# Central Bank Credibility and Reputation:
# An Historical and Quantitative Exploration

Michael D. Bordo, Rutgers University and NBER

Pierre L. Siklos, Wilfrid Laurier University and Viessmann European Research Centre[1]

[This Draft December 2013]

*Not to be quoted or cited without permission*

[1] Prepared for the 2014 Norges Bank Conference "Of the Uses of Central Banks: Lessons from History", Oslo, Norway. The second author thanks CIGI-INET for financial support in the form of a research grant. Samantha St. Amand provided excellent research assistance. An early version of this paper was presented as a keynote presentation at the 7th Conference of the South-Eastern European Monetary History Network, Bank of Albania, the Norges Bank 2016 pre-conference at the Graduate Institute in Geneva, and the 7th World Congress of the Cliometrics Society. Comments by Eugene White on an earlier draft are gratefully acknowledged. Results not presented are relegated to an Appendix.

**ABSTRACT**

In this paper we generate measures of central bank credibility. To the extent we are able to apply reliable institutional information we can also indirectly assess their role in influencing the credibility of the monetary authority. We focus on measures of inflation expectations, the mean reversion properties of inflation, term structure and quality spreads, and indicators of exchange rate risk. In addition we will place some emphasis on whether credibility is particularly vulnerable during financial crises, whether its evolution is a function of the severity of the crisis or its kind (i.e., currency, banking, sovereign debt crises). We find credibility changes over time are frequent and can be significant. Nevertheless, no robust empirical connection between the size of an economic shock (e.g., the Great Depression) and loss of credibility is found. Second, the frequency with which the world economy experiences economic and financial crises, institutional factors (i.e., the quality of governance) plays an important role in preventing a loss of credibility. Third, credibility shocks can be transmitted across countries but their impact is dependent on the type of monetary policy regime in place. Finally, credibility is most affected by whether the shock can be associated with policy errors.

M.D. Bordo, Rutgers University and NBER
P.L. Siklos, Wilfrid Laurier University and Viessmann European Research Centre

Keywords: monetary policy credibility, interest rate targeting, money growth targeting, non-linearity and asymmetry in monetary policy, central banking institution

JEL Classification Codes: E58, E31, N10, C32, C36

## 1. Introduction

Central Bank credibility is defined as a commitment to follow well articulated and transparent rules and policy goals. More precisely, credibility refers to the "…extent to which the public believes that a shift in policy has taken place when, indeed, such a shift has actually occurred"(Cukierman 1986, p.6). More generally, Brunner (1983) makes the connection between credibility and the performance of the institutions mandated to carry out policies: "Credibility depends…on the history of policy making and the behavior of the policy institution." In the case of a central bank policies have typically focused on their ability to control inflation. The concept then is best thought of as a flow like variable that changes as observed inflation is seen to deviate from a time-varying inflation objective, which need not be explicit or publicly announced, and partially determined by the relative importance the central bank attaches to real and nominal economic objectives. Regular economic shocks and the manner in which the central bank manipulates monetary policy instruments dictate how credibility evolves over time.

A central bank's credibility clearly also impacts its reputation. Reputation can be likened to a stock variable rising and falling over time as monetary policy strategies change. As with credibility, reputation is subject to the evolving nature of central bank-government relations, political factors and the personalities responsible for the implementation of monetary policy. The reputation of a central bank can be built up over time as its performance improves or it can be diminished for a variety of reasons. These include a financial crisis, a serious crisis of confidence in the governor, or a political conflict between the monetary authority and the government.

Credibility, or an institution's reputation, evolve possibly in a non-linear manner, that is, earned slowly and painstakingly yet susceptible to evaporate on a moment's notice. In the words of Benjamin Franklin "It takes many good deeds to build a good reputation, and only one bad one to lose it."[2] Identifying and measuring credibility is challenging. Nevertheless, as Cukierman (1986, p.5) again points out, "…the ability of monetary

[2] Experimental evidence (e.g., List 2006) suggests that reputation and the monitoring of quality are complements. Our definition of credibility is, in effect, a quality assessment exercise, and reputation, that is, the ability of a central bank to deliver the promised monetary policy outcome over time, seems consistent with the stock-flow distinction made above.

policymakers to achieve their future objectives depends on the inflationary expectations of the public. These inflationary expectations depend, in turn, on the public's evaluation of the credibility of the monetary policy makers…" Paul Volcker, former Chair of the U.S. Federal Reserve's Open Market Committee (FOMC), once underscored the point that "[T]o break the inflation cycle we must have credible and disciplined monetary policy" (Bernanke 2013, p. 35). Indeed, Volcker went on to remark that "…inflation undermines trust in government." (Silber 2012, p. 266). Therefore, autonomy, transparency, accountability, and the monetary policy strategy in place influence both the credibility and reputation of the monetary authority.

Not everyone shares the view that credibility is a sought after objective of central banks. Romer (2013, p. 109), for example, claims: "There is remarkably little evidence that credibility in monetary policy making buys one much when it comes to lowering the costs of disinflation." Ball (1994), and Ball and Sheridan (2005), are similarly skeptical. Notice, however, that Romer's criticism relates to views about the costs of lowering inflation and this is also highly dependent not only on how expectations are formed but on the constraints faced by the monetary authorities. Ball and Sheridan's (2005) analysis is selective and appears to be overwhelmed by contrary evidence on the success of regimes such as inflation targeting. Mishkin (2005) reviews the arguments against a role for credibility and finds them wanting.

In this paper we back up our interpretation of central bank behavior with measures of credibility. To the extent that we are able to apply reliable institutional information we can also indirectly assess their role in influencing the credibility of the monetary authority. We focus on measures of inflation expectations, the mean reversion properties of inflation, term structure and quality spreads, and indicators of exchange rate risk. In addition we will place some emphasis on whether credibility is particularly vulnerable during financial crises, whether its evolution is a function of the severity of the crisis or its kind (i.e., currency, banking, sovereign debt crises). Crises, especially of the financial variety, play a role in influencing the ability of a central bank to maintain price stability. As Carney (2013), former Governor of the Bank of Canada, points out: "Financial imbalances ultimately breed crises, and crises threaten price stability." Similarly, we ask: do recoveries signal a return to credibility? Is credibility linked to the strength of improvements in macroeconomic conditions? Is credibility in monetary policy also affected by fiscal policy or does a central bank's reputation instead suffer a precipitous drop if fiscal policy is seen as unsustainable or incompatible with stable monetary conditions?

Clearly, credibility will also be influenced not only by how observed inflation behaves over time but, by implication, by how expectations of inflation are formed. As argued above, expectations formation lies at the core of any definition of credibility. Yet, Eggertsson and Woodford (2003) point out that: "…the power of the expectations channel of monetary policy is highly sensitive to the precise manner in which expectations are formed…"

Figure 1 is intended to illustrate not only the connection between credibility and reputation of central banks but also some of the difficulties one faces when attempting to quantify these concepts. Central banks can, at least for our purposes, be thought of as institutions responsible for price stability and economic stabilization which, for simplicity, we will refer to as monetary stability, as well as having possibly a role in ensuring financial stability. The complication arises when one attempts to understand how these twin responsibilities are, institutionally, linked to each other.

Using Venn diagrams we can imagine three types of central banks, keeping in mind that over time, central banks can evolve from one type to another. The top diagram illustrates the case where monetary and financial stability are separate. The separation can be formal, as in the case of the European Central Bank, or the Bank of England prior to the recent global financial crisis, or informal as when central banks choose to focus on one activity at the expense of the other. Reinhart and Rogoff (2013) posit that the U.S. Federal Reserve is a case in point. Ostensibly, the Fed was created to manage financial stability but was led to focus on monetary stability after World War II.

Next, we have central banks where there is clear recognition that the twin responsibilities of the central bank overlap. One can imagine that the size of the overlap is a function of the institution's de facto willingness or reticence to adopt a lender of last resort role or to rely on some instrument of policy directly aimed at the financial stability function versus the monetary stability function. Arguably, most central banks were of this variety, at least until 2007 or so. Finally, the bottom diagram views monetary and financial stability as central banking functions that are integral to each other. The size of each function is determined by the emphasis placed on one form of stability vis-à-vis the other.

Consequently, the mandate of the central bank, its autonomy with respect to the government, the governance of the institution, to name but three important determinants, provide clues about where a particular central bank will fit in the simplified schematic shown in Figure 1.

Finally, the type of central bank will also dictate which instruments are at its disposal and how many are likely to be deployed at any given time. Presumably, central banks where monetary and financial stability are both integral to the conduct of policy rely on more instruments than a monetary authority where stabilization policies are effectively divorced from financial stability concerns. Therefore, except possibly for the first type of central bank and even if credibility can be narrowly defined as determined by inflation performance relative to some goal, the credibility and reputation of the central bank will be dictated by a more complex set of factors which, for brevity, we will refer to as institutionally driven.

In an historical study it is unclear how we should define the benchmark against which inflation deviates from some expected value. Accordingly, we consider a number of approaches. For example, we apply statistical break tests to determine breaks in the inflation rate. This permits us to evaluate one indicator of deviations of realized inflation from some expectation, namely deviations from a statistically estimated trend inflation rate. Alternatively, we can specify a time series model to estimate expected inflation. Models based on a New Keynesian type Phillips curve work well over long periods of time and, subject to 'breaks', can also serve as a useful benchmark.

Yet another strategy consists in comparing monetary policy performance against examples when, with the hindsight of history, policies are thought to have been delivered credibly and the reputation of the central bank was considered to be stellar. Historical examples from Germany or Switzerland, the US during the Great Moderation from approximately 1986 to 2007, or the period since certain central banks adopted and maintained numerical inflation targets beginning in the mid 1990s, readily come to mind. The implication then is that an evaluation of central bank credibility and reputation is enhanced by narratives of central bank actions through time.

Next, we ask how the hypothesized credibility indicator reacts to the past history of inflation, various proxies for economic growth performance, or the output gap, the stage and shape of particular business cycle events (i.e., recessions versus recoveries, their size and shape; see, for example, Bordo and Haubrich 2010) as well as other variables such as wars, financial crises and financial market conditions. We also aim to empirically establish whether credibility behaves asymmetrically over time. Finally, a neglected aspect of the historical analysis of central bank credibility and reputation is how these can be transmitted across countries. Certain policy regimes (e.g., a pegged exchange rate) have long been known to 'import' inflation performance from abroad.

An historical perspective also enables us to deal with another under-emphasized element of central bank performance, namely whether deflationary periods, or the threat of deflation, also influences credibility and central bank reputation. Burdekin and Siklos (2004a) have shown, based on a cross-section of countries covering a long span of time, that macroeconomic shocks are strikingly different between inflationary and deflationary samples. We can also draw upon the rich examples of the consequences of deflation covered by several other authors (e.g., also see Burdekin and Siklos 2004). The upshot is that there is potentially an asymmetry that could further contribute to introducing non-linearity in the behavior of central bank reputation over time.

The rest of the paper is organized as follows. In the following section, we provide some theoretical underpinnings for the proposed empirical exercise aimed at evaluating how central bank credibility and reputation have evolved over time. Next, we provide a brief description of the data and discuss a few methodological considerations. Section 4 discusses our main findings. Section 5 concludes.

Briefly, we find credibility changes over time are frequent and can be sizeable. Nevertheless, no robust empirical connection between the size of an economic shock (e.g., the Great Depression) and loss of credibility is found. Second, when credibility seriously impairs a central bank's reputation the resulting loss of reputation is difficult to restore and can take several years to recover. As a result, and given the frequency with which the world economy experiences economic and financial crises, institutional factors (i.e., the quality of governance) can play an important role in mitigating reputational loss. Third, credibility shocks can be transmitted across countries but their impact is dependent on the type of monetary policy regime in place. Finally, credibility is most affected by whether the shock can be associated with policy errors. Bernanke (2013, p. 23), for example, has acknowledged that such errors can, for example, an important role in explaining the severity of the most recent 'global' financial crisis.

## 2. Credibility and Reputation Through the Ages

The history of central bank credibility is tied up with the history of policy regimes. Consider, for example, the classical gold standard as a rule based on the commitment to maintain the official peg. Central banks (independent of the fiscal authorities) in many of the advanced countries of Europe adhered to this rule from 1880 to 1914. According to the rule temporary suspension was allowed during a wartime emergency or a serious financial crisis. In such situations central banks issued paper money to help finance the government's fiscal deficit. Once the emergency ended the central bank was required to restore convertibility to gold at the prewar official parity. If it did this it would ensure its credibility and allow it to use its seigniorage to finance a future war (Bordo and Kydland 1995). Credible adherence to the gold standard rule allowed central banks to have some leeway to conduct stabilization policies within the gold points (Bordo and MacDonald 2012). It also insured that it could conduct lender of last resort actions without engendering capital flight (Eichengreen 1997). The history of the pre 1914 gold standard shows how some countries, especially Britain, France and Germany, had credible regimes. Many other countries tried to gain it but were less successful (Bordo and Schwartz 1996).

Not everyone supports the view that rules implicit in regimes of the gold standard variety can generate credibility. Ferguson and Schularik (2008) suggest that in peripheral (i.e., less developed) economies there was no credibility bonus in adhering to a policy rule of the gold standard variety. Nevertheless, this view downplays the fact that credibility and reputation are inter-connected. Hence, even if the peripheral countries intended to generate credibility, theirs is an attempt to operate under rules governed by weak central banking institutions.

