Monetary policy, imperfect information and the expectations channel

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Sommaire

Résumé

Cette thèse explore les implications de la compétence et de la communication pour la politique monétaire, dans un contexte d'information imparfaite. Nous considérons la banque centrale comme le point d'ancrage des anticipations privées non plus grâce à son engagement envers une faible inflation, mais grâce à sa compétence, c'est-à-dire sa capacité à correctement prévoir les futurs états de l'économie. L'objectif de cette analyse est d'évaluer si la compétence de la banque centrale permet d'influencer les anticipations des agents privés et si cette influence permet de relâcher les contraintes pesant sur la politique monétaire pour atteindre ses objectifs macroéconomiques.

Le premier chapitre procède à une revue empirique de l'abondante littérature traitant de la performance de prévision relative de la Réserve Fédérale, une banque centrale qui ne publie ses prévisions qu'après un délai de 5 ans, et dont les conclusions sont controversées. Nous confirmons que la Réserve Fédérale a une meilleure performance de prévision de l'inflation mais pas du PIB réel, que plus l'horizon de prévisions est long, plus l'avantage est prononcé et enfin que cette supériorité semble se réduire, tout en restant significative, dans la période récente où la Reserve Fédérale a accru sa transparence. Il apparait que cette supériorité pourrait provenir d'une meilleure information sur les chocs futurs plutôt que d'un meilleur modèle de l'économie.

Le deuxième chapitre se concentre sur des banques centrales qui publient leurs prévisions en temps réel, ce qui permet de mettre en valeur le canal des anticipations de la politique monétaire et la question de la crédibilité à travers le lien entre performance de prévision relative et influence des banques centrales. Nous proposons de définir la crédibilité endogène comme la capacité d'influence provenant d'une meilleure performance de prévision, en opposition avec la crédibilité exogène pour laquelle les banques centrales n'auraient pas besoin de meilleure prévision pour être influentes. Nous trouvons qu'une banque centrale sur cinq, en Suède, a de meilleures prévisions que les agents privés et que trois banques centrales sur cinq, en Suède, Royaume-Uni et Japon, influencent les agents privés. La banque centrale de Suède semble donc bénéficier d'une crédibilité endogène, alors que celles du Royaume-Uni et Japon d'une crédibilité exogène.

Le troisième chapitre examine les implications théoriques de l'influence endogène pour les décisions de politique monétaire, à travers un modèle Néo-Keynésien avec apprentissage adaptatif (i.e. des anticipations non-rationnelles) dans lequel nous avons simultanément une hétérogénéité des prévisions, une asymétrie d'information et une influence de la banque centrale. Nous montrons que la banque centrale doit seulement respecter le principe de Taylor et ne doit pas être plus restrictive pour assurer la stabilité macroéconomique, en opposition avec la situation d'influence exogène (quand la banque centrale est influente grâce à sa crédibilité concernant son *type* et sa position de leader plutôt que grâce à de meilleures prévisions).

Le quatrième chapitre évalue les préférences de trois banques centrales qui ont adopté le ciblage d'inflation et communiquent leur prévisions en temps réel. Le deuxième chapitre a montré que la banque centrale du Canada n'a pas de crédibilité lié à l'influence, tandis que celle du Royaume-Uni a une crédibilité exogène et celle de Suède une crédibilité endogène. Nous testons ici l'hypothèse que le ciblage d'inflation donne lieu à une réponse à l'inflation plus forte de la politique monétaire. Nous utilisons trois méthodes complémentaires qui montrent que cette hypothèse n'est pas vérifiée. Il apparait en outre que les preuves les plus significatives en faveur d'une réponse à l'inflation plus faible sont à mettre au crédit de la banque centrale de Suède, confirmant ainsi le résultat théorique du troisième chapitre.

Abstract

This thesis explores the implications of competence and communication for monetary policymaking in a context of imperfect information. It considers the central bank as the coordinator of expectations because of its competence rather than its commitment *à la* Barro-Gordon. By competence, we mean the ability to correctly forecast the future state of the economy. The objective has been to assess whether competence together with communication enables influence, and whether central bank influence of private expectations enables to loose monetary policy constraints to reach its macroeconomic objectives.

Chapter 1 proceeds to an empirical review of the vast literature dealing with the relative forecasting performance of the Federal Reserve, a central bank which publishes its forecasts with a 5-year lag, and for which evidence is mixed. We assess this question by confronting the different methods, data and samples used previously that lead to opposite results and obtain unambiguous results. We confirm that the Fed has a superior forecasting performance on inflation but not on real GNP/GDP. In addition, we show that the longer the horizon, the more pronounced the advantage of Fed on inflation and that this superiority seems to decrease but remains prominent in the more recent period when the Fed has increased its transparency. It appears that this superiority may stem from better information about future shocks rather than a better model of the economy.

Chapter 2 focuses on central banks which publish their forecasts in real-time what allows for emphasizing the expectations channel of monetary policy and the question of credibility through the link between relative forecasting performance and influence of central banks. We propose to define endogenous credibility as the capacity to influence arising from a superior forecasting performance, in opposition to exogenous credibility for which central banks need not a forecasting advantage to be influential. We find that one out of five central banks, in Sweden, has a superior forecasting performance over private agents, and that three out of five central banks, in Sweden, the UK and Japan, influence private agents, while there is no evidence of influence of private agents on central banks. Sweden therefore seems to experience endogenous credibility and the UK and Japan exogenous credibility.

Chapter 3 investigates the theoretical implications of endogenous influence for monetary policymaking through a New-Keynesian economy with adaptive learning (i.e. non rational expectations) in which there are simultaneously heterogeneity of forecasts, information asymmetry and influence of the central bank. We find that the central bank must only respect the Taylor principle and need not be more restrictive to ensure macroeconomic stability, in contrast to exogenous influence (when central banks are influential due to their *type* credibility and leader position rather than because of a better forecasting record).

Chapter 4 assesses the monetary policy preferences of three central banks which have adopted the inflation targeting framework and therefore communicate their forecasts in real-time. Chapter 2 thus showed Canada does not experience *influence* credibility, while the UK has exogenous credibility and Sweden endogenous credibility. We test the hypothesis that inflation targeting has constituted a switch towards a greater focus on inflation as conventional wisdom suggests. We use three complementary methods: a structural break analysis, time-varying parameters and Markov-Switching VAR and show that inflation targeting has not led to a stronger response to inflation. It appears that the most significant evidence of a change in the direction of a lower response to inflation has to be credited to Sweden, confirming the theoretical outcome of the third chapter.

General Introduction

1. From rational expectations to the expectations channel

The effects and the role of monetary policy have received a great deal of attention in the economics literature. While there is a wide consensus on the long-run neutrality of money and the medium- and short-run real effects of monetary policy, the debate has moved on the policies and strategies the central bank may implement to make monetary policymaking more effective. The long-run money neutrality follows the simple mechanism of classical economics according to which money has only nominal effects (on prices and wages). Two kinds of imperfections have been put forward to explain that private agents do not react immediately to money variations and enable real effects of monetary policy.

The first type of imperfections is related to price stickiness and the slow adjustment and coordination of prices after variations of money. The real effects of monetary policy stem from private agents' inability to adjust their prices in every period as put forward by Rotemberg (1982), Calvo (1983) and Blanchard and Kiyotaki (1987). These models then capture through the slow adjustment of prices the long lasting effects of monetary variations. However, the prediction of the sticky-price models lack empirical support and fail to explain the time elapsed between monetary variations and their maximal impact on prices.

A second type of imperfections concerns incomplete information on which private agents base their decisions and actions. Phelps (1970) and Lucas (1972) show that the real effects of monetary policy may be derived from imperfect information on prices set on different markets. In the long-run, when private agents gather enough information, the real effects disappear. Because these models suppose that the monetary variations become common knowledge in the following period after they occurred, they do not account for the persistence of the effects of monetary variations.

One implication of these incomplete information models is that central bank must surprise private agents to obtain short-run real effects of its monetary decisions. Indeed, since the work of Muth (1961), Lucas (1972), Sargent (1973) and Barro (1976), most of macroeconomic models have been developed and fashioned with the rational expectations hypothesis as the benchmark model of expectations formation. Thus, to make stabilization possible, the central bank must create some inflation surprise to cheat on private expectations. There are two different readings of rational expectations. The first is statistical and implies that, when agents have to make forecasts, errors are unpredictable because it supposes that both private agents' and policymakers' expectations are equal to the true statistical conditional expectations of the unknown random variables. In other words, in order that expectations are rational, they cannot be systematically or persistently wrong. Expectations errors have then to be equaled to zero on average. It also means that agents take into account all available information. The second reading is more economic and implicitly assumes that agents, to form their expectations, have knowledge of the correct form of the model of the economy, knowledge of all parameters, and knowledge that other agents are rational, as well as the knowledge that other agents know that other agents are rational, etc. (the higher-order expectations mechanism). It therefore assumes that agents form their expectations consistently with the functioning of the model.

Many authors have soon criticized the unreasonably strong assumptions of rational expectations. The hypotheses of perfect knowledge and individual rationality lead to the disappearance of private agents' learning process and suppose a null adaptation delay and an infinite adjustment speed. Fitoussi (1984) questioned how these restrictions may confer to this theory some realistic foundations (see also Frydman and Phelps (1983), Zarnowitz (1985), Haltiwanger and Waldman (1985) and Fitoussi and Velupillai (1987)). Although the assumption of rational expectations is still frequently used in model construction, its empirical relevance is doubtful. Under this hypothesis, all agents have the same expectations, and there are no disagreements. This is easily rejected when looking at forecast survey data, where forecasts' dispersion appears to be particularly substantial. Moreover, inflation expectations seem to depend significantly on past and present values of inflation (see e.g. Estrella and Fuhrer (1999)). Last, Arrow (1986) explained the limits of the hypothesis of higher-order beliefs of rationality while Cornand and Heinemann (2010) recently showed, through an experimental analysis, that the assumption on the formation of higher order expectations, the iterative process of second-guessing each others' expectations, should be reconsidered. Sargent (1993), Rudd and Whelan (2006), Andrade and Le Bihan (2009), Capistran and Timmermann (2009) and Dovern, Fritsche and Slacalek (2009), among other works, reconsider the empirical realism of rational expectations.

The lack of empirical support for rational expectations and new developments in imperfect common knowledge theory have led to a revival of imperfect information models. This new class of models is based on two assumptions which create persistence and uncertainty. First, monopolistic competition makes prices strategic complements and decisions then depend on the decisions of others. It enables higher-order expectations to play a role at the aggregate level. Second, monetary variations do not become common knowledge in the period following the shock, what magnifies the effect of higher-order expectations. Indeed, under imperfect common knowledge, higher-order expectations will be slower to adjust and create uncertainty that makes real effects of monetary policy possible.

It appears that both types of imperfections, sticky prices and imperfect information, make money non neutral, while the new class of imperfect information models explain the long-lasting and gradual real effects of monetary policy. It then emerges a trade-off between inflation and output, and a potential inflationary bias of central banks. Kydland and Prescott (1977) derived the implications of this bias and show that the central bank attempt to achieve a low inflation rate may not be time consistent. If private agents expect low inflation, the central bank would face an incentive to set its policy at a higher inflation rate. Believing the policymaker will respond to this incentive, private agents correctly anticipate a higher inflation rate. Barro and Gordon (1983) have analyzed this inflationary bias and credibility aspects associated with rules and discretion. The most widespread solution to this inflationary bias in the literature has been to increase the independence and transparency of central banks. Independence prevents from political pressures, which would favor discretion, and greater transparency is commonly viewed as an important means for achieving accountability and efficiency. It ensures private agents can hold policymakers accountable for their decisions. Globally, independence enables accountability, and accountability requires transparency as Backus and Driffill (1985), Rogoff (1985) and Rogoff (1989) show. Geraats (2002) surveys the literature on the benefits of transparency.

At the same time, increased transparency and public information help making money neutral due to information symmetry between the central bank and private agents (and in absence of other frictions as sticky prices). Canzoneri (1985), Cukierman and Meltzer (1986) and Faust and Svensson (2002) have shown, among others, that central bank transparency

would render monetary policy powerless. In order for monetary policy to have some role in stabilizing the economy, there must be one of the frictions highlighted previously that breaks this neutrality result. Removing imperfect information through transparency would leave the central bank unable to cushion the economy from macroeconomic shocks, a cost emphasized by Cukierman (2001) and would make stabilization impossible. Cornand and Heinemann (2008) show it may be advantageous for the central bank to make partial announcements if complete announcements intensify inflation variability. The optimal degree of partial announcement depends on the relative weight the central bank places on inflation and output gap objectives. In the first class of imperfect information models, less transparency makes monetary policy effective, but leads to suboptimal situation.

In the new class of imperfect information models, when considering a more realistic assumption as imperfect common knowledge, less transparency may improve welfare (cf. *infra*). Communication strategies therefore play a crucial role in the characterization of the optimal conduct of monetary policy. In this thesis, we abstract from the debate in a time-inconsistency framework about transparency as a mean to achieve credibility *à la* Barro-Gordon, and focus on credible central banks, without inflationary bias, which may use transparency and communication as a tool to improve monetary policy effectiveness. This specific focus is supported by the fact that the majority of central banks benefit today from a high degree of credibility. Once abstracting from credibility issues *à la* Barro-Gordon, transparency effects can be divided in two groups. On one side, communication can be analyzed from the point of view of the welfare effect of overreaction to public information, with a focus on coordination and informative value of prices. On the other side, communication can serve the management of expectations.

First, transparency may affect welfare through overreaction of private agents to public information. Since public information is more informative about private expectations than private information as it is common knowledge, it receives a disproportionate weight relative to its precision and may destabilize the economy. The outcome of this debate depends on the social value of coordination compared to the destabilizing effect of transparency. Morris and Shin (2002) foster the latter in their seminal work, while Hellwig (2005) suppose coordination is always beneficial and therefore find that transparency is always welfare improving. Another mechanism of overreaction of private agents goes through the hypothesis that markets are informatively efficient and prices aggregate all relevant information and enable the coordination of private agents (see Angeletos and Pavan (2007)). When central banks publish public information, they decrease the informative value of prices because private agents react too much to this particular information set. This distortion in the informative content of prices creates a trade-off for central banks between releasing information and observing information about the state of the economy for their future monetary policy decisions.

Second, the management of expectations has become one important tool of monetary policy in an uncertainty context, all the more so that transparency increases the ability of central bank to shape private expectations through overreaction of private agents to public information. There has therefore been a strong recent theoretical interest for expectations formation related to information issues. Thus, Mankiw and Reis (2002, 2007) introduce information stickiness, Sims (1998, 2003) and Woodford (2003) focus on rational inattention through private agents' limited capacity for processing information, Hansen and Sargent (2003) set up information frictions where agents seek robust decisions, Guesnerie (2005, 2008) proposes an "eductive" learning approach and Evans and Honkapohja (2001, 2003) study the effects of adaptive learning where private agents are econometricians. All these researches

examine how expectations can be modeled when enriching the rational expectations hypothesis and propose different operational procedure of expectations formation. Indeed, the expectations channel of monetary policy has taken more and more importance in the analysis of the most recent macroeconomic models. In the forward-looking new Keynesian model in which expectations are endogenous, the effectiveness of monetary policy depends on the policy's ability to affect private expectations. King (2005) summarizes that "because inflation expectations matter to the behavior of the households and firms, the critical aspect of monetary policy is how decisions of the central bank affect those expectations." The formation of inflation expectations thus plays a large role in the success of monetary policy. Because prices and wages cannot be readjusted continuously, anchoring inflation expectations at a low and stable level is essential to reach price stability. With the assumption of imperfect information, private agents could not correctly infer the future stance of policy from central bank's observed behavior and economic data. Imperfect information generates disagreements among forecasters, and central banks may through communication and transparency anchor private expectations, reduce volatility in the economy and thus achieve a better economic performance.

The management of expectations goes through two channels. The central bank may guide expectations by communicating either on its monetary instrument or on macroeconomic variables. In the first case, Woodford (2005) underlines that central bank transparency helps influencing private expectations of the short-term interest rate in order to influence long-term interest rates. Rudebusch and Williams (2006) put forward a related argument. Communication about the monetary instrument therefore increases monetary policy effectiveness. The reverse mechanism – opacity, through uncertainty of firms about the policy instrument, reduces the ability of monetary policy to stabilize inflation and could produce excess inflation – has been developed by Baeriswyl and Cornand (2010). This is empirically confirmed by Demilrap and Jorda (2002) for US and Cecchetti and Hakkio (2009) for inflation targeting central banks. On the other side, the central bank may communicate on future states of the economy, that is to say on future shocks and its macroeconomic projections. The effects of central bank macroeconomic communication have been mostly studied through the lens of the coordination of private agents and little with an eye to the quality of information released. Walsh (2007) shows that publication of output forecasts may reduce welfare if the central bank has poor information. Yet, this line of research has not much been explored.

In the present thesis, we abstract from the coordination effects of releasing public information, and focus on the quality of this public information released (the central bank's competence, i.e. its ability to correctly forecast the future states of the economy), its effects on private expectations through communication (the central bank ability to influence expectations) and their effects on the conduct of monetary policy.

2. Central bank's competence

This research project fits to a situation of imperfect information in which the hypothesis of rational expectations is reconsidered for both the central bank and private agents. The main goal is to assess the effects of the interaction of competence and communication of central banks, credible *à la* Barro-Gordon (without inflationary bias), in order to emphasize the relevance of central bank influence for the conduct of monetary policy. Since communication seems to be a key determinant of monetary policy effectiveness in a context where information is imperfect and therefore essential to transmission mechanisms of real effects of monetary policy, we analyze how competence through

influence may impact the conduct of monetary policy. The intuition, in contrast with the first class of imperfect information model in which the central bank must act by *surprise*, is that competence enables the central bank to *guide* private expectations. This influence would enable the central bank to manage the trade-off between conflicting goals in a way that would make stabilization possible. Despite the potential important policy implications, competence and influence issues and their consequence for the optimal conduct of monetary policy have not much been explored.

In the last decades, communication and transparency have become the new standards of central banking. They have first been derived from the implications of rational expectations and are used by central banks to signal themselves as credible à la Barro-Gordon in the sense that they commit to a low and stable inflation without attempting to cheat on private agents. Communication (through accountability) is used to reach commitment credibility. Second, under the hypotheses of imperfect information and imperfect common knowledge, the rationale for communication has been to help coordination between private agents and to anchor inflation expectations at a low and stable level by reducing their dispersion.

This thesis explores another direction and considers a credible central bank, without inflationary bias, as coordinator of private expectations because of its competence. By competence, we mean the ability to correctly forecast the future states of the economy. The central point is therefore to assess whether competence (together with communication) increase the ability of central banks to *influence* private expectations and whether central bank influence of private expectations enables to loose monetary policy constraints to reach stabilizing policies.

We introduce the concept of *endogenous credibility* to characterize central banks that publish their forecasts in real-time and have a superior forecasting performance than private agents, and whose forecasts influence private forecasts because of their superior accuracy. In contrast, an *exogenous credible* central bank publishes in real-time forecasts of similar accuracy than those of private agents, but is still able to influence private forecasts because of private agents' inference of central bank future intentions from publication of central bank forecasts (see Geraats 2005 or Woodford 2005) and/or because of the inherent position of leader of central banks in the monetary environment in which they are a focal point for private agents (see Phelps (1983), Wilson and Rhodes (1997) and Demertzis and Viegi (2008)). We therefore propose as an unexplored development of monetary policy to consider *credibility* issues due to central banks' competence rather than their commitment to low and stable inflation, and to assess the effects of this new characterization of central bank credibility on policymaking. Competence along with communication may act as a second instrument in addition to the short-term interest rate for monetary policy to influence private agents and reach its macroeconomic objectives. It provides a way to evade the Tinbergen (1952)'s constraint of one instrument for one objective.

3. Contributions

The first contributions are empirical and assess the relative competence in comparison with private agents of different central banks: the Federal Reserve, which publishes its forecasts after five years (in chapter 1) and a set of five communicating central banks which publish their forecasts in real-time (in chapter 2).

A second series of empirical contribution deals with the ability of the set of communicating central banks, through forecasts' communication, to influence private expectations (in chapter 2).

A conceptual contribution of this thesis (in chapter 2) is to define *endogenous credibility* for a central bank as the capacity to influence private expectations arising from a superior forecasting performance, in opposition to *exogenous credibility* for which central banks need not a forecasting advantage to be influential.

The last series of contribution is both theoretical and empirical. We first analyze the theoretical implications of endogenous credibility for the conduct of monetary policy (in chapter 3), and second assess the conduct (through the relative preferences) of monetary policy for some communicating central banks: without influence ability, exogenously credible and endogenously credible (in chapter 4).

4. Outline

Chapter 1 proposes to proceed to an empirical review of the vast literature dealing with the relative forecasting performance of the Federal Reserve, a central bank which publishes its forecasts with a 5-year lag, since the seminal paper of Romer and Romer (2000). As evidence is mixed, the contribution of this chapter is to identify the opposite results and their causes. We therefore assess this question by confronting the different methods, data and samples used previously and obtain unambiguous results. We use unconditional comparisons, conditional comparisons through regressions, in the spirit of Fair and Shiller (1989, 1990), a pooling method of forecasts, and a factor analysis and confirm that the Fed has a superior forecasting performance on inflation but not on real GNP/GDP. In addition, we show that the longer the horizon, the more pronounced the advantage of Fed on inflation and that this superiority seems to decrease but remains prominent in the more recent period when the Fed has increased its transparency. The second objective of this chapter is to underline the potential sources of this superiority. It appears that it may stem from better information rather than from a better model of the economy. A policy implication of this chapter is then to support investment of central banks in their forecasting ability and in gathering information about future states of the economy.

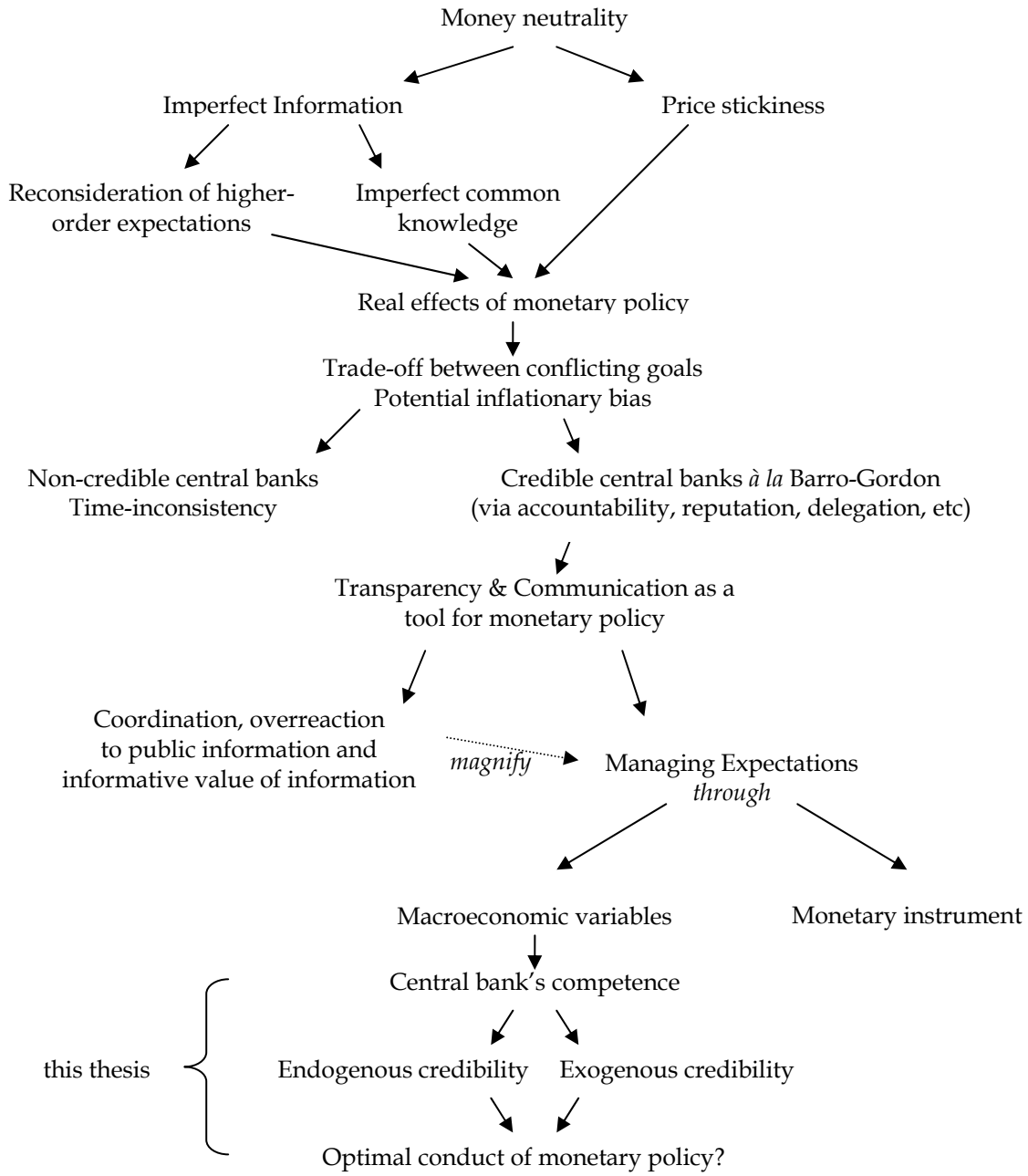
Chapter 2 focuses on central banks which publish their forecasts in real-time. This allows for emphasizing the expectations channel of monetary policy and the question of credibility through the link between relative forecasting performance and influence of central banks. We propose to define "endogenous credibility" as the capacity to influence arising from a superior forecasting performance, in opposition to exogenous credibility for which central banks need not a forecasting advantage to be influential. We find that one out of five central banks, in Sweden, has a superior forecasting performance over private agents. This reveals a puzzle as information is supposed to be symmetric since central banks' forecasts are available to private agents. It appears that the Riksbank benefits from a specific competence in gathering new private information between each forecast's release. A superior forecasting performance is therefore compatible with forecasts' communication. We then find that three out of five central banks, in Sweden, the UK and Japan, influence private agents, while there is no evidence of influence of private agents on central banks. Sweden therefore seems to experience endogenous credibility and the UK and Japan exogenous credibility. This chapter thus offers conceptual and empirical contributions and its main

policy implication is that communication of forecasts should be at the forefront of the central bank policies as it enables central banks to signal their commitment or competence.

Chapter 3 investigates the theoretical implications of endogenous influence for monetary policymaking through a New-Keynesian economy with adaptive learning (i.e. non rational expectations) in which there are simultaneously heterogeneity of forecasts, information asymmetry in favour of and influence of the central bank. The model, based on incomplete information and knowledge of households and firms, introduces adaptive learning for both private agents and the central bank. Central bank influence is considered as endogenous because the central bank has a better forecasting record than private agents and the latter are therefore naturally prone to follow central bank forecasts. We find that the central bank must only respect the Taylor principle and need not be more restrictive to ensure macroeconomic stability, in contrast to exogenous influence (when central banks are influential due to their *type* credibility and leader position rather than because of a better forecasting record) as studied by Muto (2008). This result calls for an increase of the *competence* credibility of central banks and reinforces the case for enhancing forecasting performance of central banks. The final objective is thus to attain endogenous influence in order to reach macroeconomic stability at a lower cost. In other words, a direct policy implication of this chapter is that when central banks are influential, they should invest enough resources in forecasting to guide private expectations.

Chapter 4 constitutes somewhat an empirical investigation of the theoretical outcome of the third chapter, when keeping in mind that the chapter 2 shows Canada does not experience *influence ability*, while the UK has *exogenous credibility* and Sweden *endogenous credibility*. These three countries have adopted inflation targeting in the nineties. This fourth chapter thus assesses the monetary policy preferences of these central banks which have adopted the inflation targeting framework and therefore communicate their forecasts in real-time. The literature on inflation targeting has up to now focused on its impact on macroeconomic performance or private expectations. We test the hypothesis that inflation targeting has constituted a switch towards a greater focus on inflation as conventional wisdom suggests. We use three complementary methods: a structural break analysis, time-varying parameters and Markov-Switching VAR which make possible to estimate linear or nonlinear, and forward or backward looking specifications, to account for heteroskedasticity and not to assume a date break. Our main result is that inflation targeting has not led to a stronger response to inflation. The inflation targeting *paradigm* (an inflation target at 2% would produce macroeconomic stability) should not be confounded with the inflation targeting *framework*. Beyond this common result, it appears that the most significant evidence of a change in the direction of a lower response to inflation has to be credited to Sweden, endogenously credible as shown in chapter 2.

Figure A: Positioning of this thesis in the monetary policy literature



Chapter I:
Revisiting the Federal Reserve's Superior Forecasting Performance*

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1. Introduction

In the seminal work of Lucas (1972) and Sargent and Wallace (1975, 1976), information issues impact monetary policy through the hypothesis of rational expectations. Recent macroeconomic models show monetary policy is affected by price stickiness (Rotember (1982), Calvo (1983), Dotsey, King and Wolman (1999)) which is justified among others mechanisms by a slow and imperfect information diffusion; by adaptive learning where private agents are econometricians (Evans and Honkapohja (2001, 2003), Honkaphoja and Mitra (2005) and Orphanides and Williams (2007)); by information frictions where agents seek robust decisions (Hansen and Sargent (2003)); by active learning where agents acquire information deliberately by choice but are subject to inattentiveness (Sims (1998, 2003), Woodford (2003), Reis (2006) and Adam (2007)); by noisy information of policymakers (Orphanides (2003), Aoki (2003, 2006), Svensson and Woodford (2002, 2003, 2004) and Swanson (2004)) and by information stickiness as shown by Mankiw and Reis (2002, 2007). In addition, another debate has focused on transparency and the relevance of information release to the public (Garfinkel and Oh (1995), Morris and Shin (2002)), underlining the potential crowding out effect of public information. These diverse lines of research have enlightened the importance of information issues in macroeconomic models. Furthermore, the expectations channel has taken more and more weight in monetary policymaking and its efficient use depends to some extent on the credibility of central bank expectations, therefore in part on the relative forecasting performance of the central bank.

In the US, the Federal Reserve has greatly improved transparency about its decisions with the release of the policymakers (Federal Open Market Committee or FOMC) forecasts, the statements and the minutes in the 90's, but still publishes its staff forecasts (so-called Greenbook forecasts) only after 5 years. Are Greenbook forecasts superior to private agents forecasts? If yes, what are the sources of this superior forecasting performance?

Romer and Romer (2000) show that Greenbook forecasts for inflation and output were superior to private sector forecasts[1]. This seminal paper has led many authors to assess the relative forecasting performance of the Federal Reserve and US private sector among which Peek, Rosengren and Tootell (1998, 2003), Joutz and Stekler (2000), Romer and Romer (2000), Atkeson and Ohanian (2001), Gavin and Mandal (2001), Sims (2002), Faust, Swanson and Wright (2004) and Amornthum (2006). Evidence however is mixed.

The first objective of this chapter is to identify the oppositions which conduct to conflicting conclusions, and to realize an empirical review, by gathering the different methods, data and samples used in the literature in order to obtain some clear-cut outcomes. The main oppositions are based on whether the Fed's forecasts are superior to private sector's, whether this advantage hold for inflation and GDP, whether this advantage has reduced in the recent period with the Fed's greater transparency or the drop in the predictable component of inflation as shown by Atkeson and Ohanian (2001) and Stock and Watson (2007).

This chapter uses a range of methods applied previously: unconditional comparisons, conditional comparisons through regressions, in the spirit of Fair and Shiller (1989, 1990), a pooling method of forecasts, and a factor analysis. These estimations are realized on an extended sample and with real-time and final data. An alternative measure of inflation is also tested. This work is different from the most recent papers on this topic (D'Agostino and Whelan (2008) and Gamber and Smith (2009)) in the extent that their focus is on the most

[1] Romer and Romer (2008) also show than Greenbook forecasts are superior to FOMC ones.

recent period, while the first contribution of this chapter is to proceed to an empirical investigation by identifying the opposite results and their causes in order to address the issue of the relative forecasting performance of the Fed and obtain unambiguous results.

The results are the following: first, the Fed has a superior forecasting performance on inflation but only on it. There is no evidence of any advantage for private forecasters or Fed on real GNP/GDP. These results confirm the conclusions of Gavin and Mandall (2001) and Sims (2002). Second, it comes that the longer the horizon, the more pronounced the advantage of Fed on inflation. This tends to confirm the advantage is sound and not due to access to information on the short run. This superiority is robust to timing disadvantage specification, introduction of lagged dependent variable, multicollinearity, real-time or final data, and to CPI measure of inflation. Third, one more recent debate hypothesizes that this advantage is disappearing when considering new extended samples during which the US monetary policy regime was stable and inflation expectations became fairly well-anchored. This outcome is nevertheless challenged by unconditional comparisons and estimates on the stable subsample from 1987 to 2001 which exhibits significantly better inflation forecasting performance. This chapter confirms that the gap between the Fed and private sector has narrowed but the Fed still preserves a better forecasting performance, especially at longer horizons in opposition to D'Agostino and Whelan (2008).

