy rate floor, which will be discussed in Section 3.2

Figure 2: Elastic money demand

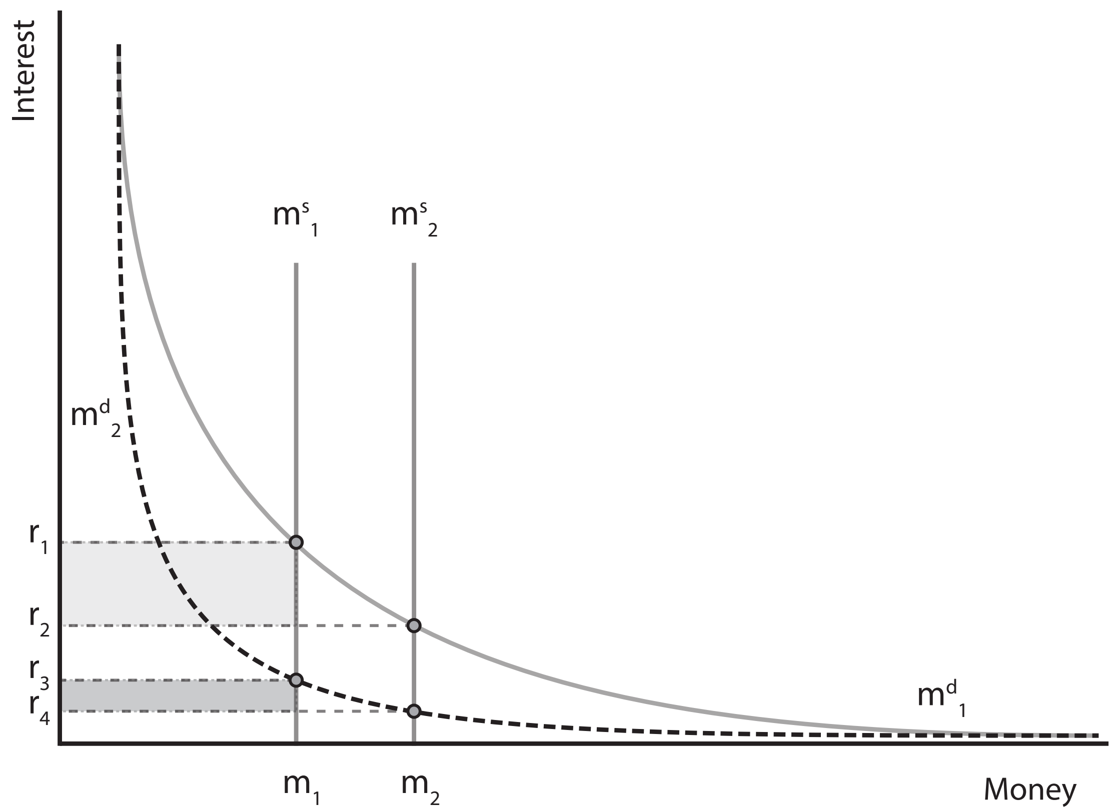
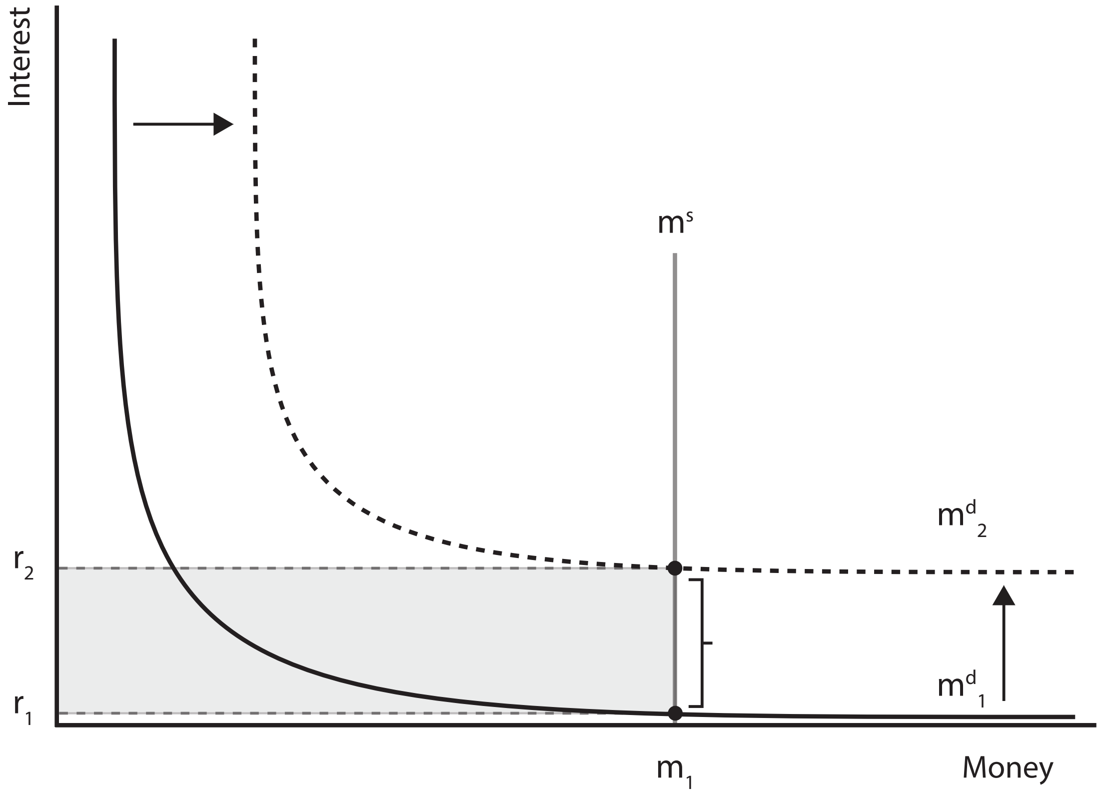


Figure 3: The announcement effect



the level of reserves is referred to as the anticipation or announcement effect (Carpenter and Demiralp, 2006a; Fullwiler, 2008).

The reserve regime has been quite popular with developing countries and a selection of advanced economies. In the section to follow, there is an historical overview of the monetary policy landscape of the sample of countries. In terms of reserve regimes, I will be looking at two case studies, South Africa (SA) and the United States of America (USA)[23], whereas Canada and Norway can be broadly categorised as countries that employ remuneration on reserves. This historical approach serves two purposes. First, it provides a context for my empirical analysis, which facilitates a richer interpretation of the results. Second, the vector autoregression analysis in Section 3.4.3 requires a logical demarcation of subsamples, which is elicited from the country-specific narratives.

[23] It should be noted that the operational framework of the US changed to a hybrid system in 2008, with the advent of the financial crisis.

3.1.1 South Africa

South Africa has had several monetary policy regimes since the Second World War. The Commission of Inquiry into the Monetary System and Monetary Policy in South Africa (aka the De Kock Commission Report) identified five distinctive monetary policy phases between 1945 and 1985. The first three phases occured between 1945 and 1965. The fourth phase, from 1965 to 1981, was characterised by the "use of direct monetary control measures" (Mollentze, 2000). Aron and Muellbauer (2007), in their classification of South African monetary policy regimes, refer to the period from 1960 to 1981 as a liquid asset ratio-based system, which entailed quantitative controls on interest rates and credit. In this regime "commercial banks held particular assets defined as 'liquid' as a specified minimum proportion of deposits" (Naraidoo and Gupta, 2010).

This regime was in place till the early 1980s and was replaced by the cash reserves-based system in 1985 (Gidlow, 1995). This period corresponds to the fifth phase identified by the De Kock Commission, the transition to a more market-related monetary policy regime. Mollentze (2000) states that the "monetary authorities deliberately started to pursue a policy of allowing interest rates to vary more readily as the forces of demand and supply changed in the market". In this regime the intermediate target was flexible monetary aggregate ranges, based on a broad definition of money (M3). The operational framework remained intact until 1998; however, there was a significant philosophical change in the focus of the central bank with the appointment of Dr CL Stals as governor in 1989.

Since 1998 the South African Reserve Bank (SARB) has followed a reserve regime with an announced policy rate charged on overnight lending. The repurchase rate (i.e. repo rate) is the SARB's operational target (Brink and Kock, 2009). This rate is made effective through the creation of a shortage in the money market. This process starts with the daily reserve requirement imposed on private commercial banks. All loans extended by the SARB to these depository institutions, to meet their liquidity requirement, are refinanced at the repo rate.[24]

The SARB can easily maintain this shortage in the market for reserves as it is the monopoly supplier of its own liabilities. Several tools, such as reverse repurchase agreements and debentures, are at the disposal of the SARB for this goal. An increase (decrease) in central bank liabilities (assets) would be associated with an increase in the money market shortage (i.e. the draining of liquidity). Brink and Kock (2009) have the following to say on this,

[24] Which is determined by the Monetary Policy Committee (MPC).

Any transaction between the banking sector and the central bank that results in a credit entry into a bank's account at the central bank, results in a creation of new money-market liquidity which, if no further transactions are undertaken, increases the bank's reserve balances with the central bank (i.e. increases the monetary base).

An important distinction needs to be made between the different types of liabilities found on central bank balance sheets. The unwinding of the central bank's balance sheet is not entirely under the control of the SARB. According to Disyatat (2008), the "precision of their control depends largely on the degree with which the autonomous factors can be anticipated by the operation desk on a daily basis". Therefore, control relies on the balance of passive/autonomous[25] and active/non-autonomous[26] liquidity management.

The liabilities side of the balance sheet can generally be divided into these two broad categories. If one considers the case of South Africa, the autonomous factors include the notes and coins in circulation and deposits by banks at the SARB. On the other hand, SARB debentures and reverse repurchase agreements are considered non-autonomous and under the full control of the central bank (Brink and Kock, 2009). In South Africa, the relative contribution of non-autonomous factors (i.e. open market operations) has been on the decline, with government deposits[27] becoming a significant component since 1998 (Brink and Kock, 2009). Non-monetary elements now comprise more than 60 per cent of liabilities.

My empirical models, in Section 3.4, explore the dimensions of the relationship between non-borrowed reserves[28] and a relevant short-term interest rate. In the textbook model of monetary policy implementation, one would expect a clear and stable negative relationship between the level of non-borrowed reserves and the repo rate. Short-term interest rates, such as the bank rate, are usually "influenced by changes in the supply of non-borrowed cash reserves" (Schoombee, 1996).

3.1.2 USA

The Federal Reserve is, in all eventuality, the most extensively studied central bank in the world. Several comprehensive works, for example, Friedman and Schwartz (1963) and Meltzer

[25]Factors that central banks retain no control over.
[26]Factors that central banks actively manage.
[27]These deposits are semi-autonomous.
[28]Non-borrowed reserves generally are calculated as total reserves minus borrowed reserves. Borrowed reserves are found on the asset side of the balance sheet, normally referred to as loans, borrowing, liquidity provided, etc. In the case of South Africa borrowed reserves were defined as the total liquidity provided (i.e. money market shortage).

(2010), map out the entire history of the Fed in meticulous detail. The focus of the world on the practice of the Fed has led many central banks to adopt policies that are closely aligned. It is therefore interesting to look at the different operational frameworks and targets that the Fed has utilised in the post-war era.[29] Romer and Romer (2004) posit the theory that fundamental changes in policy have been the result of changes in the outlook of policymakers carrying out that policy. They found that the objective of Fed chairpersons largely has remained the same, but the methods employed to reach their intended targets have been clearly distinguishable.

An appropriate way then to differentiate between monetary policy regimes in the US is by considering the different terms of each chairperson. In fact, several papers that try to empirically identify monetary policy regime switching in the US found that changes in policy outlook coincide with changes of the incumbent chairperson (Sims and Zha, 2006; Bae et al., 2011). There have been seven Federal Reserve Chairpersons since the 2nd of April, 1951, when William McChesney Martin, Jr. took office (Romer and Romer, 2004). The official position of the Fed during the Martin era was one of 'free reserves targeting', where free reserves are equal to the difference between excess and borrowed reserves (Bindseil, 2004). Several monetary policy instruments were used actively in this era, including frequent changes in reserve requirements, open market operations and the discount rate.

In February of 1970, Arthur Burns was inaugurated (Romer and Romer, 2004). The Burns era also opened with a quantitative operational target, the reserves on private deposits. The intermediate target, M1 growth, was achieved by altering the reserve position of the Fed. Burns acknowledged the importance of the federal funds rate in the implementation of monetary policy. In the second half of the decade, the funds rate was constrained to a narrow band[30] and became the implicit operational target of the Fed (Meulendyke, 1988).

Paul Volcker became the chairperson of the Board of Governors in October 1979. He was tasked with the ostensibly insurmountable objective of overcoming double-digit inflation. In order to combat the high and persistent inflation episode of the 1970s[31], Volcker adopted an aggressive contractionary policy stance. For Volcker, this meant taking a monetarist approach, substituting away from interest rate targeting to non-borrowed reserves as operational target (Meulendyke, 1988; Bindseil, 2004). In 1983, the Fed changed their operational target once again, to borrowed reserves coupled with a five per cent band around the federal funds rate.

Alan Greenspan, who became chairperson in August 1987, was probably the most influential central banker in history. Greenspan continued to use the operational targets of the Volcker era

[29] Especially after 1951, when the Fed gained its independence from the government with the Federal Reserve Accord.

[30] Movements from this band were corrected through market intervention.

[31] Also known as the Great Inflation.

until 1990. Afterwards, a gradual movement toward a federal funds target was undertaken. By 1994 the process was completed, and a federal funds rate target was explicitly announced after each Federal Open Market Committee (FOMC) meeting (Bindseil, 2004). Ben Bernanke, who became chairperson in February 2006, adopted a hybrid regime in 2008 with the advent of the financial crisis. The most recent chairperson, is Janet Yellen, who took office in February 2014. During her term, the Fed increased the federal funds rate in December 2015. This was the first rate increase since 2006.