World War I ended the classical gold standard and, after the war, many countries tried to rebuild the prewar system. Restoring the prewar parity after massive wartime inflation and changes in the political economy (suffrage) delayed the restoration of the gold standard and the standard that was established – the fragile gold exchange standard – had less credibility. Britain returned to gold at the prewar parity in 1925 but at an overvalued rate which continually threatened its adherence. The U.S. never left gold but the newly established Federal Reserve went through a lengthy learning period to become a fully functioning member of the central bank club (Meltzer 2001). France went through a period of high inflation and its central bank lost much of its credibility in scandal. Germany went through a hyperinflation fueled by the Reichsbank. By 1926 the gold exchange standard was up and running and its short-lived success depended upon the sterling reputations of Benjamin Strong, Montagu Norman, Emile Moreau and Hjalmar Schacht. Despite their efforts the system collapsed during the Great Depression. In its aftermath central bankers were blamed for the Depression and central banks lost their independence and became virtual appendages of the fiscal authorities. Academics still debate not only if too much authority was invested in central banks but whether a series of policy mistakes by governments, and other public institutions, combined to create the perfect storm resulting in the greatest economic slump of the 20th century (e.g., Ahamed 2009, Meltzer 2010).

While the rules versus discretion debate concerning the conduct of monetary policy has a long history, and is likely to dominate discussions of central bank credibility and reputation, the institutional approach evaluates performance through the prism of the mandate of the central bank. Indeed, evaluations of central bank performance according to how autonomous and accountable they are, continues to pre-occupy academics and policy makers. While there exists a fairly broad consensus that central bank independence and accountability are essential ingredients in maintaining credibility and reputation (e.g., see Waller 2011), it is equally clear that there are serious reservations about our ability to objectively make the link between central bank mandates and inflation performance or the success of a particular monetary policy regime (e.g., see Parkin 2012, Cargill 2013). Matters become still more complicated when attempts are made to link central bank mandates with inflation prior to the 1950s (e.g., Dehay and Levy 2000).[3]

Regardless of one's view about the importance of central bank autonomy in explaining monetary policy performance the result has been that central banks have become far more talkative and are placing an increasing premium on their ability to communicate with the public. In this regard we can trace the origins of this phase in the evolution of central banks

[3] Interestingly, Japan (low inflation and, until the 1990s, not an autonomous central bank) poses a problem for institutional hypotheses of central bank performance in more recent times, and also appears to be atypical of the central bank independence – low inflation nexus in the interwar era.

to the late 1950s when, then Governor of the Bank of Canada, James Coyne, was the target of heavy criticism, in both the press as well as from government officials, for speaking out in public on matters beyond the usual remit of monetary policy. Not only did Coyne view speeches and other reports published by the Bank of Canada as devices to explain monetary policy to the public but as a tool to protect the central bank's credibility and reputation (Siklos 2010, and Powell 2009). This sentiment would be echoed a little later by Karl Blessing, President of the Bundesbank from 1958 to 1969, who argued: "A central bank which never fights, which at times of economic tension never raises its voice…that central bank will be viewed with mistrust." (Marsh 1992, pp. 256-57) Therefore, whereas central banks were hampered by their unwillingness or inability to express their views or influence expectations via public pronouncements, the spread of transparency especially since the late 1990s has changed rather dramatically (e.g., see Siklos 2002, Dincer and Eichengreen 2007). Central banks are no longer shy about discussing matters beyond purely monetary policy questions.

In the 1950s, the Federal Reserve gained its independence and began following gold standard orthodoxy dedicated to price stability. Few other central banks, with the exception of the Bundesbank, the Swiss National Bank (SNB) and the Bank of Canada (BoC), followed suit. In Canada, policy makers suspended their participation in the Bretton Woods system for much of the 1950s. This allowed the BoC to regain its monetary independence although Canada's economic fortunes were increasingly linked to economic developments faced by its largest trading partner, the U.S. A crisis dented the reputation of the BoC in the late 1950s but it would be restored following important institutional reforms and with the return to the Bretton Woods fold (Siklos 2010). The theme linking independence to credibility and the role of the policy regime in dictating central bank behavior is a recurring one throughout the 20th century (Siklos 2002).

In the U.S. the return to monetary orthodoxy rested on the reputation of William McChesney Martin after the 1951 Fed-Treasury Accord restored the Fed's independence to conduct monetary policy. The regained central bank credibility was, however, short lived. In the 1960s central banks (with the exception of the Bundesbank and the SNB) began following Keynesian policies to maintain full employment at the expense of higher inflation. The subsequent Great Inflation destroyed any vestiges of credibility as well as the reputations of central bankers such as Arthur Burns (Bordo and Orphanides 2013). Paul Volcker's adoption of a monetarist style tight monetary policy in 1979 broke the back of inflationary expectations at the expense of a deep recession in the U.S. Previously, inflation had drifted upward in a seemingly permanent fashion (e.g., see Goodfriend and King 2013, and De Long 10997) and it appears that only a form of 'shock therapy' could restore lower long-run inflationary expectations (e.g., see Levin and Taylor 2013).

Similar strategies were followed in Canada, the UK, Japan and other countries so that by the mid 1980s the Great Moderation restored price stability in the advanced countries along with the reputations of central bankers. However, in all of these instances, credibility did not exist at first. It had to be earned at an economic price over time. Indeed, the lower the credibility of policies, the more adverse the economic costs are. This relationship has been understood for some time (e.g., Fellner 1976, Haberler 1980). The commitment to rules focused on low inflation helped to restore central bank credibility (e.g., see Levin and Taylor 2013 and Goodfriend 1986). What helped these central banks to succeed was that new policies were built on the reputation of their institutions. In Germany, the Bundesbank (DBB) gained credibility and a sterling reputation in the postwar period. The DBB was founded in 1948 with the express mandate to pursue price stability. This mandate was a reaction to the disastrous experience of its predecessor, the Reichsbank, in generating a hyperinflation in the 1920s.

Canada, like the US example under Volcker, offers another example of the trade-off between credibility and the costs of reducing inflation, often referred to as the sacrifice ratio. Following years of inflation rates that were persistently higher than those in the US, the Canadian government, in cooperation with the Bank of Canada, adopted inflation targeting. In spite of the joint declaration to aim for low and stable inflation the recession of the early 1990s was among the sharpest in Canadian history (e.g., see Cross and Bergevin 2012). It led some to suggest that Canada, as a result of the tight monetary policy that helped influence inflationary expectations delivered a "Great Canadian Slump" (Fortin 1996). The Bank of Canada replied that supply side factors played a much greater role than critics of monetary policy allowed (Freedman and Macklem 1998). The Canadian example also highlights a recurring theme, namely the difficulty of identifying the proximate source of economic downturns, particularly severe ones, and the extent to which central banks ought to have anticipated these and calibrated their policies to mitigate the costs of a transition in adopting a new policy regime.[4]

In Germany the DBB gained credibility and a sterling reputation in the postwar period. In the next 50 years the DBB had the best track record of any advanced country in maintaining low inflation (Beyer et al 2013). Indeed during the Great Inflation, core inflation in West Germany increased only a fraction of that of the US and UK. Unlike central banks in other advanced country, the DBB did not accommodate the oil price shocks of the 1970s. This record of credible adherence to low inflation gave the DBB a very strong reputation which the ECB, founded in 1999, tried to emulate. The Swiss National Bank also followed a policy like Germany's from its origin in 1907 and had one of the best inflation fighting track records of any central bank in the twentieth century (Bordo and James 2007).

The fact that central banks, mainly in Anglo-Saxon countries, appear to attach relatively more weight to the statutory relationship between central banks and governments suggests that certain cultural factors might also be in play (e.g., Eijffinger and De Haan 1996, La Porta, Lopez-de-Silanes, and Schleifer 2008). Moreover, if cultural factors also impact business cycles, at least in some parts of the world (e.g., see Altug and Canova 2013), then there exists another avenue through which the central bank's credibility and reputation can be altered.

The series of financial crises that have, since 2007, gripped the advanced economies especially led to massive discretionary intervention in financial markets by central banks around the world. Many of the actions mixed monetary with fiscal policy and appeared to violate central bank independence. The changes in the legislative and regulatory landscape that followed have expanded the role of central banks. Time will tell if their credibility to maintain low inflation will survive. However, unlike earlier episodes in the monetary history of the last century or so, it is the fear of deflation and depression that has fueled central banks' responses. It is, therefore, worth contemplating whether the ability of central banks to ease policies by historically unheard of amounts, without signs that inflation expectations are becoming unanchored, is a sign of the triumph of central bank credibility and the strength of their reputation.

[4] The adoption of inflation targeting was spurred by the record of monetary policy in the 1970s and 1980s. See Crow (2002) for a first-hand account by the Bank of Canada Governor at the time.

Has the industrial world, in particular, adopted a 'culture of stability' that seemingly explains Germany's and Switzerland's success in avoiding the Great Inflation of the 1970s and 1980s? (e.g., see Beyer et. al. 2013). As Bernanke (2013, p. 63) notes: "People get used to what they see." And the industrial world has experienced low and stable inflation rates for approximately two decades. The implication of Bernanke's comment is that low and stable observed inflation rates give meaning to the concept of price stability which, as former Fed Chairman Alan Greenspan (1996, p. 1) remarks: "…obtains when economic agents not longer take account of the prospective changes in the general price level in their economic decision-making."

Alternatively, central bank reputation may have suffered because, based on expectations about what central banks can and cannot do, the public does not believe the current policy is compatible with the reliance on numerical objectives for evaluating the performance of monetary policy. It may be that inflation expectations are no longer a sufficient guide of policy credibility. By the same token, changes in the responsibilities central banks are faced with also raise questions about the reputation of these institutions and whether they have become overburdened with responsibilities that are bound to conflict with each other (e.g., see Siklos 2014).

## 3. Measuring Credibility

### *3.1 The Taylor Rule, Credibility, and Policy Regimes*

Since Taylor's (1993) celebrated article many discussions about policy rules revolve around an expression of the following kind:

$$i_t = \overline{\rho} + \overline{\pi} + \alpha_2 \tilde{\pi}_t + \alpha_3 \tilde{y}_t + \varepsilon_{i,t} \quad (1.1)$$

where $i_t$ is the central bank's policy rate, $\overline{\rho}$ is the natural real interest rate, $\tilde{\pi}_t$ is an indicator of the inflation gap, $\tilde{y}_t$ is the output gap. The inflation gap can either be the difference between realized and expected or forecasted inflation, or represented by some deviation from an explicit inflation objective, as would be applicable for several central banks that adopted inflation targeting beginning in the early 1990s. In Taylor's original formulation, $\overline{\rho}$ is set at 2%, as is the inflation objective, while $\alpha_2, \alpha_3$ were each calibrated to equal ½.

Since that time many central banks have adopted a 2% inflation objective, generally for the medium-term (e.g., 2 to 3 year horizon). In the event that an explicit numerical objective is unavailable a model-based estimate of the central bank's implicit inflation objective can be used to generate $\tilde{\pi}$.

Not surprisingly, since the Taylor rule was proposed, several variations have been calibrated and estimated. Nevertheless, many questions have been raised about specifications such as (1.1). The output gap, $\tilde{y}_t$, defined as deviations of observed real GDP ($y_t$) from potential output ($y_t^*$), is likely unobserved given lags in obtaining economy-wide output data (i.e., real GDP). Consequently, many empirical applications resort to $\tilde{y}_{t-1}$ instead of relying on the contemporaneous output gap.[5] Also, note that (1.1) assumes that $\rho + \bar{\pi}$ is time-invariant. Of course, if inflation drifts over time, as was the case during the Great Inflation of the 1970s and 1980s (e.g., see Goodfriend and King 2013), then the intercept of the Taylor rule would also change over time with consequences for both the central bank's credibility and its reputation.

Arguably, a big challenge with equation (1.1) is to estimate potential or trend output. Several techniques are available. While the Hodrick-Prescott filter is probably the most widely used method there is no agreement on which method is best (e.g., see Dupasquier, Guay, and St-Amant 1999, van Norden and Orphanides 2002, and Mishkin 2007).[6]

If the hallmark of good policy making involves setting today's policy instrument in a forward-looking manner then it is preferable to replace $\tilde{\pi}_t$ and $\tilde{y}_{t-1}$ with their expected values (e.g., $E_t\tilde{\pi}_{t+1}, E_t\tilde{y}_{t+1}$), whether these are model generated or rely on published forecasts. Even if central banks are deemed to be largely forward-looking there is the matter of what horizon is appropriate. Most observers have settled on a one or two year-ahead horizon although policy actions might have an impact on the economy beyond one year. Even under these circumstances Woodford (2003) demonstrates that some history

[5] Alternatively, one can replace the output gap with an unemployment rate gap. There is the additional difficulty, in this connection, stemming from the fact that central banks may not make policy decisions on a monthly or quarterly basis for which time series are typically generated. The U.S. Federal Reserve, for one, renders decisions 8 times a year.

[6] Borio (2013) argues in favor of an output gap concept that incorporates financial asset prices. With few exceptions, however, such data are not available for a long span of time nor is it immediately clear whether financial assets were important prior to, say, the 1980s in influencing the output gap. Likely, a more significant influence on changes in potential output are recessions. Also, see Haltmaier (2012).

dependence is required to implement policy in a stable fashion. As a result, central banks generally do not always adjust their policy instrument according to equation (1.1). Instead, policy rate changes may be 'smoothed' over time. One way to introduce this feature into the reaction function is by adding a lagged dependent variable (i.e., $i_{t-1}$).[7] Another limitation of Taylor's original formulation, and many of its variants, stems from the role of the policy rate at or near the zero lower bound (ZLB). For example, simulations by Chung et al. (2012) reveal that very low inflation objectives (viz., below 2%) frequently lead to the ZLB being reached. Consequently, either the central bank reacts more aggressively to the output gap when the policy rate is low or it reduces the policy rate to zero more quickly than any standard Taylor rule might recommend.