The second objective of this work is to underline the potential sources of the superior forecasting performance of the Fed. Using a one factor model, we propose to disentangle the forecasting performance arising from the forecastable component of inflation (assumed to be based on a good model of the economy) and the forecasting performance arising from the specific component (assumed to be based on better information about future shocks). Gamber and Smith (2009) attribute to the decline of the predictable component of inflation showed by Stock and Watson (2007) the narrowing of the Fed's superior forecasting performance. We assume that a better model improves relatively more the common forecastable component, the technical element, while better private information improves relatively more the specific component, the judgmental one. The second contribution of this chapter is therefore to show that the better forecasting performance of the Fed stems from better information about future shocks. It might be due to the huge amount of resources the Fed devotes to this fastidious work. We confirm that the predictable component of inflation has decreased, but this has not impacted the relative forecasting performance of the Fed. Firstly, the decline in the predictable component of inflation affects all forecasters and not only the Fed. Secondly, the stabilization of the Fed's target and enhanced transparency seem much more responsible for the narrowing of the gap between the Fed and private agents.

The rest of the chapter is organized as follows. Section 2 deals with the related literature. Section 3 describes the data. Section 4 presents the different estimation methods. Section 5 estimates the relative forecasting performance of the Fed, while section 6 estimates the potential sources of this relative performance. Section 7 concludes this chapter.

2. Related Literature

Many authors have already assessed the relative forecasting[2] performance of the central bank and private agents and challenged the conclusions of Romer and Romer (2000). The following discussion has for objective to identify and highlight the conflicts in the literature.

[2] One question that arises from this literature is whether private forecasts do represent all private sector's information. Private forecasts are considered through surveys and are thus made on the base of responses of

Are Fed forecasts superior to private sector?

On one hand, Romer and Romer (2000) have found evidence of a superior forecasting performance of the Federal Reserve, by comparing the Greenbook[3] forecasts to private sector ones on a sample from 1969 to 1991 and over several horizons. They show that the optimal linear combination of the private and Greenbook forecasts places a weight near to one on the Fed's forecasts and essentially zero weight on the private sector's. Gavin and Mandal (2001) compare FOMC, Blue Chip and Greenbook forecasts. Based on the root mean squared errors, the Greenbook forecasts of inflation are more accurate than any other forecasts on the 1983-1994 period, while the results are more contrasted for output. They also show that the Blue Chip consensus appears to match pretty well the FOMC's central tendency forecasts. Sims (2002) is led up to analyze the performance of the Federal Reserve forecasts and finds first on the 1979-1995 period, according to their RMSE that the best inflation forecasts are those of the Greenbook, and that the difference does not seem large with the MPS model of the Federal Reserve (the ancestor of the FRB/US model). He then finds, with a factor analysis, that evidence for the superiority of the Greenbook over private forecasters is strong for inflation, and statistically negligible for output. D'Agostino and Whelan (2008) show the Fed maintains its superior forecasting performance only on inflation and at short horizons for the period 1974-1991. Gamber and Smith (2009) focus on inflation and find Fed's forecast errors are significantly smaller than the private sector's for the period 1968-2001. Amornthum (2006) also claims that the Federal Reserve has a better forecast accuracy over the private sector by comparing inflation forecasts at the individual level in opposition to consensus forecasts. Its results suggest that the Fed dominates SPF, but not all private forecasters and that this advantage decreases with longer horizon. Last, Peek, Rosengren and Tootell (1998, 2003) confirm this superiority in a different framework with specific data[4].

On the other hand, Joutz and Stekler (2000) examine the characteristics of Fed's forecasts and compare them to ARIMA models and ASA/NBER surveys on the period 1965-1989. They focus on usual errors measures, tests for rationality and features of accuracy of these forecasts and find that the Fed predictions overall tended to yield the same type of errors that private forecasters have displayed. Atkeson and Ohanian (2001) compare inflation

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many institutions, banks or firms from various horizons. They gather information from diverse places and are too a source of information for some others agents. This point of view seems to be supported by the fact that surveys are good predictors. Ang, Bekaert and Wei (2005) find that between time-series ARIMA models, regressions using real activity measures deducted from the Phillips curve, term structure models and survey based measures, the best method of forecasting US inflation out-of-sample is surveys. It is possible that forecasts of one individual institution could be more accurate than Fed's or surveys' ones at one date, but first, they do certainly not represent information of *all* private agents and second, a forecaster that would succeed to consistently provide the best forecasts on the market would become known as the reference. Evidence does not support this view. In addition, it is possible that surveys gather model-driven forecasters and "noisy" forecasters; using Sims' (2002) procedure allows for dealing with this issue. Finally, it may be argued that these surveys tend to remove idiosyncratic differences. However, one might consider the opposite as these surveys are biased since respondents are generally the better informed agents through a selection bias. This reinforces anyway the use of these surveys when assessing relative forecasting performance with the central bank.

[3] The Greenbook forecasts are prepared by the staff of the Board of Governors before each meeting of the FOMC. These forecasts are made available to the public five years after the FOMC meeting they correspond.

[4] They find that confidential supervisory information on bank ratings (CAMEL for "Capital, Assets, Management, Earnings and Liquidity". This composite rating evaluates the health of banks on these five categories and delivers a score between 1 (sound in every respect) and 5 (high probability of failure, severely deficient performance)) significantly improves private forecasts of inflation and unemployment rates, thus providing an informational advantage to the Federal Reserve. The results are consistent across the individual forecasters and for Blue Chip forecasts globally. The contribution of this rating is independent too of publicly available leading indicators. Moreover, they show supervisory information add significantly to private forecasts made even a full year after the information is gathered and released, and then supervisory data provide a persistent informational advantage, sufficiently large and persistent according to them to be exploited.

forecasts from the Greenbook with a naïve model of forecast and find that the RMSE for both "are basically the same" and argue then that Greenbook forecasts have on average been no better than the naive model. Their study covers the years 1984-1996: a period of very stable evolution of inflation. Faust, Swanson and Wright (2004) are concerned with the Federal Reserve policy surprises and whether they convey some private information. They conduct two tests of hypothesis and find that the Federal Reserve policy surprises could not systematically be used to improve forecasts of statistical releases and that forecasts are not systematically revised in response to policy surprises. They conclude that there is little evidence that Fed's surprises pass on superior information. Last, Baghestani (2008) finds unemployment rate forecasts (as a proxy of real activity) are very similar between Fed and private forecasters for 1983-2000.

Does this advantage hold for both inflation and GDP?
Romer and Romer (2000) and Peek, Rosengren and Tootell (1998, 2003) find that the better forecasting performance holds for both inflation and GDP while Gavin and Mandal (2001), Sims (2002), Joutz and Stekler (2000), Baghestani (2008) and D'Agostino and Whelan (2008) find either Fed has only a better inflation forecast accuracy or there is no relatively better forecasting performance for GDP or unemployment.

Has this advantage been reduced in the recent period?
Reifschneider and Tulip (2007) find, with unconditional comparisons, that Greenbook performs identically to SPF since 1986 and suppose this difference is due to timing and methodological issues, while D'Agostino and Whelan (2008) and Gamber and Smith (2009) find that the Fed's advantage has declined compared to private forecasters in the recent period. For the former, this advantage holds only for very short horizons, and for the latter conditional advantage has disappeared, but unconditional comparisons still evidence Fed's superiority. A further question of interest is to know whether this advantage comes from the predictable component of inflation (or GDP) or not. Sims (2002) finds the superiority of the Fed on inflation is due to a better forecasting performance of the predictable component of inflation. At the opposite, based on Stock and Watson (2007), the drop in the overall volatility during the Great Moderation comes from the drop in the volatility of the predictable component of inflation, what may explain the narrowing of the Fed's superiority according to Gamber and Smith (2009). Moreover, isolating the forecastable component may allow for disentangling the sources of superior forecasting performance. If the latter is based on a superior forecastable component, we may assume that it arises from a superior model of forecasting, while if it is based on the specific part of the forecast, we may assume that the superior forecasting performance arises from better information about future shocks.

Why previous results are different?
There are three reasons of decreasing importance why the previous results are different: first, the periods of analyses differ as shown previously; second the methods vary; third, the actual variables used are not identical. In this chapter, we therefore propose to assess the relative forecasting performance of the Fed and private sector, on different sample, with both type of actual data and the different method used in the previous literature. Each of these points is discussed in the following sections.

3. Data Description

3.1 Forecast Data

Data used are those of the Federal Reserve and the Survey of Professional Forecasters (SPF hereafter) and both are made available on the web site of the Federal Reserve Bank of

Philadelphia. As a measure of inflation, we use the GDP price deflator because it has been consistently forecasted throughout the entire period by both forecasters, compared to the Consumer Price Index for which the definition has changed across time and has started to be forecasted later. Robustness tests with CPI are nevertheless performed. As commonly used in literature, the real GDP/GNP is the variable considered for the 'growth' forecasts.

The Federal Reserve forecasts come from the Greenbook prepared by the staff of the Board of Governors before each meeting of the FOMC and are available from 1965:4 to 2001:4 for both inflation and real GDP/GNP growth at different horizons. They depend on the FOMC schedule and are then not available at a quarterly frequency. For instance, there were almost a meeting every month between 1960 and 1970 while eight forecasts per year in the 1980's. For this work, the Federal Reserve forecasts of a quarter are the forecasts made in the second month of the quarter, which the date is the closest to the 15th day. Indeed, as the objective is to compare accuracy of the forecasts, the timing issue is crucial and Greenbook and SPF forecasts should correspond to the same level of information[5]. Inflation and real GNP/GDP forecasts are the annualized quarterly growth rate.

The private forecasts are those of SPF and are now conducted by the Federal Reserve Bank of Philadelphia itself. It extends the American Statistical Association/National Bureau of Economic Research Economic Outlook Survey. It is based on several commercial forecasts made by financial firms, banks, university research centers and private firms and is made in the second month of each quarter. Data are available from 1974:4 for inflation and from 1981:3 for real GDP without missing values for long horizons[6]. Here again forecasts are the annualized quarterly growth rates of the GNP/GDP price deflator and the real GNP/GDP.

3.2 Real-Time versus Final Data

Actual data raise a particular issue. Final data are frequently revised between the different releases and the question is then to know whether comparisons have to be made with the preliminary estimate, second estimate or final estimate. Because some information is not known directly or accounting standards change, the initial estimates are often revised. The advantage of real-time data is that it is close in definition to the variable being forecast. However, final data includes slightly more information. It is reasonable[7] to consider that consistency of definitions is more important than the increase in information and hence prefer to use real-time data.

However, estimations will be performed with both types of actual data in order to check the robustness of the results and assess the importance of this point for previous different results. The final data is the final-revised data (current vintage) provided by the Bureau of Economic Analysis. Initial estimates are the data published in the next quarter, called first release data, and come from the Real-Time Data Set for Macroeconomists compiled by Croushore[8] at the Federal Reserve Bank of Philadelphia. Both actual series are calculated as the forecasts, that is to say, annualized quarterly growth rates[9].

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[5] For more details on the datasets and the timing issue, see www.philadelphiafed.org/econ/forecast/index.cfm.

[6] The term 'whole sample' used afterwards then spans on 1974:4-2001:4 for inflation and 1981:3-2001:4 for growth.

[7] Forecasters attempt to forecast future earlier announcements of data rather than later revisions (see for instance Keane and Runkle (1990)).

[8] For more details on the Real-Time Data Set, see Croushore and Stark (2001). Data are available on the website of the Federal Reserve Bank of Philadelphia.

[9] The series which are already transformed into growth rates are stationary: the null hypothesis that each variable has a unit root is always rejected at the 10% level and most of the time at the 5% level. The investigation is carried

4. Estimation Methods

4.1 Unconditional Comparisons

The simplest method to compare the forecast accuracy of both institutions is to measure their Mean Square Errors, which constitute unconditional forecast comparisons. In order to calculate the *p-value* for the test of the null hypothesis that Federal Reserve's and SPF's MSE are equal, we estimate according to Romer and Romer (2000) the following regression:

$$(\pi_{t+h} - \pi_{t,h}^{GB})^2 - (\pi_{t+h} - \pi_{t,h}^{SPF})^2 = \alpha + \varepsilon_t \quad (1)$$

where π_{t+h} is the actual inflation (or real GDP), either the real-time or the final data, $\pi_{t,h}^{GB}$ is the forecast made in date *t* for *h* horizons later by the Federal Reserve, $\pi_{t,h}^{SPF}$ by SPF in date *t* for *h* horizons later and α is the difference between the squared errors of forecasts of both institutions and then allows to calculate the standard errors of α corrected for serial correlation with the Newey-West HAC method[10]. We can thus obtain a robust *p-value* for the test of the null hypothesis that $\alpha = 0$, in order to determine whether the forecast errors are significantly different.

4.2 Conditional Comparisons: Regressions

In this section, the purpose is to compare the forecasts of the Federal Reserve with those of SPF with the regression methodology of Fair and Shiller (1989, 1990) and Romer and Romer (2000). It consists of regressing the actual inflation on forecasts made by both institutions in order to know whether the Greenbook forecasts contain information that could be useful to private agents to form their forecasts. The point as described by the authors is to see if "individuals who know the commercial forecasts could make better forecasts if they also knew the Federal Reserve's". The standard regression then follows this form:

$$\pi_{t+h} = \alpha + \beta_{GB} \cdot \pi_{t,h}^{GB} + \beta_{SPF} \cdot \pi_{t,h}^{SPF} + \varepsilon_t \quad (2)$$

The main idea behind this regression is then to see if Federal Reserve forecast contains useful information to forecast inflation and more useful information than the one given by SPF forecasts by testing whether β_{GB} is different from zero, whether β_{GB} is near to 1 and β_{GB} is different and higher than β_{SPF}. Standard errors are here again computed using the Newey-West's HAC methodology to correct serial correlation.

4.3 A Pooled Approach

This approach is based on a Davies and Lahiri (1995) and Clements, Joutz and Stekler (2007) method that consists of pooling the forecasts across all horizons. The decomposition of forecast errors developed by these authors and repeated here responds to question of whether it is adequate to pool the forecast obtained by different models, supposing that maybe forecasts at short and long horizons are not derived from the same models, and in the same manner to pool survey's consensus that represents many individual forecasters.

The method needs because of aggregating the horizons to deduct the correlation structure across errors of targets and lengths which is consistent with rationality. The forecast error is:

$$A_{t+h} - F_{t,h} = \alpha + \lambda_{t,h} + \varepsilon_{t,h} \quad (3)$$

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out with the Phillips and Perron's Test that proposes an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root. These results are available upon request.

[10] In those regressions, the problem due to the correlation between forecast errors leads to calculate robust standard errors to serial correlation. Indeed, when forecasts for four quarters ahead miss an unexpected change in the variable, this would definitely cause forecasts errors all in the same direction. Forecasts are then declared serially correlated. In order to deal with this problem, when considering forecasts for inflation h quarters ahead, the standard errors are computed correcting for heteroskedasticity and serial correlation according to the Newey and West's *HAC Consistent Covariances* method. The truncation lag is equal to the forecast horizon.

where A_{t+h} is the effective value at $t+h$, $F_{t,h}$ is the forecast made at the date t for a horizon of h periods, λ_{t+h} are the aggregate or common macroeconomic shocks and correspond to $\lambda_{t,h} = \sum_{j=1}^{h} u_{tj}$ the sum of all shocks that occurred between t and $t+h$, and $\varepsilon_{t,h}$ are the idiosyncratic shocks. The possibility of private information is noted by Davies and Lahiri (1995), their original formulation becoming:

$$A_{t+h} - F_{t,h} = \alpha + \lambda_{t,h} + \eta_{t,h} \tag{4}$$

with $\lambda_{t,h} = \sum_{j=1}^{h} u_{tj}$ and $\eta_{t,h} = \sum_{j=1}^{h} \varepsilon_{tj}$. Thus, as h gets smaller the variance of the private component, $Var(\eta_{t,h})$ declines. Without private information, the variance of the private component is constant for all h. In this analysis, we can think of the Federal Reserve or SPF as possessing confidential private information. Whether the Federal Reserve or SPF has private information, so that the idiosyncratic component is absent $\sigma^2_{\varepsilon} = 0$, σ^2_{u} the macro shock becomes the global variance of u^*_{tj}.

4.4 One Factor Model

This estimation used by Sims (2002) to rule out the high correlation between forecasts lies on factor analysis. It is related to the principal components analysis insofar as it searches to replace a large set of variables with a smaller set of new variables, but deviates from it to find a solution to the covariance between observed variable. It is used as an explanatory model for the correlations among data and attempts to explain the variance which is common to at least two variables and presume that each variable have also an own variance which represents its own contribution. The main assumption is that all forecasters have imperfect observations on a single 'forecastable component' (the common factor that gathers the strong covariance between forecasts) of actual value, which they may or may not use optimally. If f^* is the forecastable component of π_{th} the actual value or π^F_{th} the forecast, we have the model:

$$\begin{aligned} \pi^F_{th} &= \lambda + \theta f^*_{th} + \varepsilon_{th} \\ \pi_{th} &= \alpha + \beta f^*_{th} + \nu_{th} \\ Var\left(\begin{bmatrix} \varepsilon_{th} \\ \nu_{th} \end{bmatrix}\right) &= \Omega \end{aligned} \tag{5}$$

with Ω diagonal and f^*_{th} orthogonal to ε and ν.

In this model, the quality of a forecast is related inversely to the variance of its ε_{th} and to the deviation of its θ coefficients from β. The coefficients are not proportional to the forecast error variances, because they may include a dominant contribution from the variance of ν; the coefficients are inversely proportional to the relative idiosyncratic variances, even if these are an unimportant component of overall forecast error. Sims proposes the possibility of a second component of common variation: a 'common error', but argues that analysis of forecast quality would then be limited and that despite its simplicity the model above provides "a good approximation to the actual properties of the forecasts". This method could indeed allow discriminating between the part of forecast errors which arise from *unforecastable* macroeconomic shocks and the part which comes from idiosyncratic errors. Thus, to determine the quality of the forecast, we focus on the variance σ^2 of ε_{th}, the specific variance proper to each forecast once the correlation between forecasts has been gathered in a 'forecastable component'.

Considering the factor analysis methodology, the interpretation of the estimates could be difficult in general, but even more in this fit because a simple model with only one factor is obviously not sufficient to explain the pattern in these data. An analysis with multiple factors

as widely used in sociology would give better statistical results. Thereby, the likelihood ratio and the *p*-value of acceptable fit are likely to be low because of the deliberate choice of only one factor as the main hypothesis and due to the fact that this method provides results that are sensitive to serial correlation and non-normality, two characteristics of forecasts.

4.5 Purpose and Relative Advantages of Methods

The most neutral and uncontroversial method to determine forecasting performance is the unconditional comparison of mean square errors. However, as the focus of the chapter is to assess the relative forecasting performance of the Fed and private agents, the conditional regressions give more insight on the relation between both forecasts and more directly assess the information content of forecasts. This method is thus the most widespread in the related literature. One shortcoming of this method is that estimates of coefficient might be polluted by multicollinearity (Table I.1 shows correlation among variables used in this chapter). A possible way has been proposed by Sims (2002) and consists in gathering the high correlation in a single factor: the forecastable component of a forecast. This method also allows for testing whether the forecasting performance arises from superior forecasts of the forecastable component (which may be related to the accuracy of a model of the economy) or of the specific component (which may be related to more information about future shocks). Last, the pooling approach is based on a decomposition of errors and also allows for disentangling macro from private forecast errors. Another advantage concerns the interpretation of findings, not subject to each individual horizon. Indeed, it is unclear why the literature focuses on a quarterly change, one or four quarters ahead, while the cumulative error over several quarters would matter more. The pooling approach deals with this issue.

Thus, we will mostly focus on the first two methods to assess the relative forecasting performance, while the focus will be on the last two to investigate the sources of the superior forecasting performance of the Fed.

5. Estimates of the Relative Forecasting Performance

5.1 Are the Fed's forecasts superior to private sector's? For inflation and/or GDP?[11]

Table I.2 shows results of the MSE comparison. They are univocal concerning inflation forecasts: when both institutions are compared on the final data basis, Greenbook's MSE are 0.93 and 1.51 respectively at horizons h=1 and 4 while SPF's MSE are 1.25 and 2.46. The *p*-values clearly prove that these values are significantly different. The pattern is identical and as straightforward when the comparison is made with real-time data. About real GNP/GDP, results are much more mixed: the MSEs of Greenbook are comparable or a very little lower than those of SPF but the difference is not significant at all in the four cases (h=1 or 4 and with final or real-time data).

Table I.3 summarizes the results of the benchmark regression. Regarding inflation, this first regression shows first that the coefficients on the Greenbook forecasts are significant, while those of SPF are not at any time, and second that β_{SPF} is by and large near to one: 0.76 and 0.99 at horizon h=1 respectively for final and real-time data and 1.38 and 1.21 at horizon h=4, while β_{SPF} is next to zero. Concerning real GNP/GDP, the pattern is quite different: when analysing the baseline regression, at the short horizon h=1, both coefficients of Greenbook and SPF are very similar (grossly around 0.6) and significant only at the 10% level, for both actual data. At the longer horizon h=4, the coefficients of Greenbook β_{GB} are higher than 0.5,

[11] The baseline estimations presented here have been realized on the whole sample.

but are not significant at all as those of SPF. Results for the real GNP/GDP forecasts are mixed and both the Fed and private agents seem to be on an equal footing about real activity forecasts. In comparison, the inflation results show strong evidence for a better accuracy of the Fed forecasts.

Robustness Test: Timing

I test the robustness of the benchmark regression with a different specification concerning the timing of the Federal Reserve and SPF forecasts. In the benchmark case, forecasts come from the same quarter. Because the date when the forecasts are made in the quarter varies, the Federal Reserve may sometimes benefit of a possible timing advantage. Thus, this specification clearly put the Federal Reserve in a deliberate situation of a timing disadvantage[12]. The equation estimated, in which $\pi^{GB}_{t-1,h+1}$ is the forecast made by the Federal Reserve at the previous quarter *t-1* compared to SPF for one quarter later, becomes:

$$\pi_{t+h} = \alpha + \beta_{GB} \cdot \pi^{GB}_{t-1,h+1} + \beta_{SPF} \cdot \pi^{SPF}_{t,h} + \varepsilon_t \quad (6)$$

Table I.4 exhibits the regression results with a timing disadvantage for the Federal Reserve. Except for final data at short horizon (h=1), the coefficients of the Greenbook inflation forecasts are significant while those of SPF are not, are always largely superior to those of the SPF, and are included between 0.71 and 0.97, so significantly near to one. The superior forecasting performance highlighted by these coefficients seems to be higher when the horizons are longer, whatever the type of actual data.

Robustness Test: Multicollinearity

I proceed to univariate regressions of the actual inflation on one forecast at a time in order to check that estimates of the benchmark regression are not distorted by multicollinearity as discussed by Granger and Newbold (1977):

$$\pi_{t+h} = \alpha + \beta_{GB\ or\ SPF} \cdot \pi^{GB\ or\ SPF}_{t,h} + \varepsilon_t \quad (7)$$

I then compare the statistical indicators of the global significance of the model (R^2 and Square Sum of Residuals) between the different forecasts, so as to ensure that the explanatory power found in the main regression is still valid when forecasts are compared one by one and not together. It may be informative to have a look at the coefficient $\beta_{GB\ or\ SPF}$, more particularly in what extent this one is near to 1, and its significance. On table I.5, regarding inflation, one can observe that the R^2 is consistently higher and the SSR consistently lower for the Greenbook forecasts compared to the SPF ones, the gap rising when the horizon is longer, whatever actual data are. These corroborate previous results showing that the Federal Reserve make better inflation forecasts than SPF. The results concerning the real GNP/GDP are still mixed.

Robustness Test: Forward-looking information beyond a lagged dependent variable

It is informative to assess whether the coefficient associated to private or central bank forecasts are significant because they are highly correlated to actual data or because they provide additional information besides the information set known at the date when the forecast is made. If we consider that a lagged dependent variable – the actual data – comprises all the information available when the forecast is made, then we are able to assess whether the forecast really contains superior forward looking information. The equation is:

$$\pi_{t+h} = \alpha + \beta_{\pi} \cdot \pi_{t-1} + \beta_{GB} \cdot \pi^{GB}_{t,h} + \beta_{SPF} \cdot \pi^{SPF}_{t,h} + \varepsilon_t \quad (8)$$

[12] This specification do not test the durability of the superiority of Fed's forecasts since these forecasts are not published and could not then be processed by private agents.

Table I.6 presents the estimates of the regression with the lagged dependent variable. They strongly confirm the previous results: the coefficient associated to Fed's inflation forecasts is highly significant for either final or real time data, at both one and four quarter horizons.

Robustness Test: Pooling horizons

Table I.7 presents the estimates when forecasts of current and next four quarters of both institutions are pooled. It confirms the previous results for both inflation and real GNP/GDP. For the former, the pooled Greenbook RMSE are lower than those of SPF. For the latter, values of bias are very close between themselves and the RMSE are almost equal, what tends to confirm too that concerning the real GNP/GDP the Federal Reserve is not a better forecaster than private sector and do not dispose of private information on this variable.

Robustness Test: One factor model

Table I.8 shows estimates[13] for the factor analysis and suggests that the forecast accuracy of Greenbook inflation forecasts is superior to the one of SPF and arises from their low idiosyncratic error.

Robustness to an Alternative Inflation Variable

Private agents may be more prone to forecast the Consumer Price Index (CPI) than the GDP price deflator, and this might be a reason for their less accurate performance in forecasting inflation. In order to check the robustness of the previous results for inflation, we then provide additional tests with CPI. Data are available from the same sources from 1982Q1 to 2001Q4. Table I.9 displays evidence that confirms the previous results and show that the variable chosen for inflation do not lead to reconsider the accuracy of Greenbook forecasts.

Robustness to the Actual Data Issue

The superiority of the Greenbook forecasts is more pronounced with real-time data. However, in the end, whatever inflation data considered are real-time or final, the results give similar indications on the Federal Reserve's superior forecasting performance, what tend to support the conclusion that patterns of forecast accuracy presented here are not subject to variation in data definitions. Furthermore, an identical scheme emerges from all methodologies: Fed and SPF better forecast real-time value of real GDP while they both have more accurate predictions of final data of inflation. One possible explanation of this pattern is that real GDP is certainly more difficult to forecast than inflation, its determinants more multiple and subjects to fewer vagaries, while inflation could suffer from more cyclical events, but is better anchored. Another possible explanation may come from the method of constructing the GDP aggregate and the assumption about the growth trend which are always revised. The advantage of real-time data is that it is close in definition to the variable being forecast.

Discussion

Estimates on the whole sample confirm that the Fed has a significantly better inflation forecasting performance, while evidence is mixed for GDP[14]. This outcome is identical to Gavin and Mandall (2001) and Sims (2002). In addition, it appears that the longer the horizon, the more pronounced the advantage of Fed on inflation. This tends to confirm the

[13] The naïve forecast series is added in order to get a benchmark in the one factor model. This series corresponds to no-change forecasts, i.e. the value at the date t is the forecast at the date t+1.

[14] The equivalence of forecasts accuracy of GDP between the Fed and private agents could bridge with Tulip (2005) which finds uncertainty is still as high as in 1970s at long horizons and has been less reduced than volatility. It may explain in part that errors are quite similar.

advantage is robust and not due to timing advantage and access to information on the short run. The possible explanations for an advantage of the Fed on inflation and not output are not obvious. It might be supposed that the lost associated to inflation in the central bank loss function may have some impact too. If Fed greatly balances inflation, it will make everything possible to reach its inflation goal and then *endogenises* inflation by dint of focusing on it. Thus the second variable, the output growth, becomes an adjustment variable. This focus may be all the more so important that Fed attempt to reach its 'implicit' inflation target. Finally, the vision of central banking as management of expectations may strengthen the argument for an inflation focus.

5.2 Has this advantage reduced in the recent period?

I proceed to unconditional comparisons and estimate the benchmark regression on a reduced sample to take into account the choice of Atkeson and Ohanian (2001) to rule out the period of strong disinflation of the beginning of the eighties. Due to the private agents' idea that central bank won't succeed to reduce inflation, central banks forecasts could have been better than private forecasts. The first sub-sample starts in 1987Q3 when Greenspan took his function. The end of the sample is still 2001Q4. In the same manner, D'Agostino and Whelan (2008) and Gamber and Smith (2009) show that with the drop in volatility in predictable component of inflation and greater transparency of the Fed since 1992 and 1994, the superior forecasting performance of the Fed has been reduced. we therefore estimate the regression on two other reduced samples starting in 1992Q1 and 1994Q1 in order to assess the Fed's forecasting superiority on samples during which the US monetary policy regime was stable and inflation expectations became fairly well anchored.

Table I.10 reveals the coefficients of the regression made on the smaller samples. D'Agostino and Whelan (2008) argue that "updating through 2001 produces markedly different results". The estimates show a slightly different picture: if we consider the largest subsample, from 1987 to 2001, it appears that outcomes are totally in line with the previous one: significance of the Greenbook estimates at both horizons (while not for the SPF) and coefficients near to one, in the inflation case; and no difference between the central bank and the private sector in the real GNP/GDP case. However, when considering the two other subsamples from 1992 or 1994 as D'Agostino and Whelan (2008) and Gamber and Smith (2009) respectively do, it appears that the coefficient of the Fed's forecasts is not significant anymore, while it remains superior to the coefficient associated to private forecasts. These two estimations are nevertheless based on smaller samples and few observations as emphasized by Gamber and Smith (2009). In addition, these subsamples comprise a very stable period for which conditional comparisons lack variability. We therefore also assess the relative performance with unconditional comparisons.

Tables I.11 and I.12 present the Mean Square Errors for respectively GDP deflator and CPI on the three shorter subsamples and clearly shows that Greenbook inflation forecasts errors remains smaller than SPF's and this results is even more pronounced at the longer horizons (4 quarters ahead), what confirms the better forecasting performance is sound. This outcome is in contradiction with D'Agostino and Whelan (2008) which find the Fed's advantage only holds over short time horizon. Moreover, it seems striking that the four quarter ahead forecasts from the Greenbook outperform SPF ones more for GDP price deflator than for CPI. One potential explanation may be that the private forecasters pay closest attention to consumer inflation, while the Greenbook provides more accurate forecasts for the other components of GDP. To conclude this subsection, this paper confirms that the gap between the Fed and private sector has narrowed but the Fed still preserves a superior forecasting performance.

6. Potential Sources of Superior Forecasting Performance

Many arguments have been put forward in the literature to explain the better forecasting performance of the Fed: *(i)* the institutional and inherent advantage possessed by the central bank about its own future policy path, *(ii)* secrecy provides to the Fed a relative enhanced information set compared to private forecasters, *(iii)* the knowledge derived from the role of supervisor and regulator of banks (Peek, Rosengren and Tootell (1998) and (2003)), *(iv)* an expertise advantage leading Sims (2002) to argue that "the Fed is simply making better use than other forecasters of the same collection of aggregate time series available to all", *(v)* the fact that as reported by Romer and Romer (2000) the Fed succeeds in collecting better and larger detailed information about determinants of future inflation. It stems from the huge amount of resources the Fed devotes to this fastidious work, relative to individual private-sector firms or banks.

Empirical investigations[15] on market expectations of the federal funds rate show that US markets are rarely surprised by the Fed at very short horizons as a few weeks. For longer horizon, the performance of expectations is poorest, which may support the argument *(i)*. However, the second chapter will show that prior knowledge of the future policy path and secrecy are not sufficient conditions to experience a superior forecasting performance. In addition, interest rate paths result from macroeconomic forecasts and are in fact endogenous to the specific expertise of the central bank.

Concerning the argument *(iii)*, Peek, Rosengren and Tootell (1998, 2003) suggest the Fed obtains its exploitable informational advantage from its supervisory role and more specifically from non market traded banks, for which the data are confidential and remain so for a significant period of time. These works could be put together with the ones of Kashyap and Stein (1994a, 1994b, 2000) which find small banks may be particularly important for the level of economic activity because they disproportionately lend to finance inventories and small business. Thus, all information that could be gathered from this side is 'unavailable' to private sector and seems useful and used by the Fed via its supervisory role.

Although developed networks allow information to circulate very quickly, private sector as a whole employs a lot of forecasters and dedicates large amounts to forecasting, and the hypothesis that the financial markets properly aggregate information, the argument of a specific expertise either on the right model of the economy *(iv)* or in a better gathering and processing of information *(v)* seem relevant for several reasons. First, despite recent huge progresses in the information process, coordination, uncertainty, heterogeneity of information processing capacities and noisy signals are still rendering information imperfect as the thriving literature on those subjects attests; second, Bernanke and Boivin (2003)[16] develop a data-rich environment model that confirms aggregation and exploitation of a very large amount of data has an added-value for monetary policy analysis. Third, Faust and Wright (2007) show that Greenbook inflation forecasts dominate large dataset methods. The question of interest is therefore to know whether the Fed has a better model of the economy (and makes a better use of public data) or has superior (private) information.

[15] See for instance on this topic Poole, Rasche, and Thornton (2002) and Swanson (2006).

[16] Their analysis besides compare the forecasting performance of the Greenbook to their data-rich model: FM-VAR and to combination of the Greenbook and their model. They find Greenbook does marginally worse than FM-VAR for next quarter's inflation (CPI here) forecast and better for longer horizons, while unemployment forecasts are comparable. These outcomes appear to be in line with those found here. The combination forecasts have broadly similar (verily better) forecasting performance than Greenbook forecasts.

Predictable component or specific errors?