The mechanics of implementation are highly similar to those of the South African case. The primary difference is in the setting of the short-term interest rate. In the case of the Fed, the FOMC announces a target for the federal funds rate and instructs the Open Market Trading Desk (OMTD) at the New York Federal Reserve to carry out market operations to achieve the target rate. The OMTD conducts the operations by "estimating the quantity of reserves that will be demanded given the FOMC's target federal funds rate and supplying the reserves required to meet that demand at the target federal funds rate" (Kahn, 2010). Forecasting demand is not a precise science, and deviations from the forecast result in volatility of the effective federal funds rate.

3.2 Corridor, Floor and Hybrid Regimes

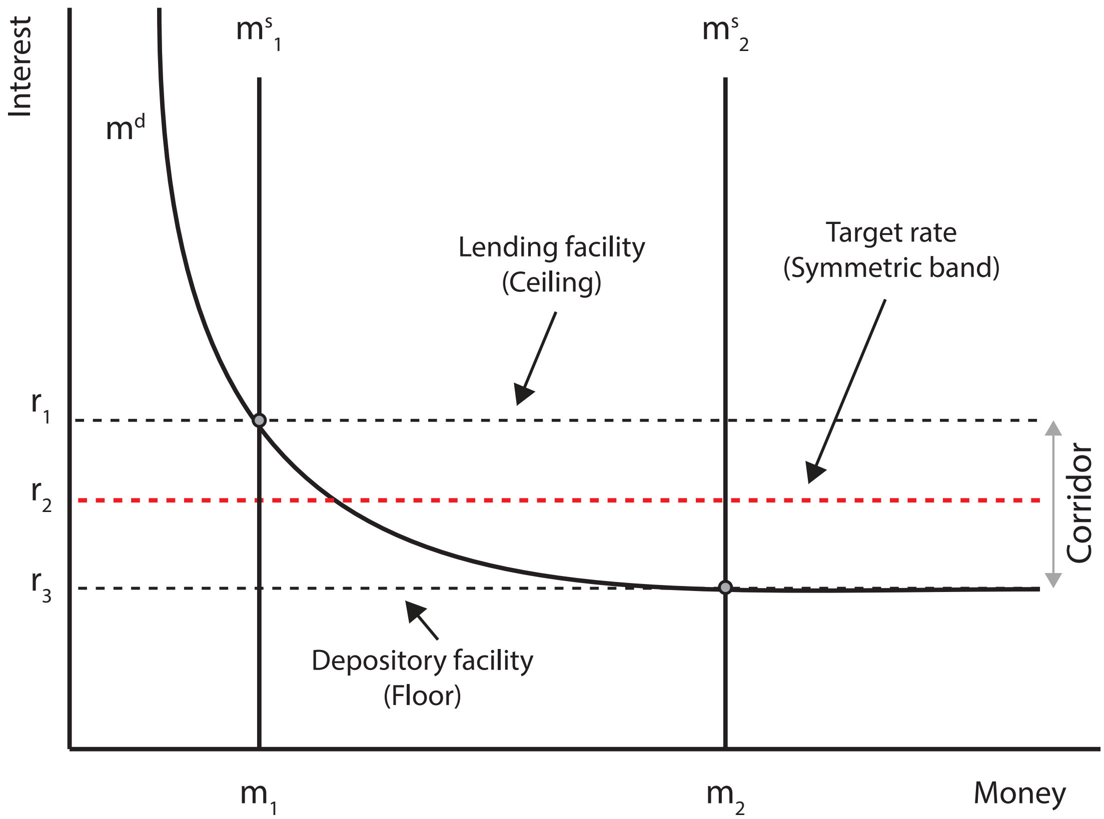
Corridor and floor regimes do not require the levying of reserve requirements to make the targeted interest rate effective; standing facilities are used instead.[32] Most central banks have a lending facility and could establish an interest rate ceiling. This interest rate charged on the lending facility, set above the target rate, imposes a "penalty on depository institutions that borrow from the central bank rather than in the interbank market" (Kahn, 2010). However, in a corridor regime, the standing facilities provide both a ceiling and floor to the target interest rate. The floor, which is established under the target rate in a corridor system, is a depository facility where private banks can deposit reserves and receive a fixed rate of interest on these deposits (Keister et al., 2008). The spread between the ceiling and floor rates is usually narrow and is called the "interest rate channel, tunnel or corridor" (Whitesell, 2006).

Both the upper and lower interest rate limits are presented in Figure 4. In a symmetric channel/corridor regime, the target will be set in the middle of the deposit and lending facility. In other words, the upper and lower limits form a symmetric band around the target rate. This is often referred to as a pure corridor regime, and is implemented by countries like Canada

[32]For the purpose of this paper, a corridor or floor regime with a reserve requirement is referred to as a hybrid regime

and Sweden. In this regime the aim of the central bank is to "keep total reserves in the banking system at zero, or marginally higher than zero" (Syrstad, 2012). Figure 5 is a graphical representation of the corridor system in Canada[33]. This corridor system has been in place since 1995, to avoid excess interest rate volatility. The Bank of Canada was forced to move temporarily to a floor system between 2009 and 2011.

Figure 4: Corridor/floor system of monetary policy implementation



The floor regime differs from the corridor system in two distinct ways. First, the deposit rate is set equal to, instead of below, the central bank's target rate (Keister et al., 2008). Second, the reserve supply is chosen to intersect the flat portion of the demand curve depicted in Figure 4. In other words "the central bank must provide the banking system with so much liquidity that the overnight rate approaches the central bank's deposit rate" (Bernhardsen et al., 2010). Norway and New Zealand are examples of countries that have implemented such a regime[34]. Figure 6 provides a look at the Norwegian floor system. As stated in Section 3.1, one of the conditions for decoupling is that changes in reserve holdings have no impact on the policy rate, as per the

[33]In this study Canada was chosen as there is an existing body of literature on the liquidity effect. In addition, it is one of few countries that has employed a corridor regime for an extended time period and therefore concerns over data availability are reduced

[34]Norway is chosen in favour of New Zealand, as it has implemented the regime for a longer period of time. The New Zealand central bank only briefly adopted the floor regime.

floor regime.

Several authors (Goodfriend, 2002; Keister et al., 2008; Borio and Disyatat, 2010; Bowman et al., 2010; Kahn, 2010; Lavoie, 2010; Ireland, 2012) have suggested that under floor regimes the 'decoupling principle' is most readily observable. Goodfriend (2002) was the first explicitly to formulate this hypothesis. He suggested that under a floor regime the central bank could potentially target any quantity of reserves, as long as liquidity is in excess of the amount required to keep the policy rate equal to the interest paid on reserves. To maintain this floor regime, the central bank has to satiate the banking system with reserves at all times. In this setting the policy rate is theoretically controlled by the level of interest on reserves (Kopchak, 2011). Following the recent decision by the Fed to impose interest on reserves, Keister et al. (2008) claim the central bank "has 'divorced' the quantity of money from the interest rate target and, hence, from monetary policy". This divorce leaves the central bank two independent policy instruments, namely the policy rate and the quantity of reserves. Ireland (2012), for example, believes that under a floor regime, "the traditional short-run liquidity effect, associating a monetary policy tightening with higher interest rates brought about through a reduction in the supply of reserves, vanishes".

In reserve regimes, depository institutions are required to hold non interest-bearing reserves, which represent an opportunity cost to these banks (Kahn, 2010). The distortion created by this tax on reserves was highlighted by Friedman (1959), who argued for the payment of interest on reserve balances at the market rate. Friedman believed that "central-bank reserves are a valuable transactions medium" and that "they should be made available in elastic supply and not taxed" (Kashyap and Stein, 2012). This entails remunerating private banks for reserve balances held at the central bank. The opportunity cost of holding money is also a central concept in the Friedman rule for the optimum quantity of money, which advocates setting the nominal interest rate to zero to address the distortion (Friedman, 1968; Cúrdia and Woodford, 2011).

Several developed nations find themselves utilising a combination of interest on reserves and a modified non-negative Friedman rule (especially since the financial crisis). This combination of interest rate floor and reserve requirement forms part of what is considered a hybrid regime.[35] In the case of the US after 2008, for example, where interest rates were driven to the floor of the interest rate corridor, the system resembles an application of a non-negative Friedman rule.[36] Pure corridor and floor regimes are not subject to these drawbacks as only settlement (working) balances are held by private banks (Borio, 1997).

[35]Countries with a corridor system and reserve requirement are also referred to as hybrid regimes

[36]This discussion is further explored in the previous, where I discuss the exit strategy currently implemented by the Fed

3.2.1 Canada

The Bank of Canada's operating framework has been relatively stable since the 1950s. Monetary policy has been implemented through the conventional method of manipulating the supply of reserves (or settlement cash in the case of Canada) to influence the overnight cost of financing (Armour et al., 1996). However, a few deviations from a focus on short-term interest rates as an operational target have been recorded. These departures normally are prompted by prevailing economic conditions, driven by volatility in the exchange rate. Seeing that Canada is a commodity-rich small open economy, it is subject to abrupt movements in the exchange rate. A floating exchange rate regime was implemented between 1950 and 1962. During this period the bank rate was floating[37] and the bank exercised control over mandated bank reserves to perform open market operations (Laidler et al., 2010).

The Canadian dollar came under pressure during the late 1950s, which instigated a futile attempt at foreign exchange intervention. In 1962, and up until 1970, the Bank of Canada relinquished its monetary policy independence in order to maintain an exchange rate peg to the US dollar. In the late 1960s a "surge in demand for Canadian exports accentuated the rising trend in the Canada/US-dollar real exchange rate, and the classic tension between incompatible goals for the exchange rate and the domestic economy became overwhelming" (Laidler et al., 2010). Canada's third monetary policy regime was enacted in 1970 with the floating of the exchange rate.

The oil-price shocks of the 1970s brought elevated inflation, along with reduced economic activity. The Bank of Canada responded by adopting "monetary gradualism" (Lange, 2010). This 'monetary gradualism' meant that the central bank was "committed to effect a gradual reduction in the mean and the variance of the growth rate of the money supply (Ml) and to maintain it thereafter at a low and stable level to establish a low and steady rate of inflation in the long run" (Fortin, 1979). Policy decisions were linked closely to the monetary policy position of the Fed at the time, which tried to establish control over monetary aggregates, and from 1979 to 1982, "the conduct of policy was complicated by shocks to M1 demand, erratic U.S. monetary policy and volatility of the exchange rate" (Armour et al., 1996).

As a result of these developments, money growth targeting was abandoned in 1982 (Laidler, 1999). Growth of M1 was still used as an indicator variable after 1982, but it lost its place as part of the formal operating framework of the central bank. In the period from 1982 until the adoption of an inflation targeting regime in 1991, it was believed that the Bank of Canada

[37] It was set at 25 basis points above the average yield on three-month treasury bills at the Federal government's weekly auction.

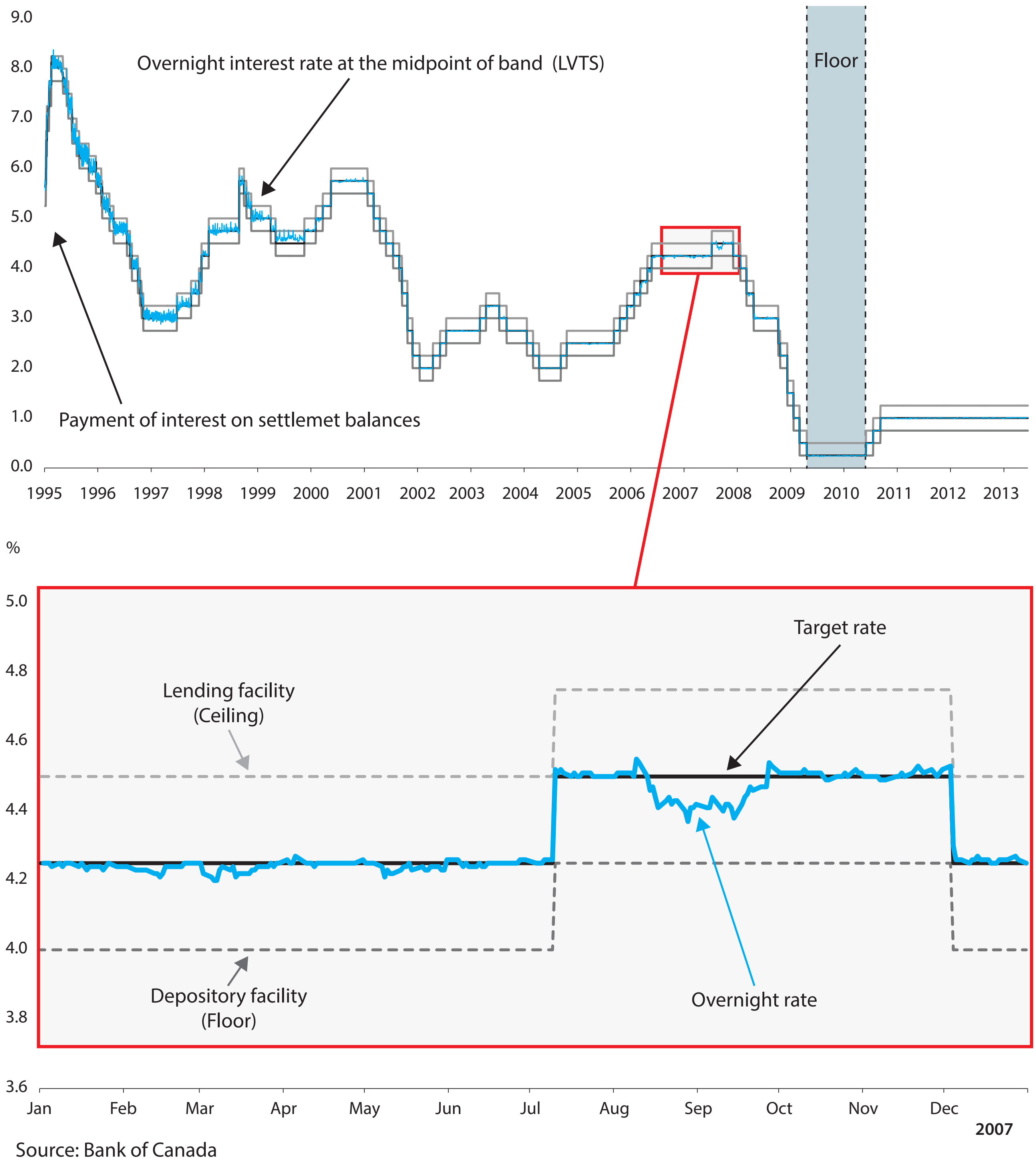


Figure 5: Canadian corridor system of monetary policy implementation

piggybacked on US policy and had an implicit exchange rate target (Bordo and Redish, 2006). The year 1982 also heralded the return of active short-term interest rate management to control inflation (Dib, 2002).