While it is generally believed that announcing an inflation objective translates into better inflation performance, there is no consensus on whether this requires an explicit inflation target, the mere announcement of an inflation objective, or some other rule-like behavior that translates into lower and more stable inflation (e.g., central bank independence). It is not an exaggeration to state that central banks through the decades have followed some type of 'rule', explicit or not, since most central banks have always been created, among other reasons, to maintain some form of price stability, in addition to performing other tasks (e.g., an exchange rate, economic activity or employment objective, banker for the State, supervisory tasks, supporting the economic policies of government, to name a few). Also, the instruments of policy used by a large number of central banks around the world have ranged over the decades from influencing interest rates, liquidity enhancing and credit easing measures, setting objectives for the exchange rate and money growth, to influencing the price of gold. The fact that one resorts to a post 1990s framework to examine central bank performance in previous decades simply means that allowances should be made for deviations from such rules. They do not, however, invalidate their use. After all, Taylor (1993, 1998) demonstrated the usefulness of his rule for the Fed using historical data for a period when few would have characterized monetary policy as acting in a rule-like manner. While it is true that focus on Taylor rules masks the

[7] Rudebusch (2006) casts doubts on the interest rate smoothing hypothesis because interest rate changes are unpredictable, among other reasons. In contrast, Goodhart (1999) posits several plausible reasons for interest rate smoothing phenomenon, including the unwillingness of central banks to be seen as frequently enacting policy reversals. Also, see Sack and Wieland (2000), and Rudebusch (2002).

fact that central banks over time have deployed different policy instruments, the formulations we develop below do not ignore other factors, such as money (or credit) aggregates in potentially influencing financial conditions.[8]

Kozicki and Tinsley (2009) explicitly demonstrate that a formulation such as (1.1) is consistent with a several policy strategies.[9] Hence, describing policy failures, synonymous here with a loss of credibility and/or reputation of the central bank, in these terms is possible because central banks have different views about the various natural rates in the Taylor rule (inflation, output, and the real interest rate), as well as different attitudes about how aggressively to react to inflation and output gap shocks (i.e., the size of $\alpha_1, \alpha_2$). It seems reasonable then, if we are interested in evaluating central bank credibility and reputation, to focus our attention on how expected inflation evolves over time when derived from alternative formulations of equation (1.1) and conditioned on the policy regime believed to be in place and, by implication, on the principal instrument of monetary policy used in each regime. Since we can allow estimates of expected inflation to evolve for both short-term economic reasons (e.g., an economic shock of some kind), as well as institutional reasons (e.g., a change in the degree of central bank independence), this serves as the starting point for our estimates of central bank credibility over time. As Kahn (2012) argues: “The Taylor rule can be seen as part of a broader movement in which commitment (and therefore credibility), transparency, and independence, replaced a culture of discretion, “mystique,” and occasional political influence.”

If we begin with the case where interest rates are not smoothed then the desired policy rate can be set according to

$$i_t^* = \bar{\rho}_t + \bar{\pi}_t + \alpha_2(E_t\pi_{t+1}) - \pi_t^* + \alpha_3(E_t y_{t+1} - y_t^*) + \alpha_4 \Delta y_t \tag{1.2}$$

[8] Reinhart and Rogoff (2013) point out that the Fed, like a few other central banks, have seen their mandate evolve over time, from financial stability to price stability, and back again to financial stability. Consequently, they favor a greater role for credit aggregates in the conduct of monetary policy, a point repeatedly made by the BIS in recent years. Nevertheless, their analysis underestimates the connection between price stability and financial stability as well as equating financial stability with bank stability. There is no allowance made for the role of shadow banking nor does the Federal Reserve Act explicitly define what financial stability means.

[9] Their formulation is expressed in terms of an unemployment gap in part because they are interested in U.S. monetary policy during the 1970s through the late 1990s. Data restrictions as well as comparability with most of the relevant literature, including Orphanides’ (2003) historical analysis of policy rules, make it impractical, in our study, to rely on the unemployment rate. Instead, we begin with a rule expressed in terms of output.

All of the variables were previously defined. Equation (1.2) is fairly standard although it is augmented by a 'speed limit' term (e.g., see Woodford 2003) that corrects for measurement type errors in specification such as (1.2) as well as the strong persistence found in the policy rate. Next, dynamic adjustment of the policy rate can be defined as follows

$$i_t = \gamma_{5,t}\Delta i_{t-1} + (1-\gamma_{6,t})i_t^* + \gamma_{6,t}i_{t-1} + \eta_t \tag{1.3}$$

Finally, if we combine (1.2) and (1.3) we obtain[10]

$$i_t = \gamma_{1,t} + \gamma_{2,t}E_t\pi_{t+1} + \gamma_{3,t}(E_t y_{t+1} - y_t^*) + \gamma_{4,t}\Delta y_t + \gamma_{5,t}\Delta i_{t-1} + \gamma_{6,t}(i_{t-1} - \bar{\rho}_t) + \bar{\rho}_t + \eta_t \tag{1.4}$$

Adapting the result from Kozicki and Tinsley (2009), the *implied inflation target* becomes

$$\bar{\pi}_t = \frac{-\gamma_{1,t}}{(\gamma_{2,t} + \gamma_{6,t} - 1)} \tag{1.5}$$

In the case of an intermediate monetary target we begin with a Quantity Theory type formulation that sets money growth ($\Delta m_t$), in both realized and equilibrium terms, according to either realized or the effective inflation target, the growth rate of the economy and velocity movements ($\Delta v_t$), so that equilibrium money growth follows

$$\Delta\bar{m}_t = \bar{\pi}_t + \Delta\bar{y}_t - \Delta\bar{v}_t \tag{1.6}$$

Realized money evolves in the same manner as equation (1.6).[11] Now, if the notional policy rate is set according to

$$i_t^* = \bar{\rho}_t + \bar{\pi}_t + \alpha_{2,t}(\Delta\tilde{m}_t - \Delta\tilde{v}_t) \tag{1.7}$$

where $\Delta\tilde{m}_t = \Delta m_t - \Delta\bar{m}_t$, and $\Delta\tilde{v}_t$ is similarly defined. Both terms represent transitory movements in money growth and velocity, respectively, and given equation (1.6), this implies that real economic considerations indirectly enter the specification as opposed to

[10] Details are not shown. For example, $\gamma_{1,t}$ is a linear combination of $\alpha_2$ and $\gamma_{6,t}$.

[11] The difference, of course, is that when the variables are expressed in the form of observed values the bars in the notation are removed.

equation (1.2).[12] Kozicki and Tinsley (2009) then demonstrate that the effective inflation target can be shown to be (also, see Orphanides 2003)[13]

$$\bar{\pi}_t = \Delta\bar{m}_t - \Delta\bar{y}_t + \Delta\bar{v}_t \tag{1.8}$$

Finally, we consider the case of a small open economy that contemplates combining interest rate and exchange rate instrument in the manner of Ball (1999) so that the policy rule is expressed as an adapted version of equation (1.1)

$$\lambda i_t + (1-\lambda)e_t = \bar{\rho}_t + \bar{\pi}_t + \tilde{\alpha}_2\tilde{\pi}_t + \tilde{\alpha}_3\tilde{y}_t + \tilde{\varepsilon}_{i,t} \tag{1.9}$$

where $e_t$ is the nominal exchange rate (i.e., the domestic price of foreign currency). Under a floating exchange rate regime, $\lambda = 1$, so we are left with an expression of the form of equation (1.1). However, augmenting equation (1.2) with a term to recognize that the central bank also has an exchange rate objective, we obtain

$$i_t^* = \bar{\rho}_t + \bar{\pi}_t + \alpha_2(E_t\pi_{t+1} - \pi_t^*) + \alpha_3(E_t y_{t+1} - y_t^*) + \alpha_5(E_t\Delta e_{t+1} - \Delta e_t) \tag{1.10}$$

where, for the sake of simplicity, the 'speed limit' term in (1.2) is set to zero, and the exchange rate objective is expressed in terms of the rate of appreciation (or depreciation) of the nominal exchange rate. Finally, if domestic and foreign inflation rates are related to each other via an (uncovered) interest rate parity relation such that

$$\pi_t = \Delta q_t - \Delta e_t + \pi_t^f \tag{1.11}$$

where $\pi_t^f$ is foreign inflation, and $\Delta q_t$ is the rate of change in the real exchange rate, then the effective inflation target is reminiscent of equation (1.5), but adapted to capture the trade-off between an interest rate and an exchange rate response so that we obtain the following expression for the *implied inflation target*

[12] As a result, this formulation of the policy rule has the distinct advantage that it does not rely on unobservable output gap measures. See, for example, Friedman (1968) and Orphanides (2003). Nevertheless, the specification does require taking a stand on how best to measure the money supply.

[13] The formal expression is still as in equation (1.5) except that, in equation (1.4), $E_t\Delta x_{t+1}$ replaces $E_t\pi_{t+1}$ and $E_t y_{t+1}$ replaces $\Delta y_t$. In other words, parameters $\gamma_{3,t}$ and $\gamma_{4,t}$ are affected. $\Delta x_t$ is a proxy for the nominal output growth gap obtained via Okun's Law (e.g., see Ball et. al. 2013). The difficulty is that Okun's Law requires data for the unemployment rate in order to estimate the relevant gap measure and this series is likely unavailable for several countries and samples in our dataset. Instead, we proxy $\Delta x_t$ by estimating $\Delta\pi_{t+1} + 0.454\Delta y_{t+1}$. The 0.454 value is obtained for the U.S. from Ball et.al. (2013) and is equivalent to the value used in Kozicki and Tinsley (2009). For the other countries in the data set we also rely on estimates in Ball et. al. (2013).

$$\bar{\pi}_t = \frac{-\gamma_{1,t}}{(\gamma_{2,t} + \gamma_{6,t} - \gamma_{7,t} - 1)} \tag{1.12}$$

where $\gamma_{7,t}$ is obtained from a variant of equation (1.4) augmented by adding the last term in equation (1.10). The upshot is that not all shocks require an immediate response of the policy instrument to maintain credibility.[14] Indeed, as long as the central bank explains clearly (i.e., there is adequate transparency)[15] then some changes in the inflation and the output gap will elicit a response, such as when the economic shock is of the aggregate demand variety while other types of shocks, namely aggregate supply shocks, are responded to in a 'balanced' fashion. Both of these actions should be reflected in the ability of the central bank to 'anchor' inflation expectations.

We can now define credibility. In the simplest terms a central bank is deemed credible when it delivers, subject to a random error, the implied inflation rate objective conditional on the monetary regime in place. Of course, as previously noted, there may well be economic and institutional reasons why the credibility of the central bank may not be so easily eroded. Consequently, we can write

$$(\pi_t - \bar{\pi}_t)^2 = \boldsymbol{\theta}\mathbf{Z_t} + \varphi(\pi_{t-1} - \bar{\pi}_{t-1})^2 + \mathbf{u_t} \tag{1.13}$$

Where the dependent variable is our indicator of credibility, $\boldsymbol{\theta}\mathbf{Z_t}$ is the product of a vector of coefficients, $\boldsymbol{\theta}$, and $\mathbf{Z}$ represents economic and institutional variables that can explain departures from the effective inflation target (see the following section). These may also impact credibility with a lag but this is not shown for simplicity. Finally, as suggested earlier, it is likely that credibility is persistent if only because inflation tends to be persistent over time.

There exist, potentially, several problems with specification (1.13). First, if there are any lags in obtaining and processing information then it is not clear that credibility will involve the differential between observed inflation and the contemporaneously implied

[14] Indeed, as a result we do not interpret what central banks have done as if they followed an optimal control (OC) policy. Orphanides and Williams (2011) demonstrate an OC policy does not deliver better outcomes unless the information possessed by the authorities is superlative. Since this is unlikely, even in the data rich environment we live in, and almost certainly a low probability event in earlier decades, our approach is more akin to the 'robust' monetary policy type of approach in the presence of significant impairments in information.

[15] Clarity and transparency need not, of course, go hand in hand (e.g., see Siklos 2003).

inflation target. While inflation rates are observed fairly quickly it may well take some time to observe the effective inflation target.[16] Of course, to some extent, the appropriateness of equation (1.13) is dependent on the sampling frequency being used. At the annual frequency, which we rely on in this study, the foregoing specification seems sensible.

There is no reason for the relationship between credibility and its determinants to be linear. For example, there may well be a threshold beyond which there is a loss of credibility whereas there might also exist a 'band of indifference' within which there is no appreciable loss of credibility. An alternative, in common for example, with the literature on policy rules and the objective function of central banks, is to assume that the loss of credibility rises with the size of the deviation from the inflation goal. A simple specification that meets this requirement is to express credibility as the squared differential between observed and the Fed's inflation goal. Hence, the dependent variable is expressed as in equation (1.13).[17]

*3.2 Challenges in Measuring Credibility Over A Long Time Span*

Obviously, there are a number of complications when dealing with historical data especially when the span of time exceeds over a century of data. In no particular order of importance one might include significant changes in the quality, scope and availability of time series useful for the kind of macroeconomic analysis in place. Consequently, the evidence marshaled below is cross-checked with additional narrative evidence about the evolution of central bank credibility and reputation over time.