The objective of this section is therefore to shed light on the potential sources of the superior forecasting performance of the Fed. We therefore use the factor model and the pooling approach to test whether the forecasting performance arises from some superior forecast of the forecastable component (which may be related to the accuracy of the model of the economy) or the specific component (which may be related to more information about future shocks). It might be argued that a better model of the economy produces low idiosyncratic errors or that better information enhances the forecastable component. However, we consider these situations as particular cases. We assume that more generally a better model improves relatively more the common forecastable component, the technical element, while better private information improves relatively more the specific component, the judgmental one. Table I.8 presents the estimates of the factor analysis on the whole sample. The model based on the hypothesis of a common and unique forecastable component ascribes a high coefficient to the forecastable component to both the Fed and the private sector, and a very low idiosyncratic error to Greenbook forecasts compared to naïve and SPF forecasts. While at a short horizon h=1, the difference is weak (as in the Sims' paper), the difference at horizon h=4 is clear for inflation with both actual data. These results suggest that the forecast accuracy of Greenbook inflation forecasts arises from their low idiosyncratic error, and therefore from better information about future shocks. This result is confirmed by estimates of the pooling approach in table I.7, which show that the specific error is relatively much smaller than the aggregate errors for the Fed than for the private sector.

One could nevertheless be surprised that the specific error of the Greenbook forecasts is so low for real GNP/GDP, as the Greenbook has a similar forecasting performance to SPF. One possible explanation might be that the Fed makes good forecasts of the 'forecastable component' (the Greenbook estimates of f^* are close to 1…), while SPF makes less precise forecast of this component (…and much lower for the SPF). However, Blix, Wadefjord, Wienecke and Adahl (2001) realize a comprehensive work on the forecasting performance of 250 major institutions and highlight the robust pattern that growth is much more difficult to forecast than inflation. It thus appears that a better forecast accuracy of a component whose determinants are more difficult to evaluate might not give a superior performance.

Last, we estimate this one factor model on three reduced samples starting in 1987Q3, 1992Q1 and 1994Q1 to assess how the predictable component of inflation has evolved, following the argument of Stock and Watson (2007). Table I.13 shows the estimates of the factor analysis on the shorter samples. First of all, it has to be specified that the estimation is based on very few observations, especially for this type of method. However, it is noteworthy that indeed the predictable component of inflation is weaker in the recent period, which confirms the outcome of Stock and Watson (2007). They indeed show that inflation has become harder to forecast as it evolves as a random walk. It appears from table I.13 that the private sector has a better forecast of the forecastable component through a high coefficient associated to this component. It thus seems that the decline of forecastable component of inflation has a negligible effect on the relatively better forecasting performance of the Fed on the most recent period, as its main source of superior forecasts is its information set about future shocks. This is consistent with the intuition that the decline in the predictable component of inflation surely affects all forecasters and not only the Fed.

More reasonable explanations may be that with the Great Moderation, the inflation rate has flattened out and lagged inflation now evolves around the Fed's target, compared to the previous period when inflation was on a downward trajectory and private sector were learning slowly the Fed's target; or that enhanced transparency's of the Fed allows for divulgating some of its private information about future shocks.

7. Conclusion

This chapter assesses the relative forecasting performance of the Fed and the private sector in the US. Since empirical evidence is mixed so far, the first objective of this work is to group the different methods, data and samples in order to obtain unambiguous results. The results are threefold: first, on the whole sample, Fed possesses a superior forecasting performance on inflation but only on it. There is no evidence of any advantage for private forecasters or Fed on real GNP/GDP. Second, it appears that the longer the horizon, the more pronounced the advantage of Fed on inflation. This tends to confirm the advantage is robust and not due to timing advantage and access to information on the short run. Third, estimates show that this advantage is decreasing but remains prominent when considering very short and recent subsamples. The second contribution of this chapter is to show that the better forecasting performance of the Fed stems from superior information about future shocks.

A further way of approaching the question of relative forecasting performance is to ask whether private information might help central banks to influence private sector's expectations in order to anchor them and facilitate the stabilization of the economy around its steady state.

Table I.1 - Correlation

Inflation +1 - Final Data				Inflation +1 - Real-Time Data			
	Actual	GB	SPF		Actual	GB	SPF
Actual	1			Actual	1		
GB	0.9333	1		GB	0.9123	1	
SPF	0.9143	0.9585	1	SPF	0.8742	0.9585	1
Inflation +4 - Final Data				**Inflation +4 - Real-Time Data**			
	Actual	GB	SPF		Actual	GB	SPF
Actual	1			Actual	1		
GB	0.8782	1		GB	0.8643	1	
SPF	0.8146	0.9555	1	SPF	0.8145	0.9555	1
Real GNP/GDP +1 - Final Data				**Real GNP/GDP +1 - Real-Time Data**			
	Actual	GB	SPF		Actual	GB	SPF
Actual	1			Actual	1		
GB	0.5048	1		GB	0.4712	1	
SPF	0.4868	0.7964	1	SPF	0.4692	0.7964	1
Real GNP/GDP +4 - Final Data				**Real GNP/GDP +4 - Real-Time Data**			
	Actual	GB	SPF		Actual	GB	SPF
Actual	1			Actual	1		
GB	0.1713	1		GB	0.1803	1	
SPF	0.0213	0.6257	1	SPF	0.0786	0.6257	1

The whole sample goes from 1974:4 for Inflation and from 1981:3 for Real GNP/GDP to 2001:4

GB and SPF forecasts are annualized quarterly percentage changes

Table I.2 - Mean Squared Errors - Whole Sample

Inflation - Final				Inflation - Real Time			
Horizon	GB	SPF	p-value	Horizon	GB	SPF	p-value
1	0.930	1.251	0.0208	1	1.196	1.716	0.0006
4	1.517	2.467	0.0001	4	1.737	2.576	0.00003
Real GNP/GDP - Final				**Real GNP/GDP - Real Time**			
Horizon	GB	SPF	p-value	Horizon	GB	SPF	p-value
1	6.097	6.234	0.7446	1	4.612	4.619	0.9855
4	6.248	6.519	0.5400	4	4.727	4.851	0.7401

The p-value is for the test of the null hypothesis that the central bank errors and private sector errors are equal.

Table I.3 - Base Regression - Whole Sample

Inflation - Final Data			Inflation - Real-Time Data		
	Coef	Std Error		Coef	Std Error
Cst	-0.5224**	(0.2593)	Cst	-0.2827	(0.2781)
GB+1	0.7650***	(0.1211)	GB+1	0.9931***	(0.1206)
SPF+1	0.2847*	(0.1514)	SPF+1	-0.0032	(0.1663)
Inflation - Final Data			**Inflation - Real-Time Data**		
	Coef	Std Error		Coef	Std Error
Cst	-0.1855	(0.4520)	Cst	-0.3846	(0.4437)
GB+4	1.3851***	(0.2228)	GB+4	1.2176***	(0.2360)
SPF+4	-0.3781	(0.2434)	SPF+4	-0.1783	(0.2247)
Real GNP/GDP - Final Data			**Real GNP/GDP - Real-Time Data**		
	Coef	Std Error		Coef	Std Error
Cst	-0.3840	(0.8778)	Cst	-0.2863	(0.8996)
GB+1	0.7277*	(0.3701)	GB+1	0.5313*	(0.2976)
SPF+1	0.6422**	(0.3017)	SPF+1	0.6250*	(0.3672)
Real GNP/GDP - Final Data			**Real GNP/GDP - Real-Time Data**		
	Coef	Std Error		Coef	Std Error
Cst	2.7710*	(1.6030)	Cst	1.8915	(1.4741)
GB+4	0.7407	(0.5537)	GB+4	0.5483	(0.4455)
SPF+4	-0.5286	(0.5794)	SPF+4	-0.1878	(0.4457)

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table I.4 - Timing Disadvantage - Whole Sample

Inflation - Final Data			Inflation - Real-Time Data		
	Coef	Std Error		Coef	Std Error
Cst	-0.6614**	(0.2651)	Cst	-0.4570	(0.2956)
GB+2	0.4805***	(0.1714)	GB+2	0.7161***	(0.2072)
SPF+1	0.5975***	(0.1969)	SPF+1	0.3121	(0.2323)
Inflation - Final Data*			**Inflation - Real-Time Data***		
	Coef	Std Error		Coef	Std Error
Cst	-0.5284	(0.4824)	Cst	-0.7914	(0.5117)
GB+5	0.9727***	(0.2859)	GB+5	0.9247***	(0.2417)
SPF+4	0.0655	(0.2833)	SPF+4	0.1802	(0.2876)
Real GNP/GDP - Final Data			**Real GNP/GDP - Real-Time Data**		
	Coef	Std Error		Coef	Std Error
Cst	-0.4633	(1.1861)	Cst	-0.0887	(1.0243)
GB+2	0.0719	(0.3882)	GB+2	-0.1880	(0.3083)
SPF+1	1.3057***	(0.3414)	SPF+1	1.2545***	(0.3773)
Real GNP/GDP - Final Data*			**Real GNP/GDP - Real-Time Data***		
	Coef	Std Error		Coef	Std Error
Cst	3.2392*	(1.7349)	Cst	2.2244	(1.5707)
GB+5	0.8660	(0.6184)	GB+5	0.2689	(0.4746)
SPF+4	-0.8467	(0.7725)	SPF+4	-0.0685	(0.6585)

*only 90 obs, because GB don't always publish forecasts at horizon h=5

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table I.5 - Significant Model - Whole Sample

Inflation - Final Data - 1974:4-2001:4			Inflation - Real Time Data - 1974:4-2001:4		
	Coef	Std Err		Coef	Std Err
GB+1	1.0193***	(0.05)	**GB+1**	0.9902***	(0.06)
	Adjusted R^2	0.87		Adjusted R^2	0.83
	SSR	92.43		SSR	118.77
SPF+1	1.0711***	(0.06)	**SPF+1**	1.0177***	(0.08)
	Adjusted R^2	0.83		Adjusted R^2	0.76
	SSR	117.58		SSR	166.96
GB+4	1.0605***	(0.12)	**GB+4**	1.0646***	(0.12)
	Adjusted R^2	0.77		Adjusted R^2	0.74
	SSR	155.50		SSR	178.90
SPF+4	1.0953***	(0.17)	**SPF+4**	1.1170***	(0.16)
	Adjusted R^2	0.66		Adjusted R^2	0.66
	SSR	228.66		SSR	238.02
Real GNP/GDP - Final Data - 1981:3-2001:4			**Real GNP/GDP - Real Time - 1981:3-2001:4**		
	Coef	Std Err		Coef	Std Err
GB+1	1.1469***	(0.31)	**GB+1**	0.9393***	(0.26)
	Adjusted R^2	0.25		Adjusted R^2	0.21
	SSR	467.32		SSR	375.68
SPF+1	1.3490***	(0.34)	**SPF+1**	1.1411***	(0.32)
	Adjusted R^2	0.23		Adjusted R^2	0.21
	SSR	478.53		SSR	376.56
GB+4	0.4887	(0.51)	**GB+4**	0.4587	(0.45)
	Adjusted R^2	0.02		Adjusted R^2	0.02
	SSR	464.35		SSR	368.08
SPF+4	0.0796	(0.65)	**SPF+4**	0.2624	(0.57)
	Adjusted R^2	-0.01		Adjusted R^2	-0.01
	SSR	478.17		SSR	378.10

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table I.6 - Regressions with lagged dependent variable - Whole Sample

Inflation

Final Data			**Real-Time Data**		
	Coef	Std Error		Coef	Std Error
Cst	-0.495*	(0.274)	Cst	-0.352	(0.299)
AR(1)	0.031	(0.101)	AR(1)	-0.031	(0.129)
GB+1	0.736***	(0.147)	GB+1	0.950***	(0.134)
SPF+1	0.277	(0.167)	SPF+1	0.087	(0.211)
Cst	-0.109	(0.417)	Cst	-0.343	(0.419)
AR(1)	-0.006	(0.146)	AR(1)	-0.001	(0.142)
GB+4	1.478***	(0.248)	GB+4	1.312***	(0.210)
SPF+4	-0.480	(0.241)	SPF+4	-0.269	(0.249)

Real GDP

Final Data			**Real-Time Data**		
	Coef	Std Error		Coef	Std Error
Cst	0.357	(0.724)	Cst	0.264	(0.942)
AR(1)	0.303***	(0.078)	AR(1)	0.086	(0.099)
GB+1	0.327	(0.306)	GB+1	0.236	(0.177)
SPF+1	0.449	(0.319)	SPF+1	0.664*	(0.362)
Cst	2.792*	(1.565)	Cst	1.597	(1.309)
AR(1)	0.002	(0.106)	AR(1)	-0.004	(0.122)
GB+4	0.746	(0.626)	GB+4	0.368	(0.516)
SPF+4	-0.580	(0.646)	SPF+4	0.086	(0.487)

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table I.7 - Forecasts Pooled over Horizon (current and next 4 quarters)

				Idiosyncratic component		No Idiosyncratic component				
			$\hat{\alpha}$	*se*	*p-val*	*se*	*p-val*	σ_ε^2	σ_u^2	RMSFE
Inflation	Final Data	GB	-0.279	0.128	0.029	0.166	0.093	0.527	0.181	1.071
		SPF	-0.476	0.170	0.005	0.196	0.016	0.456	0.330	1.293
	Real-Time Data	GB	-0.268	0.134	0.046	0.181	0.138	0.691	0.197	1.164
		SPF	-0.465	0.160	0.004	0.206	0.024	0.802	0.284	1.367
Real GNP/GDP	Final Data	GB	0.743	0.273	0.007	0.418	0.076	3.532	0.579	2.413
		SPF	0.695	0.292	0.018	0.423	0.101	3.304	0.676	2.411
	Real-Time Data	GB	0.214	0.280	0.446	0.376	0.571	2.227	0.642	2.049
		SPF	0.166	0.279	0.552	0.372	0.656	2.150	0.637	2.022

Table I.8 - One Factor Model

	Inflation - Final Data				Inflation - Real-Time Data			
	Horizon h=1		Horizon h=4		Horizon h=1		Horizon h=4	
	est	*var*	*est*	*var*	*est*	*var*	*est*	*var*
Actual	0.945	0.108	0.881	0.224	0.9179	0.1574	0.8682	0.246
GB	0.982	0.036	0.998	0.005	0.9859	0.028	0.9967	0.007
SPF	0.976	0.047	0.957	0.084	0.9717	0.0559	0.9579	0.082
Naïve	0.934	0.128	0.894	0.201	0.9037	0.1833	0.8828	0.221
	log LH	-0.048	*log LH*	-0.291	*log LH*	-0.116	*log LH*	-0.179
	p-value	0.079	*p-value*	0.000	*p-value*	0.002	*p-value*	0.000
	Real GNP/GDP - Final Data				**Real GNP/GDP - Real-Time Data**			
	Horizon h=1		Horizon h=4		Horizon h=1		Horizon h=4	
	est	*var*	*est*	*var*	*est*	*var*	*est*	*var*
Actual	0.5672	0.6783	0.1716	0.9705	0.5537	0.6934	0.1812	0.9672
GB	0.8816	0.2228	0.9975	0.005	0.8908	0.2065	0.9975	0.005
SPF	0.8988	0.1921	0.6271	0.6068	0.8849	0.217	0.6271	0.6068
Naïve	0.582	0.6613	0.1615	0.9739	0.6058	0.633	0.2925	0.9145
	log LH	-0.033	*log LH*	-0.197	*log LH*	-0.094	*log LH*	-0.174
	p-value	0.277	*p-value*	0.000	*p-value*	0.026	*p-value*	0.001

Table I.9 - Robustness: CPI - 1982:1 - 2001:4

Mean Square Errors

Horizon	GB	SPF	p-value
1	4.510	4.770	0.4433
4	4.137	4.498	0.0179

Regressions

Base

	Coef	Std Error		Coef	Std Error
Cst	0.8551	(0.8194)	Cst	1.2706	(0.8189)
GB+1	1.0658*	(0.6445)	GB+4	1.1088**	(0.4686)
SPF+1	-0.3907	(0.7745)	SPF+4	-0.5528	(0.5333)

Timing Disadvantage

	Coef	Std Error		Coef	Std Error
Cst	1.4887	(1.0333)	Cst	1.2262	(0.9912)
GB+2	1.1308***	(0.2607)	GB+5	1.2748*	(0.7468)
SPF+1	-0.6720	(0.5215)	SPF+4	-0.7104	(0.8274)

Significant Model

	Coef	Std Error		Coef	Std Error
	0.7748***	(0.1929)		0.7391***	(0.2606)
GB+1	Adj. R^2	0.1402	SPF+1	Adj. R^2	0.0850
	SSR	349.0		SSR	371.4
	Coef	Std Error		Coef	Std Error
	0.6426***	(0.1914)		0.5958***	(0.2241)
GB+4	Adj. R^2	0.1025	SPF+4	Adj. R^2	0.0678
	SSR	304.1		SSR	315.8

with Lagged Dependent Variable

	Coef	Std Error		Coef	Std Error
Cst	0.7444	(0.8402)	Cst	1.4441	(1.0013)
AR(1)	-0.1183	(0.1582)	AR(1)	-0.1813*	(0.1041)
GB+1	0.8781	(0.5709)	GB+4	1.3968***	(0.4966)
SPF+1	-0.0584	(0.7156)	SPF+4	-0.7216	(0.6715)

*,**,*** means respectively significant at 10%, 5% and 1%.

Table I.10 - Smaller Sample Periods

1987Q3-2001Q4					1992Q1-2001Q4					1994Q1-2001Q4				
Inflation					**Inflation**					**Inflation**				
Final Data			**Real-Time Data**		**Final Data**			**Real-Time Data**		**Final Data**			**Real-Time Data**	
	Coef	Std Error	Coef	Std Error		Coef	Std Error	Coef	Std Error		Coef	Std Error	Coef	Std Error
Cst	-0.0486	(0.3781)	-0.5337	(0.4333)	Cst	0.9158*	(0.4793)	0.6228	(0.6825)	Cst	1.149**	(0.4909)	0.8171	(0.7358)
GB+1	0.5331***	(0.1975)	0.8314***	(0.2058)	GB+1	0.1584	(0.3168)	0.2683	(0.2433)	GB+1	0.2016	(0.3584)	0.3951	(0.3012)
SPF+1	0.3457	(0.2084)	0.2149	(0.1932)	SPF+1	0.2708	(0.3852)	0.2431	(0.4007)	SPF+1	0.1131	(0.4314)	0.0236	(0.4962)
	Coef	Std Error	Coef	Std Error		Coef	Std Error	Coef	Std Error		Coef	Std Error	Coef	Std Error
Cst	0.2288	(0.5540)	-0.4836	(0.6528)	Cst	1.7715**	(0.6998)	0.7882	(0.9685)	Cst	2.547***	(0.8041)	1.7467	(1.0662)
GB+4	0.8041**	(0.3952)	0.9451***	(0.3463)	GB+4	0.1319	(0.6030)	0.3891	(0.4843)	GB+4	0.2545	(0.5947)	0.4254	(0.4070)
SPF+4	-0.0152	(0.4505)	0.0858	(0.4307)	SPF+4	-0.0650	(0.4468)	0.0540	(0.4572)	SPF+4	-0.5332	(0.5197)	-0.4110	(0.4998)
Real GDP					**Real GDP**					**Real GDP**				
Final Data			**Real-Time Data**		**Final Data**			**Real-Time Data**		**Final Data**			**Real-Time Data**	
	Coef	Std Error	Coef	Std Error		Coef	Std Error	Coef	Std Error		Coef	Std Error	Coef	Std Error
Cst	0.8770	(1.0720)	0.4403	(1.1918)	Cst	4.5271***	(1.5406)	5.2607***	(1.0496)	Cst	4.7347	(1.8178)	5.9497	(0.9381)
GB+1	0.3724	(0.3440)	0.1499	(0.2253)	GB+1	1.5527	(0.7713)	1.3419	(0.5894)	GB+1	1.635**	(0.8551)	1.6565	(0.5774)
SPF+1	0.5371	(0.3905)	0.7942*	(0.4628)	SPF+1	-1.8816	(0.9189)	-2.0165	(0.8638)	SPF+1	-2.064**	(1.1543)	-2.5668	(0.8206)
	Coef	Std Error	Coef	Std Error		Coef	Std Error	Coef	Std Error		Coef	Std Error	Coef	Std Error
Cst	5.5045***	(1.3727)	3.3406**	(1.3550)	Cst	7.6033***	(1.3683)	5.9808***	(1.3308)	Cst	8.6526	(1.2265)	6.8732	(1.3940)
GB+4	0.4235	(0.6567)	0.1679	(0.5685)	GB+4	-0.5711	(0.8223)	-0.6839	(0.6791)	GB+4	-0.1554	(0.7894)	-0.3793	(0.6764)
SPF+4	-1.4397*	(0.7264)	-0.4479	(0.6789)	SPF+4	-1.1132	(0.9574)	-0.4023	(0.9814)	SPF+4	-1.994**	(0.8299)	-1.0929	(1.0075)

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table I.11 - Mean Squared Errors - Smaller Sample Periods

Inflation - Final				Inflation - Real Time			
1987Q3-2001Q4							
Horizon	GB	SPF	p-value	Horizon	GB	SPF	p-value
1	0.641	0.761	0.247	1	0.790	1.013	0.059
4	0.670	1.121	0.000	4	0.796	1.298	0.0002
1992Q1-2001Q4							
Horizon	GB	SPF	p-value	Horizon	GB	SPF	p-value
1	0.626	0.672	0.648	1	0.798	0.891	0.343
4	0.639	1.094	0.001	4	0.745	1.297	0.002
1994Q1-2001Q4							
Horizon	GB	SPF	p-value	Horizon	GB	SPF	p-value
1	0.678	0.696	0.892	1	0.817	0.893	0.527
4	0.759	1.146	0.017	4	0.872	1.352	0.018

The p-value is for the test of the null hypothesis that the central bank errors and private sector errors are equal.

Table I.12 - Mean Square Errors: CPI
Smaller Sample Periods

1987:3 - 2001:4			
Horizon	GB	SPF	p-value
1	3.867	3.798	0.706
4	3.555	3.788	0.071
1992:1 - 2001:4			
Horizon	GB	SPF	p-value
1	3.493	3.521	0.898
4	3.585	3.820	0.098
1994:1 - 2001:4			
Horizon	GB	SPF	p-value
1	3.956	4.074	0.650
4	4.082	4.253	0.274

The p-value is for the test of the null hypothesis that the CB's errors and SPF's errors are equal.

Table I.13 - One Factor Model - Smaller Ssample Periods

	1987:3 - 2001:4				**1992:1 - 2001:4**				**1994:1 - 2001:4**			
	Inflation - Final Data				**Inflation - Final Data**				**Inflation - Final Data**			
	Horizon h=1		Horizon h=4		Horizon h=1		Horizon h=4		Horizon h=1		Horizon h=4	
	est	*var*	*est*	*var*	*est*	*var*	*est*	*var*	*est*	*var*	*est*	*var*
Actual	0.770	0.408	0.719	0.483	0.297	0.912	0.007	1.000	0.191	0.964	-0.240	0.942
GB	0.921	0.152	0.972	0.055	0.808	0.347	0.681	0.536	0.785	0.385	0.683	0.533
SPF	0.953	0.092	0.943	0.110	0.998	0.005	0.998	0.005	0.998	0.005	0.998	0.005
Naïve	0.716	0.488	0.696	0.516	0.243	0.941	0.128	0.984	0.182	0.967	-0.077	0.994
	log LH	-0.082	*log LH*	-0.083	*log LH*	-0.114	*log LH*	-0.084	*log LH*	-0.100	*log LH*	-0.076
	p-value	0.110	*p-value*	0.107	*p-value*	na	*p-value*	na	*p-value*	na	*p-value*	na
	Inflation - Real-Time Data				**Inflation - Real-Time Data**				**Inflation - Real-Time Data**			
	Horizon h=1		Horizon h=4		Horizon h=1		Horizon h=4		Horizon h=1		Horizon h=4	
	est	*var*	*est*	*var*	*est*	*var*	*est*	*var*	*est*	*var*	*est*	*var*
Actual	0.793	0.372	0.772	0.404	0.329	0.892	0.271	0.926	0.281	0.921	0.072	0.995
GB	0.940	0.117	0.969	0.061	0.836	0.301	0.823	0.323	0.851	0.277	0.998	0.005
SPF	0.930	0.135	0.945	0.107	0.963	0.074	0.821	0.326	0.918	0.158	0.683	0.533
Naïve	0.692	0.521	0.746	0.443	0.326	0.894	0.246	0.939	0.311	0.904	0.054	0.997
	log LH	-0.165	*log LH*	-0.103	*log LH*	-0.153	*log LH*	-0.170	*log LH*	-0.193	*log LH*	-0.233
	p-value	0.012	*p-value*	0.062	*p-value*	0.062	*p-value*	0.047	*p-value*	0.066	*p-value*	na

Chapter II:
Do Central Banks need a Superior Forecasting Record to Influence Private Agents? Endogenous vs. Exogenous Credibility*

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1. Introduction

In the last decades, there has been a strong interest in transparency and information issues in monetary policy emphasizing the role of expectations in policy outcomes. The expectations channel of monetary policy has indeed become more and more important in the most recent monetary policy models which consider central banking as management of expectations. Do central banks have superior forecasting performance and private information? Are central banks able to convey information to private agents? Can central banks influence private agents' expectations? Is greater transparency sufficient to influence them? These issues are essential because they contribute to assess the importance of one of the most uncertain and subtle channel of monetary policy.

Many authors, following the seminal work of Romer and Romer (2000), have assessed in the US the relative forecasting performance of the private sector and the Federal Reserve, a central bank which publishes[1] its forecasts after five years, and thus benefits from an informational advantage. However, this has not been extended to communicating central banks. Yet, by looking at the relative forecasting performance of some more transparent central banks that publish their forecasts more quickly, different hypotheses may be sorted out: the importance of relative information sets or of information processing capacities, for instance. It also provides a way to analyse the question of influence and credibility. If private agents know the current central bank forecast and that central bank forecasts are superior, but still have a different one, this might be more directly related to credibility than if private agents do not know the central bank forecast. Focusing on a set of communicating central banks thus allows emphasizing the expectations channel and influence of central banks.

The first contribution of this chapter is conceptual. We propose to distinguish two forms of credibility. We define endogenous credibility as the capacity to influence stemming from a superior forecasting performance. It would be rational for private agents to follow central bank if the latter has a better forecasting record. Second, we define exogenous credibility as influential power without superior forecasting performance of the central bank and stemming from a leadership and/or policymaker position or from the implicit informational content of central bank forecasts. Private agents might decide to follow the central bank even without forecasting advantage because of an inherent position of leader in the monetary environment (the central bank acts as a focal point in a situation of imperfect information and coordination games, see Phelps (1983), Wilson and Rhodes (1997) and Demertzis and Viegi (2008)) or because of the inference of central banks' preferences and future intentions from central bank forecasts by private agents (see Geraats (2005) and Woodford (2005)). Central bank forecasts act as signals about future policy decisions.

The second contribution to the literature is to provide original empirical evidence on the relative forecasting performance of central banks publishing their forecasts in real-time compared to private agents. Since this is a situation in which information is communicated

[1] It may be argued that the Fed is not a less transparent central bank as it releases its policymaker (FOMC) forecasts twice a year with a three week lag, besides its statements and minutes. However, Gavin and Mandall (2001) and Romer and Romer (2008) show that those forecasts do not contain useful information. Thus, the Fed releases its forecasts which are not informative (the FOMC ones) while publishes after a 5-year embargo those with useful information content (the Greenbook ones). The Fed is therefore transparent for some points (actions, justification of these actions for instance) and is less transparent for some other points (its forecasts) and the 5-year embargo confirms that the Greenbook forecasts have some value added. In the end, analysing whether this relative opacity is good or not is beyond the scope of this work. However, it is a reasonable statement to consider that the Fed is less transparent concerning its informative (cf. Romer and Romer (2000, 2008)) projections.

and thus supposed to be symmetric, it enable to assess whether superior forecasting performance is compatible with forecasts' communication or depends on low transparency. From this analysis, we investigate possible sources of forecasting performance and depart from a sole focus on the Fed through comparisons between diverse communication strategies, interest rate scenarios for forecasting and central banking frameworks.

The third input of this chapter is to analyse, building on the real-time publication of forecasts in the five countries considered, whether the central bank has *direct* influence on the private sector. Some papers among which Fujiwara (2005) and Ehrmann, Eijffinger and Fratzscher (2009), have tested whether central bank forecasts or the degree of central bank transparency have an impact on the dispersion of private forecasts. In this chapter, we assess the direct influence of central bank forecasts on the level of private forecasts. Independently from forecasting performance, testing whether the central bank forecasts are influential allows determining the direction of the leader-follower scheme of the monetary process. This chapter provides empirical evidence on this direction. Indeed, Bernanke and Woodford (1997) have shown that a monetary policy influenced by private expectations may lead to indeterminacy. Influential central bank is moreover supposed to make, due to its impact on private expectations, monetary policy implementation more effective. At the other hand, Muto (2008) argues that when private agents follow the central bank, this one must respond more strongly to expected inflation to achieve expectational stability. Last, influence may lead private agents to stop forming their specific information set and only refer to central bank information, as Morris and Shin (2002) argue that there might be a crowding out effect of public information on independent sources of information.

Combining influence outcomes with relative forecasting performance outcomes allows for underlining endogenous or exogenous credibility. This chapter thus exploits data collected from five developed countries, namely Sweden, the United Kingdom, Canada, Japan, and Switzerland, for which central banks communicate their forecasts in real time. More precisely, it means that the central banks publish their forecasts with very short delays. Private agents do not necessarily always know the central bank forecast when they form their own, but the central bank forecast of the previous quarter is available (in contrast with the situation in the US). Surveys of Consensus Forecasts are used for private sector forecasts as well as Prospera AB in Sweden for robustness purposes.

In order to assess the relative forecasting performance of central banks and private sector, we proceed to unconditional comparisons and conditional comparisons in the spirit of Nelson (1972), Cooper and Nelson (1975), Fair and Shiller (1989, 1990) and Romer and Romer (2000), which give the optimal combination of both forecasts to predict future variables. Results are robust to multicollinearity, to inclusion to a lagged dependent variable representing the last information set known at the date of the forecasts and allowing an assessment of the forward looking information content of forecasts. They are also robust to up and down economic phases, to comparison with each individual forecaster, and to comparison with other private forecast sets. We find that one out of five communicating central banks, the Riksbank from Sweden, has a better forecasting performance. Firstly, when comparing these communicating central banks between them and with the Federal Reserve, prior knowledge of the future policy path, low transparency and the institutional framework appear not to be sufficient conditions for superior forecast accuracy compared to private agents. Secondly, it highlights a puzzle: Riksbank has a superior forecasting performance while its forecasts are public information since they are available to private agents. Refutation of the hypotheses of low credibility of the central bank and poor capacity of information extraction by private agents suggests that the central bank experiences a specific competence in gathering or processing

new information between each forecast's release and hence reconstitutes a private information set. A superior forecasting performance is then compatible with greater transparency.

Influence is identified with the help of Granger causality tests, influence tests for various horizons and at different given date, and influence tests taking into account the impact of new information released between forecasts at the date *t-1* and forecasts at *t* following the methodology used in the finance literature. Results show that in three out of five countries (Sweden, the UK and Japan), the central bank forecast influences private forecasts, while evidence is mixed for Switzerland and Canada. There is no empirical support for influence from private agents on central banks.

There is therefore no clear-cut correspondence between forecasting performance and the ability to influence. The distinction proposed for credibility thus makes logical sense as the case of the central bank of Sweden is consistent with endogenous credibility, while in the UK and Japan, it seems that central banks exhibit exogenous credibility as a superior forecasting performance is not a necessary condition for them to be influential. They need not a forecasting advantage to influence private agents.

The rest of the chapter is organized as follows: section 2 describes the framework and the concepts of endogenous and exogenous credibility. Section 3 discusses the related literature. Section 4 presents data and timing issues. Section 5 focuses on the relative forecasting performance, while section 6 on influence tests. Section 7 concludes this chapter.

2. The Framework: Endogenous and Exogenous Credibility

In this chapter, the environment considered supposes imperfect information and non rational expectations from both the central bank and private agents. Persistent forecast errors of both actors are therefore possible. We introduce a forecasting function of private agents which depends on the information set available at the date forecasts are made and may potentially comprises the forecast of the central bank. The interaction of the central bank influence and relative forecasting performance highlights four cases[2]. Two of them are of particular interest to analyze central bank credibility.

Firstly, private agents introduce in their forecasting function the central bank forecast because it contains useful information; in other words, because of a better forecasting record of the central bank. The forecasting function of the private sector is the following:

$$E_t^{PS} y_{t+h} = f(I_t, E_{t-1}^{BC} y_{t+i} \; if \; \sigma_{BC} < \sigma_{PS}) \quad (1)$$

where $E_t^{PS} y_{t+h}$ is the forecast of the private sector made at the date t for a variable y (either inflation or real GDP) at the date $t+h$, I_t is the information set available at the date t (it does not contain the current inflation or GDP as central bank and private agents forecast current variables: this is the case h=0), $E_{t-1}^{BC} y_{t+i}$ is the forecast made at the date *t-1* by the central bank for a potentially different horizon $t+i$ (the forecast made at the same date is not necessarily available to private agents, as shown in section 4; we then focus on the forecasts that are definitely available to private agents). σ_{BC} and σ_{PS} are the average forecast errors of both actors. In line with the configuration of equation (1), we propose to define the concept of

[2] The two others are the situation where the central bank has no forecasting advantage and then does not influence private agents, and the situation where the central bank has a forecasting advantage but does not influence, what reveals either a communication problem or very weak reputation of the central bank.

endogenous credibility for a central bank which influences private agents due to a superior forecasting performance. Indeed, one would expect that relatively better forecasts of the central bank would enhance its credibility and legitimate its influence. Rational private agents would then naturally follow the central bank due to its better forecasting record[3] when forming their own expectations.