The 1990s are of special interest in the conduct of monetary policy in Canada. Some highlights include the introduction of inflation targeting, in 1991; the phasing out of reserve requirements, in 1992-1994; the shifting from the Bank rate to the "target for the overnight rate", in 1994; the introduction of the Large Value Transfer System (LVTS), in 1999; and fixed dates for announcing policy decisions, in 2000 (Bordo and Redish, 2006). In 1994 the bank introduced the payment of interest on settlement balances, the final component of its symmetric corridor operating system.[38] Standing facilities for overdrafts and deposits formed a 50 basis-point operating band for the overnight rate. In 1999, with the advent of the LVTS, the target for the overnight financing rate was defined as the midpoint of the band, to reduce volatility in interest rate movements. Important changes in operating procedures during the 1990s are shown in Figure 5.

3.2.2 Norway

Monetary policy implementation in Norway following the Second World War was characterised by a belief in the ability of the central authority to fine-tune the economy through coordinating its available instruments. Policies were conducted in a similar fashion to those of the several other countries under the Bretton Woods fixed exchange rate system, before the tumultuous events of the Great Inflation episode. The breakdown of Bretton Woods, in 1973, meant a floating exchange rate for the Norges Bank. Supply side shocks in the 1970s pushed inflation levels beyond the control of the monetary authorities, and the economy entered a price/wage spiral. Several exchange rate interventions (devaluations of the krone) were enacted, but this could not sufficiently bolster economic growth (Gjedrem, 2001). The high levels of inflation that accompanied the economic downturn indicated that monetary policy was not functioning effectively. The realisation dawned that a new policy framework needed to be adopted. In 1985 the Norges Bank gained greater independence through legislation, and subsequently, in 1986, the Bank established a fixed exchange rate as nominal anchor (Svensson et al., 2002).

The crisis in the European Monetary System in 1992 "revealed the built-in weaknesses of a fixed exchange rate regime in a world of free capital flows and deep financial markets" (Gjedrem, 2001). Because of the crisis the Norges Bank was forced to move back to a floating exchange rate regime. The exchange rate operated in a narrow band following the crisis, but in 1996 exchange rate volatility increased precipitously. This episode proved that fine-tuning operations

[38]The Bank rate forms the ceiling in this corridor system, 25 basis points above the target overnight rate.

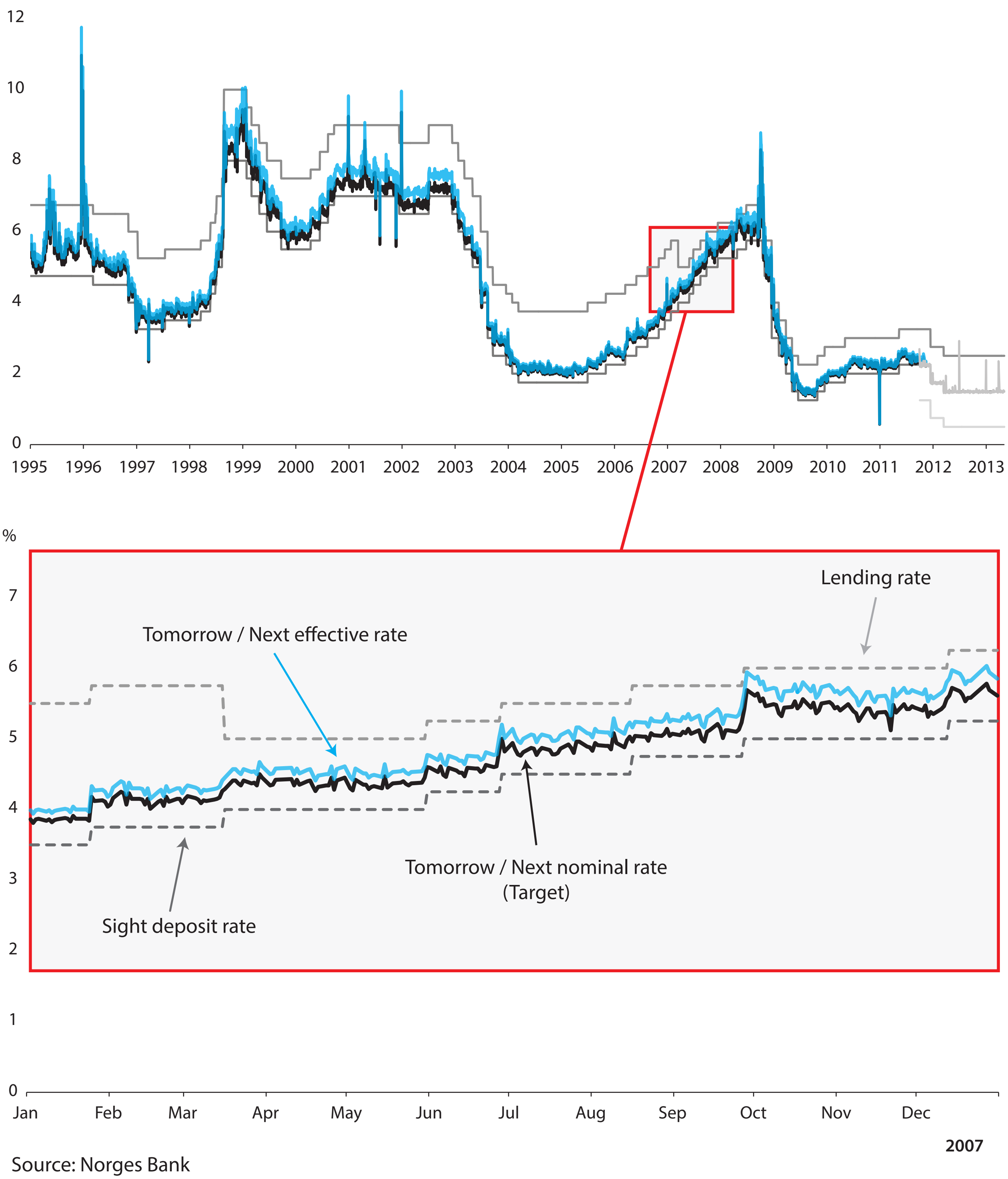


Figure 6: Norwegian floor system of monetary policy implementation

were, to a certain extent, ineffectual in the case of Norway. The Norges Bank realised that in order to maintain a stable exchange rate it would need to stabilise inflation through the management of price expectations. Consequently, in March of 2001, Norway turned to inflation targeting.

The adoption of inflation targeting does not translate into the use of open market operations. The policy rates used by the Norges bank are those of its standing facilities. Two interest rates are of importance here, the interest rate on sight deposits (i.e. the deposit rate) and the interest rate on overnight loans (i.e the lending rate). These two rates form a corridor for the shortest money market rates. The Norges Bank supplies enough liquidity to the banking system to ensure that the "sight deposit rate is the banking system's marginal rate and the key policy rate in the Bank's conduct of monetary policy" (Olivei, 2002). This is the essence of the floor system, in which the target rate equals the rate charged at the deposit facility. Figure 5 illustrates this floor system. Since October 2011 the Norges bank has introduced a new component to the floor system, called a reserve quota. Under this regime, the central bank provides only a limited quantity of liquidity (quota) at the deposit rate. Deposits made in excess of this amount receive a lower rate of interest.

4 Empirical Evidence

4.1 Data

Country	m	p	y	r	Date
RSA	NBR	CPI	IP	Banker's Acceptance	1986m01 - 2012m01
USA	NBR	CPI	IP	Federal Funds	1959m01 - 2013m04
CAN	ER	CPI	IP	Overnight	1975m01 - 2013m01
NOR	TL	CPI	IP	NIBOR	1973m01 - 2011m03

Table 1: South Africa: Data from the South Afican Reserve Bank; **USA**: Data from the Federal Reserve Bank of St. Louis; **Canada**: Data from Bank of Canada and Statistics Canada (CANSIM Tables); **Norway**: Data from Norges Bank and Statistics Norway; NBR = Non-borrowed Reserves (Total Reserves - Borrowed Reserves); ER = Excess Reserves; TL = Total Liquidity; CPI = Consumer Price Index; GDP = Gross Domestic Product; IP = Industrial Production Index

The data used are monthly observations and are summarised in Table 1. In all countries the measure of the price level is the consumer price index (CPI). The level of real income, a proxy for business cycle activity, is measured in all countries by either industrial or manufacturing production (IP). All variables are logged, except for the various interest rates. First-order differences were taken with respect to the logged values of the price level (CPI) and several of the non-stationary liquidity measures (TL, NBR, ER).[39]

4.1.1 Liquidity Measures

Several liquidity measures were used in the analysis. The variable selection criteria was largely dependent on data availability. They were tested for the presence of a unit root with the aid of an Augmented Dickey-Fuller (ADF) test. However, in the case of the VAR specification, the liquidity variables were often left in level terms, even when non-stationary, as it is believed that the transformation of variables is not always necessary when integrated of order one. The theory is that in large samples, OLS is still consistent regardless of whether the VAR contains integrated components (Fung and Gupta, 1997). Variables that needed to be seasonally adjusted were smoothed using the X-13 ARIMA package. Figure 7 presents the selection of liquidity variables.

Several calculations were necessary to obtain the relevant liquidity measures. In the case of the USA, all measures were readily available and were extracted directly from the Federal Reserve Database. The non-borrowed reserves series was discontinued, which limits the availability of data. Information pertaining to reserves for South Africa was gathered from the SARB's online database. Non-borrowed reserves (NBR) for South Africa were calculated as total reserves with the SARB minus the total liquidity provided by the SARB. Due to data availability, NBR was calculated only for the period 1986m01 to 2012m02. In the case of Canada, excess reserves were calculated as reserves in excess of the statutory minimum reserves required to be held by chartered banks. Excess and total reserves are equal after 1994m07, since the reserve requirement was phased out in July 1994. The data was gathered from the CANSIM tables, available from Statistics Canada. For Norway, NBR was not calculated; total liquidity (which is domestic sight deposits) was used instead. Data was gathered from the Norges Bank's website. The sample period for Norway ends in the third quarter of 2011, as this marks the start of the quota regime.

4.1.2 Interest Rates

Different money market rates were used in the analysis. In general, the shortest market rate was used. However, since the data is presented at a monthly frequency, the nuances of daily shifts

[39]The growth rate (first difference) of the liquidity measures was not always used, but was used in the cases where the inclusion of the variable in level terms resulted in an unstable VAR.

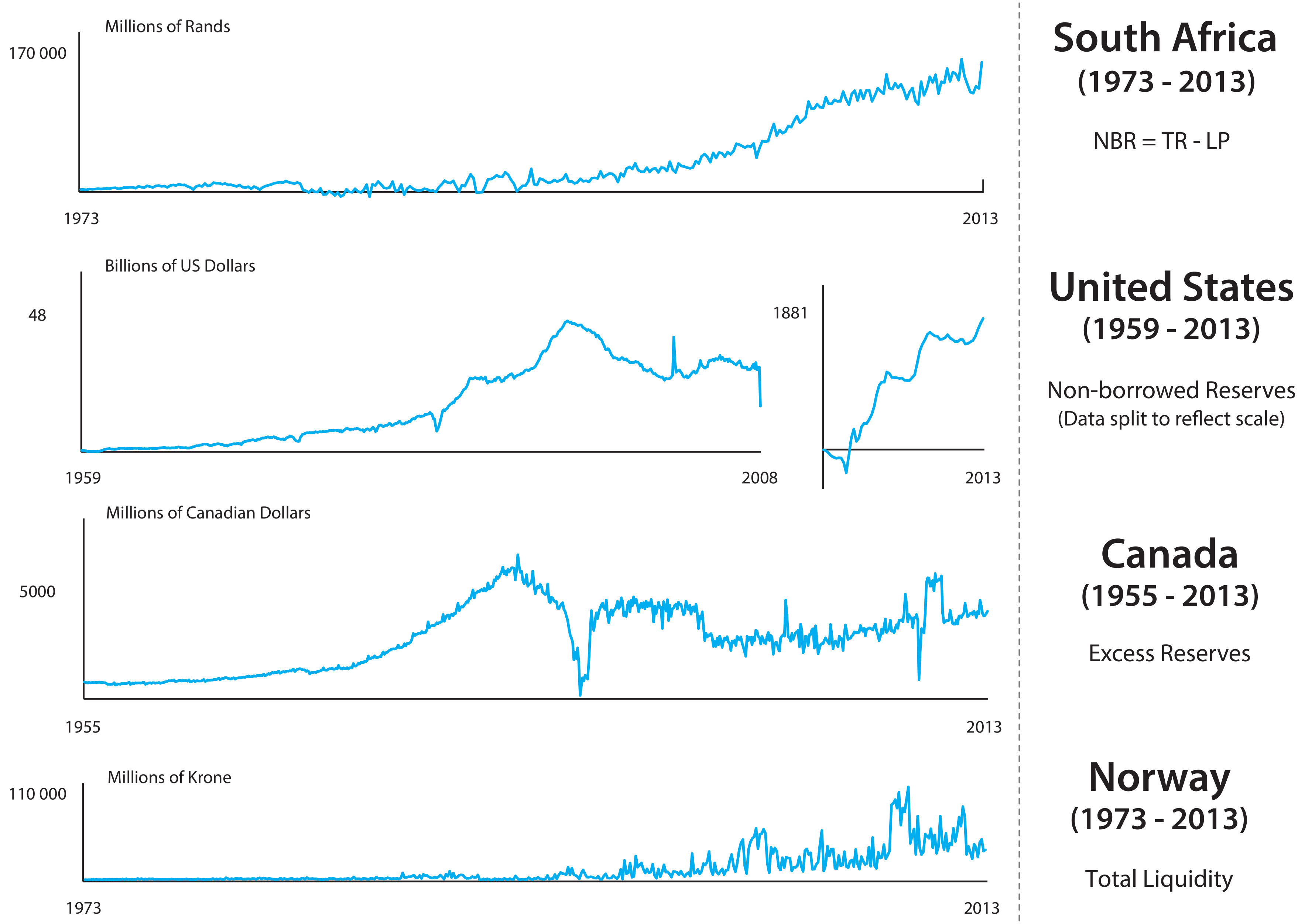


Figure 7: Raw data on different liquidity measures used

in interest rates were lost. In the case of the USA, the effective federal funds rate was used. For South Africa, the interest rate with the most observations is the Bank rate. The problem I encountered with using the Bank rate was that it is determined by the SARB for the most part, and not endogenously in the market. Other available interest rates are the 90-Day Banker's Acceptance rate (BAR), the 30 Day Treasury Bill rate (TBR) and the South African Benchmark Overnight rate (SABOR). Ideally, one would like to use SABOR, as it is the shortest market rate. However, data for SABOR was available only from September 2001, which greatly reduced my sample size. Therefore, I decided to use the Banker's Acceptance rate in my analysis. Figure 8 illustrates how these rates relate to each other. The Money Market Funds or Overnight Rate is used in Canada, and in Norway the Norwegian Interbank Offered Rate (NIBOR)[40] is used.