An additional illustration of the desirability of blending the time series econometric approach with what is known from economic history emerges when evidence that a change in the monetary policy regime is found. If such an event is associated with, say, a sudden loss of credibility, which also translates into a large loss in the reputation of a central bank, then our estimates should compare favorably with historical depictions of a policy regime

[16] In principle observing the inflation target is easier in a conventional inflation targeting (IT) regime. Recall, however, that the implied inflation target, as defined here, need not to be the same as the numerically announced inflation target. All modern IT regimes are sufficiently flexible in that they are permitted to avoid missing the target from time to time as long as departures are publicly explained. Whether these departures separately influence credibility is, of course, another matter.

[17] Indeed, if credibility is only a function of whether observed and the notional inflation objective are different from each other, so that we set $\boldsymbol{\theta}\mathbf{Z_t} = \mathbf{0}$, and $\mathbf{u}_t \sim N(0, \sigma_u^2)$, then credibility can be interpreted as observed inflation and the effective inflation objective being *attracted* to each other in the sense of being cointegrated. We do not, however, investigate this possibility here.

change. The econometric terms for type of phenomenon could be identified from a structural break test in the time series of interest.

The value of the time series exercise is also enhanced if our statistical findings reveal a break near to, but not coincident with, the actual recorded historical event since this could be a sign that policy makers delayed their response to a regime shift that is underway. Of course, structural breaks come in many forms. Of particular interest is the connection between financial crises and changes in central bank reputation and credibility. The global financial crisis of 2008-9 has been said to rest on the ineffectiveness of financial regulation and supervision by the Fed and other regulators, on the Fed keeping policy rates too low to fight the prospect of deflation, and on the inattention of central bankers to the possible link between low inflation and asset price booms leading to financial sector instability.[18] These arguments suggest that credibility and reputation are simultaneously impacted.

As the foregoing discussion indicates the lender of last resort (LOLR) function of central banks is critical. Long dormant as the growth in the financial sector provided adequate liquidity the loss of confidence in 2007-2008, the re-emergence of the LOLR role of central banks was ushered in by market failures in key financial markets. Finally, the combination of statistical testing and the narrative approach should also reduce the likelihood of identifying too many breaks.[19]

Our interest in credibility in central banking goes beyond the analysis of the experience of individual countries. Indeed, as is clear, for example, from the spread of inflation targeting as the monetary policy regime of choice in several countries beginning in the 1990s, or the linking of economies through pegged or managed exchange rate regimes, spillover effects can also play a role. Alternatively, changes in central bank credibility may contain an element of contagion. For example, a policy regime change in a core economy (e.g., the U.S.) may influence economic outcomes elsewhere. Consequently, there is scope for credibility effects to be imported from or exported to other economies over time. Changes in policy regimes may also occur via a simple demonstration effect not associated

[18] Bernanke (2013, p. 23) admits as much. "…the Federal Reserve failed [to] …adequately perform its function as lender of last resort…".

[19] In a sense this was the aim of Perron's (1989) seminal contribution to the literature on the time series properties of macroeconomic data. Hence, not all shifts in time series are permanent (i.e., level or intercept shifts). Indeed, some breaks simply alter the trend in a time series.

with any fundamental economic factors but simply because they appear to work elsewhere. One example often used to underscore this point is the Volcker era at the Fed (e.g., see Silber 2012).

## 4. Data and Methodological Considerations

Our empirical investigation consists of a time series analysis of 10 central banks around the world. They are: Canada, France, Japan, Germany, Italy, Norway, Sweden, Switzerland, the U.K. and the U.S. We rely on annual data going back to when central banks were established. This is supplemented with some additional narrative evidence from a few a few central banks in Latin and South America, where the time series are inadequate for our purposes. Table 1 provides information about the year when the central banks in our sample were created as well as a brief description of the proximate reason for their creation. It is interesting to note that, of the central banks surveyed, not all were created to fulfill the lender of last resort mandate. Indeed, other than to assist with the consequences of war finance, monetary stability is the other major proximate explanation for the creation of many central banks around the world.

For several countries in our sample (e.g., Japan, Norway, the U.K., Sweden) we can rely on over a century of data. For several other countries (e.g., the U.S.) annual data span almost a century of data. There is a rich historical narrative history to draw on to identify policy regimes, exchange rate regimes, the dating and identification of crises (e.g., see Bordo, Eichengreen, et. al. 2001, Reinhart and Rogoff 2009, Bordo and Orphanides 2013, Singleton 2012, James 2012, just to name a few). Moreover, thanks to efforts made by several central banks to greatly improve historical data sources (e.g., Norway) there are ample macroeconomic and financial data. In other cases (e.g., Canada and the U.S.) there is a long tradition of collecting historical time series and making them publicly available. To these sources must be added the sources of data the authors and their collaborators, as well as others, have compiled over the years. Finally, *Global Financial Data* (https://www.globalfinancialdata.com/index.html) is another source of long-term macroeconomic and financial data, especially for countries in Europe and Asia where publicly available historical time series are more difficult to obtain.[20]

Prior to econometric estimation three preliminary steps are followed. First, on the basis of statistical testing or relying on the narrative approach, we must identify policy regimes. Even if the narrative approach yields clear indications of the regime in place it is useful to estimate the implicit inflation objective of each central bank in our sample for the full sample. Under this strategy we effectively end up adopting a counterfactual approach, at least for a portion of the sample in question. Consequently, one may view this approach as asking whether some monetary regimes are more credible than others over time. In a second step, equation (1.4), and its variants, are estimated to obtain the key parameters of interest, namely $\gamma_{2,t}$,$\gamma_{6,t}$,and $\gamma_{7,t}$. Finally, we can obtain estimates of the implicit inflation target, $\bar{\pi}_t$, for each central bank. Notice that the parameters and the inflation objective are time-varying as are the estimates of the real policy rates. There exist, of course, a variety of techniques to generate such estimates. As discussed in the results section we also combine several proxies to improve the robustness of our estimates.

Credibility and, by implication, reputation might also be determined by governance structures that define the relationship between the central bank and government, including central bank independence. In this case we can resort to data originally constructed by Cukierman (1992), updated by Siklos (2002), with more recent data also available from the IMF (e.g., see Arnone and Romelli 2012, and Arnone et. al. 2009). However, these data are only available since the 1950s.

## 5. Empirical Evidence[21]

We begin with a description of some broad stylized facts. Figure 2 plots observed CPI inflation since the creation of the Fed together with our estimate of expected inflation. Relying on the notion that the average of forecasts delivers superior performance relative to individual forecasts the estimates of expected inflation are based on three different

[20] An Appendix (not shown) provides additional details about data sources.
[21] **NOTE: ONLY U.S. EVIDENCE IS DISCUSSED IN THIS DRAFT. Next draft will add: Canada, Sweden, Norway, Germany, U.K., and Switzerland.**

models.[22] To generate expected inflation we evaluate the three years ahead mean inflation rate, that is, $E_t\pi_{t+1} = (\pi_{t+1} + \pi_{t+2} + \pi_{t+3})/3$. Next, we estimate an AR(1) model for observed inflation and let the data select up as many breaks based on a series of econometrically determined constraints.[23] In this manner we identified four breaks: in 1924, 1933, 1973, and 1982. An *ex post* historical analysis suggests that the location of these breaks appear sensible. The first break occurs after the deflation of the early 1920s and when the Fed became more activist; the second break takes place when the Fed implements a more comprehensive response to the Great Depression. The break in 1973 is, of course, associated with the first oil price shock while the break in 1982 can be explained by the Volcker disinflation policy. Finally, following Stock and Watson (2007) we estimate a integrated moving average model of order 1 (i.e., an IMA(1,1)) as this has been shown to be a reliable inflation forecasting model in a wide variety of circumstances. In a twist on the usual approach, however, the IMA(1,1) model is separately estimated for each sub-sample obtained from the analysis of breaks in the inflation process using an AR(1) model. This approach provides us with additional insights into the changing role of permanent versus transitory shocks influencing the behavior of U.S. inflation since the creation of the Fed.[24]

One hopes, of course, that inflation expectations track observed inflation. Nevertheless, there are gaps that occasionally persist over several years. This is particularly noticeable during the period of the Great Inflation (also see Bordo and Orphanides 2013) of the 1960s and 1970s. Another observation, also commonly encountered in the more recent literature on the behavior of inflation forecasts, is that inflation is more volatile than its expectation.

---

[22] Obviously in a study that looks at credibility for roughly a century of data we are unable to construct a data set consisting of private sector, central bank or survey data that covers the entire span of the history of the Fed or, for that matter, any of the other central banks in our study. We also considered a fourth models, namely the difference between the yield on a long-term government bond and a ten year (moving) average of inflation (e.g., see Bordo and Dewald 2001). However, as the results were unaffected we did not include them in computing the final estimate of inflation expectations.

[23] This involves implementing the Bai-Perron (1998) test where the maximum number of breaks are restrict is set according to the rule T/25, where T is the number of available observations. In this manner we restrict the maximum number of structural breaks to, at most, 4 per century of data. The breaks are globally determined and a degrees of freedom adjustment is also applied. The samples are 'trimmed' using a 10% rule meaning that breaks will be located in 80% of the sample excluding the first and last 10% of the sample. It is well-known that these choices in the estimation of breaks will impact their frequency and location. This is why we cross-check the choice of breaks with the historical evidence. We return to this issue below.

[24] The samples are defined so that the year a structural break is found in the Bai-Perron test is the last observation of each sub-sample. Additional robustness tests were conducted when the sub-samples were short (e.g., less than 15 years in duration).

As a result, expectation errors are short-lived but typically far greater, for example, before World War II than say during the period of the Great Moderation from the mid- 1980s until the end of the available sample.

Figure 3 plots three critical variables in the analysis below, namely the fed funds rate (using a short-term interest rate proxy prior to the mid-1950s), observed inflation and an estimate of the output gap. Also shown are recession periods based on the NBER business cycle chronology. It is immediately clear that the gap between the nominal interest level and the level of inflation, that is, an *ex post* indicator of the real interest rate, is highly variable. As with the derivation of a proxy for expected inflation, the output gap measure used below is the mean of several proxies. They are: an H-P filter with the standard smoothing parameter (i.e., 100 in the case of annual data), two other versions of an H-P filter estimated with a 20 year window and changing end-points (one fixing the end-point at the beginning of the sample, the other fixing it at the end of the sample) and, finally, deviations from a linear trend applied to the logarithm of potential real GDP allowing for break-points beginning around the time of the Great Depression, one that starts at the time of the first oil price shock of the 1970s, and a final one at the end of the sample to capture the early stages of the so-called Global Financial Crisis.[25] The difficulties in estimating the output gap have been widely discussed. Admittedly, the task of estimating an indicator of economic slack is made even more difficult when a century of data is examined. However, as pointed out in Goodfriend and King (2013), if the output gap properly measures aggregate economic slack then it should be negatively correlated with future real GDP growth.[26] This seems to be the case for the proxy generated here, at least beginning around the mid-1920s.

Finally, and given the recent discussion over possibly excessively low inflation and the risk of deflation the horizontal axis of Figure 4 indicates the years when the U.S. faced this kind of environment. Low inflation is arbitrarily defined as CPI inflation below 1.5% while deflation, of course, obtains when inflation is negative. Approximately a quarter of the Fed's

[25] The break for the Depression begins in 1930 and is defined as an intercept break, the other two are slope breaks which begin in 1974 (oil price shocks) and 2006 (global financial crisis).

[26] A positive output gap signifies real GDP is above potential or trend real GDP. If the economy stabilizes around the trend over time then observed real GDP should eventually fall towards trend. Hence, a positive output gap should be associated with lower future real GDP growth.

existence is associated with low or negative inflation with episodes of low inflation a post-World War II phenomenon while deflation is more typical of the pre-1940s macroeconomic experience. Moreover, based on the NBER chronology, no one to one association between low inflation or deflation and recessions is found. This view is heavily skewed by the events of the Great Depression.

Table 1 provides an overall summary of the univariate results so far. Means and standard deviations for each of the sub-sample, chosen according to the endogenous break test mentioned previously, are shown for the three core series used to generate our estimates of the Fed's inflation goal. The final two columns provide the point estimates of the autoregressive parameter for each sub-sample as well as the full available sample and the point estimate of the MA parameter form the IMA(1,1) model. All the time series show considerable variation across the periods shown. There is also no apparent correlation between changes in mean inflation and changes in the output gap. Finally, other than for the Great Inflation era, mean nominal interest rates fluctuate in a fairly narrow range from 4 to 6%. There is considerable variation, however, in the estimates of the AR parameter which is often used as an indicator of inflation persistence. On this basis inflation in the pre-war period is highly persistent, as is true for the entire sample. However, persistence drops significantly after the 1970s until the present. Indeed, the persistence parameter is statistically insignificant at conventional levels of significance.[27] Turning to estimates of MA parameter, shown in the last column, the results highlight the importance of examining sub-samples. During the Fed's lifetime it would appear that inflation is dominated by permanent shocks since the estimate of $\theta$ is close to zero. Sub-sample estimation, however, shows that transitory shocks play an important role in all the sub-samples though it is smallest prior to 1924.

Figures 5 (i) and (ii) plot our estimates of the implicit inflation objective of the Fed based on equation (1.5). The discussion below focuses on the point estimates. Clearly, however, uncertainty surrounds such estimates.[28] Recall that this expression can be used

[27] As noted previously, the results are highly dependent on the location of the break in inflation. Nevertheless, a variety of robustness tests (not shown) suggest that the fall in inflation persistence since the first oil price shock is not a figment of the data.