At the opposite end, we define exogenous credibility as the ability to influence for which the central bank need not a superior forecasting performance and which rather stems from a leadership or policymaker position. The forecasting function of private agents is then:

$$E_t^{PS} y_{t+h} = f(I_t, E_{t-1}^{BC} y_{t+i} \text{ if } \sigma_{BC} \geq \sigma_{PS}) \quad (2)$$

Two possible interpretations of this influence of central banks' forecasts could be proposed. *First*, publication of forecasts allows dissemination of information about the views, models and preferences of the central bank and justifies a following behaviour of the private agents who are able to infer future intentions (see Geraats 2005, Woodford 2005 among others[4]). This case still requires credibility of the central bank, but this credibility is now exogenous in the extent that it does not depend on some forecasting advantage and rather depends on some commitment record *à la* Barro-Gordon (whether the central bank cheats and sets the inflation rate in a discretionary way, or similarly whether the central bank uses "wrong" forecasts to mislead private agents). Geraats (2005) thus shows that transparency about central bank forecasts improves the central bank's reputation. *Second*, exogenous credibility may also arise from coordination games between economic agents to form their expectations, in a context of imperfect information and higher order expectations. In a similar context, Phelps (1983), Wilson and Rhodes (1997) and Demertzis and Viegi (2008) show respectively that monetary policy can be viewed as a coordination game between the central bank and private agents, that a commonly accepted leader provides a focal point for followers, and that monetary policy with quantitative communication may provide individuals with better anchors for coordinating their expectations. Diron and Mojon (2008) provide empirical evidence of the notion of central bank as a focal point for expectations to converge. Therefore, the central bank forecasts may be viewed as a signal from an actor which can be recognized as the leader of the monetary environment. Globally, in the case of exogenous credibility, the central bank need not be more informed to be influential.

The objective of this chapter is to test the possibility for endogenous or exogenous credibility for five central bank which publish their forecasts in real-time. For this, we assess the relative forecasting performance of central banks and private agents by testing which one of these two hypotheses is verified for each country considered:

$$\begin{cases} H_1 : \sigma_{BC} < \sigma_{PS} \\ H_2 : \sigma_{BC} \geq \sigma_{PS} \end{cases}$$

We then assess for each country whether the central bank influences private agents or not and the opposite, by testing these two hypotheses:

$$\begin{cases} H_3 : E_t^{PS} y_{t+h} = f(E_{t-1}^{BC} y_{t+i}) \\ H_4 : E_t^{BC} y_{t+h} = f(E_{t-1}^{PS} y_{t+i}) \end{cases}$$

The simultaneous evidence of H_1 and H_3 would support endogenous credibility, while empirical verification of H_2 and H_3 simultaneously would reveal exogenous credibility.

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[3] One may suppose that the mechanism of endogenous credibility may be self-maintained. If a central bank has a forecasting advantage (whatever the reason is), private agents will not invest in information processing, since they know central bank forecasts are more accurate. They will be influenced by the central bank forecasts. Since they do not improve their forecasting ability, it makes their future forecasts still inferior to those of the central bank, and justifies that they follow the forecasts of the central bank. And so on and so forth.

[4] See e.g. Walsh (2007) or Baeriswyl and Cornand (2010) which focus on the signaling role of central bank actions.

3. Related Literature

This chapter deals with two strands of literature: the first concerns the relative forecasting performance of central banks compared to private sector. It starts with the seminal work of Romer and Romer (2000) finding that Greenbook (from the Federal Reserve) forecasts are superior to private sector forecasts. Gavin and Mandal (2001), Sims (2002), and Peek, Rosengren and Tootell (1998, 2003) support this analysis, D'Agostino and Whelan (2008) and Gamber and Smith (2009) find that this advantage has decreased recently, while Joutz and Stekler (2000), Atkeson and Ohanian (2001), Faust, Swanson and Wright (2004), Baghestani (2008) and to a lesser extent Amornthum (2006) arrive at a different conclusion. The first chapter gathers methodologies, data and samples to show that the Federal Reserve possesses an informational advantage on inflation, but not on GDP. Moreover, Gavin and Mandal (2001) and Romer and Romer (2008) compare Greenbook forecasts (from the Federal Reserve staff) to FOMC (Federal Open Market Committee) forecasts, which are policymakers' forecasts. It appears that Greenbook forecasts outperform FOMC ones.

Outside of the US, a few articles assess the relative forecasting performance of the central bank with the private sector. In the UK, Boero, Smith and Wallis (2008) analyse the Survey of External Forecasters (SEF) and find that its average point forecasts of inflation outperform the Monetary Policy Committee's forecast, while comparisons for GDP growth show little difference. They note that SEF error is smaller than any (regular) individual errors which support pooled surveys. Casillas-Olvera and Bessler (2006) find a similar result with density forecasts. Lastly, Groen, Kapetanios and Price (2008) compare Bank of England (BoE hereafter) forecasts to real time model forecasts, but not to private forecasts. They find that simple univariate models do better than BoE's GDP forecasts, while inflation forecasts of the BoE dominate strongly. To my knowledge, there is no other empirical assessment of the forecasting performance of the central bank or the private sector, except some boxes in *Inflation Report*s by the Bank of England and the Riksbank. It can be mentioned that Andolfson et al. (2007) compare forecasting performance of the Riksbank to BVAR and DSGE models. The latter appear to outperform the former.

Second, a vast literature deals with the costs and benefits to publish forecasts, among which are Faust and Svensson (2001, 2002), Geraats (2002, 2005), Woodford (2005) and Eusepi and Preston (2008). Forecasts, with the development of inflation targeting policies, have become a central tool of central banks communication. However, only a few papers empirically assess whether there is a direct influence from central banks on private agents through forecasts, and theoretical considerations associated. Theoretically, poor forecasting performance can impair central banks' credibility and mislead private agents, while influential and accurate forecasts might improve the effectiveness of monetary policy. Bernanke and Woodford (1997) and Muto (2008) reach opposite conclusions on the impact of the link between central banks' and private agents' forecasts. Muto (2008) sets up a theoretical framework in which private agents refer to the central bank's forecasts and finds the central bank must respond more strongly than the Taylor principle suggests to inflation. Empirically, Fujiwara (2005) shows from Japanese data that the Bank of Japan influences private forecasters, while the opposite is not true. Ehrmann, Eijffinger and Fratzscher (2009) analyse whether central bank transparency reduces dispersion in private forecasts. Both analyses focus on the dispersion of forecasts. Levin, Natalucci and Piger (2004), Gürkaynak, Levin and Swanson (2006), Jansen and De Haan (2007), Cecchetti and Hakkio (2009) and Capistran and Ramos-Francia (2010) show the influence of increased communication and transparency on private expectations. Kelly (2008) assesses the causal relationship between inflation and inflation expectations through Granger causality tests in the UK and finds that while before inflation

targeting was introduced in the UK, expectations and inflation were linked. After its implementation (and communication of forecasts), this link disappears and private agents anchor their expectations. Likewise, Boero, Smith and Wallis (2008) find that private forecasters have a tendency to follow the BoE for GDP growth forecasts, but not for inflation. This chapter then proposes to assess empirically the direct link between private and central bank forecasts and to identify whether it is the private sector or the central bank which influences the other.

4. Data and the Timing issue

I focus on five developed countries[5] for which the central bank publishes forecasts: Sweden, the UK, Canada, Japan and Switzerland. Some initial and general remarks are worth being made before focusing on the characteristics of each data[6] set.

4.1 Preliminary Issues

First, as emphasized in the previous section, we analyze potential information asymmetry through relative forecasting performance, since it is a hypothesis commonly accepted in the literature that forecasts of central banks and private agents map all information available to them. We then take those officially published by central banks and surveys of professional forecasters or consumers for the private sector. For these surveys, the mean of the point forecasts[7] collected are considered.

Second, we here focus on central banks which publish their forecasts with very short delays compared to the Federal Reserve. Private agents do not necessarily always know the central bank forecast when they form their own, but the central bank forecast of the previous quarter is available (in contrast with the situation in the US).

Third, two types of forecasts exist: fixed-event scheme and fixed-horizon scheme. Consensus Forecasts provide both, while the central banks of Sweden, the UK and Canada focus mostly on fixed-horizon forecasts (but also publish fixed-event ones) and the central banks of Japan and Switzerland[8] only publish fixed-event forecasts. Fixed-horizon forecasts have many advantages: they provide more observations and possibilities of comparison and they are not contaminated by the effects of varying lead times. It is generally admitted that it is the most appropriate format to compare forecasts between themselves. Thus, throughout this chapter, we will focus on fixed-horizon forecasts for Sweden, the UK and Canada; and on fixed-event forecasts (for the current and next years) for Japan and Switzerland.

Fourth, the period considered here falls within the Great Moderation period and predates the impact of the commodities price rise and fall, and turbulences in financial markets. It

[5] ECB is absent from this study as it starts to publish its Eurosystem Staff Macroeconomic Projections lately and only on a semi-annual basis. In addition, Svensson (2000, 2001) argues that these forecasts are much inferior to those of inflation targeting central banks as it involves all national central banks and not only the ECB staff of Executive Board. The Fed's policy for data, coupled to the already abundant literature on the US case, explain its absence in this comparison: with the embargo of 5 years to obtain forecasts and in order to compare countries on a similar sample, only a very small number of observations would have been available.

[6] Tests of stationary have been conducted for each group of series: the null hypothesis that each variable assumes a unit root process is always rejected at the 10% level and most of the time at the 5% level. The investigation is carried out with the Augmented Dickey-Fuller's and Phillips and Perron's tests. The latter proposes an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root. These results are available upon request.

[7] Engelberg, Manski and Williams (2009) find point forecasts are in general to be more optimistic (lower inflation and higher output growth) than the corresponding density forecast mean. However, Boero, Smith and Wallis (2008) note that analyses of errors in the density forecast mean and in point forecasts are similar.

[8] The Swiss National Bank has recently started to publish fixed-horizon forecasts in addition to its fixed-event forecasts. Thus, forecasts for the next twelve quarters are available since 2008Q3.

could then be argued that the task of forecasters is made easier. However, even if this were true, we here compare forecasters' performances between them *ceteris paribus*. Second, Stock and Watson (2007) show this assumption is not relevant as it is very difficult to beat simple and naïve forecast models during macroeconomic stability. Indeed, inflation should have become easier to forecast with the drop in volatility, but is more difficult as it evolves now as a random walk. Discrepancy between the private sector and the central bank over a stable sample would then be even more significant.

4.2 Central bank forecasts: staff or policymakers?

In Sweden, the UK, Canada and Switzerland, the publication of forecasts is made through formal *Inflation Reports* while in Japan the forecasts are published in the *Outlook for Economic Activity and Prices* and reflect each Policy Board member's forecast.

More precisely, Riksbank's forecasts are produced by the staff and are revised by the Executive Board and are then a mix of technical and judgmental approaches. Bank of England's forecasts are made by the staff and agreed by the Monetary Policy Committee. They note that this is not a mechanical exercise: they use a model to help produce these projections, but the final forecast involves some judgment. In Canada, forecasts published are the staff projections and include a recommendation on the appropriate level of the key policy rate. Alternative scenarios are also provided. In Switzerland, forecasts involve the staff and policymakers. Lastly, in Japan, forecasts made available to the public are those of the policymakers only. Globally, these five central banks which communicate their forecasts in real time publish a mix of staff and policymakers forecasts in Sweden, the UK and Switzerland, staff forecasts in Canada and policymaker ones in Japan. Thus, except for Japan where the nature of forecasts appears to be similar to those of the FOMC, real-time forecasts considered here can be treated as broadly equivalent to those of the Greenbook.

4.3 Central bank forecasts: Which interest rate scenario?

It appears from the literature that unconditional forecasts should be preferred, as Woodford (2000) argues that central bank forecasting based on private expectations give too much weight to forward-looking variables when policymaking. Faust and Leeper (2005) show that unconditional forecasts are more effective communication tools than conditional forecasts. Faust and Wright (2008) provide specific tests for conditional forecasts and consider that these types of forecast "represent a substantial impediment to the analysis of their quality". Indeed, there are three potential scenarios on which central bank forecasts may be based: constant interest rate, interest rate expected by future markets, and central banks' projected interest rate. The Riksbank's forecasts from Sweden were based before October 2005 on a constant interest rate scenario, until February 2007 on implicit forward rates (interest rate expected by financial markets), and since then on Riksbank's preferred path for the future interest rate. The Riksbank publishes a fan chart of this projected path. The Bank of Canada also bases its forecasts on a projected path for its central bank rate, but without releasing its trajectory. Forecasts in Japan and Switzerland are based on the assumption of a constant interest rate, while the Bank of England uses two scenarios: a constant interest rate since 1993Q1 and a scenario based on the interest rate expected by markets since 1998Q1.

This might make forecast comparisons difficult; however it may be reasonably argued that in the end all these forecasts are close to being unconditional forecasts. First, communication of forecasts is not pre-commitment. Second, the last three central banks use constant interest rates and the first two do not commit to this trajectory (Sweden) or do not publish it (Canada). Third, the delays of transmission of the traditional channels of monetary policy are longer than the horizons of forecasts considered. Finally, it seems reasonable to assume that forecasters want to maximize their predictions' accuracy.

4.4 Characteristics of each data set[9]

For Sweden, the Riksbank provides 12-month change forecasts at different quarters in the future. These are regularly available for inflation (CPI) for forecasts 1 year (Q+4) and 2 years (Q+8) ahead from 1997Q1 and for all quarters from the current one to Q+6 from 1999Q3. Concerning GDP, from current quarter to Q+6 forecasts are available since 2003Q4. The 12-month rate forecasts in current and next 6 quarters are compared to the quarterly forecasts gathered by Consensus Forecasts. These are available since 1999Q2 for both inflation and GDP. For these quarterly forecasts comparison, Inflation Reports which contain forecasts of the Riksbank, are on average published around March 16th, June 8th, October 10th and December 7th, and surveys of Consensus Forecasts in the end of the first half of March, June, September and December. Private agents do not necessarily know the central bank forecasts when they make theirs and the timing of release is not a controversial issue[10] here.

For the UK, the BoE publishes year-over-year forecasts for current to next 8 quarters only for inflation since 1993Q1 with a scenario of constant interest rate, and for both inflation and GDP as from 1998Q1 with both scenarios[11]. Moreover, the measure of inflation has been RPIX until 2003Q4 and CPI-H since 2004Q1. These forecasts are compared to private forecasts[12] of Consensus Forecasts available until the 6th future quarter since 1999Q2 for both inflation and GDP. The switch from RPIX to CPI-H is here made in 2005Q1. Next, because of the change of measure for inflation, the analysis of inflation forecasts' accuracy is separated in two subsamples for comparisons with Consensus Forecasts: the first concerning RPIX until 2003Q4 and the second for CPI-H from 2005Q1, because the two institutions do not forecast the same measure of inflation in the year 2004. Finally, the issue of the timing of publications is slightly in advantage of Consensus Forecasts, which consistently releases its surveys one month after the BoE.

For Canada, the Inflation Reports are published in January, April, July and October of each year and provide projections of Total CPI and real GDP at year-over-year rate for current and next four quarters respectively since 2003Q2 and 2005Q2. We compare the 12-month rate quarterly forecasts with similar projections made by Consensus Forecasts (CF). The timing of publication is however different: these quarterly forecasts are published in March, June, September and December. There is then strong timing disadvantage (and then information disadvantage) for Bank of Canada (BoC hereafter). It seems more reasonable to compare CF's forecasts from the preceding quarter to the BoC's forecasts of a current quarter than both in the current quarter. Indeed, CF's forecasts from quarter *q-1* are closer to BoC's forecasts of quarter *q* (a gap of 1 month between both) than to BoC's forecasts of quarter *q-1* (2 months gap). We therefore provide comparisons on the standard basis (the 'base specification' in the tables) and with this timing correction.

For Japan, the central bank publishes only twice a year, in the last days of April and October, the lower and higher forecasts of the majority of policy board members, for real GDP and CPI (excluding fresh food) at an average annual rate basis. These forecasts are available for

[9] All samples finish in 2007Q4.

[10] The following results are similar if we exclude the third quarter of each year, for which the timing gap between both central bank and private forecasts is the largest.

[11] We report Mean Square Errors for forecasts with both scenarios but focus afterwards on the constant interest rate scenario (*unconditional forecasts*).

[12] Two other private forecasts sets were used: a survey of public attitudes to inflation conducted by Gfk NOP and inflation and GDP forecasts of "other forecasters" for two years ahead available in each *Inflation Report* (called the Survey of External Forecasters (SEF), that is in average 25 institutions, banks and miscellaneous forecasters). Both sets confirm the results obtained with Consensus Forecasts.

the current year since October 2000 and for next year at a regular frequency only since October 2004[13]. For this study we take the middle point of the range which very regularly coincides with the median forecast which has started to be published more recently. The forecasts of the private sector are taken from Consensus Forecasts. They publish at the beginning of each month the forecasts of various institutions and we then take the survey of early May and November, for which the publication gap between both institutions is the smallest.

For Switzerland, the central bank publishes twice a year since 1999Q4 and on a quarterly basis since 2003Q1 forecasts of CPI for current, next year and the following one. We compare them to the Consensus Forecasts of current and next year calculated on the same basis: annual average rate. The Swiss National Bank publishes its Inflation Reports in the last days of March, June, September and December, while the date of publication of Consensus Forecasts' surveys is at the end of the first half of the same months. The timing of release then favours the central bank.

4.5 The Timing issue

The timing issue deserves some attention. For the assessment of the relative forecasting performance, we compare the forecast made in the same quarter at the nearest date but it still remains some time elapsed between each released, which favours the one that publishes its forecasts in second. It appears that in the UK, Japan and Canada, the private sector is the second mover and benefits from the informational advantage. As the focus of this chapter is to determine whether the central bank has a superior forecasting performance, this bias goes against the central bank so that evidence in favour of the central bank would be even more convincing. In the case of Sweden, in 2 quarters out of 4 the central bank is the second mover, in the 2 others, the private sector is. There is therefore no clear second mover advantage in this configuration. We nevertheless control for this in robustness checks. For Switzerland, the central bank is the second mover and evidence should be analysed cautiously.

Concerning the assessment of influence, we do not compare the forecasts within the same quarter, so the timing of publication within the quarter has no relevance for this specific question. The three influence tests described hereafter assess whether the forecasts of private agents made at the quarter *t-1* influence forecasts of the central bank made at the quarter *t*, or the opposite. Nevertheless, as the second mover publishes its forecasts later, it should contain more information (the second mover advantage) and then there might be a bias in the extent that the second mover's forecast should be more prone to influence the following forecasts. We control for that effect in section 6.

5. Relative Forecasting Performance

In this section, we test which one of the hypothesis H_1 and H_2 is verified. We use two methods: unconditional comparisons with Mean Square Errors and conditional comparisons with regressions in the spirit of Nelson (1972), Cooper and Nelson (1975), Fair and Shiller (1989, 1990) and Romer and Romer (2000). We provide results for both benchmark methods for all five countries, and present results of robustness tests[14] only when benchmark estimates justify it, that is to say, for Sweden. As the focus of the chapter is on relative

[13] For this reason, there is very little data available and we then report only MSE for next year forecasts and exclude them from regressions.

[14] Robustness tests for other countries confirm that there is no superior forecasting performance.

forecasting performance and the interaction of central bank forecasts with private sector's ones since the former are public, the analysis focuses more on conditional comparisons.

5.1 Unconditional Comparisons: Mean Square Errors

The standard method to compare forecasts accuracy of both actors is to measure their Mean Square Errors, which constitute unconditional comparisons. Some advantages of this method are to provide absolute forecast errors and to be the most neutral or uncontroversial one. In order to calculate the *p-value* for the test of the null hypothesis that central banks and private forecasts MSEs are equal, we estimate following Romer and Romer (2000) this regression[15]:

$$(Y_{t+h} - CB_t^h)^2 - (Y_{t+h} - PS_t^h)^2 = \alpha + \varepsilon_t \quad (3)$$

where Y_{t+h} is the actual value of inflation or GDP, CB_t^h the forecast made by the central bank in date t for h horizons later, PS_t^h by the private sector in date t for h horizons later, and α the difference between the squared errors of forecasts of both institutions. It allows calculating the standard errors of α corrected for serial correlation with the Newey-West HAC method[16]. Robust *p-value* can thus be obtained for the test of the null hypothesis that $\alpha = 0$, in order to determine whether the forecast errors are significantly different.

5.2 Conditional Comparisons: Regressions

The second method consists of regressing the actual inflation on forecasts made by both institutions in order to know whether the Greenbook's forecasts contain information which could be useful to private agents to form their forecasts. This method is applied from Nelson (1972), Cooper and Nelson (1975), Fair and Shiller (1989, 1990) and Romer and Romer (2000) to quantify the marginal contribution of one actor compared to the other. The objective as described by the latter authors is to see if individuals who know the private sector forecasts could make better forecasts if they also knew those of the central bank. The equation is:

$$Y_{t+h} = \alpha + \beta_{CB} \cdot CB_t^h + \beta_{PS} \cdot PS_t^h + \varepsilon_t \quad (4)$$

I test the hypothesis that central bank's forecasts at different horizons contain useful information to forecast inflation or GDP if its associated coefficient β_{CB} is significant and additional information compared to private sector's forecasts by testing whether β_{CB} is superior to β_{PS} and is near to 1. Standard errors are here again computed using the Newey-West's HAC methodology to correct serial correlation.

Availability and compatibility of data determines the length of samples. Although the available time series are relatively short (most of central banks which publishes forecasts started in late nineties or in this decade), the general sample corresponds to a period in which inflation has been very stable. Thus, strongly significant evidence is all the more noteworthy as inflation and GDP growth rate have been extremely stable on the period considered despite short samples (especially for Canada). Second, there is then no problem of credibility of the central bank and its decisions (for instance, private agents' views that central banks won't succeed to fight strong inflation in the beginning of the eighties) that could favor central banks to the detriment of private sector. The sample is stable here and rules out Atkeson and Ohanian (2001)'s remark on this point.

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[15] Diebold and Mariano (1995) and Clark and McCracken (2001) propose different tests of forecast accuracy. Since the focus of this paper is on conditional comparisons, we use the standard method for unconditional comparisons.

[16] In these regressions, the problem due to the correlation between forecast errors leads to calculate robust standard errors to serial correlation. Indeed, when forecasts for four quarters ahead miss an unexpected change in the variable, this would definitely cause forecasts errors all in the same direction. Forecasts are then declared serially correlated. In order to deal with this problem, when considering forecasts for inflation h quarters ahead, the standard errors are computed correcting for heteroskedasticity and serial correlation according to the Newey and West's *HAC Consistent Covariances* method.

5.3 Benchmark Results

For Sweden, table II.1 displays Mean Square Errors for fixed-horizon quarterly forecasts and shows that CPI's Riksbank errors are largely smaller than those of CF, while quite similar for GDP. In addition, table II.2 displays regressions that strongly validate these findings for CPI and let us suppose that if the Riksbank has an advantage on GDP, evidence is in this case more mixed.

For the UK, table II.1 shows Mean Square Errors of the Bank of England compared to Consensus Forecasts and it appears that forecasts errors are globally very similar and not significantly different either for inflation than for GDP. One can only note that for inflation at long horizons[17] (Q+4, Q+6) private forecasters have a very little advantage on the BoE. This might be explained by the timing advantage of CF and the fact that private agents know central bank forecasts. Regressions (table II.2) do not show evidence of better forecasting performance in favor of one or the other actor and confirm that any of both actor has a strongly better forecasting performance.

For Canada, in table II.1, Mean Square Errors show slightly better forecasts for Consensus Forecasts at short horizons (current quarter and Q+1) and equivalent accuracy at longer horizons for both CPI and GDP. One has nevertheless to keep in mind that CF benefits from a strong (2 months) timing advantage and knows central bank forecasts. The regression analysis in table II.2 specifies the results: with the base timing, there is a weak advantage of CF on short horizons (which is more visible for GDP) while similar forecast errors have a weak advantage on longer horizons. With the timing correction, the small advantage of CF disappears and there is no evidence of better forecasting performance in any case.

For Japan, results are hardly interpretable in order to evaluate relative forecasting performance. Focusing on current year forecasts, Mean Square Errors of CPI forecasts (table II.1) are equivalent, while regressions (table II.2) give more weight to the BoJ. For GDP, MSEs are significantly smaller for the Bank of Japan (BoJ), but regressions do not confirm this outcome. All in all, there is no evidence of any informational advantage.

For Switzerland, results for current year CPI forecasts appear to favor Consensus Forecasts: Mean Square Errors are very close but significantly different (table II.1) and regressions show a coefficient associated with private forecasts significant (table II.2). At the contrary, the pattern for next year's forecasts appears less clear: Consensus Forecasts show smaller forecast errors but are not significant useful in regressions. Globally, there is no evidence of a relatively better forecasting performance of the central bank and the timing issue is not blurring the results, as the central bank is in the position of the second mover in Switzerland.

5.4 Robustness: Multicollinearity

In order to check that regressions are not distorted by multicollinearity (forecasts are indeed highly correlated between themselves) as discussed by Granger and Newbold (1977), the actual variable is regressed on only one forecast at the same time:

$$Y_{t+h} = \alpha + \beta_{CB\,or\,PS} \cdot [CB_t^h \text{ or } PS_t^h] + \varepsilon_t \qquad (5)$$

The objective of this univariate regression is to assess the validity of the previous regression with forecasts combination by simply comparing the statistical tools of significance of the model between the different forecasts, so as to ensure that the explanatory power found in the main regression is still valid when forecasts are compared one by one and not together. It is then more informative to look at the R^2 and to what extent $\beta_{CB\ or\ PS}$ is near to 1 rather than the significance of the coefficient associated with the forecast.

[17] This result is confirmed at the two year horizon by the SEF.

5.5 Robustness: Additional information beyond last information set

It is important to assess whether the coefficient associated with private or central bank forecasts are significant due to high correlation to actual data or because they provide additional information besides the information set known at the date when the forecast is made. If we consider that an autoregressive term of the dependent variable – the actual data – comprises all the information available when the forecast is made, then we may assess whether the forecast really contains superior forward-looking information. In other words, is there a real value added of the forecasts beyond a lag of the dependent variable, supposed to contain all information available? Moreover, variables are persistent and this test allows verifying the robustness of the coefficient associated with forecasts when taking into account this persistence, in the case of forecasts of the current quarter. The equation estimated is then:

$$\pi_{t+h} = \alpha + \beta_{\pi} \cdot \pi_{t-1} + \beta_{CB} \cdot CB_t^h + \beta_{PS} \cdot PS_t^h + \varepsilon_t \quad (6)$$

where the analysis still lies on the significance of the coefficient associated with both the central bank and the private forecasts.

5.6 Robustness: Economic Phases

Forecasts are usually known to have mean reversion properties (see among others Fama and Bliss (1987), Kim, Nelson and Startz (1991) and Kilian and Taylor (2003)) and fail to forecast turning points (see Neftci (1982), Diebold and Rudebusch (1989), Hamilton (1989), and Lahiri and Wang (1994)). The former property could lead to a bias in the benchmark regression, as projections are underestimated in upward phases and overestimated in downward ones, while the second property shows great forecast errors when a turning point occurs. One possible way to check whether the previous outcomes are not distorted by these two characteristics is to restrict ex-post the analysis to up or down phases of the variable of interest forecasted. Heterogeneity between upward and downward phases and turning points are thus ruled out. The main regression is therefore estimated by dividing the sample according to economic conditions: rising inflation and the opposite.

5.7 Robustness: Controlling for the Second Mover Informational Advantage

In the case of Sweden, there is no clear second mover advantage as the central bank publishes its forecasts after the private sector in March and October and the private sector after the central bank in June and December. In order to verify that the superior forecasting performance of the Riksbank is due to some imbalances in the second mover advantage which would have favored the central bank, we assess the relative forecasting performance when the central bank is the second mover and when the private sector is the second mover.

5.8 Robustness: Individual Forecasters' Comparison

I compare forecasts of central banks to individual private forecasts for the country, Sweden, for which the comparison of survey's aggregate forecasts shows a clear advantage in favor of the central bank. The question is whether this advantage of the Riksbank holds only for some private forecasters, for a large majority or for all18. Indeed, Kim, Lim and Shaw (2001) show that surveys do not completely capture the full set of new information available to the pool of individual forecasts and therefore tend to reveal inefficiency (i.e. they are correlated with their own forecast errors). This inefficiency associated to Consensus Forecasts might then introduce a bias in favour of the central bank. First, it has to be noted that this inefficiency may apply as well to central bank forecasts, as Clements, Joutz and Stekler (2007) show for the Greenbook. Second and more importantly, if indeed the inefficient consensus forecasts

[18] The closer forecasts of the central bank and the mean of the private sector, the weaker the rationale for individual comparisons, because there will inevitably be some smaller individual forecast errors when the mean is near to the central bank forecast.

favor the central bank forecasts, we should find evidence of superior forecasting performance for all central banks. For 4 out of 5 central banks, there is no superior forecasting performance, so if there is a bias, it is not significant. For the only central bank (in Sweden) which exhibits a superior forecasting performance (so where the bias might be responsible for this result), we compare the central bank forecasts to individual forecasts to avoid this inefficiency bias.
Consensus Forecasts only provide individual fixed-event forecasts. Thus, the average annual rate forecasts of current and next calendar years of both actors are compared since 1999. We retain only major individual forecasters of Consensus Forecasts who respond to more than two third of surveys during the sample period. Due to differences in the planning of forecasting on a fixed-event scheme, the calendar forecast is compiled as the average of all forecasts made for a year during the preceding and the current ones (except the forecast of December for the current year because the Riksbank already focus on two next years in each December report). For instance, for the year 2001, we compare the forecasts of March, June, September, and December 2000, and March, June, and September 2001.

5.9 Robustness: Other Private Forecast Set

Last, we compare forecasts of the central bank with a different private forecast set: Prospera AB. The 12-month rate Riksbank's forecasts in 1 year and 2 years ahead are compared to private forecasts gathered via a survey by Prospera AB available since 1996Q1 for inflation. These forecasts are split in two categories: All respondents to the survey, and Market Players. Surveys of Prospera AB are published in early March, late May, early October and late November, which corresponds to the timing of publication of the Riksbank.

5.10 Robustness Results[19]

The better forecasting performance of the Riksbank for inflation and mixed evidence for GDP are confirmed by the robustness tests. In table II.3a, the R^2 of the univariate regressions shows a higher predictive power of the Riksbank's inflation forecasts. Table II.3b shows that Riksbank's inflation forecasts are still significant when adding a lagged dependent term in order to take into account the information set available at the date the forecast is made. Moreover, table II.3c confirms the same result when we divide the sample and focus on upward[20] phases. Table II.3d focuses on the second mover informational advantage and shows that the central bank outperforms the private sector across both sets of results. Individual forecasts from table II.3e confirm that the superiority of the Riksbank is not only for the mean of Consensus Forecasts' respondents but also for each individual respondent for inflation and that no inefficiency bias distorts the results. Finally, when comparing in table II.3f the Riksbank forecasts with Prospera AB's survey, CPI forecasts' errors of the central bank are lower than those from all respondents and are only similar to those from money market players at the two year horizon.

5.11 Discussion

All in all, Sweden is the only central bank of the set to benefit from a significantly better inflation forecasting performance than private agents. There is no evidence of any advantage for Canada and Japan. For the UK and Switzerland, evidence is mixed, however central banks seem not to have as good of inflation forecasts as private agents for respectively long and short horizons.

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[19] We only provide in the paper robustness tests for Sweden to confirm the better relative forecasting performance of the Riksbank. For the other countries where there is no evidence of information asymmetry, these robustness tests are available upon request.

[20] In the sample studied here, upward phases represent 28 of the 34 observations, so we only estimate this robustness test on those phases.

In comparison to the literature, Boero, Smith and Wallis (2008) find that the SEF average point forecast of inflation outperforms the BoE's forecast. This chapter confirms this specific result but limit its scope. Indeed, SEF is constructed asking for forecasts of the fourth quarter of the current year, of the following year and two years ahead, thus at longer horizons than in the Consensus Forecast. In this study, due to data availability, we focus on SEF's forecasts two years ahead. The comparison with Consensus Forecasts shows that while there is an advantage on inflation for private agents at longer horizons, both actors are equal for short horizons inflation forecasts. Moreover, Blix, Wadefjord, Wienecke and Adahl (2001) make a comprehensive work on the forecasting performance of 250 major institutions and find among other patterns that growth is more difficult to forecast than inflation. This result is confirmed for 4 out of 5 countries, the Bank of Canada and private agents having a better record for GDP forecasts. In general, the relatively good forecasting performance of surveys legitimates the choice to consider them as proxy of forecasts of private agents[21].

Concerning the possible sources of better forecasting performance, the results obtained in this section can be compared to those in Romer and Romer (2000) and in the first chapter, in which the Fed, which publishes its forecasts with a 5-year lag, is shown to benefit from an informational advantage on private agents about inflation. Indeed, it might be argued that releasing its forecasts with a 5-year lag enhance the Fed's relative information set. Romer and Romer (2008) for that matter show that (less transparent) Greenbook forecasts outperform (more transparent) FOMC forecasts. However, one can note that a low degree of transparency – the advantage of a relatively bigger information set due to non-publication of forecasts - is not a sufficient condition to explain Fed's better forecasting performance as the Riksbank's example demonstrates. Moreover, the monetary framework does not seem to play a role in benefiting from a better forecasting performance, as there are major institutional, status and strategic differences between the Fed and the Riksbank. Thus, targeting inflation does not seem either to be a sufficient condition.