4.2 Rolling Regression

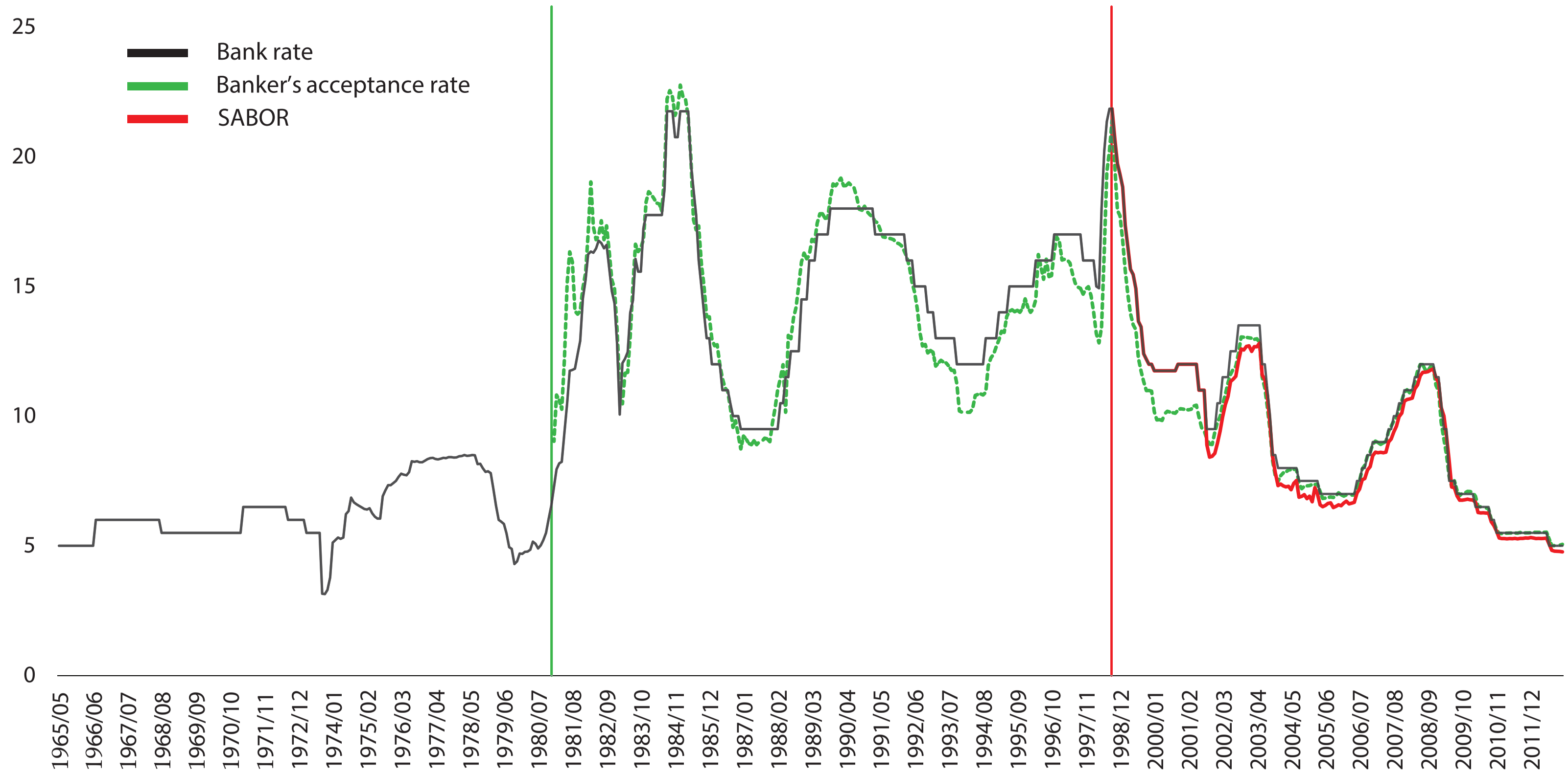
The regression equation is a dynamic version of the static equation used in Section 2 to explain the liquidity effect. The empirical specification for this dynamic regression model tries to link interest rates to liquidity, output growth and inflation.

$$r_t = \alpha + \beta_i r_{t-i} + \delta_i m_{t-i} + \eta_i g_{t-i} + \theta_i p_{t-i} + \varepsilon_t, \quad \varepsilon_t \sim (0, \sigma_\varepsilon^2) \tag{3}$$

where, r_t is the interest rate, m_t represents liquidity, g_t is real output growth, p_t is inflation and ε_t is the error term. The lag length for each country was determined primarily by a general to specific approach of adding lags to the model up to the point where the introduction of additional lags delivered statistically insignificant results. The information criterion was also used to determine whether deepening the lags would contribute to improved homoscedasticity of the errors.[41] The lag length for the different specifications varied between two and four lags. One of the shortcomings of the specification is that it does not consider country-specific historic events, such as banking crises (Norway), major political events (South Africa), and so forth.

A rolling (or moving window) regression was performed for all four countries. A rolling analysis of a time series is often used to determine model stability over time (i.e. whether a parameter is constant over time) (Zivot and Wang, 2006). In my case, a parameter estimate of liquidity, δ, was computed over a moving window, where the size of the sliding window was fixed at fifty months and incremented by one month. Several regressions were performed using this technique, each providing a parameter estimate at a different time window. By using this

[40] The shortest form of interest rate (i.e. Tomorrow/Next) was used, which is the equivalent of an overnight rate.
[41] The results from these tests are not provided.



Source: South African Reserve Bank

Figure 8: South African short-term interest rates

method, one can see the spatial variations in the sample. Only a specific sample of observations was taken into account in each window. Data outside this window have no influence and were not taken into account. Observations within this window were weighted equally (Zivot and Wang, 2006). This time-varying parameter model provides insight into the changing nature of the relationship between interest rates and liquidity. More advanced state-space models, such as the TVP-VAR model in Section 4.4, were used to provide a more accurate description of the true nature of δ. The function of the rolling regression was to confirm the time-varying nature of the parameters of the model.

4.2.1 Results

In this section the results of the rolling regressions for all four countries, with country-specific liquidity measures, are depicted and discussed. Figure 9 shows the rolling regressions for all four countries, with previously defined liquidity variables of interest.[42] The results for each country are discussed in turn.

4.2.1.1 South Africa The rolling regression with respect to non-borrowed reserves took place over a small sample period, from 1986 to 2012. The results are not definitive, with parameter estimates on both sides of the horizontal axis. The confidence interval indicates that there is most likely no effect of non-borrowed reserves on the interest rate in this sample. Several other, broader liquidity measures, like high-powered money (MB) and the money supply (M1 and M2), were also tested, and are shown in Appendix A. However, the tests revealed relatively little new information, as a similar trend is recorded for these variables. In other words, analyses undertaken with a range of liquidity measures, from narrow to broad monetary aggregates, illustrates no concrete evidence for a stable or persistent relationship with the Banker's Acceptance rate.

4.2.1.2 USA The relationship between NBR, in the second panel of Figure 9, and the federal funds rate is consistently negative until we reach the moving window samples ending in 1992.[43] There are point estimates along the series where the relationship turns positive, but these observations are scattered. The segment between 1992 and 2008 shows a stable parameter value centred on zero, indicating little to no relationship between the federal funds rate and

[42]Dashed lines indicate 95% confidence intervals.

[43]The inference of a negative relationship is tentative as the upper bound of the confidence interval indicates the possibility of a slightly positive relationship.

non-borrowed reserves. A similar trend is seen when other liquidity variables are used. Exact inference pertaining to the interdependence of interest rates and liquidity will not be hazarded. However, it would be appropriate to say that the relationship has changed with time and that the response of the federal funds rate to movements in liquidity has been dampened. In 2008 the Fed transitioned to a floor regime, paying interest on reserves equal to the target funds rate.

4.2.1.3 Canada The third panel in Figure 9 shows the results from a rolling regression on the Canadian data. The liquidity measure used in this instance is excess reserves. The motivation for using this liquidity measure is attributed to the paper on the liquidity effect in Canada by Fung and Gupta (1997). They determine that excess cash reserves, as a liquidity variable, is the appropriate measure to use for Canada and delivers a significant liquidity effect. Non-borrowed reserves are believed to be inappropriate in the Canadian institutional setting. According to Dingle et al. (1972), "in the short run the central bank seeks to influence the asset holdings of chartered banks and interest rates in the money market by adjusting the supply of excess cash reserves in relation to the continually changing level desired by the banks". This sentiment is reinforced by White and Poloz (1980), who believe that the "Bank of Canada influences changes in the short-term interest rates by supplying quantities of *excess cash reserves*". The literature, therefore, suggests that "cash management by the banks focusses on excess reserves" (Clinton, 1991).

The graph illustrates that capturing a liquidity effect is plausible for regression window samples ending before 1995. However, after these observations the relationship seems to wither. This result speaks to the transition to a corridor system. One can postulate that after this transition the Bank of Canada appears to have successfully insulated the market for bank reserves from their open market operations, and thereby have dulled the accompanying liquidity effect. In addition, broader monetary aggregates do not show signs of a significant and stable relationship with the overnight rate.

4.2.1.4 Norway As previously stated, NBR was not calculated for Norway. A proxy for this variable, referred to as total liquidity, was used. Total liquidity was calculated as the sight deposits made at the Norges Bank. An analysis of the relationship between total liquidity and the short-term interest rate reveals that an sporadic liquidity effect is plausible. The positive values recorded in the late 1980s and early 1990s is in part attributable to the Norwegian banking crisis that peaked during 1991 and 1992. A systemic failure of the banking system resulted in a frantic pursuit of liquidity during this period. The transition to a floor regime in 2001 shows up clearly in the graph. It is possible to state that in this selected sample, after

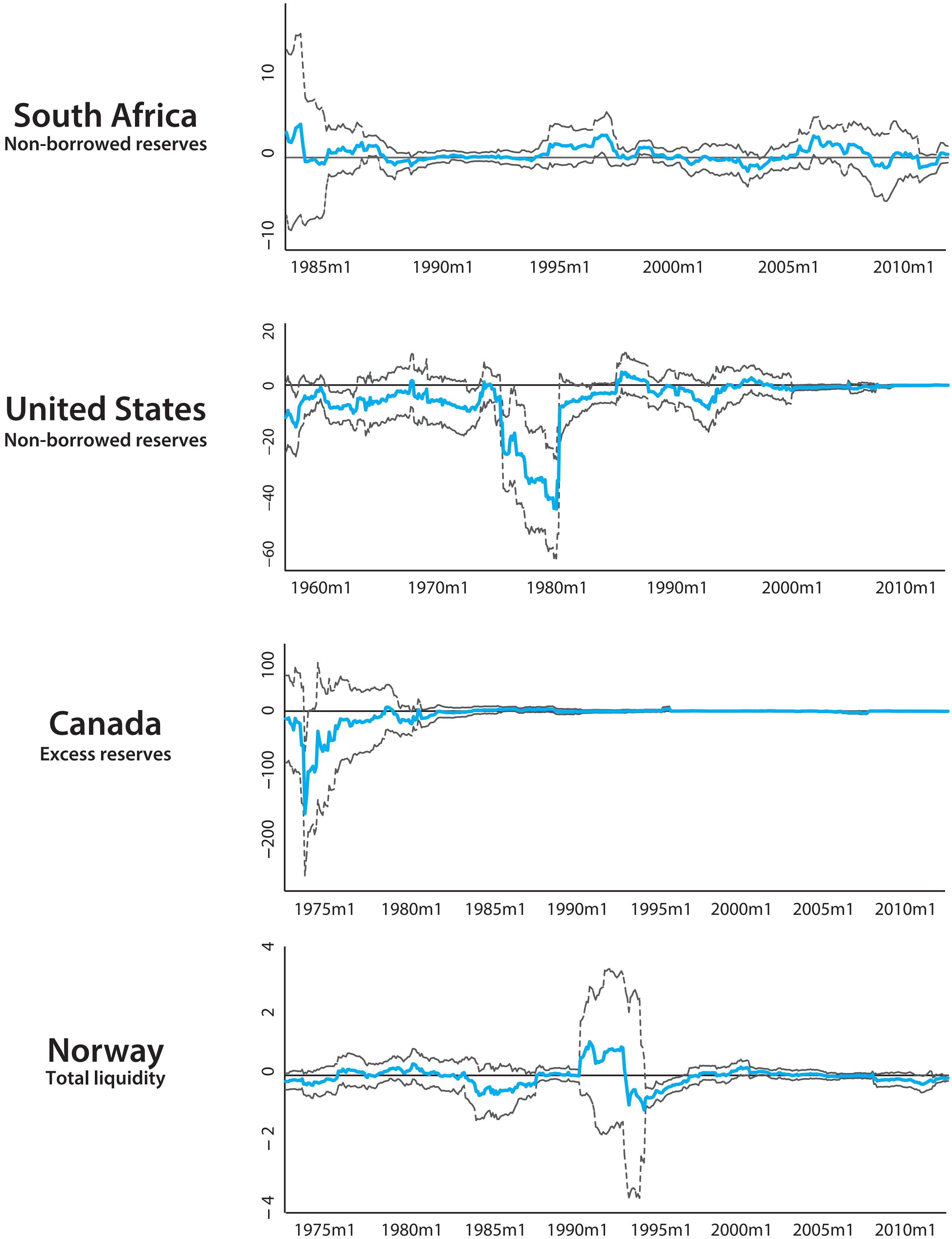


Figure 9: Rolling regression results for four countries - δ coefficient estimate

2001, there is little to no effect on the interest rate from fluctuations in the level of liquidity holdings. Looking at the movement of the parameter estimates for high-powered money, in Appendix A, one observes a resemblance to the results obtained for total liquidity.