[28] Given the manner in which $\bar{\pi}_t$ is evaluated it is not straightforward to estimate a confidence interval for these estimates. Kozicki and Tinsley (2009) do not even consider the possibility.

whether the Fed is assumed to rely on an interest rate instrument or money growth. Since, with some exceptions (e.g., since the late 1980s), the instrument of policy is neither purely an interest rate nor precisely money growth some of the estimates are of the nature of a counterfactual. Also shown are the NBER recession dates while the 1-3% range for inflation, a fairly common target adopted by many central banks today, is also shown.

It is immediately apparent that the Fed does not appear to have adopted anything resembling a 2% inflation target throughout its history when an interest rate instrument is applied although it begins to look like that kind of central bank during the 2000s. It is also clear that a significant downward shift in the inflation objective begins to take place during the 1970s, that is, in the midst of the two oil price shocks. Indeed, the implied inflation objective is close to zero during much of the 1980s. This no doubt reflects the impact of the substantial Volcker disinflation. Finally, two periods are notable for their stable estimates of the Fed's inflation goal, namely the 1950s until around the middle of the 1960s and again since the 1990s. Turning to the case of the money growth instrument, part (ii) of Figure 5 reveals a different picture. The 1-3% range now characterizes the Fed's inflation goal from the 1930s through the early 1960s and is stable. The inflation goal declines during the Great Inflation an indication that, while the Fed aimed for price stability it was consistently surprised by actual inflation performance. The estimates of the last two decades are clearly counterfactual and highlight the fact that money growth as an instrument does not square with actual fed behavior.

Figures 6(i) and (ii) plot two different versions of our measure of central bank credibility (i.e., the left hand side of equation (1.13)). The recursive estimates are based on equation (1.5) estimates of $\pi_t - \bar{\pi}_t$. Since the weight of the last observation declines under the recursive scheme it is conceivable that our proxy for central bank credibility will too readily fluctuate with observed inflation as we approach the end of the available sample. Therefore, we also consider a measure of credibility based on rolling estimates of $\bar{\pi}_t$ using a 20 year window for the calculations. The solid lines in Figure 6 plot the recursive estimates while the vertical bars represent the rolling estimates.

When the instrument of monetary policy is assumed to be an interest rate we observe that our measure of credibility, no matter how it is estimated, is fairly close to zero during much of the Fed's history. This indicates that observed inflation and the Fed's inflation goal are fairly closely matched. Nevertheless, there are notable exceptions to this rule. The first takes place during the second half of the1930s. This is the period when the Fed was attempting a return to a more 'normal' monetary policy following the Great Depression. Combined with an overly restrictive fiscal policy, in hindsight, these events combined to negatively impact the Fed's credibility. The next substantial period of reduced Fed credibility takes place during the second half of the 1960s, that is, when, again looking back, the Fed lost the battle against inflation with the consequent loss of reputation under Arthur Burns who went on to lament the high inflation in *The Anguish of Central Banking* (1979). The final episode of credibility loss takes place during the early 1980s. This period overlaps, of course, with the wrenching disinflation of the early 1980s. As Volcker himself later noted (see Silber 2012), the Fed had little credibility at the time of the temporary switch from interest rate to reserves targeting. Rising credibility would come later and benefit Volcker's successors, Alan Greenspan and Ben Bernanke. The Great Moderation is seen, therefore, as a period of high Fed credibility.

The story is much the same when we assume the Fed operates with a money growth instrument. The precise years when the Fed loses credibility in a significant way do not, of course, exactly match those of the interest rate instrument case but they come close. One interesting departure of sorts is that the money growth instrument case reveals a significant loss of credibility during the mid 1920s no doubt the culmination of the residual effects of the deflation of the early 1920s and perhaps even reflects attempts by the Congress, through the so-called Stabilization Bills, to require the Fed to target the price level (e.g., see Siklos 2002). It is also difficult to argue that the loss of credibility shown in the late 1980s and early 1990s can be explained by residual effects of the Volcker era. The fed funds rate was, by then, the principal instrument of policy. What the result suggests then is that, had a money growth instrument been used, observed inflation would have been permitted to rise substantially above the Fed's inflation goal. Once again, a retrospective analysis suggests that the confluence of two events, namely the severe recession of the early 1990s may well have also contributed to reducing the Fed's credibility under the circumstances.

As a cross-check and to provide additional insights into the factors that might impact credibility over time, Figures 7(i) and (ii) and Table 2 provide a break down of the behavior of our measures of credibility during the periods of 'decisive' tightening of monetary policy, at least according to the Romer and Romer (1989) narrative exploration of Fed performance in the post-war era until the early 1980s. The vertical lines in Figures 7 indicate when Fed policy was tightened[29] while the bars indicate the value of $\pi_t - \bar{\pi}_t$ the year before and the year after monetary policy is tightened. Although a money supply instrument is likely most appropriate for the sample shown we also provide the credibility estimates when an interest rate instrument is used. Broadly speaking, the results are comparable. For the first three episodes, that is, 1947, 1955 and 1968 credibility is lower just before monetary policy is decisively tightened. Likewise credibility improves in the year following the tightening in half the cases shown when money growth is targeted while improvement is seen in 4 of 6 episodes considered when an interest rate instrument is assumed to be employed.

Table 2 provides a breakdown, again relying on the estimated break dates from the AR(1) inflation model and relying on recursive estimates previously discussed. On average Fed credibility is high but there is considerable variation across the sub-samples. Not surprisingly, credibility is lowest in the early years of the Fed and, especially during the period that overlaps the Great Depression. However, in absolute value, credibility is almost as low during the period of the oil price shocks. The Volcker-Greenspan era sees a significant increase in Fed credibility.[30]

Next, we consider the institutional determinants of credibility. As discussed previously, credibility is evaluated as the squared deviation from the Fed's inflation goal. We then consider some available institutional determinants at our disposal. Accordingly, we define $\mathbf{Z}_t$, the matrix of institutional determinants as follows:

$$\mathbf{Z}_t = [loans_t, FOMC\_chair_t, CRISIS_t, debt_t, CBI_t]$$

[29] Romer and Romer (1989) identify the months when tightening was 'decisive'. Their chronology provides the following dates: October 1947, September 1955, December 1968, April 1974, August 1978, October 1979. We equate the month with the entire year since we are relying on annual data.
[30] Since the sample ends in 2007 we can only include the first year of Chairman Ben Bernanke's term.

where *loans* represents the ratio of bank credit to GDP, *FOMC_chair* represents a dummy variable set to one for every FOMC chair in the sample although the focus of the empirical analysis will be on post-World War II personalities, *CRISIS* are dummy variables to capture various financial crises (banking, currency, stock market and/or sovereign debt of the domestic or external varieties) as dated by others, *debt* is the central government debt to GDP, and *CBI* is an index of central bank independence.[31] As noted previously, we also estimated versions of (1.13) with the institutional determinants in lagged form.

An obvious concern, among others, is that some of the determinants of credibility may be endogenous, reflecting both the impact of past Fed credibility and, in turn, influencing future Fed credibility. This concern is considerably mitigated under the circumstances either because lags are used, the persistence properties of credibility are recognized, and the economic determinants listed above are likely to influence credibility instead of the other way around. Consequently, equation (1.13) is estimated using OLS.[32] Finally, it is likely that some of the determinants (e.g., the CRISIS dummies) interact with others (e.g., debt to GDP ratio). Therefore, we also consider interaction terms. In addition, we present only the final estimated specifications. Considerable experimentation led us to the results presented below.

Table 3 presents the regression results. Not surprisingly, coefficient estimates are sensitive according to whether an interest rate or a money supply target instrument is assumed. Nevertheless, some common features are apparent. Credibility is persistent although considerably more so when an interest rate instrument is used. This may reflect the relatively more transparent signals that emanate when a policy rate is used to set the stance of monetary policy. The expansion of credit reduces credibility in both specifications. However, the impact is three times as large when a money supply target is

[31] Data are only available since the 1950s. we also considered an indicator of central bank transparency but annual data only go back to 1998.

[32] With the limited number of instruments we also estimate the same specification using GMM. Typically, we use lagged values of the variables shown above although a few additional variables (e.g., lagged inflation, money growth) are also candidates. The conclusions discussed below hold when instrumental variable techniques are applied but the results, perhaps unsurprisingly, can be highly sensitive to the choice of instruments. Our metric for whether the instruments are adequate is the Stock-Yogo test (e.g., see Stock and Yogo 2005). Essentially, a linear regression of the variable suspected of being endogenous on the collection of instruments must yield an F-test statistic of at least 10, as a rule of thumb. In practice more formal tests were used to assess the weakness of the chosen instruments.

used. Depending on one's definition of the monetary aggregate the relatively greater sensitivity in the money supply target specification may well reflect the connection between money and credit growth over long periods of time. The differences are equally illuminating. Thus, it is notable that the Greenspan era, when an interest rate instrument is clearly in use, is associated with an increase in credibility. Also significant is the interaction of the debt to GDP ratio and the dummy for domestic debt crises. These combine to enhance credibility, presumably because it activates the Fed's role as a lender of last resort.

Next, Table 4 considers an alternative way of looking at the determinants of credibility. We separately estimate versions of equation (1.13) when observed inflation is above the Fed's inflation goal versus the case where actual inflation falls below the central bank's inflation objective. This is a fairly straightforward way of exploring whether credibility responds asymmetrically according to whether inflation is higher or lower than the Fed's target. As we expect, the results depend on whether an interest rate or a money supply target is the instrument of monetary policy. However, there are also significant differences depending on whether inflation rises or falls below the central bank's inflation objective. In particular, when an interest rate instrument is used, past credibility can actually improve current period credibility only when inflation is above the target. Otherwise, when inflation moves away from the central bank's goal this contributes to a further erosion of credibility in future, regardless of the instrument of monetary policy. Furthermore, in absolute value, persistence is the same when $\pi_t - \overline{\pi}_t < 0$ while persistence is higher (but in the wrong direction) when a money supply target serves as the instrument. Finally, and again irrespective of the instrument of policy, rising credit, an increase in the debt to GDP ratio, or a crisis in the stock market generally reduce credibility irrespective of the sign of the credibility indicator. There is one exception, namely when the debt to GDP ratio increases and inflation is above target, this enhances the Fed's credibility. Note, however, that in these specifications we are unable to include interaction variables with the crisis dummies as was the case for the results presented in Table 3.

## 6. Conclusions

This paper seeks to determine how central bank credibility and reputation have changed over time in a cross-section of central banks around the world. Theory links credibility with how well the central bank is able to anchor inflation expectations to some implicit target over time that can change and shift given the variety of shocks that hit an economy. Reputation is viewed as having a stock-like representation so that persistent credibility can build the stock of reputation while financial crises diminish the stock of reputation. In addition, there are institutional factors that also impact a central bank's credibility, such as when a particular Governor puts his or her imprint on the institution.

We find credibility changes over time are frequent and can be significant. Nevertheless, no robust empirical connection between the size of an economic shock (e.g., the Great Depression) and loss of credibility is found. Second, the frequency with which the world economy experiences economic and financial crises, institutional factors (i.e., the quality of governance) plays an important role in preventing a loss of credibility. Third, credibility shocks can be transmitted across countries but their impact is dependent on the type of monetary policy regime in place. Finally, credibility is most affected by whether the shock can be associated with policy errors. Bernanke (2013, p. 23), for example, has acknowledged that such errors can, for example, an important role in explaining the severity of the most recent 'global' financial crisis.

## References


Ahamed, L. (2009), *Lords of Finance* (New York: The Penguin Press).

Altug, S., and F. Canova (2013), "Do Institutions and Culture Matter for Business Cycles?", working paper, European University Institute, March.

Arnone, M., and D. omelli (2012), "Dynamic Central Bank Independence Indices and Inflation Rates: A New Empirical Explanation", Paolo Baffi Centre Research Papper No. 2012-118.

Arnone, M., B. Laurens, S. Segolato, and J-F. Sommer (2009), "Central Bank Autonomy: Lessons from Global Trends", *IMF Staff Papers* 56 (2):263-296.

Bai, J., and P. Perron (1998), "Estimating and Testing Linear Models with Multiple Strcutural Changes", *Econometrica 66* (January): 47-78.

Ball, L,. D. Leigh, and P. Loungani (2013), "Okun's Law: Fit at Fifty?", NBER working paper 18688, January.

Bernanke, B. (2013), "The Federal Reserve and the Financial Crisis" (Princeton, N.J.: Pricenton University Press).

Beyer, A., V. Gaspar, C. Gerbeding, and O. Issing (2013), "Opting Out of the Great Inflation: German Monetary Policy After the Break Down of Bretton Woods", in M.D. Bordo and A. Orphanides (Eds.), *The Great Inflation: The Modern Rebirth of Central Banking* (Chicago: University of Chicago Press).

Blinder, A., and J. Rudd (2013), "The Supply-Shock Explanation of the Great Stagflation Revisited", in M.D. Bordo and A. Orphanides (Eds), *The Great Inflation: The Modern Rebirth of Central Banking* (Chicago: University of Chicago Press).

Bordo, Michael and Athanasios Orphanides (2013), *The Great Inflation: The Modern Rebirth of Central Banking* (Chicago: University of Chicago Press).

Bordo, Michael, and Ronald MacDonald (2012), *Credibility and the International Monetary Regime*. New York: Cambridge University Press

Bordo, Michael, and Joseph Haubrich (2010), "Credit Crises, Money and Contractions: An Historical View", *Journal of Monetary Economics* 57: 1-18.