It is generally admitted that one natural source of informational advantage is the private and prior knowledge of the future policy path. Yet, this prior knowledge does not lead to better forecasting performance in 4 out of 5 central banks. In the United Kingdom, Japan and Switzerland, forecasts are based on constant interest rate scenario or interest rate expected by future markets, so the hypothesis that the private and prior knowledge of the future policy path is a source of better forecasting performance does not seem reasonable[22]. From both central banks, the Riksbank and the Bank of Canada, which use their projected interest rate path as a forecasting scenario, the latter has no better forecasting record, while the former experiences a significantly better forecasting performance, but also publishes explicit interest rate paths[23], so make this information public. It might represent a forecasting advantage for the central bank on private agents, but it is not a sufficient condition. Interest rate path results from macroeconomic forecasts and are in fact endogenous to the specific expertise of the central bank. Private and prior knowledge of the future policy path seems not to be a source of better forecasting.

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[21] One might even consider that respondents to these surveys are generally the better informed agents through a selection bias. This reinforces anyway the use of these surveys when assessing relative forecasting performance with the central bank.

[22] It might be argued at the opposite that central banks base their forecasts on constant or expected by markets interest rate precisely not to reveal its private information about future policy path, but this goes against the very principle of transparency and would be inconsistent with the objective of producing the most accurate forecasts.

[23] One can nevertheless wonder whether the Riksbank deliver relevant and private information to the public through its interest rate path projections as they generally differ from realizations (Svensson (2009)).

5.12 The Swedish Puzzle

The better forecasting performance of the Riksbank reveals a puzzle as forecasts are communicated to the public. Indeed, at the time of the publication, each actor has its own private information, but this information becomes public, then private agents could use it for their next forecasts. Thus, different forecasting performance for current quarter is justified, as private agents have not the information of the central bank. At the opposite, for future forecasts of following quarters, private agents could use information published. However, estimates show a better forecasting performance for every horizon.

One can therefore put forward a series of hypothesis to explain this puzzle: the low credibility of the central bank that tempers private agents to use central bank's forecasts, the better gathering of new information by the central bank between each forecasts, which reconstitutes a private information set, or some inability of private agents to extract information contained in central bank forecasts, either due to the fact that forecasts are considered as a black box or because of the large amount of data received by private agents and their inability to deal with.

Section 6 of this chapter refutes the first argument, as it shows a strong credibility of private agents from the Riksbank. Moreover, the better forecasting record would convince private agents of the high credibility of the central bank. The third argument is disproved by table II.3g, which shows estimates of the test of the hypothesis that private agents are not able to extract and incorporate new information. We estimate the benchmark equation augmented with a timing advantage for the private sector. We suppose that if β_{PS} is not significant, it means the private sector has not been able to incorporate either information released by the central bank's forecast or new information revealed between *t-1* and *t*.

$$\pi_{t+h} = \alpha + \beta_{CB} \cdot CB_{t-1}^{h+1} + \beta_{PS} \cdot PS_t^h + \varepsilon_t \quad (7)$$

Table II.3g exhibits significant β_{PS} which invalidates the hypothesis of a low information processing and extracting capacity of private agents. Moreover, section 5 shows that forecasts of private agents are influenced by previous forecasts of the central bank, which confirms the proposition that private agents extract information from the central bank's forecast. The previous findings support the argument that the better relative forecasting performance of the Riksbank stems from some specific expertise in gathering new private information (or a better use and information extraction of public data) between each forecast. A possible reason is that central banks' staffs devote enormous resources to forecasting. Policymakers themselves (as shown by Romer and Romer (2008) in the case of the Fed) and private forecasters do not expend these resources.

To conclude, it appears that for 4 central banks, there is no difference with private agents in the forecasting performance. In Sweden, it is striking to notice that communication of forecasts and of the future policy path to the public coexists with better forecasting performance of the central bank. This suggests the Riksbank has a specific informational expertise: a competence in reconstituting private information between each forecast's release.

6. Influence of Central Banks

I now assess to what extent the central bank and the private sector, represented by surveys of Consensus Forecasts, influence one another, by testing the two hypotheses H_3 and H_4. We consider the influential power of each actor through its forecasts. Practically, three tests are implemented to estimate whether the central bank's (respectively the private sector) publication of forecasts influences those of the private sector (respectively the central bank). In this set of tests, we do not infer influence with regard to accuracy of the forecasts. We evaluate whether the central bank forecasts are based on its forecasts or on those of the

private sector independently of relative forecasting performance. In other words, we do not consider whether it is desirable that the central bank uses good or bad quality forecasts or whether it uses *only* its information, while it would be optimal to take into account private sector's information. We focus beyond these considerations on the influence of each actor on the other. Finally, testing the influence of a central bank also allows determining its credibility and reputation, as it reflects whether private agents follow its forecasts.

6.1 Granger causality test

The first analysis implemented is a standard test of Granger causality between forecasts of private sector and central bank.

$$CB_t^h \text{ or } PS_t^h = \alpha + \beta_{CB} \cdot CB_{t-1}^h + \beta_{PS} \cdot PS_{t-1}^h + \varepsilon_t \quad (8)$$

Influence of the central bank (resp. the private sector) is estimated regarding the significance of the coefficient associated with its forecast in the regression where the dependent variable is the private sector forecast (resp. the central bank). We then compare for each specification the significance of the central bank (CB) forecast to determine private sector (PS) forecast and the opposite. As a robustness check, we estimate this test and the following for different horizons and in the case of influence test, for different given dates of realization of forecasts.

6.2 Benchmark Results

Table II.4 presents the Granger causality analysis[24]. For Sweden, it clearly shows for CPI that private sector's forecasts are never significant when the central bank's forecasts are the dependent variable, while this latter is significant at 1% in the private sector equation. Concerning GDP, there is no evidence of influence in either direction. For the UK, it shows that for RPIX and CPI-H, there is a strong influence of the central bank, as forecasts are very significant for the determination of the private sector's forecasts and the inverse is not true. For GDP, there is no influence of one on the other. For Canada, in the base specification (for which there is a timing advantage of 2 months for Consensus Forecasts), CF's forecasts are always significant for CPI, though at different levels according to horizons observed. When considering the timing correction specification, there is no evidence of influence from either side: forecasts of the one are respectively significant in determining the forecasts of the other. Concerning GDP and comparing with influence specifications, it appears that there is also no respective influence. For Japan, outcomes are straightforward. Whatever the forecasts are for CPI or GDP, the BoJ influences the private sector. These results are consistent with those of Fujiwara (2005). For Switzerland, there is no consistent evidence of influence of the central bank but there is some evidence of influence of private agents on the central bank for forecasts of the current year. However, these estimates are not confirmed by influence tests. All in all, there is no support for any respective influence.

6.3 Influence test[25]

Because the Granger causality test compares series of forecasts at the same horizon, there is weak *practical* basis that forecasts for the current (or next) quarter are influenced by the forecasts at the previous date for current (or next) quarter. It seems more plausible that forecasts for a given future quarter are influenced by previous forecasts for this same given future quarter.[26] We therefore introduce a second test, in which we assess the influence of each actor for the construction of a forecast at the *given* date for the *given* horizon, through

[24] Relevant comparisons of estimates determining influence are highlighted in bold type in tables II.4, II.5 and II.6.
[25] Both tests of influence are shown only for CPI in Sweden, RPIX and CPI in the UK and CPI and GDP in Japan, for which Granger tests show evidence of influence. All other tables of these two tests are available upon request.
[26] Theoretically however, both tests are consistent as agents are supposed to incorporate all information available at date *t* in their decision making process.

the forecasts of both actors at the *previous* date for one horizon *later*.[27] The generic form of the regression is then the following, with *i* being the time-lag:

$$CB_t^h \text{ or } PS_t^h = \alpha + \beta_{CB} \cdot CB_{t-i}^{h+i} + \beta_{PS} \cdot PS_{t-i}^{h+i} + \varepsilon_t \quad (9)$$

Here again, we test whether the coefficient associated with the central bank forecast is significant or not in determining the private forecast. We test for each country for various horizons *h* and lags *i*, in order to assure the robustness of the results.

6.4 Influence test with News Released[24]

This third test has the objective of confirming that influence of one forecaster on the other is robust to the inclusion of the news released between the date *t-1* when first forecasts are made and *t* when the potentially influenced forecasts are then made. This specification with a news variable allows distinguishing between influence from previous forecasts and influence from news released during this interval of time. The equation estimated is:

$$CB_t^h \text{ or } PS_t^h = \alpha + \beta_I \cdot I_{t-1 \leftrightarrow t} + \beta_{CB} \cdot CB_{t-1}^{h+1} + \beta_{PS} \cdot PS_{t-1}^{h+1} + \varepsilon_t \quad (10)$$

The variable $I_{t-1 \leftrightarrow t}$ represents the information set released between the date *t-1* and *t*. It is constructed as the difference between the actual data in *t* and the forecast for *t* made in *t-1*, following the literature on the impact of economic news (see among others Pearce and Roley (1985), McQueen and Roley (1993) and Balduzzi, Elton and Green (2001)), which suppose that this variable of economic data announcements could be computed as the difference between announced values and forecasted values.

6.5 Robustness Results

Table II.5 shows the influence tests and gathers horizons and dates of forecasts. For Sweden, the two previous results are confirmed: the Riksbank has a clear influence on private sector for CPI. Its coefficients are always significant at 1%. There is no influence for GDP from either side. In general, one can note that influence from the central bank is more visible for the most recent forecasts. For the UK, influence of the central bank is robustly confirmed for inflation. The switch from RPIX to CPI-H still presents an influential power of the BoE, but only visible for the more recent forecasts (those made in *t-1*). For Japan, influence tests confirm previous results for inflation and output.

Table II.6 displays the influence tests when taking into account the information set released between both forecasts. Results are strongly confirmed for each three central banks: the Riksbank, the Bank of England and the Bank of Japan. Forecasts of these central banks are always highly significant to determine next private forecasts even in presence of the new information set released afterwards. One striking result is noteworthy: while in Sweden and Japan, private agents form their forecasts on the basis of the central bank forecasts and the information set, in the UK, private agents only consider central bank forecasts and do not use new information released in the interval of time. This is great evidence in favor of the high credibility of the Bank of England.

The previous results evidence influence of the central bank in Sweden, the UK and Japan. In the latter two, the private sector is the second mover and has informational advantage. Then a bias should favour the private sector forecasts to influence the central bank. The fact that there is no evidence of influence of private forecasts and evidence of influence of the central bank acts like a control for first/second mover effects and confirms the robustness of the results. In the case of Sweden, there is no clear second mover effect as the central bank and

[27] Due to series' format and differences between the rhythm of publication and horizon of forecasts, the forecast for the next horizon (the next year) that is supposed to give information on the forecast for the current year is shifted back respectively 4 periods for Switzerland (quarterly publications) and 2 periods for Japan (biannually).

the private sector have half of the time each role, so estimations should not be biased by this effect. Moreover, as table II.5 shows, when we consider different previous quarter *t-1*, *t-2*, *t-3* or *t-4*, so cases where either the central bank is second mover or the private sector is second mover, the influence of the central bank remains extremely significant, while there is definitely no evidence of the private forecasts.

6.6 Discussion

Sweden, the UK and Japan display strong influence of the central bank on private agents mainly through inflation forecasts, while for Canada and Switzerland evidence is mixed and does not support influential power and high credibility of the central bank. There is no clear empirical support for influence of the private sector on policymakers. In general, influence is more significant from the nearest forecasts (those made in *t-1* and *t-2*), which is consistent with the hypothesis that agents form expectations with the largest and most recent information set (except for the UK). Moreover, influence is more significant for forecasts at very short horizons. Lastly, evidence of influential power of GDP forecasts is weak (except for Japan).

It has to be noted that there is no single and direct empirical relationship between forecasting performance and influence. Switzerland experiences some slightly better forecasting performance of the private sector but no evidence of influence, while the BoE is in a similar situation of having lower forecast accuracy at long horizons compared to the private sector but clearly influences it. Correspondingly, central banks of Sweden, Japan and the UK all influence their respective private sector, with different degrees of relative forecasting performance.

Finally, estimates suggest that the central bank in Sweden could experience endogenous credibility as H_1 and H_3 are simultaneously verified, and that the central banks of United Kingdom and Japan experience exogenous credibility and need not be more competent or informed to be influential as H_2 and H_3 are simultaneously verified.

7. Conclusion

This chapter contributes to the literature in three ways: first, we propose the concept of endogenous and exogenous credibility to disentangle influence based on superior forecasting performance or not. Second, we provide an empirical assessment of the relative forecasting performance of both the central bank and private agents in five countries for which central banks publish forecasts in real time. We find that one out of five, the Riksbank, benefits from a specific expertise to reconstitute private information between each forecast's release. Third, we test the influential power of central bank's forecasts on private agents and the inverse. We find that in three out of five countries: Sweden, the UK and Japan, the central bank forecast influences the private forecasts, while the opposite is not true. There is then no support for a sole direct link between forecasting performance and influence. This confirms that influence may arise from two forms of credibility: endogenous or exogenous. In the second case, central banks need not be more competent or informed to be influential.

Table II.1 - Unconditional comparisons - Mean Square Errors

12-month rate

SWEDEN

CPI - 1999Q3-2007Q4

	Riksbank	CF	p-value
Current	**0.05**	0.30	0.19
Q+1	**0.21**	0.43	0.17
Q+2	**0.32**	0.70	0.17
Q+3	**0.46**	0.91	0.13
Q+4	**0.57**	1.07	0.11
Q+5	**0.80**	1.25	0.09
Q+6	**0.99**	1.52	0.03

GDP - 2003Q4-2007Q4

	Riksbank	CF	p-value
Current	0.67	**0.60**	0.69
Q+1	**0.80**	0.87	0.77
Q+2	**0.93**	0.96	0.92
Q+3	**0.71**	0.95	0.39
Q+4	**0.68**	1.03	0.25
Q+5	**0.60**	1.11	0.11
Q+6	**0.63**	1.19	0.04

UNITED KINGDOM

RPIX - 1999Q2-2003Q4

	BoE - CIR	BoE - MIR	CF	p-value
Current	**0.07**	**0.07**	0.08	0.46
Q+1	0.10	0.10	0.10	0.89
Q+2	**0.10**	**0.10**	0.11	0.78
Q+3	0.14	0.14	**0.13**	0.80
Q+4	**0.14**	**0.14**	0.15	0.96
Q+5	0.17	0.18	**0.15**	0.67
Q+6	0.24	0.25	**0.17**	0.11

CPI - 2005Q1-2007Q4

	BoE - CIR	BoE - MIR	CF	p-value
Current	0.07	0.07	0.07	0.97
Q+1	**0.13**	**0.13**	0.15	0.51
Q+2	0.20	0.20	0.20	0.95
Q+3	0.26	0.25	0.25	0.93
Q+4	0.47	0.46	**0.40**	0.04
Q+5	0.62	0.57	**0.48**	0.11
Q+6	0.59	**0.53**	0.56	0.05

GDP - 1999Q2-2007Q4

	BoE - CIR	BoE - MIR	CF	p-value
Current	**0.57**	0.58	0.68	0.38
Q+1	**0.65**	**0.65**	0.78	0.37
Q+2	**0.71**	**0.71**	0.87	0.36
Q+3	0.75	**0.74**	0.84	0.67
Q+4	0.56	**0.54**	0.64	0.67
Q+5	0.41	**0.38**	0.50	0.54
Q+6	0.36	**0.35**	0.52	0.34

CANADA

CPI - 2003Q2-2007Q4

	BoC	CF	p-value
Current	0.38	**0.22**	0.05
Q+1	0.43	**0.34**	0.17
Q+2	0.65	**0.40**	0.07
Q+3	0.48	**0.45**	0.71
Q+4	0.46	0.46	0.98

GDP - 2005Q2-2007Q4

	BoC	CF	p-value
Current	0.17	**0.10**	0.03
Q+1	0.36	**0.14**	0.01
Q+2	0.34	**0.33**	0.83
Q+3	**0.30**	0.34	0.75
Q+4	0.25	**0.19**	0.32

average annual rate

JAPAN

CPI - 2000S2-2007S2

	BoJ	CF	p-value
Curr. Year	0.039	**0.036**	0.876
Next Year	0.162	**0.103**	0.251

GDP - 2000S2-2007S2

	BoJ	CF	p-value
Curr. Year	**0.364**	0.674	0.052
Next Year	**0.313**	0.509	0.473

SWITZERLAND

CPI - 1999Q4-2007Q4

	BNS	CF	p-value
Curr. Year	0.027	**0.019**	0.077
Next Year	0.250	**0.124**	0.044

The p-value is for the test of the null hypothesis that the central errors and private sector errors are equal. In the case of the UK: that central bank's constant rate errors and private sector errors are equal.
CIR and MIR respectively means Constant Interest Rate scenario and Market Interest Rate scenario.

Table II.2 - Regressions

12-month rate													average annual rate				
SWEDEN			**UNITED KINGDOM**				**CANADA**						**JAPAN**			**SWITZERLAND**	
							Base (2 months gap)			*Timing Correction (1month gap)*							
Sample start	1999Q3	2003Q4		1999Q2	2005Q1	1999Q2		2003Q2	2005Q2		2003Q2	2005Q2		2000S2	2000S2		2003Q1
Variable	CPI Y_{t+h}	GDP Y_{t+h}	Variable	RPIX Y_{t+h}	CPI Y_{t+h}	GDP Y_{t+h}	Variable	CPI Y_{t+h}	GDP Y_{t+h}		CPI Y_{t+h}	GDP Y_{t+h}	Variable	CPI Y_{t+h}	GDP Y_{t+h}	Variable	CPI Y_{t+h}
$CB^{h=0}_t$	**0.885*****	1.162**	$CB^{h=0}_t$	0.799*	0.535	0.381	$CB^{h=0}_t$	-0.161	-0.699**	$CB^{h=0}_t$	0.436	0.249	$CB^{h=0}_t$	0.551**	0.482	$CB^{h=0}_t$	-0.064
	(0.026)	(0.410)		(0.381)	(0.715)	(0.415)		(0.435)	(0.309)		(0.288)	(0.651)		(0.207)	(0.302)		(0.270)
$PS^{h=0}_t$	0.079*	-0.965	$PS^{h=0}_t$	-0.070	0.581	0.143	$PS^{h=0}_t$	1.101	2.345***	$PS^{h=1}_{t-1}$	0.122	0.731	$PS^{h=0}_t$	0.216	0.176	$PS^{h=0}_t$	0.807***
	(0.038)	(0.603)		(0.399)	(0.770)	(0.556)		(0.697)	(0.438)		(0.280)	(0.882)		(0.233)	(0.246)		(0.265)
R^2	0.94	0.43	R^2	0.57	0.66	0.26	R^2	0.41	0.88	R^2	0.26	0.52	R^2	0.87	0.78	R^2	0.82
$CB^{h=1}_t$	**0.890*****	1.118***	$CB^{h=1}_t$	0.493	0.481	0.361	$CB^{h=1}_t$	0.115	-0.925**	$CB^{h=1}_t$	0.330	0.141				$CB^{h=1}_t$	-0.196
	(0.100)	(0.345)		(0.853)	(0.566)	(0.267)		(0.256)	(0.381)		(0.483)	(0.733)					(0.279)
$PS^{h=1}_t$	0.132*	-1.507***	$PS^{h=1}_t$	0.235	0.421	0.043	$PS^{h=1}_t$	0.433	1.753***	$PS^{h=2}_{t-1}$	0.159	0.117				$PS^{h=1}_t$	0.537
	(0.066)	(0.420)		(0.933)	(1.026)	(0.406)		(0.335)	(0.416)		(0.660)	(1.184)					(0.385)
R^2	0.74	0.51	R^2	0.34	0.36	0.12	R^2	0.22	0.75	R^2	0.19	0.03				R^2	0.13
$CB^{h=2}_t$	**1.036*****	0.980**	$CB^{h=2}_t$	0.668	-0.297	0.335	$CB^{h=2}_t$	-0.318	-0.420	$CB^{h=2}_t$	-0.264	0.391					
	(0.134)	(0.421)		(0.485)	(0.836)	(0.257)		(0.199)	(1.130)		(0.325)	(1.249)					
$PS^{h=2}_t$	0.012	-1.876***	$PS^{h=2}_t$	0.022	1.501	-0.358	$PS^{h=2}_t$	0.780**	0.500	$PS^{h=3}_{t-1}$	0.985	-0.913					
	(0.083)	(0.577)		(0.683)	(1.025)	(0.366)		(0.263)	(0.690)		(0.791)	(1.331)					
R^2	0.61	0.34	R^2	0.31	0.29	0.05	R^2	0.21	0.05	R^2	0.08	0.02					
$CB^{h=3}_t$	**1.118*****	0.780**	$CB^{h=3}_t$	0.420	-0.553*	0.027	$CB^{h=3}_t$	0.277	1.318	$CB^{h=3}_t$	-0.051	-0.022					
	(0.178)	(0.319)		(0.350)	(0.281)	(0.296)		(0.424)	(1.302)		(0.207)	(1.070)					
$PS^{h=3}_t$	0.028	-1.591	$PS^{h=3}_t$	0.337	3.074***	-0.969**	$PS^{h=3}_t$	0.362	-2.065	$PS^{h=4}_{t-1}$	-0.173	-0.082					
	(0.118)	(0.880)		(0.687)	(0.680)	(0.394)		(0.542)	(1.084)		(0.779)	(2.705)					
R^2	0.45	0.21	R^2	0.13	0.56	0.16	R^2	0.07	0.14	R^2	0.00	0.00					
$CB^{h=4}_t$	**1.107*****	0.817	$CB^{h=4}_t$	0.457	0.076	-0.023	$CB^{h=4}_t$	0.011	0.866								
	(0.324)	(0.577)		(0.285)	(3.691)	(0.486)		(0.326)	(1.303)								
$PS^{h=4}_t$	0.028	-0.023	$PS^{h=4}_t$	-0.499	-2.228	-1.279**	$PS^{h=4}_t$	-0.192	-2.144								
	(0.172)	(1.735)		(0.996)	(9.338)	(0.469)		(0.772)	(5.169)								
R^2	0.25	0.19	R^2	0.09	0.10	0.16	R^2	0.00	0.07								

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%. All samples finish in 2007Q4, except RPIX in the UK in 2003Q4 and Japan in 2007S2

Y_{t+h} is the actual value of inflation or GDP at the date t+h, CB^h_t the forecast made by the central bank in date t for h horizons later and PS^h_t by the private sector in date t for h horizons later

Table II.3a - Sweden - Robustness: Multicollinearity

Variable	CPI		GDP	
	Y_{t+h}	Y_{t+h}	Y_{t+h}	Y_{t+h}
$CB^{h=0}_t$	**0.950*****		0.487*	
	(0.027)		(0.240)	
$PS^{h=0}_t$		0.810***		0.429
		(0.189)		(0.274)
R^2	**0.93**	0.67	0.29	0.15
$CB^{h=1}_t$	**0.993*****		0.378	
	(0.082)		(0.215)	
$PS^{h=1}_t$		0.843***		-0.129
		(0.218)		(0.436)
R^2	**0.74**	0.52	0.16	0.01
$CB^{h=2}_t$	**1.044*****		0.126	
	(0.112)		(0.361)	
$PS^{h=2}_t$		0.709**		-0.606
		(0.345)		(0.583)
R^2	**0.61**	0.27	0.01	0.08
$CB^{h=3}_t$	**1.128*****		0.415	
	(0.180)		(0.287)	
$PS^{h=3}_t$		0.538		-0.597
		(0.489)		(1.073)
R^2	**0.45**	0.08	0.09	0.02
$CB^{h=4}_t$	**1.110*****		0.812**	
	(0.325)		(0.273)	
$PS^{h=4}_t$		0.29		1.246
		(0.427)		(0.819)
R^2	**0.25**	0.02	0.19	0.06

Numbers in parentheses are robust standard errors.
*,**,*** means respectively significant at 10%, 5% an
Y_{t+h} is the actual value of inflation or GDP at the dat
CB^h_t the forecast made by the central bank in date t
h horizons later and PS^h_t by the private sector in dat
for h horizons later

Table II.3b - Sweden - Robustness: Additional information beyond last information set

Variable	CPI	
	Y_{t+h}	*se*
Y_{t-1}	-0.007	(0.117)
$CB^{h=0}_t$	**0.869*****	(0.101)
$PS^{h=0}_t$	0.104	(0.169)
R^2	0.94	
Y_{t-1}	-0.252*	(0.136)
$CB^{h=1}_t$	**0.775*****	(0.240)
$PS^{h=1}_t$	0.510	(0.348)
R^2	0.76	
Y_{t-1}	-0.19	(0.212)
$CB^{h=2}_t$	**0.911*****	(0.298)
$PS^{h=2}_t$	0.386	(0.447)
R^2	0.62	
Y_{t-1}	-0.13	(0.193)
$CB^{h=3}_t$	**1.042*****	(0.254)
$PS^{h=3}_t$	0.337	(0.386)
R^2	0.45	
Y_{t-1}	-0.18	(0.283)
$CB^{h=4}_t$	**1.090****	(0.442)
$PS^{h=4}_t$	0.407	(0.810)
R^2	0.26	

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5%, 1
Y_{t-1} is a lag of the dependant variable
the actual variable forecasted, and represent the information set known at the date when the forecast is made

Table II.3c - Sweden - Robustness: Economic Phases

Variable Y_{t+h}	CPI 24 obs	*se*
$CB^{h=0}_t$	**0.905*****	(0.023)
$PS^{h=0}_t$	0.072*	(0.037)
R^2	0.94	
$CB^{h=1}_t$	**0.891*****	(0.097)
$PS^{h=1}_t$	0.103**	(0.049)
R^2	0.74	
$CB^{h=2}_t$	**1.070*****	(0.162)
$PS^{h=2}_t$	-0.001	(0.093)
R^2	0.61	
$CB^{h=3}_t$	**1.037*****	(0.245)
$PS^{h=3}_t$	-0.119	(0.125)
R^2	0.37	
$CB^{h=4}_t$	**0.889****	(0.344)
$PS^{h=4}_t$	-0.039	(0.186)
R^2	0.19	

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5%, 1
Upward phases are 1999Q3-2001Q3, 2002Q3-2003Q1and 2004Q1-2007Q4

Table II.3d - Sweden - Disentangling the second mover informational advantage

central bank is second mover				**private sector is second mover**			
Variable	CPI			Variable	CPI		
	Y_t	*se*	R^2		Y_t	*se*	R^2
$CB^{h=0}_t$	**0.886*****	(0.029)	0.95	$CB^{h=0}_t$	**1.046*****	(0.134)	0.94
$PS^{h=0}_t$	0.084*	(0.043)		$PS^{h=0}_t$	-0.086	(0.167)	
$CB^{h=1}_t$	**0.785*****	(0.161)	0.62	$CB^{h=1}_t$	**1.089*****	(0.333)	0.89
$PS^{h=1}_t$	0.082	(0.072)		$PS^{h=1}_t$	0.100	(0.411)	
$CB^{h=2}_t$	**1.209*****	(0.129)	0.67	$CB^{h=2}_t$	**0.858***	(0.475)	0.60
$PS^{h=2}_t$	-0.096	(0.086)		$PS^{h=2}_t$	0.223	(0.490)	
$CB^{h=3}_t$	**0.960*****	(0.306)	0.29	$CB^{h=3}_t$	**0.964*****	(0.297)	0.65
$PS^{h=3}_t$	-0.135	(0.154)		$PS^{h=3}_t$	0.642	(0.592)	
$CB^{h=4}_t$	**1.551*****	(0.381)	0.40	$CB^{h=4}_t$	**0.551**	(0.539)	0.14
$PS^{h=4}_t$	0.044	(0.182)		$PS^{h=4}_t$	0.361	(0.623)	

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5%, 1%.

Table II.3e - Sweden - Robustness: Individual Forecasters Comparison

CPI			GDP		
from 1999 to 2007			from 1999 to 2007		
		Riksbank			Riksbank
National Institute - NIER	0.14	0.14	HQ Bank	0.85	
JP Morgan	0.16		Nordea	1.12	
Morgan Stanley	0.17				1.13
Nordea	0.21		SE Banken	1.14	
MEAN	0.22		Svenska Handelsbanken	1.32	
HQ Bank	0.23		MEAN	1.35	
Merrill Lynch	0.26		Öhman	1.41	
SE Banken	0.26		JP Morgan	1.46	
Öhman	0.30		Morgan Stanley	1.52	
Confed of Swed Enterprise	0.35		National Institute - NIER	1.54	
Svenska Handelsbanken	0.41		Merrill Lynch	1.56	
			Confed of Swed Enterprise	1.90	
from 1999 to 2005			from 1999 to 2005		
Finanskonsult	0.76	**0.17**	Finanskonsult	1.77	**1.36**
from 1999 to 2004			from 1999 to 2004		
Alfred Berg	0.57	**0.17**	Alfred Berg	1.92	**1.53**
from 2000 to 2007			from 2000 to 2007		
Swedbank	0.31	**0.12**	Swedbank	1.24	**0.89**
UBS	0.25	**0.12**	UBS	0.97	**0.89**
from 2002 to 2007			from 2002 to 2007		
Skandiabanken	0.37	**0.10**	Skandiabanken	**0.50**	0.53
from 2003 to 2007			from 2003 to 2007		
SBAB	0.15	**0.11**	SBAB	0.62	**0.60**
from 2004 to 2007			from 2004 to 2007		
Econ Intelligence Unit	0.46	**0.12**	Econ Intelligence Unit	0.95	**0.74**
ING Financial Markets	0.41	**0.12**	ING Financial Markets	**0.59**	0.74

Reported values are the MSE of each individual forecasters

Table II.3f - Sweden - Robustness: Other Private Forecasts Set

1 year ahead (Q+4) - 1996Q4-2007Q4			
		Riksbank	p-value
Prospera - ALL	1.78	**1.31**	0.11
Prospera - Money Market Players	1.44		0.45
2 years ahead (Q+8) - 1996Q4-2006Q4			
		Riksbank	p-value
Prospera - ALL	2.08	1.89	0.29
Prospera - Money Market Players	1.77		0.32

Reported values are the MSE of both categories of private forecasters and of the Riksbank. The p-value is for the test of the null hypothesis that the central errors and private sector errors are equal.

Table II.3g - Sweden - Timing Disadvantage of the Riksbank

Variable	CPI		
	Y_t	*se*	R^2
$CB^{h=1}_{t-1}$	0.073	(0.717)	0.86
$PS^{h=0}_{t}$	**0.925*****	(0.000)	
$CB^{h=2}_{t-1}$	0.369	(0.130)	0.71
$PS^{h=1}_{t}$	**0.772*****	(0.002)	
$CB^{h=3}_{t-1}$	0.396	(0.138)	0.53
$PS^{h=2}_{t}$	**0.853****	(0.010)	
$CB^{h=4}_{t-1}$	0.635*	(0.062)	0.33
$PS^{h=3}_{t}$	**0.811****	(0.035)	

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5%, 1%.