4.3 Structural Vector Autoregression

Vector autoregressive (VAR) models have been the workhorse of empirical macroeconomics since the early 1980's (Kilian, 2011).[44] In his iconic *Econometrica* paper[45], Sims (1980) first suggested the usage of VAR models in favour of the large-scale simultaneous equation models of the time. These large macroeconometric models were remnants from the Cowles Commission and often involved hundreds of equations, where identification was achieved through the exclusion of variables without economic, or statistical, prejudice (Bjørnland, 2000). Sims was especially critical of the "incredible identifying restrictions" imposed by econometricians in these large structural models, as these restrictions had no theoretical basis (Sims, 1980). In addition, he suggested to shift the focus from structural to reduced-form models, where endogenous variables are modelled jointly. An extensive literature has developed around the idea of reduced-form VAR models, as discussed in Watson (1994) and Lütkepohl (2011).

Early attempts at VAR modelling were considered atheoretical, as outlined by Cooley and LeRoy (1985). Developing a structural model requires believable restrictions on certain variable coefficients, to generate mutually uncorrelated structural shocks. It was only in the work of Sims (1986), Bernanke (1986), Blanchard and Watson (1986) and Blanchard (1989) that a more structural approach to VAR modelling started to develop. As explained by Kilian (2011), a structural approach involves "identifying assumptions that must be motivated based on institutional knowledge, economic theory, or other extraneous constraints on the model responses". Initially, restrictions were made in terms of short-run relationships, but the work of Blanchard and Quah (1989) helped extend this to include long-run dynamics. The literature on identification is ever expanding, with a gamut of restrictions possible, ranging from short-run, long-run, sign or even heteroscedasticity restrictions. In the next section the methodology for the structural vector autoregression (SVAR) is briefly described, which is followed by a discussion on the identification strategy implemented.

[44]There is a detailed discussion on the impact of VAR models on empirical macroeconomics in the work of Canova (1999)

[45]This paper is one of his contributions to "empirical research on cause and effect in the macroeconomy" that eventually led to him being awarded the Nobel Memorial Prize in Economic Sciences in 2011. He shared the prize with Thomas Sargent.

4.3.1 Methodology

The structural model of the economy is represented by the following simultaneous equation system[46],

$$A\mathbf{y}_t = F_1\mathbf{y}_{t-1} + \ldots + F_s\mathbf{y}_{t-s} + u_t \qquad u_t \sim N(0, \Sigma\Sigma) \tag{4}$$

where $t = s+1, \ldots, n$. In this specification $\mathbf{y}_t$ is a $k \times 1$ vector of variables that summarise the state of the economic system (i.e. observed variables), while u_t is a $k \times 1$ vector of the orthogonal (iid) structural shocks, whereby,

$$\Sigma = \begin{pmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_k \end{pmatrix}$$

$F_1, \ldots, F_s$ is a $k \times k$ matrix of coefficients, and the matrix A is a square $(k \times k)$ matrix of structural parameters that indicates the contemporaneous relationships in the model. In this paper, the vector $\mathbf{y_t}$ contains current observations on four variables. The variables in the system are $[r, m, y, p]$, where r is a short-term interest rate, m is the liquidity measure, y is the growth in real output and p is inflation.

We are unable to estimate the equation because the system is not observable. Instead we transform the equation into the following estimable reduced form:

$$\mathbf{y}_t = B_1\mathbf{y}_{t-1} + \ldots + B_s\mathbf{y}_{t-s} + A^{-1}\Sigma\epsilon_t, \qquad \epsilon_t \sim N(0, I_k) \tag{5}$$

where $B_i = A^{-1}F_i$ for $i = 1, \ldots, s$. Equation 5 is the vector autoregression (VAR) representation of the structural model. The explicit variance-covariance decomposition, as presented by $A^{-1}\Sigma\epsilon_t$, will prove useful in the discussion of time-varying parameter VARs in the next section (Primiceri, 2005).

4.3.2 Identification Strategy

According to the structural VAR approach, a proper identification strategy requires imposing restrictions on the structural parameters found in the A matrix. Restrictions imposed in this

[46]As presented in (Nakajima, 2011).

matrix should reflect the contemporaneous feedback between the elements of the matrix. The simultaneous relations are identified recursively, with a lower triangular structure of the form:

$$A = \begin{pmatrix} y \\ p \\ m \\ r \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 \\ a_{41} & a_{42} & a_{43} & 1 \end{pmatrix}$$

4.3.2.1 Restriction. *The primary restriction imposed is that the short-run policy rate reacts contemporaneously to output, prices and reserves*.

Identification in the liquidity effect literature originates from the research on the monetary transmission mechanism, illustrating how monetary policy is thought to be implemented and transmitted. A substantial literature has developed around the impact of monetary policy shocks on real activity. In fact, the monetary transmission channel must be one of the most vigorously studied mechanisms in empirical macroeconomics. The emphasis on understanding how the use of monetary policy instruments transmit to the broader economy is crucial to policymakers and research economists alike. An extensive survey on the impact of monetary policy in the US is conducted by Christiano et al. (1999), with similar work done for the Euro area by Peersman and Smets (2001), and low-income countries by Mishra and Montiel (2013).

The identification scheme used in this paper is similar to that of Christiano and Eichenbaum (1992). The restriction can be blocked into two parts. First, the effect that output, prices and reserves have on the policy rate. In terms of the first block, the explanation provided in the literature is that the central bank cannot respond immediately to changes in real activity (Arias et al., 2015). In this setup, the central bank takes information on the current level of output and prices into account when making decisions as to its policy stance. This informational assumption was first suggested by Bernanke and Blinder (1992). However, this idea has been contested by the fact that central banks do not have monthly data available on output and prices (Christiano et al., 1999). Another way to view this, is that output and prices (endogenous macroeconomic variables) react to changes in the policy rate, with a lag.

Second, the response of the interest rate to the liquidity measure. In this ordering the central bank will, for example, adjust the level of liquidity with changes in the current effective interest rate, which means that a shock to the liquidity measure "reflect exogenous shocks to monetary policy" (Christiano et al., 1999). Another feasible ordering would have been $(y, p, r, m)'$, such as that of Christiano et al. (2005). However, results remained qualitatively similar, despite changes in these short-run restrictions[47]. Decisions about the level of liquidity will therefore be made

[47] Several plausible alternative orderings were tried with no reversal of sign or significance encountered.

taking into consideration the contemporaneous changes in the interest rate. In addition, the level of liquidity is contemporaneously influenced by the price level and real economic output.

4.3.3 Results

This section discusses the impulse response functions from my SVAR. The shock was applied to selected liquidity measures. Only narrow measures of money were used in the analysis, as these measures are believed to carry the most information on the behaviour of relevant market participants. The first step in estimating the VAR was to determine the appropriate lag length. In this regard, the Schwarz Information Criterion (SIC) and Akaike Information Criterion (AIC) were used for each model. The results from the tests are not reported. AIC often suggests lags in excess of 12 for the models that span the entire sample, but the SIC suggests a more modest lag depth of between 10 and 12. The related literature suggests 12 lags, which appears to be consistent with the findings of the SIC. In the case where different subsamples were used the suitable lag length was found to be between 4 and 6.

	Monetary policy regime sample periods				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
RSA		1965 - 1980	1980 - 1989	**1990 - 1998**	**1998 - 2012**
USA	**1959 - 1970**	**1970 - 1979**	**1979 - 1987**	**1987 - 2006**	**2006 - 2013**
CAN	1963 - 1970	**1971 - 1982**	**1983 - 1991**	**1992 - 2000**	**2000 - 2012**
NOR		**1973 - 1985**	**1986 - 1992**	**1993 - 2000**	**2001 - 2011**

Table 2: Subsamples identified from country-specific literature

The different subsamples identified from the literature for each country are presented in Table 2. The actual subsamples used are in bold; these are in line with the specified dates but are subject to data availability. The IRFs only demonstrate the effect of an innovation on money to the relevant short-term interest rate. The dashed lines represent the 95% confidence interval around the point estimates of the IRFs. One generally considers the result to be significant if both the upper and lower confidence bands appear on the same side of the horizontal (zero) line (Fung and Gupta, 1997). The transmission to the broader economy is not important for our analysis.

4.3.3.1 South Africa Figure 10 represents the impulse response functions (IRFs) from the VAR estimation over different sample periods. The liquidity variable enters the VAR equation in