Bordo Michael, Barry Eichengreen, Daniela Klingebiel and Maria Soledad Martinez – Peria ( 2001) 'Is the Crisis Problem Growing More Severe?" *Economic Policy*. April.

Bordo, Michael and Anna Schwartz (1996), "The Operation of the Specie Standard: Evidence for Core and Peripheral Countries, 1880-1990" in Barry Eichengreen and

Braga de Macedo, J. , *Historical Perspectives on the Gold Standard: Portugal and the World* (London: Routledge).

Bordo, Michael and Finn Kydland (1995), "The Gold Standard as a Rule: An Essay in Exploration", *Explorations in Economic History* 32: 422-464.

Borio, C. (2013), "Rethinking Potential Output: Embedding Information About the Financial Cycle", BIS working apper 404, February.

Burdekin, R.C.K., and P.L. Siklos, Eds. (2004), *Deflation: Current and Historical Perspectives* (Cambridge: Cambridge University Press).

Burdekin, R.C.K., and P.L. Siklos (2004a), "Fears of Deflation and the Role of Monetary Policy: Some Lessons and An Overview", in Burdekin, R.C.K., and P.L. Siklos, Eds., *Deflation: Current and Historical Perspectives* (Cambridge: Cambridge University Press), pp. 1-27.

Burdekin, R. and Siklos, P. (1999), 'Exchange Rate Regimes and Shifts in Inflation Persistence: Does Nothing Else Matter?', *Journal of Money, Credit and Banking*, Vol. 31, May, pp. 234–247.

Brunner, K. (1983), "The Pragmatic and Intellectual Tradition of Monetary Policymaking." In *Lessons of Monetary Experiences from the 1970s* (Karl Brunner, ed.).

Burns, A. (1979), *The Anguish of Central Banking*, Per Jacobsson Lecture, September.

Cargill, T. (2013), "A Critical Assessment of Measures of Central Bank Independence", *Economic Inquiry* 51 (January): 260-72.

Chung, H., J-P. Laforte, D. Reifschneider, and J. Williams (2012), "Have We Underestimated the Likelihood and Severity of Zero Lower Bound Events?", *Journal of Money, Credit and Banking* 44 (February): 47-82.

Cross, P., and P. Bergevin (2012), "Turning Points in Business Cycles in Canada Since 1926", C.D. Howe Commentary No. 366, October.

Crow, J. (2002), *Making Money* (Toronto: John Wiley & Sons).

Cukierman, Alex (1986), "Central Bank Behavior and Credibility: Some Recent Theoretical Developments", *Review* of the Federal Reserve Bank of St. Louis (May): 5-17.

Cukierman, Alex (1992), *Central Bank Strategy, Credibility and Independence: Theory and Evidence* (Cambridge, Mass.: MIT Press).

De Long, B. (1997), "America's Peacetime Inflation: the 1970s", in *Reducing Inflation: Motivation and Strategy*, Edited by C.D. Romer and D.H. Romer (Chicago: University of Chicago Press),

Dehay, E., and N. Levy (2000), "L'independenance des banques centrales pendant l'entre-deux guerres et ses effects sur l'inflation et la croissance", working paper, Universite de Paris X-Nanterre.

Dincer, N. and B. Eichengreen (2007), "Central Bank Transparency: Where, Why, and With What Effects?", NBER working paper 13003, March, http://www.nber.org/papers/w13003

Dreher, A., J.E. Sturm, and J. de Haan (2998), "Does High Inflation Cause Central Bankers to Lose Their Job? Evidence Based on a New Data Set", *European Journal of Political Economy* 24 (December): 778-87.

Dupasquier, C., A. Guay, and P. St-Amant (1999), "A Survey of Alternative Methodologies for Estimating Potential Output and the Ouput Gap", *Journal of Macroeconomics* 21 (Summer): 577-595.

Eijffinger, S., and J. De Haan (1996), The Political-Economy of Central Bank Independence", Special Papers in International Economics, Prineton University, no. 19, May.

Eggertsson, G., and M. Woodford (2003), "The Zero Bound on Interest Rates and Optimal Monetary Policy", *Brookings Papers on Economic Activity* 34: 139-211.

Eichengreen, B. ( 1997), " The Gold Standard Since Alec Ford" in Barry Eichengreen and Marc Flandreau ( eds) The Gold Standard in Theory and Practice. Second Edition. London: Routledge.

Enders, W., and P.L. Siklos (2001), "Cointegration and Threshold Asjustment", *Journal of Business and Economic Statistics* 19 (April): 166-176.

Fellner, William (1976), *Towards a Reconstruction of Macroeconomics : Problems of Theory and Policy* (Washington, D.C.: American Enterprise Institute).

Ferguson, N., and M. Schularik (2008), "The 'Thin Film of Gold': Monetary Policy Rules and Policy Credibility in Developing Countries", NBER working paper 13918, April.

Fortin, P. (1996), "The Great Canadian Slump", *Canadian Journal of Economics* 29 (November): 761-787.

Freedman, C. and T. Macklem (1998), "A Comment on the 'The Great Canadian Slump'", *Canadian Journal of Economics* 31 (August): 646-65.

Friedman, M. (1968),"The Role of Monetary Policy", *American Economic Review* 58 (March): 1-17.

Goodfriend, M. (1986), "Monetary Mystique: Secrecy and Central Banking", *Journal of Monetary Economics* 17 (January): 63-92.

Goodfriend, M., and R. King (2013), "The Great Inflation Drift", in M.D. Bordo and A. Orhanides (Eds), *The Great Inflation: The Modern Rebirth of Central Banking* (Chicago: University of Chicago Press).

Goodhart, C.A.E. (1999), "Central Bankers and Uncertainty", Bank of England *Quarterly Bulletin* (February): 102-121.

Greenspan, A. (1996), "Opening Remarks", in *Achieving Price Stability*, A Symposium sponsored by the Federal Reserve Bank of Kansas City, August.

Haberler, Gottfried (1980), "Notes on Rational and Irrational Expectations", reprint 111, American Enterprise Institute (March).

Haltmaier, J. (2012), "Do Recessions Affect Potential Output?" Board of Governors of the Federal Reserve System, International Finance Discussion Papers, No. 1066, December.

Kahn, G. (2012), "Estimated Rules for Monetary Policy", *Economic Review*, Federal Reserve Bank of Kansas City, Fall5-29.

Killian, L. (2009), "Oil Price Shocks, Monetary Policy and Staglflation", in *Inflation in an Era of Relative Price Shocks*, edited by R. Fry, C. Jones and C. Kent (Sydney: Reserve Bank fo New Zealand), pp. 60-84.

Kozicki, S., and P.A. Tinsley (2009), "Perhaps the 1970s FOMC Did What it Said it Did", *Journal of Monetary Economics* 56: 842-855.

La Porta, R., F. Lopez-de-Silanes, and A. Schleifer (2008), "The Economic Consequences of Legal Origins", *Journal of Economic Literature* 46 (2): 285-332.

Levin, A., and J. Taylor (2013), "Falling Behind the Curve: A Positive Anlysis of Stop-Start Monetary Policies and the Great Inflation", in M.D. Bordo and A. Orphanides (Eds.), *The Great Inflation: The Modern Rebirth of Central Banking* (Chicago: University of Chicago Press).

Mauro, P., R. Romeu, A. Binder, and A. Zaman (2013), "A Modern History of Fiscal Prudence and Profligacy", IMF working paper 13/05, January.

Meltzer, Allan (2001), *A History of the Federal Reserve, Volume 1: 1913-1951* (Chicago: University of Chicago Press).

Mishkin, F. (2007), "Estimating Potential Output", speech given at the Conference on Price Measurement for Monetary Policy, Federal Reserve Bank of Dallas, Dallas, Texas, available from http://www.c.federalreserve.gov/newsevents/speech/mishkin20070524a.htm.

Mishkin, F. (2005), "The Inflation Targeting Debate", John Kusczcak Memorial Lecture, Bank of Canada, May.

Orphanides, A. (2003), "The Quest for Prosperity without Inflation." *Journal of Monetary Economics*, 50(3), 633-663.

Orphanides, A. and S. van Norden (2002), "The Unreliability of Output Gap Estimates in Real-Time", *Review of Economics and Statistics* 84 (November): 569-583.

Orphanides, A. and J. Williams (2011), "Monetary Policy Mistakes and the Evolution of Inflation Expectations", working paper, June.

Parkin, M. (2012), "Central Bank Laws and Monetary Policy Outcomes: A Three Decade Perspective", available from http://ideas.repec.org/p/uwo/epuwoc/20131.html.

Perron, P. (1989), "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis", *Econometrica* 57 (November): 1361-1401.

Pesaran, Hashem, T. Schurmann, and S.M. Weiner (2004), "Modelling Regional Interdependencies Using a Global Error-Correcting Macroeconometric Model", *Journal of Business and Economic Statistics* 22: 129-162.

Powell, J. (2009), *The Bank of Canada of James Elliot Coyne* (Montreal and Kingston: McGill-Queen's University Press).

Reinhart, C., and K. Rogoff (2013), "Shifting Mandates: The Federal Reserve's First Centennial", *American Economic Review Papers and Proceedings* 103 (May): 48-54.

Romer, C. (2013), "Comments", in M.D. Bordo and A. Orhanides (Eds), *The Great Inflation: The Modern Rebirth of Central Banking* (Chicago: University of Chicago Press).

Rudebusch, G. (2006), "Monetary Policy Inertia: Fact or Fiction?" *International Journal of Central Banking*, December, pp. 85-135.

Rudebusch, G. (2002), "Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia", *Journal of Monetary Economics* 49 (September): 1161-1187.

Sack, B., and V. Wieland (2000), "Interest-Rate Smoothing and Optimal Monetary Policy: A Review of Recent Empirical Evidence", *Journal of Economics and Business* 52 (January-April): 205-228.

Siklos, P.L., and C.W.J. Granger (1997), "Regime-Sensitive Cointegration with an Application to Interest-Rate Parity", *Macroeconomic Dynamics* 1: 640-657.

Siklos, P.L. (2002), *The Changing Face of Central Banking* (Cambridge: Cambridge University Press).

Siklos, P.L. (2003), "Assessing the Impact of Changes in Transparency and Accountability at the Bank of Canada", *Canadian Public Policy* 29 (September): 279-299.

Siklos, Pierre (2008), "No Single Definition of Central Bank Independence is Right for All Countries", *European Journal of Political Economy* 24: 802-816.

Siklos, Pierre (2010), "Revisiting the Coyne Affair: A Singular Event that Changed the Course of Canadian Monetary History", *Canadian Journal of Economics* 43 (3): 994-1015.

Siklos, P. (2014), "Communications Challenges for Multi-Tasking Central Banks: Evidence and Implications", *International Finance* (forthcoming).

Silber, W.L. (2012), *Volcker* (New York: Bloomsbury Press).

Stock, J.H.. and M.W. Watson (2007), "Why Has US Inflation Become Harder to Forecast?", *Journal of Money, Credit and Banking* (February).

Stock, J., and M. Yogo (2005), "Testing for Weak Instruments in Linear IV Regressions", in *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, D.W.K. Andrews and J.H. Stock, Eds. (Cambridge: Cambridge University Press).

Taylor, J. (1998), "A Historical Analysis of Monetary Policy Rules", in J. Taylor (Ed.), *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 314-341.

Taylor, J. (1993), "Discretion versus Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy*, vol. 39, December, pp. 195-214.

Waller, C. (2011), “Independence and Accountability: Why the Fed is a Well-Designed Central Bank”, *Review* of the Federal Reserve Bank of St. Louis (Sept/Oct): 293-301.

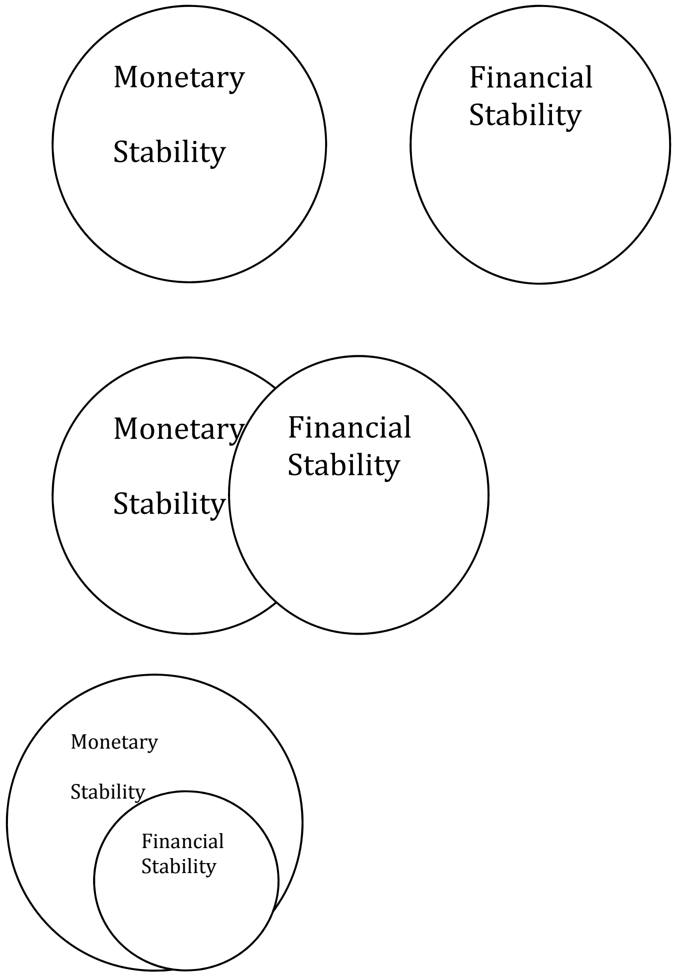
Woodford, M. (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton: Princeton University Press.