Table II.4 - Granger Causality Tests

SWEDEN

	CPI		GDP	
	CB^h_t	PS^h_t	CB^h_t	PS^h_t
	h=0		h=0	
CB^h_{t-1}	0.765***	**0.870*** **	0.915**	0.359
	(0.148)	(0.119)	(0.386)	(0.246)
PS^h_{t-1}	**0.060**	-0.014	-0.605	0.291
	(0.093)	(0.092)	(0.541)	(0.333)
R^2	0.57	0.73	0.39	0.66
	h=1		h=1	
CB^h_{t-1}	0.925***	**0.837*** **	0.843**	0.344***
	(0.143)	(0.062)	(0.362)	(0.111)
PS^h_{t-1}	**-0.048**	-0.017	-0.473	0.239
	(0.105)	(0.047)	(0.414)	(0.235)
R^2	0.65	0.78	0.39	0.67
	h=2		h=2	
CB^h_{t-1}	0.772***	**0.591*** **	0.898***	0.198
	(0.185)	(0.074)	(0.263)	(0.140)
PS^h_{t-1}	**-0.082**	0.026	-0.688*	0.321
	(0.105)	(0.074)	(0.380)	(0.317)
R^2	0.41	0.56	0.41	0.45
	h=3		h=3	
CB^h_{t-1}	0.705***	**0.436*** **	0.645**	0.078
	(0.237)	(0.091)	(0.282)	(0.144)
PS^h_{t-1}	**0.034**	0.157*	-0.523	0.263
	(0.105)	(0.087)	(0.521)	(0.338)
R^2	0.37	0.54	0.32	0.13
	h=4		h=4	
CB^h_{t-1}	0.785***	**0.305*** **	0.697***	0.095
	(0.150)	(0.083)	(0.224)	(0.148)
PS^h_{t-1}	**0.048**	0.298*	-0.687	0.239
	(0.096)	(0.169)	(0.634)	(0.276)
R^2	0.54	0.41	0.37	0.12

UNITED KINGDOM

	RPIX		CPIH		GDP	
	CB^h_t	PS^h_t	CB^h_t	PS^h_t	CB^h_t	PS^h_t
	h=0		h=0		h=0	
CB^h_{t-1}	0.585*	**0.616** **	0.103	**0.574** **	0.880***	0.499*
	(0.299)	(0.233)	(0.354)	(0.235)	(0.229)	(0.268)
PS^h_{t-1}	**0.086**	0.079	**0.473**	-0.203	-0.249	0.221
	(0.402)	(0.343)	(0.456)	(0.304)	(0.246)	(0.262)
R^2	0.40	0.59	0.38	0.34	0.50	0.62
	h=1		h=1		h=1	
CB^h_{t-1}	1.083***	**0.943*** **	0.246	**0.574** **	0.738***	0.135
	(0.342)	(0.242)	(0.300)	(0.220)	(0.186)	(0.173)
PS^h_{t-1}	**-0.476**	-0.342	**0.577**	0.039	-0.163	0.485***
	(0.370)	(0.249)	(0.454)	(0.373)	(0.235)	(0.170)
R^2	0.58	0.78	0.62	0.62	0.47	0.50
	h=2		h=2		h=2	
CB^h_{t-1}	0.940***	**0.896*** **	0.431	**0.718*** **	0.570***	0.008
	(0.247)	(0.193)	(0.330)	(0.173)	(0.157)	(0.116)
PS^h_{t-1}	**-0.463**	-0.678**	**0.374**	-0.091	-0.128	0.545***
	(0.274)	(0.289)	(0.482)	(0.260)	(0.226)	(0.140)
R^2	0.47	0.62	0.44	0.56	0.33	0.35
	h=3		h=3		h=3	
CB^h_{t-1}	0.745***	**0.321*** **	0.626	**0.847** **	0.502***	-0.109
	(0.199)	(0.076)	(0.398)	(0.291)	(0.146)	(0.071)
PS^h_{t-1}	**-0.319**	-0.151	**-0.128**	-0.610	-0.009	0.558***
	(0.714)	(0.192)	(0.969)	(0.744)	(0.264)	(0.172)
R^2	0.41	0.52	0.23	0.39	0.27	0.27
	h=4		h=4		h=4	
CB^h_{t-1}	0.469**	0.069	1.546***	**1.732*** **	0.452***	-0.152***
	(0.174)	(0.085)	(0.346)	(0.275)	(0.162)	(0.047)
PS^h_{t-1}	-0.336	0.281	**-2.383***	-2.983***	0.019	0.721***
	(0.657)	(0.204)	(1.108)	(0.855)	(0.317)	(0.240)
R^2	0.20	0.13	0.26	0.36	0.21	0.43

CANADA

Base - 2months gap

	CPI		GDP	
	CB^h_t	PS^h_t	CB^h_t	PS^h_t
	h=0		h=0	
CB^h_{t-1}	-0.380	-0.277	-0.870	-1.004***
	(0.425)	(0.310)	(0.466)	(0.245)
PS^h_{t-1}	1.304*	0.815	2.151**	1.860***
	(0.639)	(0.467)	(0.826)	(0.465)
R^2	0.38	0.28	0.72	0.68
	h=1		h=1	
CB^h_{t-1}	-0.234	-0.403	-0.393*	-0.747**
	(0.365)	(0.354)	(0.177)	(0.250)
PS^h_{t-1}	1.021**	0.675	1.118***	0.946**
	(0.450)	(0.435)	(0.314)	(0.307)
R^2	0.41	0.14	0.62	0.42
	h=2		h=2	
CB^h_{t-1}	-0.365*	-0.080	0.728	0.354
	(0.186)	(0.164)	(0.433)	(0.525)
PS^h_{t-1}	0.924***	0.232	0.064	0.049
	(0.273)	(0.238)	(0.331)	(0.348)
R^2	0.36	0.03	0.36	0.09
	h=3		h=3	
CB^h_{t-1}	0.170	-0.260	0.451*	0.104
	(0.197)	(0.224)	(0.218)	(0.235)
PS^h_{t-1}	0.528**	0.536***	1.169**	1.120
	(0.197)	(0.177)	(0.363)	(0.698)
R^2	0.43	0.18	0.76	0.46
	h=4		h=4	
CB^h_{t-1}	0.665***	0.154	-0.667	-0.194
	(0.196)	(0.140)	(0.565)	(0.126)
PS^h_{t-1}	0.058	0.120	3.667	0.968
	(0.253)	(0.253)	(1.916)	(0.459)
R^2	0.49	0.06	0.66	0.39

Timing Correction - 1month gap

	CPI		GDP	
	CB^h_t	PS^h_t	CB^h_t	PS^h_t
	h=0		h=0	
CB^h_{t-1}	0.908***	0.545***	1.091***	0.712**
	(0.147)	(0.140)	(0.207)	(0.241)
PS^h_{t-2}	-0.762***	-0.502***	-0.887	-0.784*
	(0.126)	(0.104)	(0.484)	(0.381)
R^2	0.47	0.38	0.49	0.36
	h=1		h=1	
CB^h_{t-1}	0.749***	0.430**	0.597	0.370
	(0.181)	(0.158)	(0.459)	(0.479)
PS^h_{t-2}	-0.501**	-0.814***	-0.293	-0.644
	(0.229)	(0.215)	(0.481)	(0.566)
R^2	0.35	0.37	0.16	0.16
	h=2		h=2	
CB^h_{t-1}	0.239	0.462***	1.038**	0.903***
	(0.280)	(0.099)	(0.305)	(0.191)
PS^h_{t-2}	-0.018	-0.834***	-0.341	-0.7445*
	(0.259)	(0.254)	(0.358)	(0.357)
R^2	0.06	0.49	0.53	0.47
	h=3		h=3	
CB^h_{t-1}	0.260	0.315	0.885	1.092
	(0.313)	(0.263)	(0.547)	(0.627)
PS^h_{t-2}	0.258	-0.545*	-0.147	-1.501
	(0.345)	(0.303)	(1.255)	(1.265)
R^2	0.24	0.18	0.55	0.44
	h=4		h=4	
CB^h_{t-1}	0.645	0.174	0.188	0.000
	(0.209)	(0.144)	(0.439)	(0.206)
PS^h_{t-2}	-0.323	-0.657**	0.625	0.500
	(0.401)	(0.243)	(1.446)	(0.865)
R^2	0.49	0.38	0.16	0.11

JAPAN

	CPI		GDP	
	CB^h_t	PS^h_t	CB^h_t	PS^h_t
	h=0		h=0	
CB^h_{t-1}	1.252***	**1.037*** **	1.480**	**1.678** **
	(0.279)	(0.132)	(0.526)	(0.584)
PS^h_{t-1}	**-0.498**	-0.285	**-0.725**	-0.693
	(0.327)	(0.203)	(0.474)	(0.611)
R^2	0.73	0.86	0.52	0.61

SWITZERLAND

	CPI	
	CB^h_t	PS^h_t
	h=0	
CB^h_{t-1}	0.060	**0.162**
	(0.203)	(0.176)
PS^h_{t-1}	**0.712*** **	0.604***
	(0.142)	(0.136)
R^2	0.67	0.65
	h=1	
CB^h_{t-1}	1.016***	0.427**
	(0.310)	(0.194)
PS^h_{t-1}	-0.727**	-0.132
	(0.341)	(0.292)
R^2	0.45	0.38

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

CB^h_t the forecast made by the central bank in date t for h horizons later and PS^h_t by the private sector in date t for h horizons later

Table II.5 - Influence Tests

SWEDEN

	CPI			**CPI**			**CPI**	
	CB^h_t	PS^h_t		CB^h_t	PS^h_t		CB^h_t	PS^h_t
	h=0			h=1			h=2	
CB^1_{t-1}	1.014***	**0.997*** **	CB^2_{t-1}	0.962***	**0.800*** **	CB^3_{t-1}	1.123***	**0.772*** **
	(0.101)	(0.115)		(0.119)	(0.109)		(0.138)	(0.063)
PS^1_{t-1}	**0.035**	-0.004	PS^2_{t-1}	**0.086**	0.132	PS^3_{t-1}	**0.037**	0.181
	(0.081)	(0.133)		(0.073)	(0.149)		(0.106)	(0.111)
R^2	0.79	0.84	R^2	0.72	0.76	R^2	0.70	0.76
	h=0			h=1			h=2	
CB^2_{t-2}	1.011***	**0.884*** **	CB^3_{t-2}	1.008***	**0.882*** **	CB^4_{t-2}	1.322***	**0.832*** **
	(0.132)	(0.138)		(0.194)	(0.124)		(0.279)	(0.124)
PS^2_{t-2}	**0.129**	0.158	PS^3_{t-2}	**0.222**	0.257*	PS^4_{t-2}	**0.296***	0.431***
	(0.084)	(0.149)		(0.132)	(0.134)		(0.156)	(0.138)
R^2	0.64	0.65	R^2	0.48	0.57	R^2	0.49	0.49
	h=0			h=1				
CB^3_{t-3}	1.148***	**0.954*** **	CB^4_{t-3}	1.290***	**1.002*** **			
	(0.182)	(0.130)		(0.313)	(0.195)			
PS^3_{t-3}	**0.085**	0.308*	PS^4_{t-3}	**0.296**	0.372*			
	(0.149)	(0.173)		(0.206)	(0.188)			
R^2	0.47	0.49	R^2	0.38	0.36			
	h=0							
CB^4_{t-4}	1.092***	**1.113*** **						
	(0.347)	(0.315)						
PS^4_{t-4}	**0.270**	0.358*						
	(0.196)	(0.196)						
R^2	0.27	0.32						

UNITED KINGDOM

	RPIX		**CPIH**			**RPIX**		**CPIH**			**RPIX**		**CPIH**	
	CB^h_t	PS^h_t	CB^h_t	PS^h_t		CB^h_t	PS^h_t	CB^h_t	PS^h_t		CB^h_t	PS^h_t	CB^h_t	PS^h_t
	h=0		h=0			h=1		h=1			h=2		h=2	
CB^1_{t-1}	1.060**	**0.864*** **	0.246	**0.574** *	CB^2_{t-1}	1.265***	**0.941*** **	0.722	**0.754*** **	CB^3_{t-1}	0.976***	**0.715*** **	0.503**	**0.504*** **
	(0.366)	(0.284)	(0.300)	(0.220)		(0.198)	(0.177)	(0.417)	(0.214)		(0.207)	(0.147)	(0.213)	(0.131)
PS^1_{t-1}	**-0.205**	0.036	**0.577**	0.039	PS^2_{t-1}	**-0.602** *	-0.256	**-0.100**	-0.202	PS^3_{t-1}	**-0.444**	-0.417	**0.258**	0.190
	(0.430)	(0.348)	(0.454)	(0.373)		(0.244)	(0.253)	(0.538)	(0.255)		(0.656)	(0.647)	(0.319)	(0.174)
R^2	0.63	0.80	0.62	0.62	R^2	0.75	0.82	0.58	0.70	R^2	0.57	0.54	0.47	0.58
	h=0		h=0			h=1		h=1			h=2		h=2	
CB^2_{t-2}	0.597*	**0.856*** **	0.299	-0.044	CB^3_{t-2}	0.740***	**0.707*** **	0.236	-0.182	CB^4_{t-2}	0.322	0.332**	-0.775	-1.003**
	(0.334)	(0.231)	(0.371)	(0.525)		(0.242)	(0.212)	(0.347)	(0.315)		(0.211)	(0.148)	(0.697)	(0.318)
PS^2_{t-2}	**0.405**	-0.106	0.552	0.732	PS^3_{t-2}	**-0.328**	-0.664	0.515	0.999	PS^4_{t-2}	-1.690*	-1.140*	2.565	2.572**
	(0.415)	(0.324)	(0.638)	(0.911)		(0.744)	(0.549)	(0.915)	(0.654)		(0.819)	(0.640)	(2.203)	(0.872)
R^2	0.43	0.52	0.47	0.34	R^2	0.28	0.36	0.23	0.26	R^2	0.24	0.26	0.20	0.25
	h=0		h=0			h=1		h=1						
CB^3_{t-3}	0.597*	**0.585** *	-0.160	-0.044	CB^4_{t-3}	0.238	0.174	-1.025	-0.898					
	(0.299)	(0.289)	(0.296)	(0.291)		(0.309)	(0.201)	(1.027)	(0.859)					
PS^3_{t-3}	**-0.072**	-0.505	1.762**	1.016	PS^4_{t-3}	-1.209	-1.420**	3.135	1.800					
	(0.723)	(0.640)	(0.540)	(0.760)		(0.835)	(0.555)	(2.251)	(2.351)					
R^2	0.15	0.16	0.56	0.30	R^2	0.11	0.20	0.20	0.13					
	h=0		h=0											
CB^4_{t-4}	0.054	0.176	0.307	-0.223										
	(0.502)	(0.398)	(2.031)	(1.257)										
PS^4_{t-4}	-0.867	-0.743	-1.161	-0.256										
	(1.039)	(0.795)	(5.726)	(3.646)										
R^2	0.03	0.04	0.01	0.06										

JAPAN

	CPI		**GDP**	
	CB^h_t	PS^h_t	CB^h_t	PS^h_t
CB^{h+1}_{t-1}	1.651***	**0.769*** **	1.538**	**1.212** *
	(0.473)	(0.219)	(0.604)	(0.488)
PS^{h+1}_{t-1}	**-0.985**	-0.007	**-0.598**	0.054
	(0.556)	(0.266)	(0.484)	(0.403)
R^2	0.86	0.88	0.65	0.75

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

CB^h_t the forecast made by the central bank in date t for h horizons later and PS^h_t by the private sector in date t for h horizons later

Table II.6 - Influence Tests with News Released

	SWEDEN		UNITED KINGDOM				JAPAN			
	CPI		RPIX		CPIH		CPI		GDP	
	CB^h_t	PS^h_t		CB^h_t	PS^h_t	CB^h_t	PS^h_t		CB^h_t	PS^h_t	CB^h_t	PS^h_t
	h=0			h=0		h=0						
CB^1_{t-1}	1.105***	**1.055*** **	CB^1_{t-1}	1.257***	**0.937*** **	0.451	**0.738*** **	CB^{h+1}_{t-1}	1.660***	**0.779*** **	1.659****	**1.328*** **
	(0.043)	(0.133)		(0.232)	(0.259)	(0.252)	(0.166)		(0.377)	(0.120)	(0.315)	(0.244)
PS^1_{t-1}	**-0.076**	-0.074	PS^1_{t-1}	**-0.291**	0.005	**0.410**	-0.094	PS^{h+1}_{t-1}	**-0.660**	0.325	**-0.267**	0.373
	(0.060)	(0.136)		(0.302)	(0.285)	(0.302)	(0.256)		(0.390)	(0.134)	(0.355)	(0.333)
$I_{t-1\leftrightarrow t}$	0.829***	0.529***	$I_{t-1\leftrightarrow t}$	0.459***	0.170	0.396***	0.320*	$I_{t-1\leftrightarrow t}$	-0.719***	-0.734***	-1.900***	-1.831***
	(0.064)	(0.114)		(0.135)	(0.125)	(0.053)	(0.151)		(0.163)	(0.097)	(0.269)	(0.435)
R^2	0.96	0.92	R^2	0.76	0.82	0.85	0.81	R^2	0.91	0.96	0.88	0.87
	h=1			h=1		h=1						
CB^2_{t-1}	0.971***	**0.805*** **	CB^2_{t-1}	1.402***	**0.984*** **	0.726*	**0.756*** **					
	(0.103)	(0.133)		(0.125)	(0.164)	(0.327)	(0.202)					
PS^2_{t-1}	**0.069**	0.123	PS^2_{t-1}	**-0.608*** **	-0.258	**-0.088**	-0.196					
	(0.085)	(0.183)		(0.151)	(0.232)	(0.401)	(0.240)					
$I_{t-1\leftrightarrow t}$	0.748***	0.433***	$I_{t-1\leftrightarrow t}$	0.418***	0.132	0.311***	0.140					
	(0.088)	(0.091)		(0.073)	(0.094)	(0.045)	(0.121)					
R^2	0.88	0.83	R^2	0.89	0.84	0.78	0.75					
	h=2			h=2		h=2						
CB^3_{t-1}	1.057***	**0.744*** **	CB^3_{t-1}	1.068***	**0.716*** **	0.429*	**0.480** **					
	(0.094)	(0.094)		(0.178)	(0.156)	(0.186)	(0.140)					
PS^3_{t-1}	**0.074***	0.197	PS^3_{t-1}	**-0.343**	-0.416	**0.338***	0.216					
	(0.041)	(0.149)		(0.598)	(0.671)	(0.144)	(0.165)					
$I_{t-1\leftrightarrow t}$	0.704***	0.298***	$I_{t-1\leftrightarrow t}$	0.422***	0.005	0.232***	0.075					
	(0.111)	(0.096)		(0.135)	(0.129)	(0.064)	(0.083)					
R^2	0.86	0.81	R^2	0.75	0.54	0.62	0.60					
	h=3			h=3		h=3						
CB^4_{t-1}	1.037***	**0.573*** **	CB^4_{t-1}	0.659***	**0.271*** **	0.433	0.202					
	(0.188)	(0.089)		(0.181)	(0.050)	(0.310)	(0.427)					
PS^4_{t-1}	**0.270*** **	0.361**	PS^4_{t-1}	**-1.206***	-0.322	-0.038	-0.333					
	(0.090)	(0.168)		(0.649)	(0.196)	(0.831)	(1.057)					
$I_{t-1\leftrightarrow t}$	0.554***	0.064	$I_{t-1\leftrightarrow t}$	0.177	-0.127*	0.117	0.064					
	(0.110)	(0.101)		(0.207)	(0.065)	(0.144)	(0.078)					
R^2	0.80	0.63	R^2	0.47	0.54	0.25	0.03					

Numbers in parentheses are robust standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

CB^h_t the forecast made by the central bank in date t for h horizons later and PS^h_t by the private sector in date t for h horizons later

Chapter III:
Endogenous Central Bank Influence: Learning from Information Asymmetry*

* I thank Jérôme Creel and Francesco Saraceno for helpful comments, as well as seminar participants at the Sciences-Po's Department of Economics, OFCE and the 27th GDRE Symposium (Bordeaux).

1. Introduction

Policymakers' practices such as discussing private sector forecasts or publishing their internal forecasts may appear puzzling as the Rational Expectations (RE) hypothesis supposes all expectations are only based on the observable fundamentals. Three main arguments may explain these practices. First, the expectations channel of monetary policy has become more and more important both in theory and practice and need the policymakers to be able to manage private expectations. Second, indeterminacy and multiplicities of RE equilibria need to balance forward-looking components of monetary policy (Bernanke and Woodford 1997). Third, the consideration of the hypothesis of imperfect information or incomplete knowledge modifies both the macroeconomic environment and policymakers' behaviour. Thus, Mankiw and Reis (2002, 2007) introduce information stickiness, Sims (1998, 2003) and Woodford (2003) focus on rational inattention, Hansen and Sargent (2003) set up information frictions, Guesnerie (2005, 2008) proposes an "eductive" learning approach and Evans and Honkapohja (2001) study the effects of adaptive learning. All these procedures intend to model some expectations formation process enriching the RE hypothesis.

Monetary policymaking through interest rate rules has been widely studied in a New-Keynesian framework (Clarida, Gali, and Gertler (1999), McCallum (1999) and Woodford (2001) for instance) and gives a central role for forecasts of future inflation and output. Nevertheless, the precise role of both central bank and private forecasts in the decision making of central banks has not been put forward. Based on the assumption of imperfect information and knowledge, recent researches using adaptive learning have focused on the consequences of forecasting errors and the resulting correction devices. Bullard and Mitra (2002) and Evans and Honkapohja (2003b) show that some interest rate rules may lead to instability as private agents inefficiently seek to correct their forecast functions over time. A subsequent literature has then focused on the effects of the heterogeneity of forecasts between the central bank and private agents (Honkapohja and Mitra 2005, 2006, Preston 2008), on information asymmetry (Honkapohja and Mitra 2004) and influence of either the central bank of private agents on the other (Muto 2008).

An empirical strand of the literature has shown that some central banks may have a superior forecasting performance compared to private agents (Romer and Romer 2000, Sims 2002, and the first chapter of this thesis, among others) and that central banks may influence private agents either indirectly (see e.g. Fujiwara 2005, Ehrmann et al. 2009, in which the focus is on the dispersion of private expectations) or directly (see the second chapter, where the focus is on the level of private expectations). The latter thus proposes a distinction between endogenous credibility, characterized by influence arising from a superior forecasting performance, and exogenous credibility as a situation where the central bank need not be more informed to be influential.

This chapter proposes through adaptive learning (a simplified and realistic form of non-rational expectations) to consider simultaneously the heterogeneity of forecasts between the central bank and private agents, superior forecasts (through information asymmetry) and influence of the central bank in a New-Keynesian model, in order to provide a theoretical framework to assess the optimal monetary policy rule in a situation of endogenous credibility. The model, based on incomplete information and knowledge of households and firms, introduces adaptive learning for both private agents and the central bank. The latter communicates its macroeconomic forecasts to the public. The central assumption of this

theoretical framework is that the central bank has a better forecasting record modelled through information asymmetry, and then that the forecasting function of private agents comprises the central bank forecasts.

King (1982), in an early work, recognized that monetary policy rules affect real outcomes in models with imperfect information through "prospective feedback actions" responding to shocks that are imperfectly known by private agents. The mechanism goes through the effect of policy rules on the information content of prices. The main device at work in this chapter complements the precedent and considers the effect of monetary policy through communication to the public and the signalling role of policy setting. Amato, Morris and Shin (2002), Morris and Shin (2005) and Amato and Shin (2006) analyze the social value of public information and find that full transparency might deter the efficiency of monetary policy. Hellwig (2005) and Angeletos and Pavan (2004, 2007) challenge this conclusion[1] on the extent that more public information facilitates coordination. Walsh (2006) and Cornand and Heineman (2008) finally show that it may be advantageous for a central bank to make partial announcements to offset future shocks or if complete announcements intensify inflation variability. Here, we do not focus on communication about the policy instrument but on communication of policy makers' forecasts.

The purpose of this analysis is to compare the theoretical implications of endogenous and exogenous credibility. The present work then differs from Muto (2008) in the extent that it provides a framework in which central bank influences private agents because the central bank is the leader and private agents the followers of the monetary process. Muto (2008) moreover assumes that private agents only refer to the central bank forecast when forming their own forecasts. Influence results from a position of leader of the central bank in a leader-follower game and Muto (2008) then implicitly supposes influence is exogenous and actually assesses the effects of exogenous credibility. He finds that central bank must respond more strongly to the expected inflation rate than the Taylor principle suggests. We here consider influence of the central bank as an endogenous process, due to superior forecasting performance of the central bank. The central question is therefore to assess the conditions the central bank must respect to reach macroeconomic stability when considering superior forecasting performance as the source of influence and therefore influence as endogenous.

The central result of this chapter is that the Taylor principle is sufficient to reach expectational stability and determinacy in a situation of endogenous credibility. The intuition is quite straightforward: if the central bank has lower forecast errors than private agents and therefore that private agents follow the central bank forecasts, the central bank must only respond to its forecasts errors to reach macroeconomic stability. Compared to the situation of exogenous credibility where central bank errors and private forecasts errors add up to each other, the central bank need not respond more aggressively to inflation. In a situation of imperfect information, influencing private expectations enable the central bank to reach E-stability at a lower cost.

The model developed to assess the effects of endogenous credibility for policymaking can be related to King, Lu and Pasten (2008) who define short-term and long-term credibility of the central bank associated with the commitment to low and stable inflation. Their analysis

[1] Svensson (2006) also challenged this conclusion because the numerical condition under which transparency reduces welfare is unrealistic since it requires that the precision of public information is smaller than the precision of private information.

focuses on some central bank's *type* credibility (whether the central bank is of strong or weak type in the Barro and Gordon (1983)'s classic monetary game), while we focus here on credibility linked to the *competence* of the central bank (whether the central bank has better forecasts or not than private agents). Moscarini (2007) reconciles both concepts and shows a reputation for competence implies *type* credibility and transparency, while Geraats (2002, 2005) and Eusepi and Preston (2008) confirm that transparency enhances central bank's *type* credibility and that central bank communication is very powerful tool to reach private expectations stabilization. In this chapter, we assess how a communicating central bank, influential due to its *competence* credibility, may reach macroeconomic stability.

While the main message of Muto (2008) about exogenous credibility (when central bank are influential due to their *type* credibility and leader position) is that central banks must be more restrictive than the Taylor principle suggests, we find in the case of endogenous credibility that central bankers could be more accommodative. This result calls for an increase of the *competence* credibility of central banks and reinforces the case for enhancing forecasting performance of central banks. The final objective is thus to attain endogenous influence in order to reach macroeconomic stability at a lower cost. In other words, a direct policy implication of this chapter is that when central banks are influential, they should invest enough resources in forecasting to guide private expectations.

The rest of the chapter is organized as follows. Section 2 discusses the framework of analysis. Section 3 presents the assumptions and the conditions for stability and determinacy of endogenous influence. We compare these results to those of exogenous influence and other standard cases of the literature. Section 4 concludes this chapter.

2. The Framework

Expectations play an important role in recent macroeconomic models. The benchmark model of expectation formation in macroeconomics has been RE since the seminal papers of Muth (1961), Lucas (1972), and Sargent (1973). RE are a very strong hypothesis as it implicitly assumes perfect information, knowledge of the correct form of the model, knowledge of all parameters, and knowledge that other agents are rational. Households are considered as dynamic optimizers whose are be concerned with expected future incomes, employment and inflation while firms forecast future demand, costs and productivity levels. Monetary policy-makers forecast future inflation and aggregate economic activity and consider both the direct impact of their policies and the indirect effect of policy rules on private-sector expectations. Reconsidering the RE hypothesis and introducing imperfect information, the learning approach proposes another model of expectation formation and describes agents (private and the central bank) as forming their expectations by estimating and updating forecasting models in real time. Agents are considered as econometricians who estimate and re-estimate models as new data become available. They therefore engage in a process of learning about the economy.

2.1 A standard version of the New Keynesian model

The aggregate demand or IS curve is obtained by log-linearizing the consumer's Euler equation and employing the goods market-clearing condition, so that the equation is expressed in terms of the output gap.

$$x_t = E_t^{PA} x_{t+1} - \varphi(i_t - E_t^{PA} \pi_{t+1}) + g_t \quad (1)$$

The aggregate supply or AS (or NK Phillips) curve is derived as a linearization of the firms' optimality condition under the price setting constraint.

$$\pi_t = \lambda x_t + \beta E_t^{PA} \pi_{t+1} + u_t \tag{2}$$

Here x_t is the output gap, π_t is the inflation rate, i_t is the nominal interest rate, g_t is the demand shock and u_t is the cost push shock. E_t^{PA} denotes the private sector expectations (not necessarily rational as agents do not know the structural parameters) which influence the economy directly through aggregate demand and the Phillips Curve. Each variable is defined as the deviation from its steady state. φ is the elasticity of intertemporal substitution of the representative household, λ is the degree of price stickiness and β is the household's discount factor. These structural parameters satisfy $\lambda > 0$, $\varphi > 0$ and $0 < \beta < 1$.

The central bank uses a forward-looking rule[2] to set its interest rate according to its forecasts of future inflation and output gap.

$$i_t = \phi_0 + \phi_\pi E_t^{CB} \pi_{t+1} + \phi_x E_t^{CB} x_{t+1} \tag{3}$$

E_t^{CB} is the forecast of the central bank made at a date t for some variable, while ϕ_π and ϕ_x represents the response to future inflation and future output gap.
The shocks g_t and u_t are assumed to follow these processes:

$$w_t = \begin{pmatrix} g_t \\ u_t \end{pmatrix} = F \cdot \begin{pmatrix} g_{t-1} \\ u_{t-1} \end{pmatrix} + \begin{pmatrix} \tilde{g}_t \\ \tilde{u}_t \end{pmatrix} \text{ with } F = \begin{pmatrix} \mu & 0 \\ 0 & \rho \end{pmatrix}$$

Since our focus is on learning behaviour, these expectations need not be rational. E_t^{CB} and E_t^{PA} are not necessarily rational as agents do not know the true values of the structural parameters. They denote subjective expectations that are instead formed as forecasts from an estimated model and observations.

The model can be written under the following reduced form:

$$y_t = \begin{pmatrix} x_t \\ \pi_t \end{pmatrix} = D + A^{PA} \cdot E_t^{PA} y_{t+1} + A^{CB} \cdot E_t^{CB} y_{t+1} + B \cdot w_t \tag{4}$$

$$\text{where } D = \begin{pmatrix} -\varphi\phi_0 \\ -\lambda\varphi\phi_0 \end{pmatrix},\ A^{PA} = \begin{pmatrix} 1 & \varphi \\ \lambda & \lambda\varphi + \beta \end{pmatrix},\ A^{CB} = \begin{pmatrix} -\varphi\phi_x & -\varphi\phi_\pi \\ -\lambda\varphi\phi_x & -\lambda\varphi\phi_\pi \end{pmatrix} \text{ and } B = \begin{pmatrix} 1 & 0 \\ \lambda & 1 \end{pmatrix}$$

2.3 Expectations Formation: the Adaptive Learning Mechanism

First, agents' expectations are described by a simple forecasting model. Agents are assumed to use a perceived law of motion (PLM) where true values of parameters are not known. They estimate this model to obtain estimates for the parameters in the PLM. It is postulated that agents use the most popular estimation method: least squares. Thus, agents estimate by recursive least squares (RLS) this equation with past and current data.

$$y_t = a + b w_t \quad with\ y_t = (\pi_t, x_t)'\ and\ w_t = (g_t, u_t)'$$

[2] This form of monetary policy rules in terms of key macroeconomic variables is derived from the seminal Taylor (1993) rule. This interest rate rule can be derived explicitly to maximize a policy objective function of a quadratic form, which can alternatively be viewed as a quadratic approximation to the welfare function of a representative agent. The form of the policy rules affects the determinacy and learnability properties of the NK model. Bullard and Mitra (2002) assess various interest-rate rules under learning and find that rules responding to expectations of inflation and output deviations are the most desirable to reach stability and determinacy.

Given the parameters estimated, agents form forecasts for variables relevant to their decision problems, on the basis of the shock they observe. This forecast is therefore obtained by so-called adaptive learning.

$$E_t^i y_{t+1} = a + bFw_t \quad with\ y_t = (\pi_t, x_t)'\ and\ w_t = (g_t, u_t)'$$

2.4 The standard case

We now describe the standard case of adaptive learning in which expectations are homogenous. We therefore have $E_t^{CB} y_{t+1} = E_t^{PA} y_{t+1}$. By replacing the forecast in the reduced form, we obtain the actual law of motion (ALM) that describes a temporary equilibrium of the economy, that is to say temporary equilibrium relations between the variables.

$$y_t = D + (A^{PA} + A^{CB})a + ((A^{PA} + A^{CB})bF + B)w_t \quad (5)$$

The conditions of convergence of the model are given by the local stability conditions of the associated ordinary differential equations (ODE). Evans and Honkapohja (2001)[3] shows that the local stability is determined by this ODE:

$$d\theta / d\tau = T(\theta) - \theta \quad (6)$$

where τ is "virtual" or "notional" time and $T(\theta)$ is the mapping function (T-maps) from PLM to ALM. The expectational stability (E-stability) of this model depends on the local stability of this ODE under RLS learning. E-stability defines the convergence of the economy to the RE equilibria.

The mapping functions from PLM to ALM are the following:

$$T(a) = D + (A^{PA} + A^{CB})a \quad (7)$$

$$T(b) = (A^{PA} + A^{CB})bF + B \quad (8)$$

Bullard and Mitra (2002) show in this case with a simple forward-looking interest rule that the derivations of expectational stability conditions yield to the following inequality:

$$\lambda(\phi_\pi - 1) > \phi_x(\beta - 1) \quad (9)$$

which is exactly the Taylor principle (as put forward by Taylor (1993) and Woodford (2001) and consists in a response of the central bank to inflation higher than respectively one or a threshold value equal to $1 + \phi_x(\beta - 1)/\lambda$) and is the necessary and sufficient condition for the E-stability of this model.

3. Endogenous Central Bank Influence

We here develop the theoretical model that combines heterogeneous forecasts, superior forecasting performance and influence of the central bank.

3.1 Assumptions and the timing of decisions

Assumption 1: the central bank and private agents have imperfect knowledge of the model of the economy, imperfect information about the future state of the economy and forecast the future inflation rate and output gap.

[3] See Chapter 2 of Evans and Honkapohja (2001).

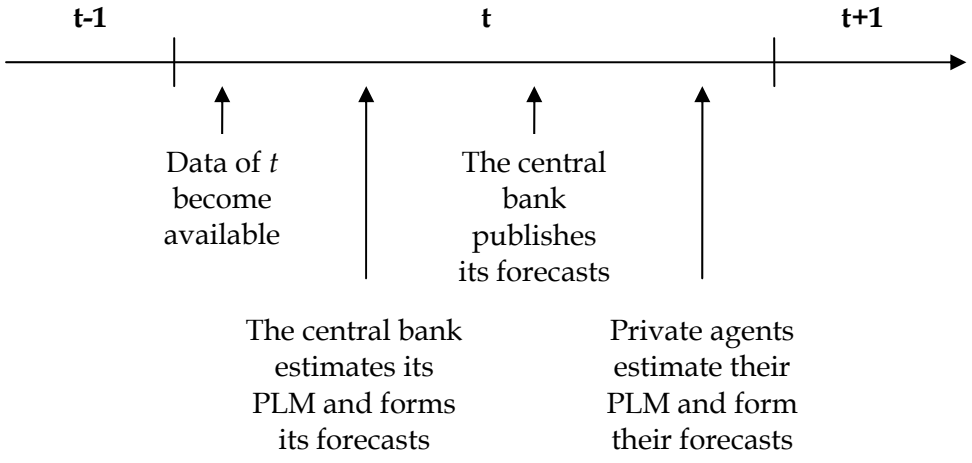
Assumption 2: the central bank observes both shocks the economy may face, while the private agents (households and firms) only observe one of the shocks. There is thus some information asymmetry between both actors. This assumption is not decisive and mandatory by itself, but responds to the need for a better forecasting performance of the central bank compared to private agents in order to set up the endogenous influence framework. The superior forecasting performance of the central bank is the *crucial* assumption of this model. Romer and Romer (2000) and Sims (2002) among others provide empirical evidence of the superior forecasting performance of the Federal Reserve, while the chapter II shows that the forecasts of the Riksbank, the central bank of Sweden, outperforms those of private agents. In the end, we could imagine that a better forecasting performance might arise from other sources than information asymmetry, as for instance a better model of the economy or a better use of the same information set. However, this does not change the rationale for this assumption. Endogenous credibility stems from some clarity of vision (the precision of the forecasts) of the central bank acknowledged by private agents and calls for a better forecasting record whatever its source.