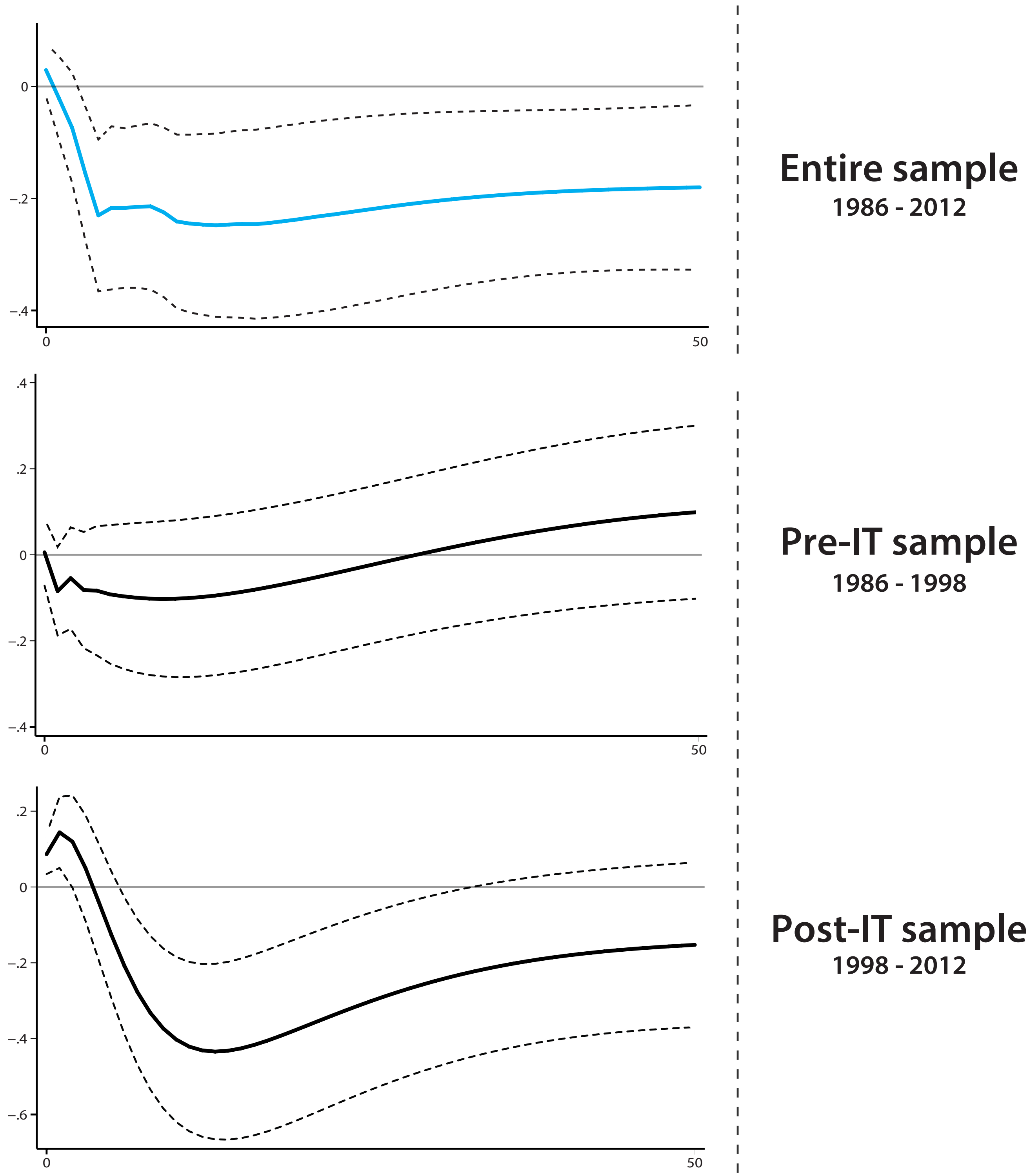


Figure 10: Impulse response functions for South Africa

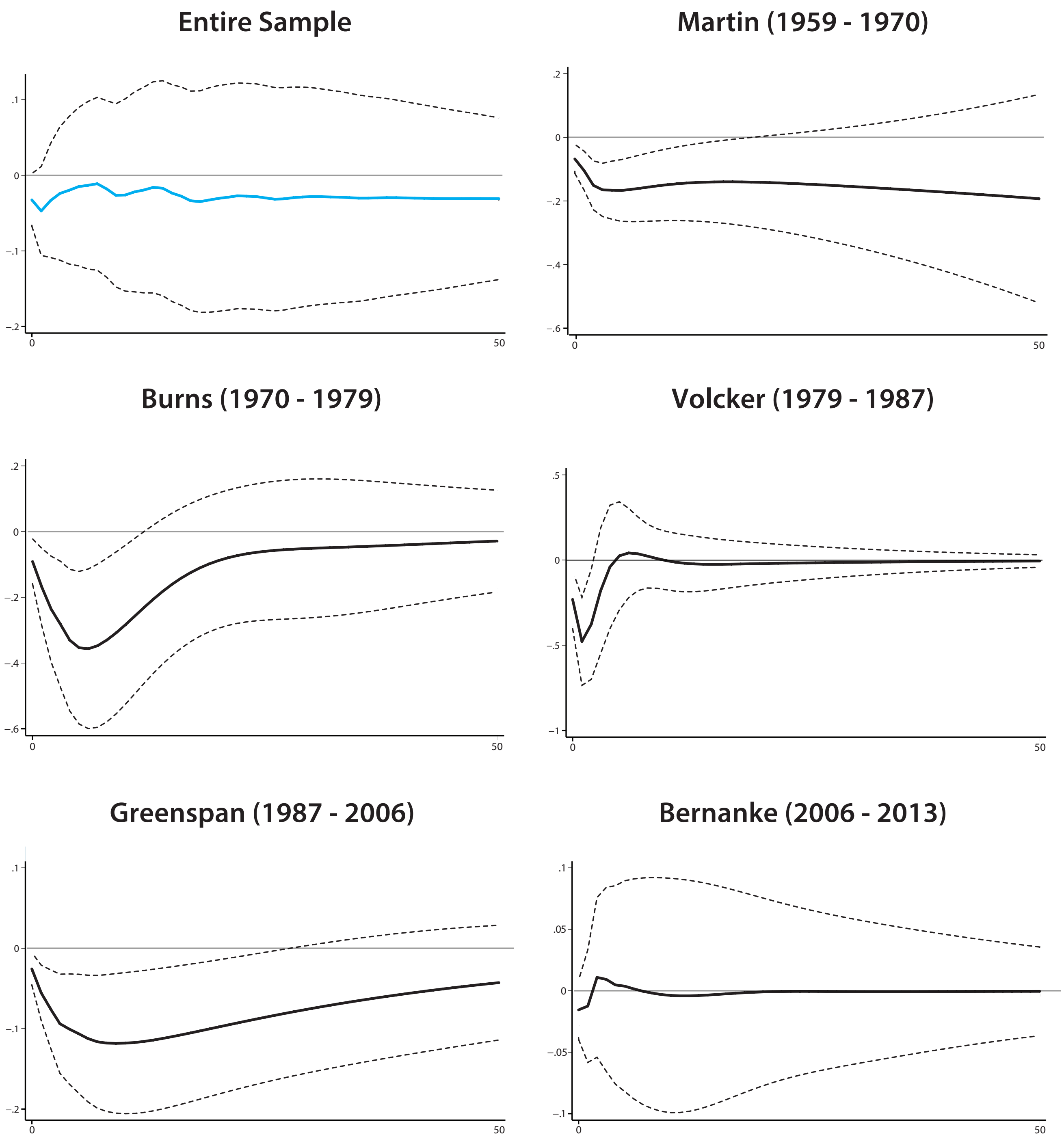


Figure 11: Impulse response functions for USA

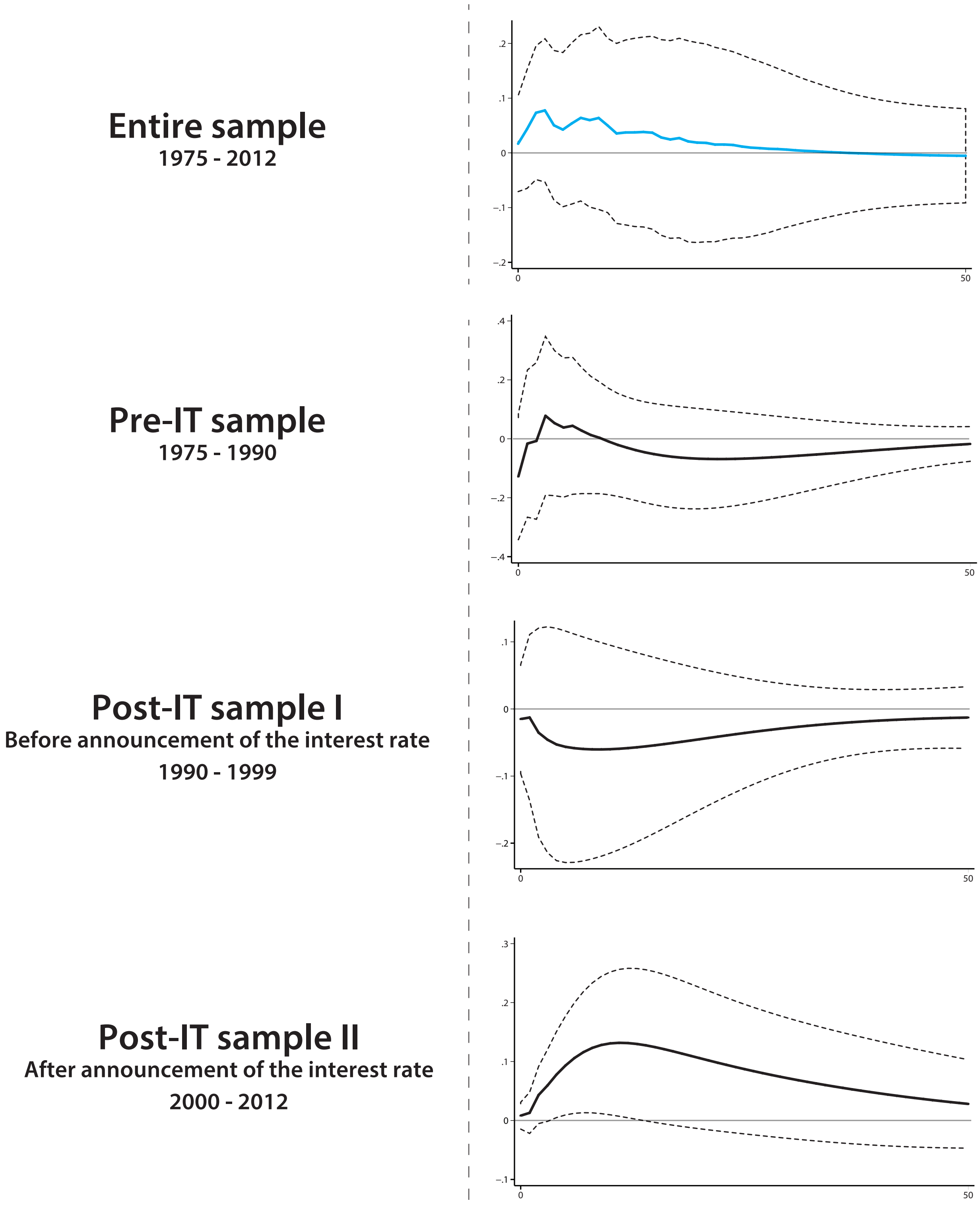


Figure 12: Impulse response functions for Canada

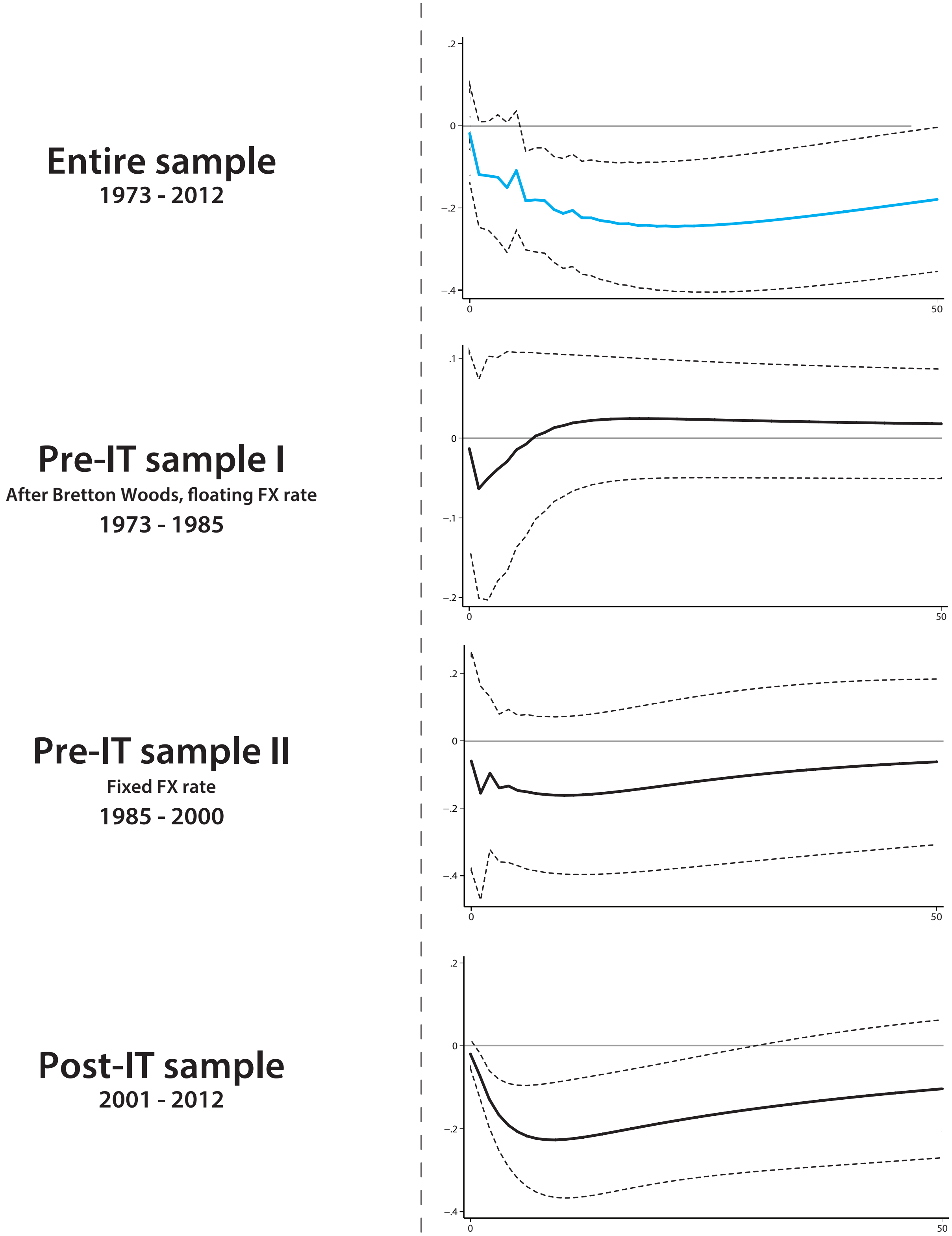


Figure 13: Impulse response functions for Norway

levels, and the VAR satisfies the stability condition, whereby all eigenvalues lie within the unit root circle. The first panel represents the entire sample. In this sample a delayed liquidity effect is captured. However, the second panel indicates the presence of a liquidity puzzle, whereby a negative relationship between money and the interest rate is not readily observable. The second panel corresponds to the period before the adoption of inflation targeting (i.e. 1998), while the third panel is the post-IT sample. The response shown in the third panel is similar to the first, with the post-IT sample potentially the biggest driver of the IRF of the whole sample. In terms of sensitivity analysis, several VAR specifications were tested, using different interest rates and liquidity variables. Obtaining a significant liquidity effect with other liquidity measures was rare and normally occurred with a lag. There is little evidence that this relationship has been stable and persistent across monetary policy regimes.

4.3.3.2 USA The results obtained from the VAR estimation for the USA agree with the findings in the literature. Figure 11 reveals that the relationship of the federal funds rate and non-borrowed reserves remains negative and eventually disappears once a hybrid / floor system is adopted. The results are compelling and indicate that in the USA there is some evidence of a decoupling of the balance sheet. This result is not surprising as most of Bernanke's term as Fed chairperson has involved an unprecedented expansion of the balance sheet, while nominal interest rates were pushed close to the zero lower bound.

4.3.3.3 Canada When excess reserves are used as the measure of money, in Figure 12, a liquidity puzzle is observed for Canada. The relationship between interest rates and excess reserves seems to appear as zero for all samples considered. The final sample period represents the adoption of an inflation targeting regime in 1999. Evidence of the decoupling principle seems especially strong in Canada, with the movement in excess reserves after 1999 eliciting almost no response in the overnight interest rate.

4.3.3.4 Norway Figure 13 reflects the IRFs from an innovation in total liquidity holdings. The pre-IT samples indicate no significant result from the perturbation in liquidity. The post-IT samples suggest the possibility of a liquidity effect. This is an interesting result in that one would expect the Norwegian money market rates to be completely immune to movements in the level of bank reserves, since the Norges bank maintains a high level of liquidity in the market (in excess of demand), as indicated by line m_{s_2} in Figure 4. Owing to the arbitrary nature of selecting sample spaces in this exercise, it might be more useful to look at a methodology that combines the time-varying nature of the parameters together with elements of a structural modelling approach.