**Table 1 The Origins of Central Banks**

| Year | Country | Name | Motivation |
|---|---|---|---|
| 1668 | Sweden | Bank of the Estates of the Realm. Forerunner of the Riksbank | Finance war |
| 1694 | UK | Bank of England | Finance war |
| 1800 | France | Banque de France | Manage public debt, generate seignorage |
| 1816 | Norway | Bank of Norway | Economic crisis in Denmark prompts monetary reform |
| 1876 | Germany | Reichsbank. Forerunner of Bundesbank | Consolidation of previous note issuing authorities following unification |
| 1882 | Japan | Bank of Japan | Part of modernization of Meiji regime |
| 1893 | Italy | Banca d'Italia | Consolidation of previous note issuing authorities following unification |
| 1907 | Switzerland | Swiss National Bank | Elimination of note issuing competition |
| 1913 | USA | Federal Reserve System | Creation of lender of last resort and other banking related functions |
| 1925 | Chile | Central Bank of Chile | Monetary stability and management under a gold standard |
| 1925 | Mexico | Bank of Mexico | Creation of a single note issuing authority |
| 1934 | Canada | Bank of Canada | Lender of last resort |
| 1934 | New Zealand | Reserve Bank of New Zealand | Lender of last resort |
| 1935 | Argentina | Central Bank of Argentina | Replacement of a currency board and banking reforms |

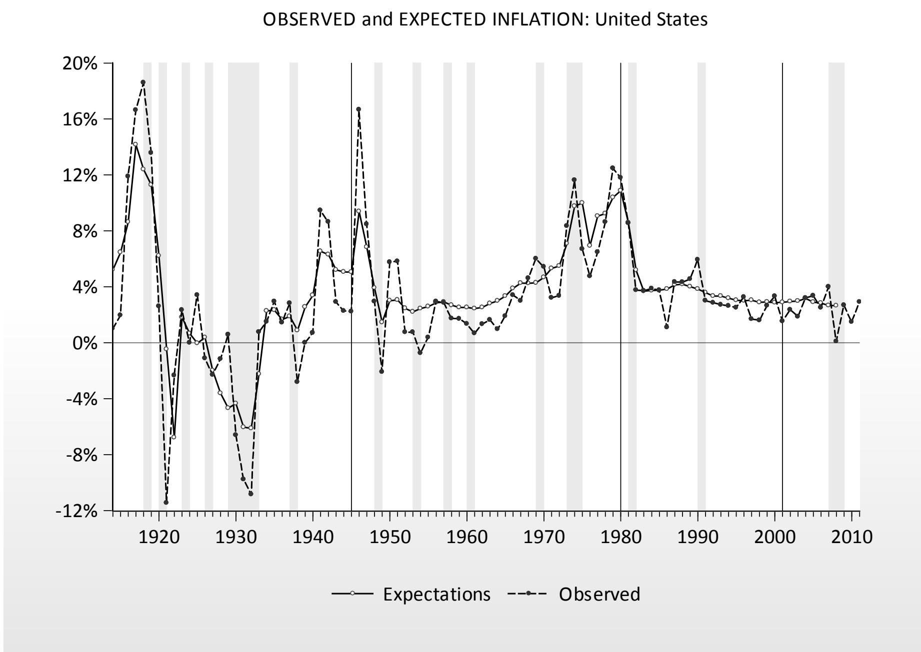
**Sources**: Siklos (2002) and updated from individual central bank websites accessible through the BIS's Central bank hub, http://www.bis.org/cbanks.htm.

**Figure 1 Mapping Central Bank Types**

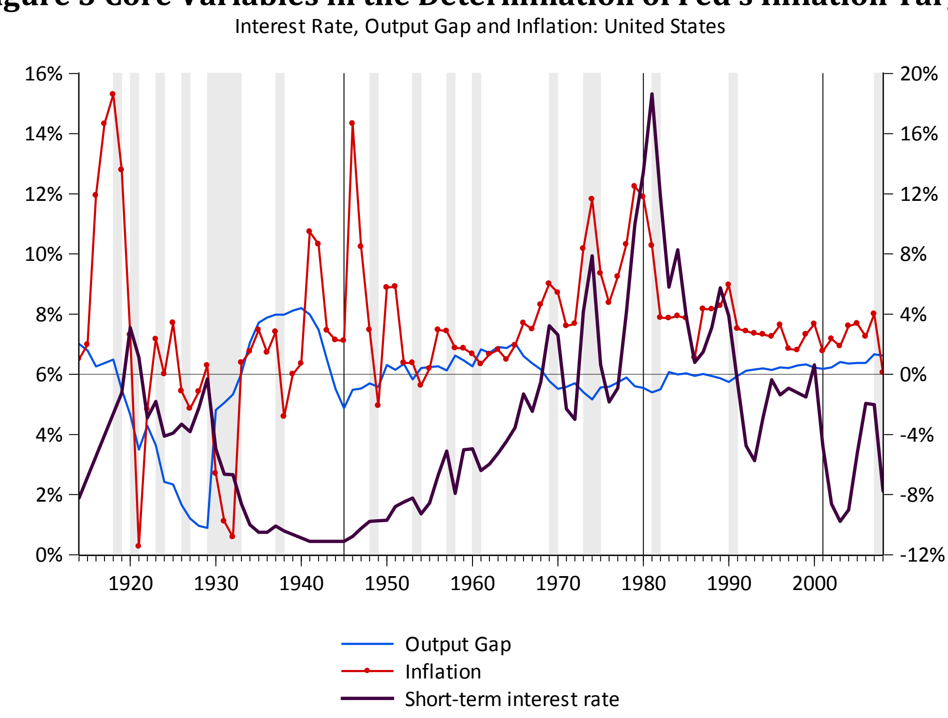



Note: The top diagram illustrates a central bank where the monetary and financial stability functions are separate, de jure or de facto. The middle figure shows a central bank where the two functions overlap with the size of the overlap possibly differing across central banks. Nevertheless, to some extent the functions continue to be separated. There could be institutional or other mechanisms built-in to ensure some coordination of the two functions. In the bottom diagram the financial stability is entirely subsumed in the monetary stability function. Note that while the former dominates, for historical reasons, there is the possibility that, in future, the roles could be reversed for a time.

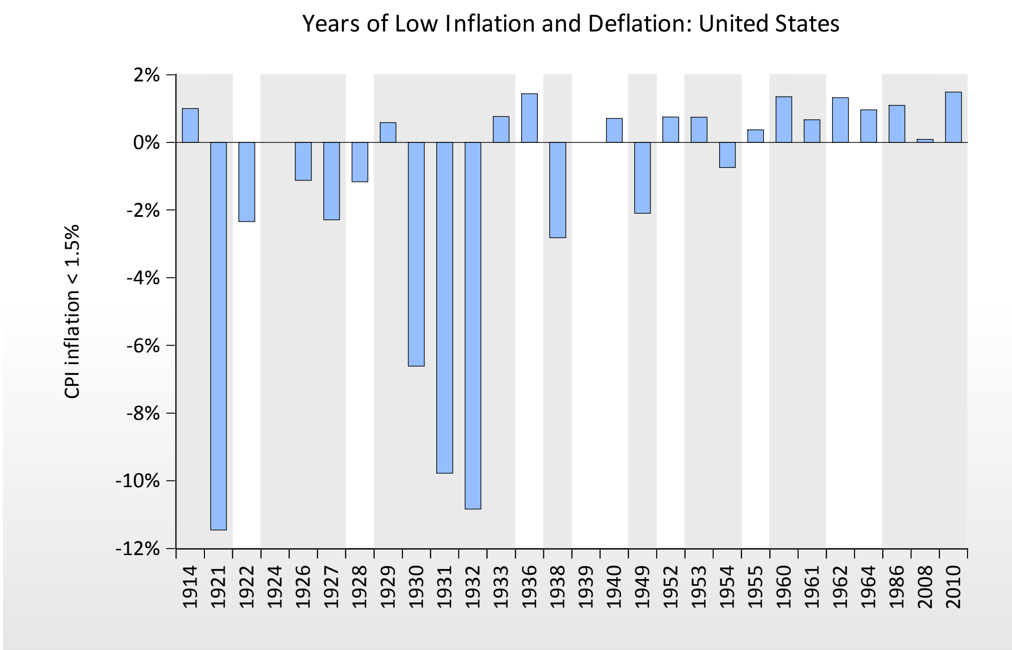
## Figure 2 Inflation and Expected Inflation in the U.S. Since the Fed's Creation



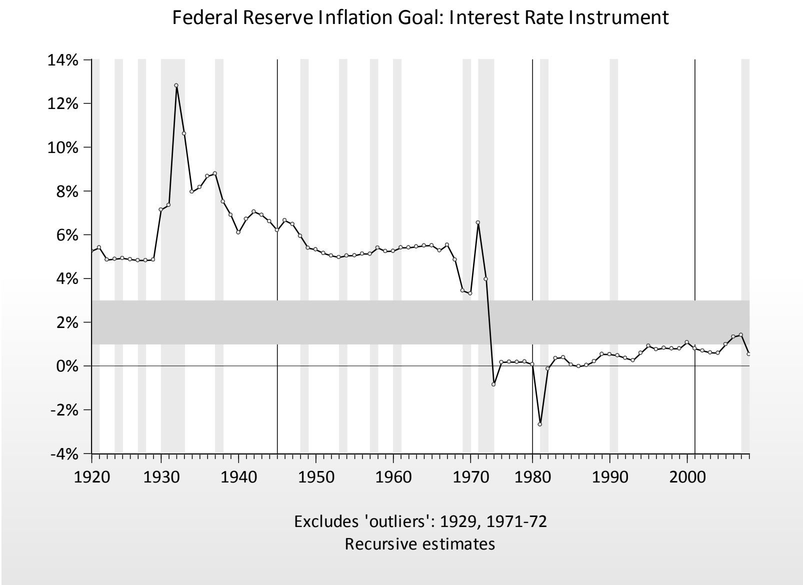

## Figure 3 Core Variables in the Determination of Fed's Inflation Target



## Figure 4 Low and Deflationary Periods in the U.S. Since the Fed's Creation



# Figure 5 The Fed's (Implicit) Inflation Goals: Interest Rate Versus Money Growth Instruments



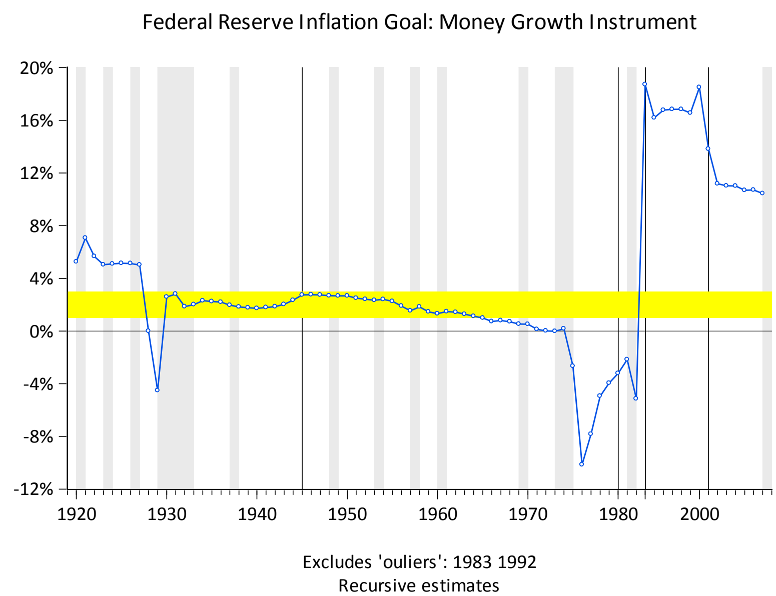
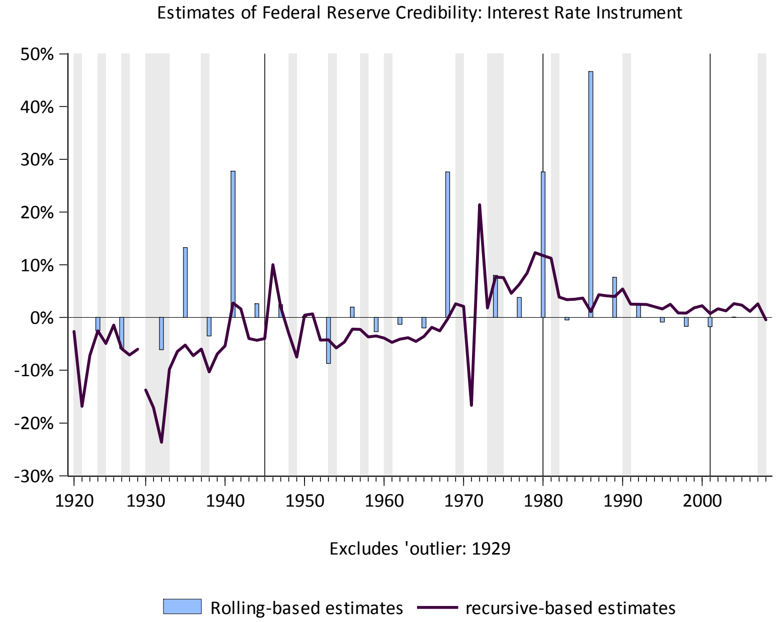