Assumption 3: the central bank communicates its macroeconomic forecasts to the public in real-time.

Assumption 4: private agents face uncertainty about the central bank's interest rate setting. They do not know the precise behaviour of the policymaker. They cannot infer future shocks from policy setting, but may infer central bank's *type* from the combination of forecasts and policy decisions. Geraats (2002, 2005), King, Lu and Pasten (2008) and Eusepi and Preston (2008) show that transparency helps central bank to signal itself as committed to low and stable inflation. We then assume the policymaker *type* is observable and that communicating central banks are of strong type (in reference to the terms used in the framework of Kydland and Prescott (1977) and Barro and Gordon (1983)).

Assumption 5: in each period, private agents form their forecasts after those of the central bank and are then able to incorporate them in their forecasting function. Private forecasts are thus influenced by central bank forecasts. This assumption is justified by Fujiwara (2005) and the chapter II that display strong evidence of the influential power of central banks on private agents, while there is no empirical evidence of the opposite.

Figure A: the timing of decisions



Because private agents know the central bank's forecasts, they form their forecasts according to the relative forecasting performance record of the central bank and then either follow the central bank's forecasts (endogenous influence) or focus on their information set.

3.2 The Model and E-Stability Conditions

The central bank and private agents have asymmetric information about the disturbances that affect economy. Influence is endogenous and results from the central bank's superior forecasting performance. It is therefore rational for private agents to follow central bank forecasts.

The PLM of the central bank is

$$y_t = a^{CB} + b^{CB} \cdot w_t \tag{10}$$

and can be written

$$y_t = a^{CB} + b_g^{CB} \cdot g_t + b_u^{CB} \cdot u_t \tag{11}$$

$$\text{with } a^{CB} = \begin{pmatrix} a_x^{CB} \\ a_\pi^{CB} \end{pmatrix},\ b_u^{CB} = \begin{pmatrix} b_{xu}^{CB} \\ b_{\pi u}^{CB} \end{pmatrix} \text{ and } b_g^{CB} = \begin{pmatrix} b_{xg}^{CB} \\ b_{\pi g}^{CB} \end{pmatrix}$$

The functional form of the PLM (11) corresponds to the minimal state variable (MSV) solution of the reduced form (4), following McCallum (1983) who introduces this concept for linear rational expectations models. The MSV allows for a solution which depends linearly on a set of variables (here the coefficients associated to shocks and the intercept) and which is such that there is no solution which depends on a smaller set of variables.

The forecasting function of the central bank, when data from date *t* are available, is therefore:

$$E_t^{CB} y_{t+1} = a^{CB} + b_g^{CB} \cdot \mu \cdot g_t + b_u^{CB} \cdot \rho \cdot u_t \tag{12}$$

The PLM of private agents is

$$y_t = a^{PA} + b^{PA} \cdot g_t + c^{PA} \cdot E_{t-1}^{CB} y_t \tag{13}$$

and can be written

$$y_t = (a^{PA} + c^{PA} \cdot a^{CB}) + (b^{PA} + c^{PA} \cdot b_g^{CB}) \cdot g_t + c^{PA} \cdot b_u^{CB} \cdot u_t \tag{14}$$

$$\text{with } a^{PA} = \begin{pmatrix} a_x^{PA} \\ a_\pi^{PA} \end{pmatrix} \text{ and } b^{PA} = \begin{pmatrix} b_x^{PA} \\ b_\pi^{PA} \end{pmatrix}$$

This form of the PLM of private agents is a simple forecasting function based on the only shock private agents observe, to which is added the central bank forecast they also observe. It is consistent with the linear combination of forecasts of Nelson (1972), Cooper and Nelson (1975), Fair and Shiller (1989, 1990) and Romer and Romer (2000). This approach consists in regressing the actual variable on forecasts made by both actors in order to know which one has the most accurate prediction of the actual variable. This linear combination of forecasts allows for comparing the relative forecasting performance of private agents and the central bank. If b^{PA} is equal to one, it means that private agents have better forecasts. At the opposite, if c^{PA} is equal to one, the central bank has more accurate forecasts. When private agents estimate (13), they determine whether the central bank forecasts contain information that could be useful to form their forecasts. To avoid explosive forecasts, the following condition should be met $b^{PA} + c^{PA} = 1$.

Private agents thus compare their forecasting performance and those of the central bank, and put a weight of one on the best forecast. Endogenous influence can therefore be analysed as follows: when b^{CB} is low, then c^{PA} will also be low and private agents follow their own forecasts. At the opposite, if b^{CB} is equal to one, c^{PA} is equal to one too and private agents are influenced by the better forecasts of the central bank. b^{CB} and b^{PA} reflect the forecasts' accuracy of both actors.

The forecasting function of private agents is then:

$$E_t^{PA} y_{t+1} = a^{PA} + b^{PA} \cdot \mu \cdot g_t + c^{PA} \cdot E_t^{CB} y_{t+1} \tag{15}$$

and can be written

$$E_t^{PA} y_{t+1} = (a^{PA} + c^{PA} \cdot a^{CB}) + (b^{PA} + c^{PA} \cdot b_g^{CB}) \mu \cdot g_t + c^{PA} \cdot b_u^{CB} \cdot \rho \cdot u_t \tag{16}$$

At the equilibrium, the coefficients are $a^{PA} = 0$, $b^{PA} = 0$, $c^{PA} = 1$ and $b_u^{CB} = b_g^{CB} = 1$. The central bank makes clearly better forecasts and private agents follow them without noise. Expectations are homogeneous between private agents and the central bank. Expectations are the same as those of the MSV solution of the standard case. The Taylor principle is therefore a sufficient condition to reach E-stability when the economic dynamics are at equilibrium.

Heterogeneous expectations may not have negative properties on stability conditions, as suggested by Evans and Honkapohja (1996) and Giannitsarou (2003). However, Honkapohja and Mitra (2006) find that interaction of structural and expectational heterogeneity may make the conditions for stability more severe than those under homogeneous or transitional heterogeneous expectations. The benchmark E-stability condition continues nevertheless to have implications as it yields necessary conditions for convergence of persistently heterogeneous learning. In a companion paper, Honkapohja and Mitra (2005) show that when private agents and central banks have different expectations the Taylor principle is sufficient to reach E-stability if the learning algorithms are asymptotically similar. McCallum and Nelson (2004) moreover show that when the central bank uses its own forecasts and have different learning rules, we may have stability under the same conditions as in the homogeneous case if the central bank puts a relatively high weight on new information about the state of the economy and future shocks at each period (i.e. δ_{CB} is superior to 0.7 in their paper) what seems likely in theory and practice. In this chapter, we therefore consider heterogeneity of forecasts to introduce endogenous influence (i.e. superior forecasting performance and influence of the central bank) but not of learning algorithms as it is beyond the focus of this chapter, and focus on Recursive Least Squares for both private agents and the central bank since it is the standard approach in the literature.

Another important aspect of heterogeneous expectations deals with the specific properties of each type of expectations. It appears from computing the determinant of $(A^{PA} - I)$ that one eigenvalue has a positive real part and therefore that the private sector through its expectations has a destabilizing effect on the economy, while the central bank expectations have a stabilizing effect. The reason is simple: when private sector expectations (of inflation or output) deviate from the fundamental value, the actual inflation or output deviates in the same direction what leads the private expectations to continue to deviate. This is because all the values of A^P are positive. At the opposite, when the central bank forecasts deviate upward, the actual inflation or output decreases. This is due to the fact that all the values of A^{CB} are negative, which acts as a counter weight to deviations. This is why central bank and private forecasts may have different effects for stability of the economy in the case of

heterogeneous expectations. Thus, monetary policy has an important role to play in this model: it must be designed to offset the tendency toward instability from private agents' learning.

Without loss of generality, we suppose $\phi_0 = 0$ and so $D = 0$. The actual law of motion of the economy is therefore:

$$\begin{aligned} y_t = {} & A^{PA} \cdot (a^{PA} + c^{PA} \cdot a^{CB}) + A^{CB} \cdot a^{CB} \ldots \\ & \ldots + (A^{PA} \cdot (b^{PA} + c^{PA} \cdot b_g^{CB}) + A^{CB} \cdot b_g^{CB})\mu + B_g) \cdot g_t \\ & \ldots + ((A^{PA} \cdot c^{PA} \cdot b_u^{CB} + A^{CB} \cdot b_u^{CB})\rho + B_u) \cdot u_t \end{aligned} \tag{17}$$

Following Evans and Honkapohja (2003a), the T-maps defining E-stability and derived from the correspondence between PLM to ALM are then:

$$T(a^{CB}) = A^{PA} \cdot (a^{PA} + c^{PA} \cdot a^{CB}) + A^{CB} \cdot a^{CB} \tag{18}$$

$$T(a^{PA}) = A^{PA} \cdot (a^{PA} + c^{PA} \cdot a^{CB}) + A^{CB} \cdot a^{CB} - c^{PA} \cdot a^{CB} \tag{19}$$

$$T(b_g^{CB}) = (A^{PA} \cdot (b^{PA} + c^{PA} \cdot b_g^{CB}) + A^{CB} \cdot b_g^{CB})\mu + B_g \tag{20}$$

$$T(b^{PA}) = (A^{PA} \cdot (b^{PA} + c^{PA} \cdot b_g^{CB}) + A^{CB} \cdot b_g^{CB})\mu + B_g - c^{PA} \cdot b_g^{CB} \tag{21}$$

$$T(b_u^{CB}) = (A^{PA} \cdot c^{PA} \cdot b_u^{CB} + A^{CB} \cdot b_u^{CB})\rho + B_u \tag{22}$$

$$T(c^{PA}) = (A^{PA} \cdot c^{PA} + A^{CB})\rho + B_u (b_u^{CB})^{-1} \tag{23}$$

The equations for (a^{CB}, a^{PA}), (b_g^{CB}, b^{PA}) and (b_u^{CB}, c^{PA}) are independent of each other. Following the work of Honkapohja and Mitra (2006) on heterogeneous forecasts, the E-stability of the subsystems is satisfied if and only if all the eigenvalues of the Jacobian of M_1, M_2 and M_3 have negative real parts.

$$M_1 = \begin{pmatrix} T(a^{CB}) - a^{CB} \\ T(a^{PA}) - a^{PA} \end{pmatrix}$$

$$M_2 = \begin{pmatrix} T(b_g^{CB}) - b_g^{CB} \\ T(b^{PA}) - b^{PA} \end{pmatrix}$$

$$M_3 = \begin{pmatrix} T(b_u^{CB}) - b_u^{CB} \\ T(c^{PA}) - c^{PA} \end{pmatrix}$$

Proposition: The model is E-stable under learning if all eigenvalues of the following matrix $A^{PA} + A^{CB} - I$ have negative real parts. It corresponds to the following inequality:

$$\lambda(\phi_\pi - 1) > \phi_x(\beta - 1) \tag{24}$$

The proof is in the Appendix. This condition is exactly the Taylor principle, the condition for stability without learning or with learning and homogenous forecasts.

3.3 Determinacy

In the preceding section, we have obtained the E-stability condition but not the determinacy condition that defines the uniqueness of the equilibrium (if a unique stationary solution exists, the economy is said to be determinate; if multiple equilibria exist, the model is indeterminate). This issue is particularly important when the monetary policy rule of the central bank comprises forward-looking components as Bernanke and Woodford (1997) show. We have first focused on the MSV solution, unique in this model.

The standard determinacy condition is stated by Blanchard and Kahn (1980). In the case of RE, the equation (4) can be rewritten:

$$y_t = D + (A^{PA} + A^{CB}) \cdot E_t\, y_{t+1} + B \cdot w_t \tag{25}$$

and the determinacy condition is therefore $|A^{PA} + A^{CB}| < 1$ and leads to the resulting condition:

$$\phi_x(\beta+1) > \lambda(\phi_\pi - 1) > \phi_x(\beta-1) \tag{26}$$

Bernanke and Woodford (1997) conclude from this proposition that the central bank should not respond too aggressively to future inflation, since it may raise the possibility of sunspot equilibria. Bullard and Mitra (2002) shows that monetary rule based on expectations deliver both E-stability and determinacy compared to fundamentals-based rules.

In the situation in which private agents are following the central bank forecasts because of a central bank's better forecasting record, the E-stability given by *(24)* and the determinacy condition is similar to (26):

$$\phi_x(\beta+1) > \lambda(\phi_\pi - 1) > \phi_x(\beta-1) \tag{27}$$

The determinacy condition is a sufficient condition for the E-stability of the equilibrium and this is consistent with McCallum (2007) that shows that in a forward-looking model where the current period information set is available to agents to form their forecasts through adaptive learning, the determinacy condition is sufficient for E-stability. Our result for a forward-looking monetary rule can be extended to different rules comprising a smoothing parameter or current-period data as Bullard and Mitra (2002) show that a monetary rule with current-period data becomes more robust for the determinacy because in the New Keynesian model, current inflation is determined by private agents' expected inflation and the central bank therefore respond to its inflation forecasts and private forecasts. Moreover, Bullard and Mitra (2007) show that a monetary rule with some interest smoothing is also more robust for the determinacy of the REE.

3.4 Reversing the shock observed by private agents

If we consider that private agents only observe the cost-push shock u_t (rather than the demand shock g_t) and the central bank still both shocks, the condition for stability related to the central bank preferences is the same as above and the second condition on the economy shown in the appendix is also similar with μ replacing ρ.

3.5 Comparison to exogenous influence

The case of exogenous influence corresponds to the situation where the central bank influences private agents. The latter incorporate the forecasts of the central bank in their forecasting function, while those forecasts do not exhibit lower forecast errors. The central bank then succeeds to be influential without being more informed. This influential power may stem from the central bank position of leader and private agents of followers in the monetary process.

Muto (2008) assesses a particular configuration of exogenous influence in which private agents refer to the central bank forecasts in forming their expectations because the central bank is the leader of the monetary process; but only have the possibility to refer to it[4]. The

[4] This latter assumption will be discussed later.

main result of his work is that if the central bank is the leader of expectations formation, the forward-looking monetary policy rule faces serious problems and therefore that the central bank must be more restrictive than in the benchmark case of homogenous learning and satisfy this condition:

$$\lambda(\phi_\pi - 2) > \phi_x 2(\beta - 1) \quad (28)$$

The intuition is the following. The central bank makes some forecast errors and because of the assumption that private agents can only refer to the central bank forecasts, the noise with which private agents follow the central bank forecasts is correlated to the central bank forecast errors. This means that in the end, the private agents' forecasts errors (or following errors) add to the central bank forecast errors and needs the central bank to respond more aggressively to inflation to reach E-stability. This result stems from the cumulative process of central bank and private forecasting errors, but this specific hypothesis is not necessary to obtain the result in question. If private agents and the central bank have in average similar forecasting performance (as defined by exogenous credibility), the central bank does not know at each period whether the forecasting performance of private agents is better than its own and must therefore respond more aggressively to inflation to avoid self-fulfilling expectations. The stronger response to inflation stems from the uncertainty faced by policymakers at each period about the possibility that private agents make larger forecast errors than the central bank.

In comparison, in the situation of endogenous influence and when the private agents have their own forecasting function in addition to the possibility to follow the central bank forecasts, private agents reduce their forecast errors when they are influenced by the central bank and the latter therefore needs to respond only to its forecast errors. The Taylor principle is thus a sufficient condition to reach E-stability as in benchmark cases.

One possible alternative to Muto (2008)'s specific configuration may be that both actors have symmetric imperfect information about future shocks, private agents incorporate central bank forecasts with a given weight but also form their own forecasts based on their information set. Central bank influence is then exogenous and the given weight associated with central bank forecasts represents the capacity of the central bank to be a leader in the monetary game. In the end, private agents do not completely follow the central bank forecasts. Private forecast errors might therefore be superior or inferior to central bank forecasts. The central bank should then respond more aggressively to inflation than the Taylor principle suggests, but less than in Muto (2008) in which private errors necessarily add to central bank errors.

Finally, the important result when comparing endogenous and exogenous influence is that the former allows for less aggressive response to inflation and then calls for strong investment of central banks in their forecasting capacities in order to guide private expectations and benefit from more room for manoeuvre in their response to inflation.

3.6 Comparisons to other cases (without influence)

Honkapohja and Mitra (2006) analyse the situations in which a part of the agents (private or the central bank) is learning, while the other part (the central bank or private agents) have rational expectations (RE). In a similar New-Keynesian framework, they show that when the central bank has RE and private agents are learning, the condition for stability of the economy is precisely the Taylor principle as for homogenous rules under learning. The intuition is that because the central bank has more information than the private agents, it is able to stabilize the economy whatever the potential destabilizing effect of private

expectations (which stems from the positive eigenvalue of $A^{PA} - I$). At the opposite, when private agents have RE and the central bank is learning, the necessary condition for the economy to be stable needs the Taylor principle to be violated. However, violation of the Taylor principle is not a sufficient condition as the conditions are related to μ and ρ. According to benchmark numerical parameters used in the literature, the economy may be stable or unstable even if the Taylor principle is not met. This confirms that the assumption on who has more information is not meaningless and calls for central bank investment in information capacities.

Honkapohja and Mitra (2004) focus on the case where both the central bank and private agents are learning, but there is some information asymmetry between the two types of agents. They show that the conditions are more restrictive when the central bank has less information compared to when it has more information then private agents. Asymmetric information in favour of the central bank makes stability easier to reach. This chapter therefore suggests that central bank should allocate enough resources for information acquisition about the state of the economy and future shocks.

4. Conclusion

We study central bank policymaking in a situation of endogenous credibility in which the central bank has a better forecasting performance and it is therefore rational for private agents to follow central bank forecasts when forming their expectations. In contrast to the situation in which the central bank influences private agents without better forecasts (i.e. the case of exogenous credibility) and must respond more strongly to future inflation than the Taylor principle suggests; this chapter shows that the central bank must only respect the Taylor principle and need not be more restrictive to ensure macroeconomic stability. The direct policy implications is that because the central bank is the leader and private agents the follower of the monetary process, the former should invest enough resources in forecasting to guide private expectations.

Appendix

The T-maps defining E-stability and derived from PLM to ALM are then:

$$T(a^{CB}) = A^{PA} \cdot (a^{PA} + c^{PA} \cdot a^{CB}) + A^{CB} \cdot a^{CB} \tag{18}$$

$$T(a^{PA}) = A^{PA} \cdot (a^{PA} + c^{PA} \cdot a^{CB}) + A^{CB} \cdot a^{CB} - c^{PA} \cdot a^{CB} \tag{19}$$

$$T(b_g^{CB}) = (A^{PA} \cdot (b^{PA} + c^{PA} \cdot b_g^{CB}) + A^{CB} \cdot b_g^{CB})\mu + B_g \tag{20}$$

$$T(b^{PA}) = (A^{PA} \cdot (b^{PA} + c^{PA} \cdot b_g^{CB}) + A^{CB} \cdot b_g^{CB})\mu + B_g - c^{PA} \cdot b_g^{CB} \tag{21}$$

$$T(b_u^{CB}) = (A^{PA} \cdot c^{PA} \cdot b_u^{CB} + A^{CB} \cdot b_u^{CB})\rho + B_u \tag{22}$$

$$T(c^{PA}) = (A^{PA} \cdot c^{PA} + A^{CB})\rho + B_u (b_u^{CB})^{-1} \tag{23}$$

The expectational stability (E-stability) of the Actual Law of Motion (ALM) is satisfied if these T-maps are locally stable, what is satisfied if and only if all eigenvalues of the Jacobian of M_1, M_2 and M_3 have negative real parts. Those Jacobian matrices are computed at the equilibrium values $a^{PA} = b^{PA} = 0, c^{PA} = 1$ and $b_u^{CB} = 1$:

$$J_1 = \begin{pmatrix} A^{PA} + A^{CB} - I & A^{PA} \\ A^{PA} + A^{CB} - I & A^{PA} - I \end{pmatrix}$$

$$J_2 = \begin{pmatrix} \mu(A^{PA} + A^{CB}) - I & \mu A^{PA} \\ \mu(A^{PA} + A^{CB}) - I & \mu A^{PA} - I \end{pmatrix}$$
$$J_3 = \begin{pmatrix} \rho(A^{PA} + A^{CB}) - I & \rho A^{PA} \\ -B_u & \rho A^{PA} - I \end{pmatrix}$$

Following Honkapohja and Mitra (2006), the determinant for computing the eigenvalues of J_1, J_2 and J_3 may be simplified as follows

$$\det(J_1) = \begin{vmatrix} A^{PA} + A^{CB} - I & A^{PA} \\ A^{PA} + A^{CB} - I & A^{PA} - I \end{vmatrix}$$
$$\det(J_1) = \begin{vmatrix} 0 & I \\ A^{PA} + A^{CB} - I & A^{PA} - I \end{vmatrix}$$

After subtracting the second row from the first, the computation shows that J_1 has eigenvalues with negative real parts if and only if $A^{PA} + A^{CB} - I$ has the same property. Similarly, we obtain:

$$\det(J_2) = \begin{vmatrix} \mu(A^{PA} + A^{CB}) - I & \mu A^{PA} \\ \mu(A^{PA} + A^{CB}) - I & \mu A^{PA} - I \end{vmatrix}$$
$$\det(J_2) = \begin{vmatrix} 0 & I \\ \mu(A^{PA} + A^{CB}) - I & \mu A^{PA} - I \end{vmatrix}$$

After subtracting the second row from the first, the computation shows that J_2 has eigenvalues with negative real parts if and only if $\mu(A^{PA} + A^{CB}) - I$ has the same property. Because $0 < \mu < 1$, it suffices to have only the eigenvalues of $A^{PA} + A^{CB} - I$ for E-stability. The necessary and sufficient condition of J_2 is therefore similar to the one for J_1.

As the system of M_3 is not linear, the Jacobian J_3 is analyzed differently. For b_u^{CB}, the standard E-stability arguments apply and yield to the same property than for J_1 and J_2, because $0 < \rho < 1$. For c^{PA}, the E-stability condition is $\rho A^{PA} - I$.

For the special case of a 2× 2 matrix A, it can be shown that the condition that both roots of A have negative real parts is equivalent to the condition that the trace of A is negative and the determinant of A is positive. Thus, all the eigenvalues of $A^{PA} + A^{CB} - I$ have negative real parts if and only if the two conditions apply. It corresponds to the following inequalities:

$$\varphi\phi_x - \lambda\varphi + \lambda\varphi\phi_\pi - \beta\varphi\phi_x > 0 \quad (29)$$
$$\varphi\phi_x - \lambda\varphi - \beta + \lambda\varphi\phi_\pi + 1 > 0 \quad (30)$$

If (29) holds then (30) holds. The E-stability condition therefore corresponds to (29) that can be rewritten:

$$\lambda(\phi_\pi - 1) > \phi_x(\beta - 1) \quad (24)$$

The second condition needs ρ the autocorrelation of the cost push shock to be sufficiently small as A^{PA} has an eigenvalue higher than one (see Honkapohja and Mitra (2004) for more details), but has no effect on the optimal responses to inflation or output of the central bank to reach E-stability.

Chapter IV:
Has Inflation Targeting Changed Monetary Policy Preferences?*

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1. Introduction

The growing concern about the financial crisis originating on the subprime mortgage market has emphasized the role of monetary policy in either fuelling or dampening[1] the crisis but, in the meantime, it has blurred the debate over the adoption of inflation targeting (IT) in the US[2]. Such a debate had been raised after B. Bernanke's nomination as Fed's Governor, as a consequence of his long-standing position in favor of IT (see e.g. Bernanke et al., 1999). Walsh (2009), among others[3], recalls that the debate "*has centered on the view that IT places too much emphasis on inflation, potentially at the expense of other monetary policy goals*", a situation which is quite at odds with the definition that Bernanke et al. (1999) gave of IT. Indeed, the authors advocated a general framing of monetary policymaking, encompassing a numerical target on inflation, publication of internal forecasts, accountable policymakers, increased transparency and a flexible strategy[4].

Our contribution is to investigate whether the adoption of the inflation targeting framework has changed monetary policy preferences and more particularly the weight put on inflation. We focus on early adopters of IT among developed countries, which still operate under this framework and for which a sufficiently long sample of data is available. In this respect, the paper focuses on three of them: Canada, Sweden and the United Kingdom.

Empirical papers dedicated to the inflation targeting can be split into two main categories: the first one deals with the change in private expectations whereas the second is dedicated to inflation performance. Most contributions are cross-country studies involving a control group. Conclusions are mixed between these two categories. Evidence points to lower and better anchored inflation expectations with IT adoption, while there is no significant effect on inflation performance. Johnson (2002) produced evidence of lower expected inflation in IT countries and Levin et al. (2004) and Gurkaynak et al. (2006) showed that in comparison with non-IT countries, inflation targeters have been able to better anchor long-run inflation expectations: UK and Swedish inflation expectations have not been sensitive to economic events since IT adoption. Johnson (2002) and Levin et al. (2004) used data from the Consensus Forecasts, while Gurkaynak et al. (2006) extracted expected inflation from the difference between forward rates on indexed and non-indexed 10-year public bonds. Fregert and Jonung (2008) showed that long term wage agreements increased steeply right after IT had been adopted in Sweden, testifying for a decrease in inflation expectations. However, Ball and Sheridan (2003) found no evidence of a beneficial impact of IT on a country's economic performance[5] in comparison with non-IT countries, while Angeriz and Arestis (2007) do not find a significant break in the estimated evolution of inflation in the UK compared with the US and EMU and Genc (2009) assesses regime switches in four developed IT countries in a univariate model for inflation and finds no evidence of a structural break in the inflation levels. Cecchetti et al. (2002) conclude that the extent to which IT exerts a measurable influence on monetary policy is limited. Last, Lin and Ye (2007), using propensity score matching, conclude that IT has had no significant effects.

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[1] See respectively e.g. Taylor (2009), Bullard (2009) and Frappa and Mésonnier (2010).

[2] See e.g. McCallum (2007) and Hetzel (2007).

[3] See e.g. Friedman (2004) and Leijonhufvud (2007).

[4] Although the Fed has not adopted IT, it is sometimes suggested that it is an implicit targeter. This definition of the IT framework proves that the Fed is not even an informal targeter: there is neither a clear target on inflation on which the Fed communicates, nor transparency on future monetary policy strategy since staff forecasts are not made public until five years have passed.

[5] Economic performance was assessed using a very large scope of statistics: inflation, inflation variability and persistence, output growth and variability, long-term interest rates, and variability of short-run interest rates.

These papers are all confronted with the control group problem first enlightened by Gertler (2003) in this strand of the literature and magnified by the exceptional stability of world inflation during the last decade. Insofar as all countries in the world have seen inflation rates decrease, it is highly difficult in a comparative setting[6] to evidence a change either in inflation expectations or in inflation performance that could be solely attributed to a change in institutions.

These papers are also confronted with the self-selection problem of policy adoption: what may have led actually to low inflation in IT countries was their decision to aim specifically at lower inflation than in earlier (pre-IT) periods. Stated in the above-mentioned terms, the argument claims that good inflation performance may stem from a policy switch towards a greater focus on inflation, at the expense of other policy objectives. This stronger response to inflation, due to the central bank's official focus on and commitment to inflation has not been proved so far and depends on whether or not the behavior of central bankers has changed after the institutional adoption of IT.

Compared to the vast literature on the impact of IT on macroeconomic performance or private expectations, this paper investigates whether the institutional adoption of IT has modified the monetary policy preferences. To our knowledge, only few studies have been performed in this respect for countries having adopted IT. Seyfried and Bremmer (2003) find a break in the monetary policy reaction functions of six IT countries, and they conclude that IT central banks pay more attention to inflationary pressures (proxied by the output gap) than to current inflation (whose coefficient is never significant), while Baxa, Horvath and Vasicek (2009) find the response to inflation has become less aggressive after IT adoption. For the UK, Trecroci and Vassalli (2009) find higher response to inflation (but with a significantly negative interest rate smoothing parameter, inconsistent with central bank interest rate evolutions) and Assenmacher-Wesche (2006) low and non-significant response to inflation before IT, while Davradakis and Taylor (2006) find significant response to inflation only since IT adoption and when the latter is above the target.

We depart from these papers by the multiplicity of the estimation methods used in order to uncover the changes in policy preferences. We use estimation methods which allow us to have to assume neither potential break dates nor nature of the breaks: sudden switch or gradual evolution. We thus perform structural break *à la* Qu and Perron (2007), Time-Varying Parameters (TVP) and Markov-Switching Vector Autoregressive (MSVAR) estimations to test the three possibilities of changes: no switch at all in the preferences, a switch towards a higher focus on inflation, or the opposite. Without probability priors regarding these three possibilities, our standpoint is to "let the data speak". These methods contrast with split-sample approach which needs to suppose a structural break and a date for it. Last, TVP and MSVAR methods also contrast with simple tests of monetary rules that generally do not capture multiple shifts in variance because they do not make enough allowance for heteroskedasticity.

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[6] All countries have experienced common macroeconomic evolution (for instance strong disinflation) and Lin and Ye (2007) themselves note that "*one can reasonably suspect that the low inflation (variability) might be caused by some common uncontrolled factors that affect both targeting and non-targeting countries*". For this reason, our focus is not on the inflation performance of IT versus non-IT countries, but solely on changes in monetary preferences within IT countries. Moreover, many authors (see e.g. Boivin (2006) or Sims and Zha (2006)) have shown for US, a non-IT country, that changes in the reaction function of the Federal Reserve happened when Volcker started his mandate and that the monetary preferences of the Fed have been stable since then (i.e. on our sample). Our own MSVAR checks on US data confirm this result. This suggests that evidence presented in this paper is not due to factors that would have also affected non-IT central banks.

Dealing with a change in the preferences of policymakers over time has given rise to an abundant literature since the seminal contribution of Clarida et al. (2000) where they showed that the response of the Fed to changes in inflation was higher during Chairmen Volcker and Greenspan's eras than during the preceding period. In this paper, an agnostic view has been endorsed as to which estimation method better fits our hypothesis: tests have been performed using the three empirical methods in order to assess changes - and their nature - in the conduct of monetary policy without making assumptions or imposing binding conditions on those changes, dates and nature of potential breaks.

We use a forward-looking Taylor (1993) type rule, which corresponds to the normative description of central banking to estimate both potential structural breaks with the Qu and Perron (2007)'s procedure when the date and number of breaks is unknown and Time-Varying Parameters (TVP) through a Kalman filter to capture shifts in policymakers' preferences. In the literature, TVP has been developed and used in various aspects. Canova (1993), Stock and Watson (1996), Cogley and Sargent (2001) and Primiceri (2005) estimate VARs with drifting coefficients, while Boivin (2006), Kim et al. (2005), and Kim and Nelson (2006) focus on forward-looking monetary rules in the US. Because of our focus on a change in the preferences of central bankers since IT adoption, we focus on the single equation approach in the vein of Boivin (2006).

We complement these approaches with the use of MSVAR as developed by Hamilton (1989, 1994) and Sims and Zha (2006). It permits to date breaks and assess whether a new regime appears or a previous one re-emerges. Our assessment of policy changes goes beyond earlier attempts to estimate the potential changes involved by IT adoption. To our knowledge, no study has been ever implemented in order to estimate regime shifts in IT countries with an MSVAR model. Assenmacher-Wesche (2006) used this method to estimate monetary policy reaction functions in the UK, USA and Germany and she did not devote much attention to inflation targeting *per se* in the UK, nor did she extend the empirical analysis to other IT countries. Ammer and Freeman (1995) had estimated a canonical VAR whose sample stopped just before inflation targets were first announced, and then, they compared actual values for GDP, inflation, and the real interest rate with the (out-of-sample) forecasted ones. They interpreted the differences between couples – actual and forecasted – of all variables as evidence of a change of regime. In contrast, using MSVAR can reveal a new regime rather than assume it. Moreover, the focus on the emergence of regimes rather than on the occurrence of pure breaks also enables to check the argument that anti-inflation policies had already existed before IT adoption. Last, identification of forward-looking monetary reaction functions is generally supposed to be fragile (see *e.g.* Sims and Zha, 2006). MSVAR models, with their backward looking estimations, nicely complement the more usual range of tests performed previously.