4.4 Time-Varying Parameter Vector Autoregression

VARs have been highly influential in macroeconomic research during the last three decades. In particular, these models have proven valuable in the process of identifying comovements among multiple economic variables (Doh and Connolly, 2012). Estimating impulse response functions have given researchers a way to determine the effect of imposing structural shocks on a system of variables. There are, however, two general concerns with the usage of VARs. First, the VAR approach assumes time-invariant coefficients and variances, which turns out to be a quite strong and perhaps too restrictive assumption (Doh and Connolly, 2012; Koop and Korobilis, 2010; Charleroy, 2013). In recent years it has been posited that the data generating process of economic variables has "drifting coefficients and shocks of stochastic volatility" (Nakajima, 2011). Pursuant to this notion, the hypothesis of this paper points to the potential time-varying impact of changes in monetary policy implementation. In the context of the SVAR used, regime shifts were identified based on the analysis of country-specific historical readings. A TVP-VAR model could potentially reduce the subjective nature of subsample selection, by combining the strengths of both the rolling regression and the traditional VAR model.

Second, even for VARs of moderate size, like the model utilised in Section 4.3.1, the number of parameters become quite large in relation to the observations, which translates to wider confidence regions (i.e. less precise estimates) for the impulse response functions (Eisenstat et al., 2013). This problem is exacerbated in the case of TVP-VAR models, which have high dimensionality due to the introduction of time variation in coefficients and/or volatility. Bayesian methods have been proposed to address concerns of "tractability and over-parameterisation in small samples" (Doh and Connolly, 2012). To this end, this paper employs a multivariate Bayesian time-varying parameter vector autoregression (TVP-VAR) model.

4.4.1 Methodology

The introduction of time variation in either the coefficients or volatility started in the late 1990s (Doh and Connolly, 2012). One of the first papers to incorporate time-varying coefficients into a VAR model, was that of Cogley and Sargent (2001), with the objective of defining the contours of the US inflation and unemployment dynamics over the post-war period. Their research was criticised by Sims (2001) and Stock (2001) for making the assumption of constant variance, while the data clearly indicates the presence of stochastic volatility. It was argued that the "variance of exogenous shocks may have changed over time; which motivates the inclusion of multivariate stochastic volatility to VAR models" (Koop and Korobilis, 2010). In response to these claims of model misspecification, Cogley and Sargent (2005) proceeded to include volatility in their time-varying coefficient model. This framework provided the platform for the hugely influential paper by Primiceri (2005).

The biggest contribution of Primiceri's (2005) paper was the fact that all parameters are allowed to vary over time, even the simultaneous relations of the structural shock. Several macroeconomic issues have been evaluated under this framework, as it captures the "time-varying nature of the underlying structure in the economy in a flexible and robust manner" (Nakajima, 2011). The major drawback to this method is that estimation is difficult, with the likelihood function becoming intractable (i.e. almost impossible to solve analytically). In response to this problem, Bayesian methods that utilise Markov Chain Monte Carlo (MCMC) and Gibbs sampling techniques are usually employed to derive posterior parameter estimates.

In order to comprehend the structure of the TVP-VAR it is easiest to start with the SVAR framework, as presented in Section 4.3.1. Following the work of Primiceri (2005) and Nakajima (2011), one can rewrite (5) as,

$$\mathbf{y}_t = X_t\boldsymbol{\beta} + A^{-1}\Sigma\epsilon_t, \tag{6}$$

where the rows of the B_is have been stacked to form $\boldsymbol{\beta}$ and $X_t = I_k \otimes (\mathbf{y}'_{t-1}, \ldots, \mathbf{y}'_{t-s})$. The coefficients and volatility in this SVAR are time-invariant, which means that there is no need to employ a state-space framework, as there are no state transition equations. All state variables are observed and the distinction between measurement and the state transition equation is superfluous. In order to extend this model to the TVP-VAR framework, where the various parameters may change over time, the specification would then utilise a state-space. Accordingly, the specification became a state-space representation of the VAR with time-varying coefficients and stochastic volatility:

$$\mathbf{y}_t = X_t\boldsymbol{\beta}_t + {A^{-1}}_t\Sigma_t\epsilon_t, \tag{7}$$

where the coefficients $\boldsymbol{\beta}_t$ and parameters A_t and Σ_t all become time-varying.[48] The variables and sample period used in the application of the TVP-VAR model are identical to those used in Section 4.3.1. Four lags were used in this VAR. There are several plausible ways to model the process of the time-varying parameters. Let $\mathbf{a}_t = (a_{21}, a_{31}, a_{32}, \ldots, a_{k,k-1})'$ be a stacked vector of lower triangular elements in the A_t matrix and $\mathbf{h}_t = (h_{1t}, \ldots, h_{kt})'$ with $h_{jt} = \log \sigma^2_{jt}$. Adopting the methodology of Primiceri (2005), the dynamics of the parameters in (7) are specified as

[48] Equation 5 is known as the measurement equation.

follows,

$$\boldsymbol{\beta}_{t+1} = \boldsymbol{\beta}_t + u_{\beta_t} \tag{8}$$
$$\mathbf{a}_{t+1} = \mathbf{a}_t + u_{a_t} \tag{9}$$
$$\mathbf{h}_{t+1} = \mathbf{h}_t + u_{h_t} \tag{10}$$

The elements of $\boldsymbol{\beta}_{t+1}$, the free elements of matrix A_t, and the standard deviations (σ_t), are assumed to evolve as random walks. A popular alternative to the random walk process is to select one of the more general autoregressive processes. However, the assumption of a random walk process enables the model to take permanent shifts into account, as opposed to the gradual nature of shifts associated with autoregressive processes. In addition, there are fewer parameters to be estimated under the random walk assumption. The distributional assumptions with regard to the parameters in (7) are illustrated in the following matrix:

$$\begin{pmatrix} \epsilon_t \\ u_{\beta_t} \\ u_{a_t} \\ u_{h_t} \end{pmatrix} \sim N \left(0, \begin{pmatrix} I & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_a & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix} \right)$$

for $t = s+1, \ldots, n$, where $\boldsymbol{\beta}_{s+1} \sim N(\mu_{\beta_0}, \sigma_{\beta_0})$, $\mathbf{a}_{s+1} \sim N(\mu_{a_0}, \sigma_{a_0})$ and $\mathbf{h}_{s+1} \sim N(\mu_{h_0}, \sigma_{h_0})$. I followed the convention of assuming that the variance-covariance structure for the innovations of the time-varying parameters (Σ_a, Σ_h) are diagonal matrices.

The TVP-VAR model relies on the implementation of Bayesian inference through MCMC methods, which means that priors will need to be specified. For the purpose of this study, an uninformative prior was assumed for the initial state: $\mu_{\beta_0} = \mu_{a_0} = \mu_{h_0} = 0$ and $\Sigma_{\beta_0} = \Sigma_{a_0} = \Sigma_{h_0} = 10 \times I$. This is equivalent to stating that no *a priori* information was available to the researcher.[49] A popular alternative is the training sample prior, used by Primiceri (2005), where parameters are set according to OLS estimates taken from a small presample of the data. The following priors were selected for the i-th diagonals of the covariance matrices:

$$(\Sigma_\beta)_i{}^{-2} \sim IW(25, 0.01I), \quad (\Sigma_a)_i{}^{-2} \sim \Gamma(4, 0.02), \quad (\Sigma_h)_i{}^{-2} \sim \Gamma(4, 0.02) \tag{11}$$

where IW and Γ are the inverse Wishart and Gamma distributions, respectively. An in-depth discussion on the estimation methodology is provided in Primiceri (2005) and Nakajima (2011). Gibbs sampling, a Bayesian estimation algorithm, was used to obtain the joint posterior distribution of parameters. This MCMC algorithm iteratively draws parameters and unobserved

[49]For a detailed discussion on prior selection in TVP-VAR models, refer to the monograph of Koop and Korobilis (2010).

states from lower dimensional conditional posteriors (drawing one parameter at a time while keeping other parameters constant). Computation of the posterior estimates was achieved through a draw of 10 000 samples, after the first 1000 burn-in draws were disposed of[50].

4.4.2 Results

The IRFs for the TVP-VAR are interpreted in a similar fashion to the rolling regression estimates. The three IRF lines in, for example, Figure 14, depict the first, second and fourth period impulse responses to a one standard deviation shock in non-borrowed reserves at different points in time. In other words, each point in time has three corresponding impulse responses. The reason for the selection of the first, second and fourth period ahead IRFs is that I was trying to capture the short-run effect of reserves on interest rates.

4.4.2.1 South Africa In contrast to the results shown for the rolling regression parameter estimates in Section 4.2 and somewhat similar to IRFs in Section 4.3.1, the IRFs for the TVP-VAR (at one, two and four periods ahead) indicate that there is a negative relationship between non-borrowed reserves and the banker's acceptance rate that deepens at each point in time with subsequent impulse responses. This relationship is stable throughout the sample and parameter volatility abates even further after adopting the inflation targeting regime in 1998. This relationship indicates a strong liquidity effect for the South African reserve regime. This result is in line with the traditional model of monetary policy implementation. It appears that the South African Reserve Bank does not insulate its interest rate from movements in reserves, which means that the decoupling or separation of monetary policy instruments is not plausible.

4.4.2.2 United States The narrative elicited from the SVAR for the United States in Section 4.3.1 was one of a waning liquidity effect over time. The results obtained from the TVP-VAR, from Figure 15, preserves this narrative and confirms the intuition that monetary policy implementation has undergone a significant metamorphosis. In particular, it is believed that a transition has been facilitated by the changing of the guard at the Federal Reserve. Looking at Figure 15, which delineates the different eras of the Federal Reserve chairpersons since the Second World War, one observes a clear deterioration of the liquidity effect corresponding to the changeover of incumbents. The most distinct change in the liquidity effect occurs with the induction of Volcker as chairman; with a clear upward trajectory originating in the late 1970's

[50] Computational results are achieved in MATLAB R2014a using the TVP-VAR code provided by Jouchi Nakajima at https://sites.google.com/site/jnakajimaweb/tvpvar.

in all three IRFs. This corresponds to the literature on the liquidity effect, with researchers finding it particularly difficult to identify this effect as time progresses.

4.4.2.3 Canada The Bank of Canada appears to be quite adept at insulating its interest rate from movements in excess reserves. This sentiment rings true for the entire sample, but is most palpable after the adoption of the inflation targeting regime. The post inflation targeting sample reflects a lower volatility of the IRFs, as well as movement on both sides of the horizontal axis. This pattern is similar to the one observed in the rolling regression from Section 4.2. It is therefore plausible that there is a decoupling of balance sheet movements from interest rate policy in Canada.

4.4.2.4 Norway The final case to consider is that of Norway. One would expect that with the floor regime enacted by the Norges Bank since 1992, there would be a distinct separation of the movements in liquidity and overnight interest. This is not exactly the case, and perhaps requires a more detailed investigation as to why. Consider the TVP-VAR IRFs from Figure 17, with particular interest paid to the post-1990 period. The precipitous dip in the period from 1990 to 1995 could be attributed, in part, to the European Monetary system crisis of the early 1990s. During this period commercial banks were stockpiling liquidity in the expectation of liquidity drying up in the interbank market. In addition, the Norges Bank reduced the interest rate to bolster economic growth.

The combination of these events has produced a liquidity effect, which is potentially spurious considering that the overnight interest rate movement was not necessarily driven by the demand for reserves, but rather was a policy response to the economic environment. It is entirely possible that some deviation in the overnight rate was caused by the liquidity hoarding, but the magnitude of the effect would be difficult (if not impossible) to identify. The only thing that is certain in this case is that the magnitude of the effect is exaggerated in Figure 17. After this period the relationship rapidly moves toward zero, becomes positive, and then turns negative again. Identifying a clear narrative here is difficult.