**Figure 6 The Fed's Credibility Over Time: Recursive and Rolling Estimates**



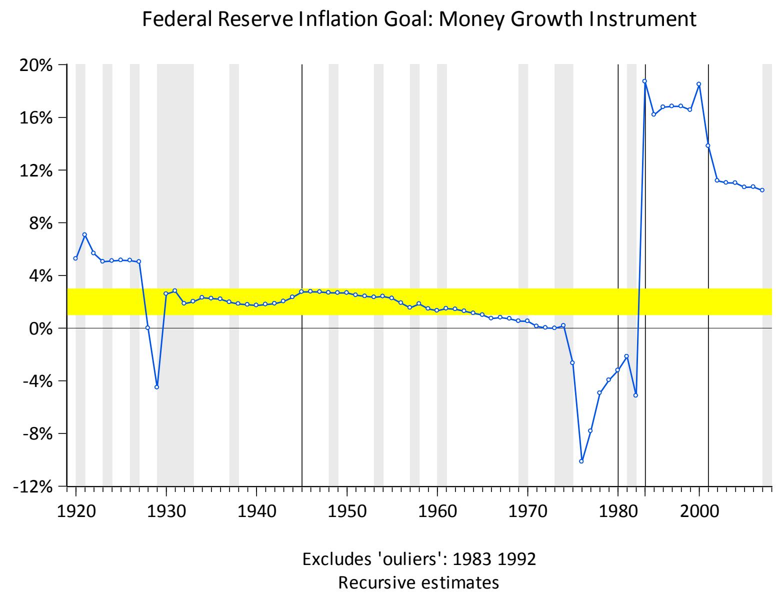
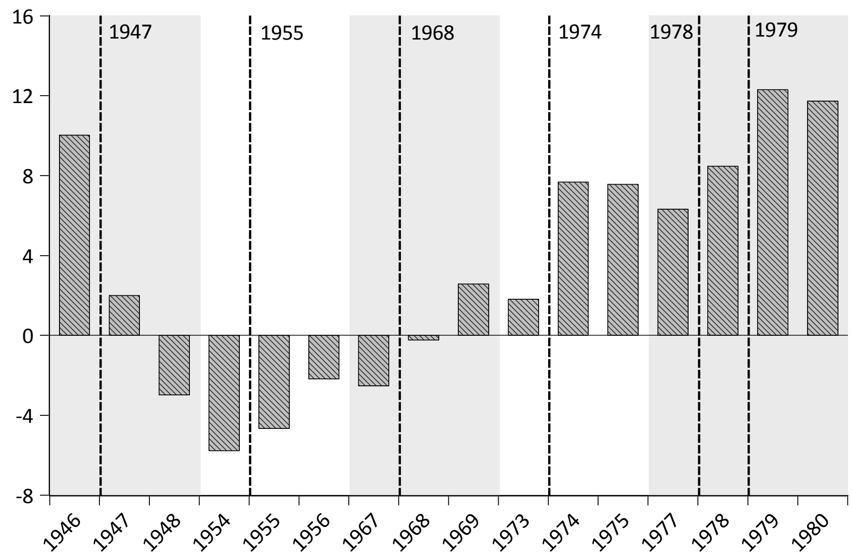
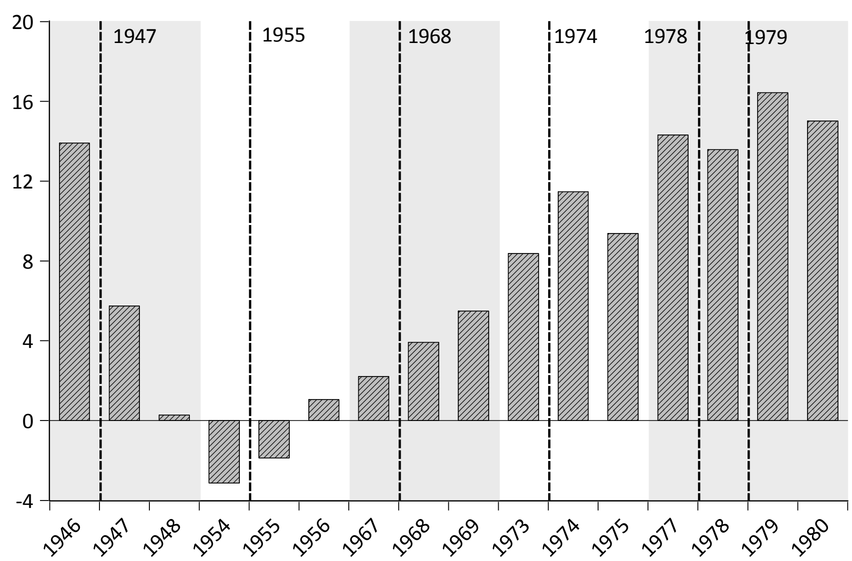



**Figure 7 Credibility and "Decisive" Episodes of Monetary Policy Tightening**

Interest Rate Instrument




Money Growth Instrument




Note: The vertical shaded areas have no particular significance.

**Table 1 Summary Statistics for the U.S.**

| Episodes | Inflation (s.e.) | Nominal interest rate (s.e.) | Output gap (s.e.) | AR estimate | MA estimate |
|---|---|---|---|---|---|
| 1914-1923 | 5.48 (9.44) | 4.85 (1.65) | -1.10 (2.66) | 0.64* | 0.44* |
| 1924-1932 | -3.09 (4.88) | 4.00 (1.01) | -6.52 (3.66) | 0.87* | -0.86* |
| 1933-1972 | 2.94 (3.44) | 2.38 (1.95) | 1.02 (1.73) | 0.29** | -0.79* |
| 1973-1981 | 8.82 (2.07) | 9.12 (3.44) | -0.92 (0.42) | 0.28 | 0.84* |
| 1982-2007 | 3.09 (1.10) | 5.70 (2.62) | 0.27 (0.48) | 0.16 | -0.92* |
| 1914-2007 | 3.24 (4.90) | 4.36 (3.04) | -0.32 (2.80) | 0.65* | 0.08 |

Significant at the 1% (*), and 5% (**) levels.

**Table 2 Mean Fed Inflation Objective**

| | Interest Rate Instrument | | Money Growth Instrument | |
|---|---|---|---|---|
| Episodes | Recursive (s.e.; T) | Rolling (s.e.; T) | Recursive (s.e.; T) | Rolling (s.e.; T) |
| 1914-1923 | -7.30 (6.73; 4) | NA | -7.96 (7.47; 4) | NA |
| 1924-1932 | -9.41 (6.83; 10) | -5.44 (0.94; 3) | -5.21 (5.60; 10) | 6.33 (18.71; 3) |
| 1933-1972 | -2.82 (5.85; 40) | 4.45 (1.44; 13) | 1.20 (3.49; 40) | -22.04 (75.42; 13) |
| 1973-1981 | 7.96 (3.47; 9) | 13.13 (12.71; 3) | 12.63 (12.80; 9] | 16.15 (6.14; 3) |
| 1982-2007 | 2.51 (1.23; 26) | 6.53 (16.50; 3) | -0.95 (24.09; 26) | 1.02 (7.59; 8) |
| 1914-2007 | -1.01 (6.77; 88) | 4.66 (12.77; 28) | 0.62 (14.19; 88) | -7.40 (52.76; 28) |

T= number of observations.

## Table 3 The Institutional Determinants of the Fed's Credibility: Interest Rate Versus Money Supply Growth Instruments

Dependent Variable: CREDIBILITY, interest rate instrument

Method: Least Squares

Sample: 1921 1928 1930 2008

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| Constant | -46.91 | 49.42 | -0.95 | 0.35 |
| *Loans to GDP ratio* | 2.45 | 1.38 | 1.77 | 0.08 |
| *McChesney MARTIN* | -5.33 | 28.84 | -0.18 | 0.85 |
| *BURNS & MILLER* | 20.61 | 31.53 | 0.65 | 0.52 |
| *GREENSPAN* | -48.97 | 25.58 | -1.91 | 0.06 |
| *CREDIBILITY (t-1)* | 0.46 | 0.14 | 3.42 | 0.00 |
| *Sovereign Debt Crisis*Debt to GDP ratio(t-1)* | -6.42 | 3.26 | -1.97 | 0.05 |
| *Stock market Crisis* | 23.52 | 20.60 | 1.14 | 0.26 |

| | |
|---|---|
| R-squared | 0.34 |
| Adjusted R-squared | 0.28 |
| S.E. of regression | 81.97 |
| Log likelihood | -461.80 |
| F-statistic | 5.32 |
| Prob(F-statistic) | 0.00 |

Dependent Variable: CREDIBILITY, Money Growth Instrument

Method: Least Squares

Sample: 1921 1952 1954 1967 1969 1990 1992 2007

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| *Constant* | -171.97 | 131.46 | -1.31 | 0.20 |
| *Loans to GDP ratio* | 7.89 | 3.79 | 2.08 | 0.04 |
| *CREDIBILITY (t-1)* | 0.19 | 0.06 | 3.53 | 0.00 |
| *Sovereign Debt Crisis*Debt to GDP ratio* | -0.08 | 8.04 | -0.01 | 0.99 |
| *Money Growth (t-1)* | 9.31 | 7.13 | 1.31 | 0.20 |

| | |
|---|---|
| R-squared | 0.21 |
| Adjusted R-squared | 0.17 |
| S.E. of regression | 273.00 |
| Log likelihood | -538.60 |
| F-statistic | 4.88 |
| Prob(F-statistic) | 0.002 |

## Table 4(i) Asymmetry in the Fed's Credibility: Interest Rate Instrument

Dependent Variable: CREDIBILITY, interest rate instrument
Method: Least Squares
Sample: 1914 1928 1930 2008 IF CREDIBILITY>0
Included observations: 40

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| *Constant* | 17.15 | 3.29 | 5.21 | 0.00 |
| *Loans to GDP ratio* | -0.09 | 0.08 | -1.15 | 0.26 |
| *CREDIBILTY (t-1)* | -0.39 | 0.10 | -3.99 | 0.00 |
| *Debt to GDP ratio (t-1)* | -0.19 | 0.03 | -5.70 | 0.00 |
| *Stock Market Crisis* | 2.32 | 1.10 | 2.11 | 0.04 |
| R-squared | 0.57 | | | |
| Adjusted R-squared | 0.52 | | | |
| S.E. of regression | 2.87 | | | |
| Log likelihood | -96.21 | | | |
| F-statistic | 11.47 | | | |
| Prob(F-statistic) | 0.00 | | | |

Dependent Variable: CREDIBILITY, interest rate instrument
Method: Least Squares
Sample: 1914 1928 1930 2008 IF CREDIBILITY<0
Included observations: 40

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| *Constant* | -4.71 | 5.64 | -0.83 | 0.41 |
| *Loans to GDP ratio* | -0.07 | 0.11 | -0.58 | 0.56 |
| *CREDIBILITY (t-1)* | 0.26 | 0.15 | 1.75 | 0.09 |
| *Debt to GDP ratio (t-1)* | 0.06 | 0.06 | 1.00 | 0.32 |
| *Stock market Crisis* | -2.89 | 1.52 | -1.90 | 0.07 |
| R-squared | 0.35 | | | |
| Adjusted R-squared | 0.28 | | | |
| S.E. of regression | 4.25 | | | |
| Log likelihood | -111.93 | | | |
| F-statistic | 4.73 | | | |
| Prob(F-statistic) | 0.00 | | | |

## Table 4(ii) Asymmetry in the Fed's Credibility: Money Growth Instrument

Dependent Variable: CREDIBILITY, money growth instrument
Method: Least Squares
Sample: 1921 1952 1954 1967 1969 1990 1992 2008 IF CREDIBILITY>0
Included observations: 36

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| *C* | -43.71 | 15.88 | -2.75 | 0.01 |
| *100*USA_LOANSGDP* | 1.27 | 0.41 | 3.11 | 0.00 |
| *CREDIBLE_17(-1)* | 0.50 | 0.15 | 3.38 | 0.00 |
| *USA_DTOY(-1)* | 0.28 | 0.12 | 2.41 | 0.02 |
| *USA_CRISISRR4* | -0.73 | 2.01 | -0.36 | 0.72 |
| R-squared | 0.77 | | | |
| Adjusted R-squared | 0.73 | | | |
| S.E. of regression | 5.90 | | | |
| Log likelihood | -112.27 | | | |
| F-statistic | 25.24 | | | |
| Prob(F-statistic) | 0.00 | | | |

Dependent Variable: CREDIBILITY, money growth instrument
Method: Least Squares
Sample: 1921 1952 1954 1967 1969 1990 1992 2008 IF CREDIBILITY<0
Included observations: 41

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| *C* | 10.82 | 3.92 | 2.76 | 0.01 |
| *100*USA_LOANSGDP* | -0.30 | 0.08 | -3.68 | 0.00 |
| *CREDIBLE_17(-1)* | 0.256839 | 0.06 | 4.25 | 0.00 |
| *USA_DTOY(-1)* | -0.11 | 0.04 | -2.78 | 0.01 |
| *USA_CRISISRR4* | -3.23 | 1.49 | -2.17 | 0.04 |
| R-squared | 0.62 | | | |
| Adjusted R-squared | 0.58 | | | |
| S.E. of regression | 3.93 | | | |
| Log likelihood | -111.62 | | | |
| F-statistic | 14.97 | | | |
| Prob(F-statistic) | 0.00 | | | |