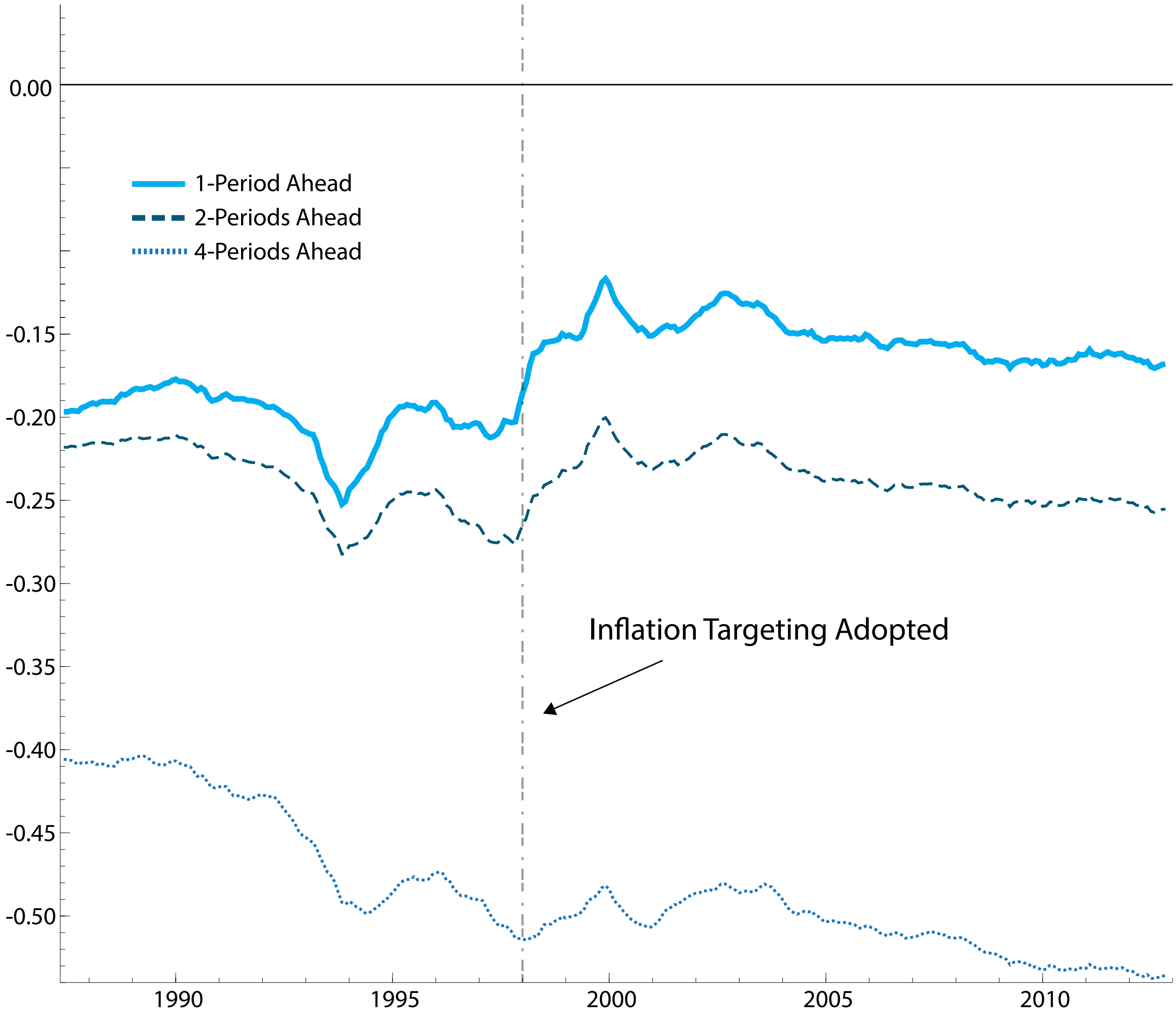


Figure 14: Impulse response functions from TVP-VAR for South Africa

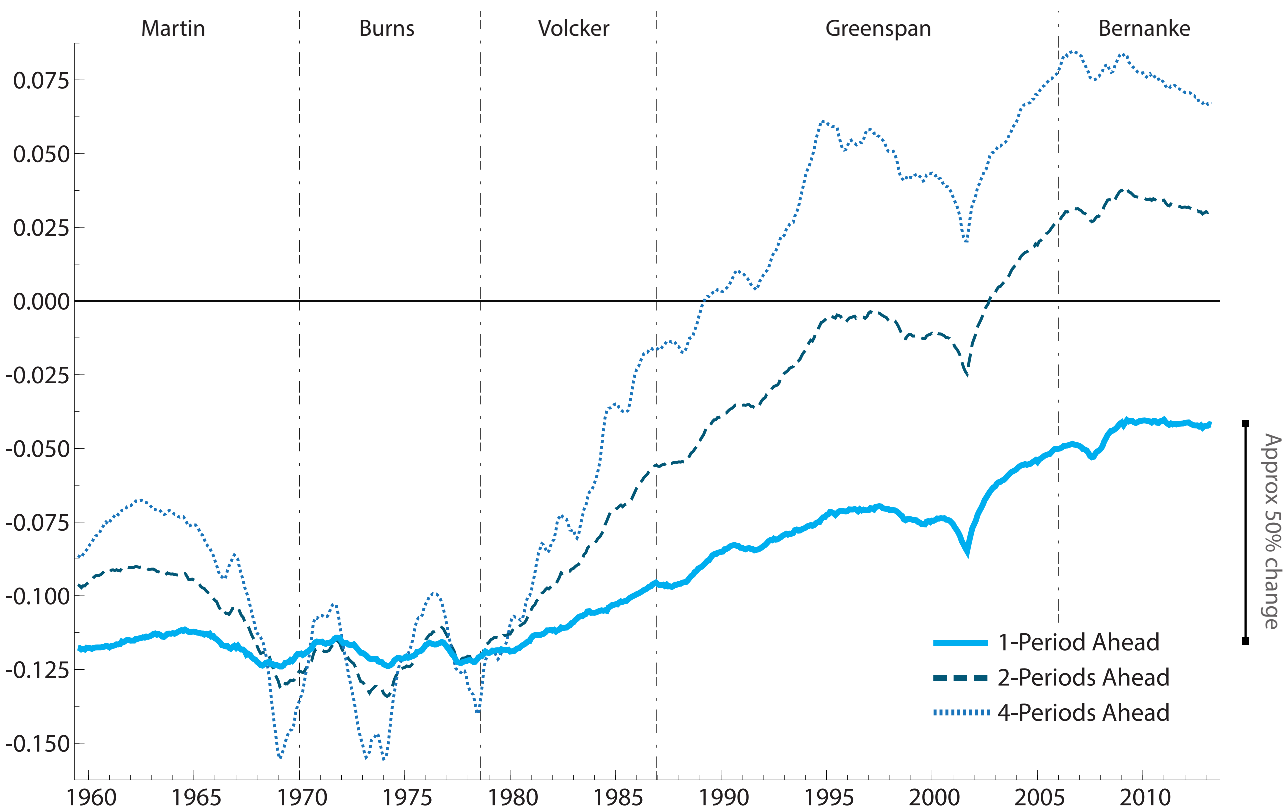


Figure 15: Impulse response functions from TVP-VAR for USA

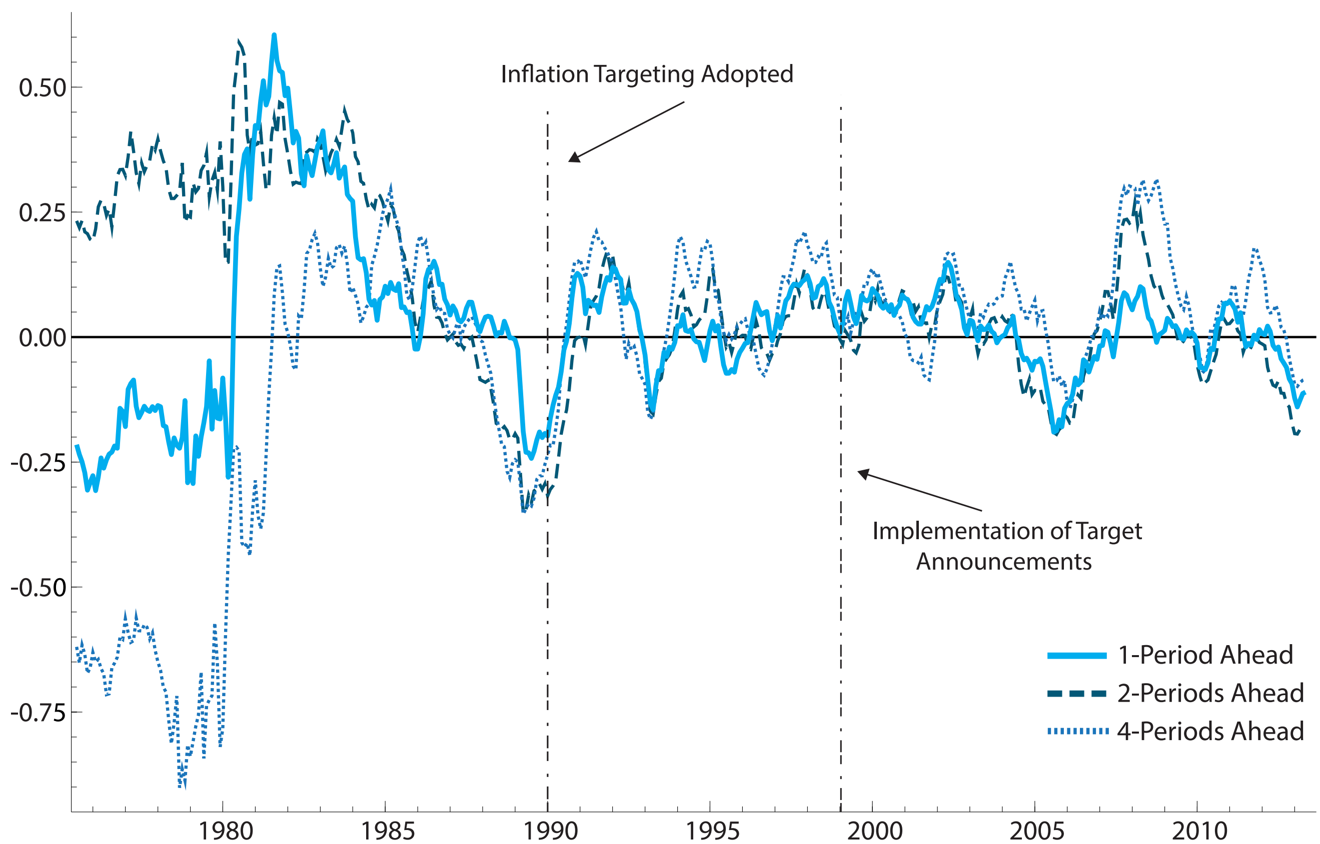


Figure 16: Impulse response functions from TVP-VAR for Canada

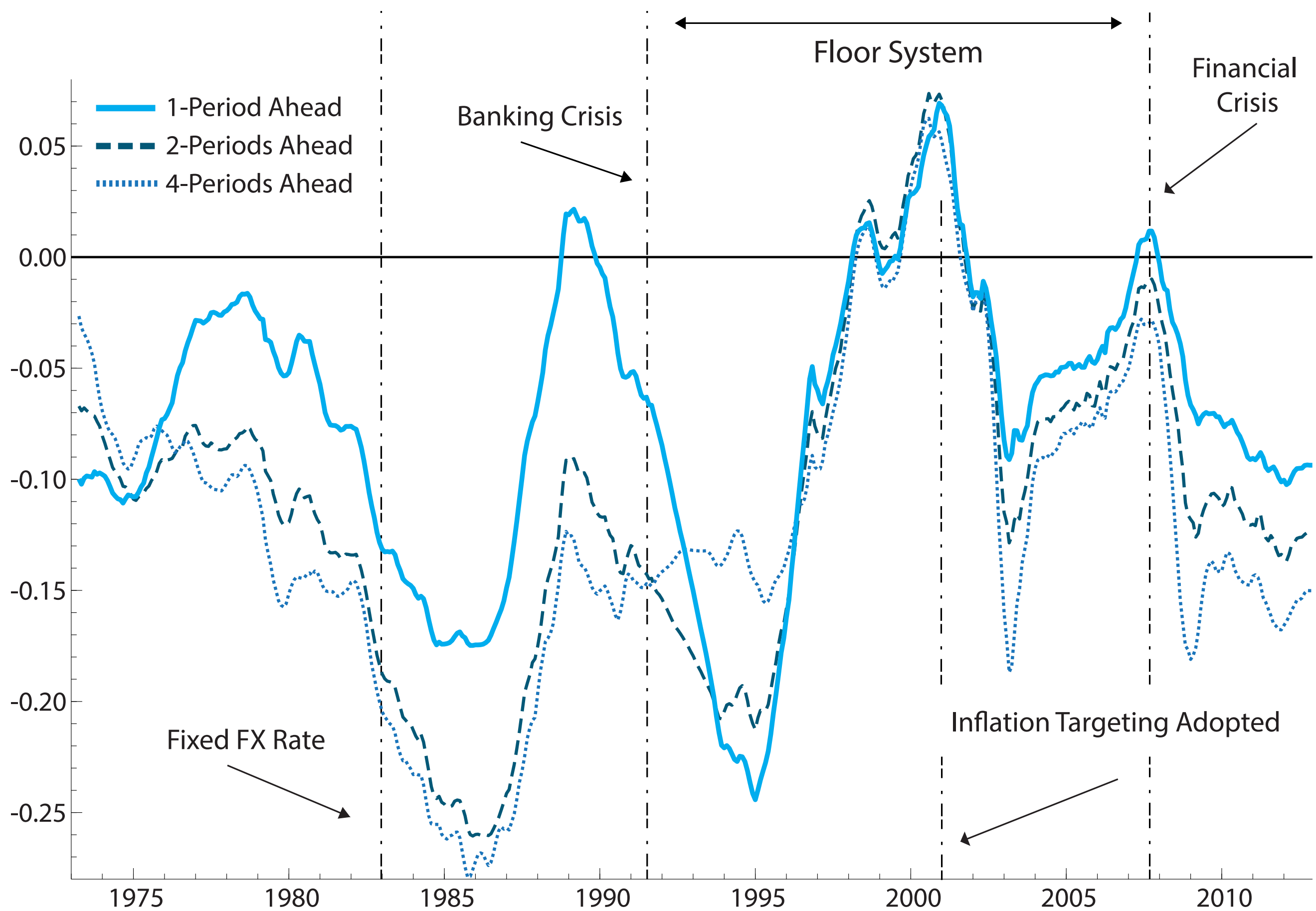


Figure 17: Impulse response functions from TVP-VAR for Norway

5 Conclusion

The hypothesis of the paper is that no clear and stable link exists between liquidity and interest rates, so that various levels of reserves can exist for a given interest rate. One can gather from the VAR results that the relationship between money market interest rates and the various reserve concepts used changes significantly with the sample used. This result is corroborated by the rolling regression and TVP-VAR results for the USA, Canada and Norway.

The most patent proof of decoupling was observed in the USA and Canada. One would expect Norway to show signs of decoupling because of their floor system; however, there is evidence to suggest a small liquidity effect exists. The result is surprising, but the negative relationship recorded could be due to several factors, in particular, it could reflect a combination of the expansionary stance of the Norges Bank and the liquidity-seeking behaviour of banks during a credit crunch. In the case of our reserve regime, South Africa, the results seem to indicate that a liquidly effect is plausible. It would be wrong to claim that the decoupling principle was in full force. This means that the South African market for reserves is not insulated fully from movements in the short-term interest rate and vice versa.

A tentative conclusion is that the decoupling principle exists for countries that do not employ a reserve regime. The implication for monetary policy is that central banks might be able to use their balance sheets independently from their interest rate instrument, providing an additional dimension to monetary policy conduct. This policy option is not recommended as such, but the result is significant in the wake of the events of the financial crisis of 2007. Central banks could potentially use their balance sheets to combat financial instability while retaining their key policy rate as a tool with which to combat inflation.

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