The main result is the following. In the three countries considered, the adoption of inflation targeting has not led to a greater focus on inflation. The consistency of results whatever the method is acknowledged. Moreover, there is no evidence of a higher response to output which may suggest increased concern about inflation if output is considered as a leading indicator of inflation. Two intertwined interpretations of our result are put forward, which are based on two supposed benefits of inflation targeting. First, IT -through central bank commitment to a target- is meant to help anchor private inflation expectations, which will enable a central bank to control inflation without pursuing aggressive action towards inflation variations. Second, the central bank's decision to lower inflation may have led to low and stable inflation and hence to a lower response to inflation. Last, the outcome of this paper suggests that the inflation targeting *paradigm* (which consists in strong response to

inflation to reach low and stable inflation, that will produce in the end stable macroeconomic conditions) should not be confounded with the inflation targeting *framework* (which consists in a commitment to a numerical target, publication of forecasts and increased transparency). Indeed, countries who have adopted the IT *framework* have not over-emphasize inflation deviations from target like "inflation nutters" to take the words of King (1997), while the IT *paradigm* common to IT and non-IT central banks in the last decade has made emerge a consensus around the inflation target at a 2% level. The debate on IT adoption might therefore be centered on the level of the inflation target[7] rather than on the emphasis on inflation.

It is important to acknowledge that this paper does not assess the efficiency of monetary policy. Hence, our tests do not address the debate on the Great Moderation. The latter is usually associated with the great decline in output, employment and inflation volatility and attributed to more efficient monetary policy, increased globalization, better inventory policies and/or "good luck" (see Davis and Kahn, 2008, for a critical empirical review of these arguments)[8]. It remains that our results are not blurred by the debate around the Great Moderation. We do not investigate the reasons for the decline in inflation, but we rather focus on the relationship between the inflation rate and the policy instrument, without any judgment on its effectiveness over time. We focus on the changes in monetary policy preferences which have occurred since IT adoption and find no higher response to inflation.

The remainder of the paper is organized as follows. Section 2 deals with data. Section 3 focuses on the Qu and Perron (2007)'s structural break procedure. Section 4 displays TVP estimation. Robustness checks are discussed. In section 5, the regime-switching method is presented along with estimation outcomes and related robustness tests. Section 6 concludes.

2. Data

We concentrate on three industrialized IT countries, the biggest ones among those having adopted it at the earliest and making long time series at a high frequency available. Thus, if we focus on OECD countries that have adopted IT the earliest, we are left with 8 countries which have turned formally to an IT regime since the early 1990s: between New-Zealand, which adopted it in 1990, and Spain, in 1995, the six others were: Australia, Canada, Finland, Israel, Sweden and the UK. From this list, we decided to focus[9] on Canada, Sweden and the UK. IT was adopted in Canada in February 1991 and was in its completion form at the end of 1995 when the decelerating path of inflation was transformed in a fixed target range. The same process took place in the UK: an adoption in October 1992 and a completion in May 1997 that corresponds to the statute change of the Bank of England and its increased independence. In Sweden, IT was adopted in January 1993 with the objective to be fully applied in January 1995, and the inflation target has remained the same since IT adoption: no decelerating path of inflation occurred[10] during the implementation period.

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[7] See recently on this point Blanchard et al. (2010).

[8] Davis and Kahn (2008) use US micro data and conclude that improved supply-chain management (or better inventory controls) is the most prominent cause of the Great Moderation. They also show that no decline in uncertainty for the households can be associated with the Great Moderation.

[9] We dropped New-Zealand and Australia due to their multiple modifications of their IT framework, Israel as it is an emerging economy and Finland and Spain due to their accession to the eurozone.

[10] In Sweden and Canada, no change in the target has occurred since the completion of IT. In the UK, the target changed once: in December 2003, the target moved from 2.5% per year (for the RPIX) to 2% per year (for the CPI). It is generally admitted that because the RPIX and the CPI are not measured similarly, a 2% target for the CPI amounts to a 2.5% target for the RPIX (*cf.* King, 2004; Cukierman and Muscatelli, 2008). With respect to the

We focus on the period from 1987:1 to 2007:12 in order to rule out the disinflation period of the early 1980s during which most of central banks have fought against high inflation. We consider a period of stable inflation over which potential changes in monetary policy would be ever more striking. We therefore escape the usual criticism that better inflation performance under IT is concomitant with disinflation policies that started being implemented all over the industrialized world in the early 1980s. There has been a global focus on inflation since then and we may suppose IT adopters may have behaved as IT central banks prior to the official adoption. Focusing on a stable sample starting in 1987:1 enables to assess if the *institutional* adoption had an effect on central bankers' behavior and preferences.

Our concern being on monetary policy preferences, we focus on the three standard variables of the Taylor (1993) rule: the nominal short-run interest rate, the officially-targeted CPI index and the output gap. We use monthly data. The interest rate is the central bank reference rate as advertised by central banks themselves. The inflation rate is the measure of inflation targeted by central banks. For the UK, the series is extrapolated from RPIX, RPI and CPI-H, the harmonized index of consumer prices. In Canada, the series is the CPI excluding eight of the most volatile components; and for Sweden, UND1X, a core CPI index, is used. Interest rates and price indices come from central banks' statistical databases. The output gap measure comes from the OECD whereas unemployment rates, which are used to check the robustness of our outcomes in replacement of output gap measures, are national measures taken from Thomson Financial Datastream. Inflation rates are expressed as the first difference of the log of the price index and all variables are expressed in percent. Figure IV.1 represents these series. The grey bars represent the implementation period between the institutional adoption of IT and its completion in the final form.

3. Has Monetary Policy Changed? A Structural Break analysis

The first step of our analysis is to assess whether monetary policy preferences have changed during the sample considered and to compare potential break dates with the IT adoption date. In order to test the hypothesis that the adoption of inflation targeting may have changed the coefficients in the monetary policy reaction function, we use the estimation procedure of Qu and Perron (2007), which enables the estimation of unknown break dates in a multivariate framework.

3.1 Method

We characterize the monetary policy preferences with a usual Taylor-type rule with a smoothing term as advocated by Woodford (2003) and responses to future inflation and output as in Clarida, Gali, Gertler (1998, 2000). This forward looking rule takes the form:

$$r_t = \alpha + \rho(L) \cdot r_{t-1} + \beta_\pi \cdot \pi_{t+h_\pi} + \beta_y \cdot y_{t+h_y} + \varepsilon_t \quad (1)$$

where r_t is the central bank reference rate and $\pi_{t+h\pi}$ and y_{t+hy} are central bank's expectations of inflation and output gap, respectively at horizons h_π and h_y. Results displayed hereafter are always long-run responses to inflation and output gap, that is to say $\beta_\pi/(1-\rho)$ and $\beta_y/(1-\rho)$. For the sake of convenience, we use the notations β_π and β_y in all the tables.

The empirical model we use to characterize the monetary policy preferences is therefore forward looking. This raises two issues. First, in the absence of proper internal forecasts of

motivations of our study, the fact that changes in targets have been almost nonexistent or scarce at least is important in that it helps to escape finding a change of monetary regime that would ensue solely from a change in the target, and not from a change in the preferences in order to achieve it.

these central banks over a long time span[11], we suppose that they behave under rational expectations. The relatively recent use of dynamic stochastic general equilibrium models under rational expectations in these institutions reinforces this assumption[12]. In absence of real-time forecasts for those three central banks (compared to the Federal Reserve which makes its real-time forecasts available), inflation and output expectations of central banks in the monetary rule are therefore assumed to be realized values, in accordance with the assumption made in the literature when facing data availability constraints. Second, we may be faced with the endogeneity problem. To circumvent it, we rely on arguments from Boivin (2006). We can assume that endogeneity is regular throughout the whole period; then, it should not distort the changes in the policy parameters. Moreover, in order to assess that our findings are not blurred by endogeneity, we estimate changes in monetary policy using different positive forecasting horizons h_π and h_y in the forward looking rule and with the current values of inflation and output gap ($h_\pi=h_y=0$) which are not affected by contemporaneous policy shocks and then not subject to potential endogeneity issue. Since changes are similar between future realizations and current values, it suggests that evidence regarding the policy coefficients is unaltered by this endogeneity problem. Last, we assess the robustness of our analysis by complementing it with a MSVAR backward-looking estimation (see section 5 below).

The benchmark specification of the monetary policy rule comprises four lags of the interest rate and we suppose the central bank focuses on inflation and output gap three quarters ahead, hence $h_\pi = h_y = 9$. We apply the multivariate procedure of Qu and Perron (2007) which allows us to test for the presence of breaks in the coefficients and variance of error of the monetary policy reaction function. It first tests the null hypothesis of no breaks against an unknown number of breaks up to a maximum of *M*, and then identifies the exact number and the locations of the breaks using a sequential approach. The procedure is as follows. The supremum statistic SupLR is a Wald-type test statistic for structural change at *M* unknown break dates. Then a sequential F-type test is used to determine the number of breaks and their locations. The SupSEQ is designed to detect the presence of *j+1* breaks conditional on having found *j* breaks. The statistical rule is to reject *j* in favor of a model with *j+1* breaks if the overall minimal value of the sum of squared residuals (over all the subsamples where an additional break is included) is sufficiently smaller than the sum of squared residuals from the model with *j* breaks. The dates of the selected breaks are the ones associated with this overall minimum. The sequential test statistic is applied until the test fails to reject the null hypothesis of no additional structural break. The maximum number *M* of breaks needs to be specified as well as the minimum fraction of the sample in each regime in proportion of the total sample size. The latter has to be chosen large enough for tests to have approximately correct size and small enough for them to have decent power. Moreover, when the errors are autocorrelated and/or heteroskedastic, it has to be larger than when these features are absent. In order to balance these issues, we set the minimal length at 0.20 and $M = 3$.

3.2 Results

Table IV.1 summarizes the estimated break dates. The Qu and Perron (2007) multiple structural breaks test reveals breaks at the date 1991:9, 1995:10 and 2001:7 for Canada, when allowing for 3 breaks. The most important one is in 1995:10 with a confidence interval at 90% from 1994:8 to 1995:11. This date corresponds to the end of the implementation period of IT. In the United Kingdom, the three estimated breaks are 1992:8, 1996:8 and 2001:7 with the

[11] Canada started publishing internal forecasts in mid-2000s, Sweden in late 1990s and the UK in mid-1990s.

[12] See the Bank of England Quarterly Model, ToTEM model at the Bank of Canada and RAMSES model of the Sveriges Riksbank.

third being non significant. The most important break is in 1992:12 with a confidence interval from 1990:12 to 1993:1. The break estimated takes place two months after the formal adoption of IT by the Bank of England. In Sweden, two break dates are evidenced: 1992:7 and 1996:7, with the second being only significant at the 10% level. The most important break when considering only one is 1992:10 with a confidence interval from 1992:9 to 1992:11. This break predates from 2 months the formal adoption of IT.

A change in the monetary policy preferences therefore happens just around the formal adoption of the new framework in Sweden and the United Kingdom, while the change happens in the end of the implementation period in Canada. Thus, the structural break estimated for each country coincides with the adoption or implementation of IT.

3.3 Linear Estimates

We provide in table IV.1 the linear estimates of the two regimes determined before and after the break date. In Canada, the response to inflation β_π is non significant before and after, while the response to output β_y is significant and equals one before and is not significant afterwards. For Sweden, neither the response to inflation nor to output is significant before and after. In the UK, the response to inflation is high ($\beta_\pi = 1.52$) and significant before and non significant after, while the response to output is never significant. All in all, there is no evidence of a policy change towards a greater focus on inflation.

3.4 Alternative forecasting horizons

Table IV.2 summarizes the linear estimates of responses to inflation and output for alternative forecasting horizons from h=0 to h=12. Estimated break dates are similar to the ones of the benchmark case. For Canada, the linear responses to inflation are very unstable from one horizon to the other, being positive, null or negative, while the decrease in the response to output seems to be confirmed. For Sweden, both responses are unstable. In the UK, the pattern is stable: both responses are lower after the break, but coefficients are not significantly different before and after the break. The outcomes show the instability of linear estimation of coefficients of monetary rules and calls for an estimation method that is able to reveal a gradual change in monetary policy preferences.

4. How has Monetary Policy Changed? A Time-Varying analysis

The Time-Varying Parameters model is well fitted for revealing a potential gradual and permanent change in the strategy of policymakers after IT was adopted. Indeed, Boivin (2006), Canova and Gambetti (2008) and Koop et al. (2009), among others, show monetary policy may change smoothly. Compared to MSVAR, TVP models permit to uncover changes in parameters separately. This model is of course less suitable for detecting a simultaneous single discrete jump for all parameters compared to the structural break analysis but allows to assess the evolution of monetary policy parameters at different points of the sample.

4.1 Method

We estimate policy changes induced by inflation targeting through a forward looking Taylor-type (1993) rule augmented with time varying coefficients. A generally accepted characterization of the monetary policy conduct takes the following form:

$$\begin{aligned} r_t &= \alpha_t + \rho_t(L)\cdot r_{t-1} + \beta_{\pi t}\cdot \pi_{t+h_\pi} + \beta_{yt}\cdot y_{t+h_y} + \varepsilon_t \\ &= \Psi_t' Z_t + \varepsilon_t \end{aligned} \qquad (2)$$

where r_t is the central bank reference rate and $\pi_{t+h\pi}$ and y_{t+hy} are central bank's expectations of inflation and output gap, respectively at horizons h_π and h_y. Every coefficient has a *t*

subscript to denote its time varying characteristics. We use this policy rule to assess the conduct of monetary policy in inflation targeting countries and determine the extent to which monetary policy has changed with the adoption of this monetary framework.

The Time-Varying Parameter model assumes that all policy parameters in the measurement equation (the Taylor rule) follow a driftless random walk, called the transition equation:

$$\Psi_t = \Psi_{t-1} + \upsilon_t \quad with \ \ \upsilon_t \sim N(0, \sigma_\upsilon^2) \tag{3}$$

This transition equation is estimated[13] using the Kalman filter. Evolution of coefficients depends therefore on the value of the noise to variance ratio, which is the ratio between the variance of the transition equation and the variance of the measurement equation ($\sigma_\upsilon^2 / \sigma_\varepsilon^2$). A regression with fixed regressors would consist in fixing $\sigma_\upsilon^2 = 0$ in the transition equation, thus having a noise to variance ratio equal to 0. When parameters are time invariant, the estimation would then produce OLS results. This noise to variance ratio defining the variance of the transition equation can be estimated by Maximum Likelihood (ML). However, when this variance is small, the "pile-up" case arises: the estimate is biased in the direction of 0, because the ML has a large point mass at 0. Stock and Watson (1998) propose to estimate it through a median unbiased estimator.

To uncover the evolution of the coefficients across time, we quite simply rely on an agnostic view as regards the value of the noise to variance ratio, which we set equal to 0.01: it means that the variance of the transition equation is small in comparison with the variance of the measurement equation. This is in line with the idea that policymakers do not change their reaction function very frequently. Indeed, this ratio is not essential in itself as it sets the variability of the coefficients. The rationale for using this method is to uncover the changes and the direction of these changes in policy coefficients more than the variability of these coefficients. We show later that our results are not sensitive to more or less volatility of policy parameters with a large range of ratios.

Last, the TVP approach allows dealing with heteroskedasticity, as some authors among which Sims (2001), Sims and Zha (2002), Primiceri (2005) and Kim and Nelson (2006) argue that time-varying variance of the shocks is more important than time-varying coefficients in modeling the monetary policy rule.

4.2 Results

Figure IV.2 reports the evolution across time of the responses, respectively to inflation and to the output gap, of the central bank interest rate for the benchmark policy rule with four lags and $h_\pi = h_y = 9$. The response to inflation has clearly decreased in Canada and Sweden, while being stable and non significant in the UK. In the former countries, the response is statistically significant in the beginning of the sample and not afterwards. The response to output gap has risen from negative and significant values to non significant values after 1995 in Canada and Sweden. In the UK, the response is not significant all over the sample.

All in all, estimates for Canada and Sweden testify for a lower monetary reaction towards inflation over the sample, at the benefit of a higher reaction towards the output gap. Time-varying estimates for the three countries clearly reject the hypothesis of a stronger focus on inflation with the adoption of inflation targeting and show that the conduct of monetary policy has not changed in the direction usually admitted since the late 1980s or since IT

[13] We used the *Captain* toolbox to perform the estimations, from CRES, Lancaster University, Lancaster, LA1 4YR, United Kingdom, http://www.es.lancs.ac.uk/cres/captain/.

adoption. The latter has not led so far to an increase of the policy response to inflation. Moreover, IT adoption did not lead to a clear decrease of the policy response to output.

4.3 Robustness

Figure IV.3 exhibits the time-varying responses to future inflation and output at various horizons. For Canada and Sweden, the response to inflation has decreased whatever the forecasting horizon, while the response to output gap has increased. The picture is less pronounced for the UK, where depending on the forecasting horizon, the evolution of the monetary policy reaction towards inflation is mixed. The response is stable at the 9-month forecasting horizon, while is decreasing at the current, 6-month and 12-month horizon and thus the downward trend is similar to Canada's or Sweden's. For the response to the output gap, the difference with the other two countries under study is sizeable: the responses to the output gap range between a limited decrease and stagnation. Globally, the evolution of policy coefficients is consistent across forecasting horizons (between positive horizons and current values which are not subject to potential endogeneity issue) to the extent that they reject the hypothesis that the conduct of monetary policy has focused more strongly on inflation since IT adoption.

In order to check whether our results are dependent on the value of the noise to variance ratio, we have estimated the same specifications of the forward looking monetary policy rule with a noise to variance equal to resp. 0.1 and 0.001. We report[14] in figure IV.4 the estimates obtained with a noise to variance ratio of 0.001, hence with a smaller variance in the random walk process of policy parameters than the variance of policy shocks. The responses to inflation and to the output gap have evolved consistently with baseline estimates. It is even noteworthy that the decrease of the policy response to inflation in the UK is clearer with this specification of the noise to variance ratio than in the previous context.

Rejection of the hypothesis of an increase of the response to inflation is consistent with the time-varying estimations of Baxa et al. (2009), which find low and decreasing responses to inflation in Canada, Sweden and the UK.

5. A Complementary Analysis through Markov-Switching VAR

In order to complement the structural break analysis, we now assess whether the potential break in the policy coefficients gives rise to a new regime and whether there have been or there have not been occurrences of return to the previous regime. For this, we adopt the nonlinear stochastic dynamic simultaneous equations model of Assenmacher-Wesche (2006) and Sims and Zha (2006). The Markov-Switching method allows us to confirm the break underlined in section 3 and to assess the possibility of a return to the previous regime. This analysis departs from the rest of the paper as the procedure does not involve a forward-looking monetary rule, but a (backward-looking) 3-equation VAR with the same three variables: the central bank interest rate, the inflation rate and the output gap. We acknowledge that a backward looking specification is not much representative of the behavior of central bankers, but it avoids the potential endogeneity bias and enables to verify the robustness of our forward looking results.

[14] Estimates of policy coefficients with a noise to variance ratio equal to 0.1 are available from the authors upon request and display similar evolutions of policy coefficients.

5.1 Method

The Markov-Switching VAR, as proposed by Hamilton (1989, 1994), allows the structural coefficients and the covariance matrix to be dependent on an unobserved state variable S_t which is assumed to follow a 1st order Markov chain. The joint distribution of the shocks can be non-constant across the sample periods. The general framework is described by the following equation:

$$\begin{cases} y_t = x_t \cdot \beta_{S_t} + u_t & t = 1,...,T \\ u_t \left| S_t \sim N(0, \Sigma_{S_t}) \right. & S_t = \{1,...,M\} \end{cases} \tag{4}$$

where $y_t = (y_{1,t},..,y_{p,t})$ is an 1 × n vector of endogenous variables, with n the number of variables of interest, x_t is an 1 × np vector of p lagged endogenous variables, S_t is an unobserved state, β_{St} is an np × 1 vector of parameters, T is the sample size and M the number of states (or regimes). The covariance matrix Σ_{S_t} takes the form:

$$\Sigma_{S_t} = \sigma_S^2(S_t) \cdot I_p \tag{5}$$

The transition probabilities matrix, noted P, is defined following Hamilton (1994):

$$P = \begin{pmatrix} p_{11} & \cdots & p_{M1} \\ p_{12} & \cdots & p_{M2} \\ \vdots & \cdots & \vdots \\ p_{1M} & \cdots & p_{MM} \end{pmatrix} \tag{6}$$

$$\text{with } \sum_{j=1}^{M} p_{kj} = 1 \text{ and } p_{kj} \geq 0, \quad \forall k, j \in \{1...M\}.$$

Initial values of the vector of parameters are calculated. A conditional probability density function is defined according to the information set in *t-1*. The model is recursively estimated through the ML "EM" algorithm, starting from the unconditional density of y_t which is calculated by summing conditional densities over possible values for S_t. The ML estimates are finally obtained by maximizing the log-likelihood function and allows to attain the final matrix of parameters.

Our approach is very close to that of Assenmacher-Wesche (2006). First, the baseline equation of the model is free of restrictions. The *ad hoc* nature of restrictions is totally opposed to the seminal motivation of our methodology: since we do not know *ex ante* the possible changes of monetary policy effects implied by IT and because the empirical approach is data driven (*i.e.* we are looking for what data tell us about this framework setting aside any preconceived conclusions), it becomes obvious that we cannot impose any restrictions on parameters. Second, the use of Bayesian techniques, though it represents a great advancement in structural estimation, runs up against the same motivation. Indeed, the link between estimation and calibration is strong and depends on subjective priors, which we chose not to use. In the end, the nearest method to the Bayesian one is the Maximum Likelihood (ML)'s, which is free of calibration.

Our variables of interest introduced in the VAR are the central bank interest rate, the inflation rate and output gap (M3 and energy prices have also been tested without modifying the outcomes). Four lags have been introduced in the VAR. We focus on a full changes specification, *i.e.* a specification with changes in coefficients as well as in disturbance terms. We can underline different regimes with different monetary policy coefficients and thus test whether monetary policy has actually changed. We have tested for two to three different states (or regimes); since results are consistent and robust, we only present the 2-state

specification which fits well into the issue of whether during a relatively short sample (1987-2007), IT has constituted a regime with a stronger focus on inflation *per se*.

5.2 Results

Results are reported in figure IV.5: they show the implied state-probabilities over time[15] and the coefficients[16] of the interest equation which characterize each monetary regime: the degree of persistence ρ, the respective long run response of the interest rate to inflation β_π, and to the output gap (or the unemployment rate) β_y. By long run response, we mean coefficients of response divided by one minus the autoregressive terms. The degree of persistence ρ comes from the sum of the coefficients on the lagged interest rates.

Canada does not show any regime shift over the sample: regime 1 has been prominent since the beginning of the sample and is characterized by a response to inflation satisfying the Taylor principle in the long run, as well as by a relatively high response to the output gap (see table IV.3 for point estimates and standard errors and table IV.4 for matrices of transition probabilities). Canada only experiences a period of adaptation between announcement and completion of IT and this regime 2 shows weak responses to inflation and the output gap. It seems that the break evidenced in section 3 corresponds to the implementation period and that central bank's preferences have not changed with the adoption of IT. Moreover, the preference of monetary authorities between both policy objectives – inflation and the output gap – under regime 1 is not biased in favor of an excessive focus on inflation: the coefficient on the output gap is higher.

In the UK, the MSVAR estimation does not underline a precise break but rather a situation evolving slowly from regime 2 to regime 1. Estimates indicate a progressive transition. The response to inflation of the gradually-more-frequent regime 1 is lower than the one in regime 2. Hence, the gradual prominence of regime 1 goes hand in hand with a lower focus of the Bank of England on inflation deviations from target. This latter result may complement those reported in Assenmacher-Wesche (2006)[17]: she opposed "high inflation" and "low inflation" states, and showed that during the "low inflation" state, the Bank of England had a higher reactivity to inflation deviations and the output gap than under "high inflation", which stopped being dominant before the beginning of our own sample. Our analysis focuses exclusively on the "low inflation" sample and shows that the evolution of policy preferences has not led to a greater focus on inflation.

As a matter of fact, the adoption of IT in Sweden has constituted a regime shift: regimes 1 and 2 were intertwined before IT adoption. Regime 1 has almost fully disappeared since IT announcement in 1993. This is a clear-cut result for Sweden which confirms the break estimated in section 3. It corresponds to the usual assessment by Swedish central bankers

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[15] Figures depict at each date the average probability to stand in the corresponding regime over the last 6 months.

[16] Coefficients of response are "artificial long run responses" of the policy rate to both objectives of monetary policy, and they have been computed as in SZ (2006), using the same confidence interval at 68 percent. ρ, β_π , β_y, correspond respectively to the AR coefficient, the long run coefficient on inflation and the long run coefficient on either the output gap or the unemployment rate, in the interest rate equation. According to SZ, "(artificial long run responses) are neither an equilibrium outcome nor multivariate impulse responses, but are calculated from the policy reaction function *alone*, asking what would be the permanent response in (the policy rate) to a permanent increase in the level or rate of change of the variable in question, if all other variables remained constant".

[17] Results are in contrast with those reported by Cukierman and Muscatelli (2008). Their estimations tend to show that the UK has entered a regime of "inflation dominance" since 1993, after a regime of "recession avoidance" until 1990. Contrary to the present paper, Cukierman and Muscatelli (2008) impose prior restrictions on the monetary policy reaction function, strongly assuming that a standard new Keynesian framework fits the data.

that monetary policy has entered into a new era after "flexible inflation targeting" was adopted (see Svensson, 2009). The hypothesis of a higher response to inflation is also challenged as regime 1 being dominant after IT adoption exhibits a lower response to inflation than regime 2, consistently with the evolution estimated in section 4.

These findings for the three countries suggest that IT adoption has not constituted a change in the monetary policy reaction function *in the direction of* a higher focus on inflation. Two arguments have been used in this respect. First, in Canada, there has been a break during the implementation period (confirming estimates of the section 3), but not the emergence of a new monetary policy regime. Second, there has been a switch, abrupt for Sweden and smooth for the UK, towards a new regime with a lower response to inflation than in the other regime. Though this can raise concerns about whether monetary policy has been more permissive or more efficient, it remains that reaction of central banks to inflation has been reduced since IT adoption or completion, showing that monetary policies have not changed in the way generally admitted.

5.3 Robustness

A comparison of the estimated monetary reaction functions with those reported in the literature shows that they are common (see table IV.5). The long run responses of the Canadian central bank rate towards inflation and the output gap are consistent with Muscatelli et al. (2002)'s; the coefficient on inflation has a negative sign in Seyfried and Bremmer (2003), though the coefficient on the output gap is relatively close to ours. The negative sign reported for the monetary reaction towards inflation in the UK is also found in Kuttner (2004) and Seyfried and Bremmer (2003), whereas Valente (2003) found that the Taylor principle was violated. The violation of the Taylor principle in Sweden is shared by Muscatelli et al. (2002), whereas the negative Swedish monetary reaction towards the output gap can also be found in Kuttner (2004) and Muscatelli et al. (2002).

In order to assess the robustness of baseline MSVAR results, we ran new estimations with unemployment data, rather than output gaps. Unemployment rate can be considered as a proxy for the output gap, via Okun's law; moreover, it is a good measure of real activity at a monthly frequency (see Orphanides and Wieland, 2008). One, four and three lags have been introduced respectively for Canada, Sweden and the UK according to the Schwarz information criterion.

Regimes probabilities are reported on figure IV.6. Under this alternative setting, Canadian outcomes are similar: the second regime has only occurred during the implementation period towards full completion of IT, and the monetary regime has always remained the same before IT announcement and after IT completion. It confirms that no regime shift in favor of a stronger focus on inflation happened in Canada between 1987 and 2007. The conclusion is also reinforced in the case of the UK: the gradual prominence of regime 1 (with a lower focus on inflation) across time is in accordance with TVP estimates. For Sweden, the regime shift after IT adoption is also confirmed and consistent with TVP and structural break estimates. Computed estimations of monetary reaction functions including the unemployment rate (see tables IV.3 and IV.6), first, confirm the initial results while, second, they improve initial outcomes in that all reported coefficients show the expected signs.

6. Concluding remarks

The three preceding sections have shown that the official adoption of IT has not led to stronger responses to inflation in the monetary reaction functions. Two intertwined mechanisms may explain this result. First, IT is meant to help anchor private inflation expectations, which will enable a central bank to control inflation without pursuing aggressive action towards inflation variations. Second, the central bank's decision to lower inflation may have led to low and stable inflation and hence to a lower response to inflation. We also note differences between the three countries: in Sweden and the UK, it appears that the response to inflation has decreased, while there is not a new monetary policy regime in Canada. One potential interpretation of this difference may stem from the communication policies of the central banks. Indeed, Ehrmann, Eijffinger, Fratzscher (2009) have evidenced the significant role of central bank communication in guiding private forecasts. While the Bank of England and the Riksbank have started to publish their internal macroeconomic forecasts in the 1990s, the Bank of Canada has only started to do so in the mid-2000s. Furthermore, the former two publish their own policy rate projections, while the third do not. This analysis is consistent with the findings of the second chapter showing that the Bank of England's and Riksbank's inflation forecasts influence private inflation forecasts while those of the Bank of Canada do not. The better anchoring of private inflation expectations in the UK and Sweden may then have allowed central banks to reduce their response to inflation.

The central contribution of this paper is to provide an empirical assessment of the changes in monetary policy coefficients induced by the adoption of inflation targeting without assuming the date and the nature of potential breaks. Indeed, a vast literature deals with the macroeconomic impact of inflation targeting, but there is only few papers which assess whether the institutional adoption of inflation targeting has really changed the conduct of monetary policy. The analysis is carried out with structural break and time-varying parameters estimations of a forward-looking standard monetary policy rule and complemented with an estimation of a (backward-looking) Markov-switching VAR with a focus on the interest equation. The main result is the following. In Canada, Sweden and the UK, the adoption of inflation targeting has not led to a greater focus on inflation whatever we consider steep or gradual estimation procedures. These outcomes, linked to evidence on the stability of private expectations in IT countries, suggest that the inflation targeting framework does not constitute a binding commitment to inflation, but permits to implement a flexible strategy.

Table IV.1 - Testing Structural Break in the Benchmark monetary rule - 4 lags & h=9 when allowing for a break in the regression coefficients and in the covariance matrix of errors

CANADA			
Maximum number of breaks allowed†	3 breaks		
SupLR test: 0 vs. 1	128.67***		
SupSEQ test: 1 vs. 2	31.64***		
SupSEQ test: 2 vs. 3	27.80**		
Estimated break dates	1991:9	1995:10	2001:7
Estimated break date when 1 break allowed	**1995:10**		
90% interval confidence	1994:8	1995:11	
OLS estimates	inflation - $\beta\pi$	output - βy	sigma resid.
Sample pre-break	0.49 (1.60)	1.00* (0.55)	0.48
Sample post-break	-1.63 (1.17)	0.32 (0.30)	0.25
SWEDEN			
Maximum number of breaks allowed†	3 breaks		
SupLR test: 0 vs. 1	467.69***		
SupSEQ test: 1 vs. 2	25.31*		
SupSEQ test: 2 vs. 3	0		
Estimated break dates	1992:7	1996:7	2002:6
Estimated break date when 1 break allowed	**1992:10**		
90% interval confidence	1992:9	1992:11	
OLS estimates	inflation - $\beta\pi$	output - βy	sigma resid.
Sample pre-break	0.75 (0.25)	-0.61 (0.18)	0.80
Sample post-break	1.13 (0.60)	-0.10 (0.40)	0.37
UK			
Maximum number of breaks allowed†	3 breaks		
SupLR test: 0 vs. 1	173.86***		
SupSEQ test: 1 vs. 2	35.22***		
SupSEQ test: 2 vs. 3	21.45		
Estimated break dates	1992:8	1996:8	2001:7
Estimated break date when 1 break allowed	**1992:12**		
90% interval confidence	1990:12	1993:1	
OLS estimates	inflation - $\beta\pi$	output - βy	sigma resid.
Sample pre-break	1.52* (0.85)	0.16 (0.75)	0.46
Sample post-break	1.07 (0.95)	-0.46 (0.60)	0.15

† Given the minimal length criteria of a regime (set at 20% of the total length of the sample) and the location of the breaks from the global optimization with 3 breaks there is no more place to insert additional breaks that satisfy the minimal length requirement. Numbers in parentheses are standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table IV.2 - OLS estimates for both subsamples

	CANADA - 1995:10		**SWEDEN - 1992:10**		**UK - 1992:12**	
	inflation - $\beta\pi$	output - βy	inflation - $\beta\pi$	output - βy	inflation - $\beta\pi$	output - βy
			Benchmark - h=9			
Sample pre-break	0.49 (1.60)	1.00* (0.55)	0.75 (0.25)	-0.61 (0.18)	1.52* (0.85)	0.16 (0.75)
Sample post-break	-1.63 (1.17)	0.32 (0.30)	1.13 (0.60)	-0.10 (0.40)	1.07 (0.95)	-0.46 (0.60)
			h=0			
Sample pre-break	-0.24 (0.60)	1.08*** (0.29)	0.36 (0.54)	-0.59 (0.40)	0.37 (0.82)	1.18** (0.42)
Sample post-break	1.67* (0.91)	0.20 (0.21)	1.63*** (0.57)	0.08 (0.27)	0.14 (0.88)	-0.69 (0.52)
			h=6			
Sample pre-break	-2.01 (2.01)	2.21*** (0.71)	0.63* (0.32)	-0.60** (0.23)	1.25*** (0.42)	-0.06 (0.31)
Sample post-break	-2.18** (1.00)	0.32 (0.25)	1.42** (0.67)	0.11 (0.39)	0.10 (1.13)	-0.52 (0.69)
			h=12			
Sample pre-break	1.72 (1.26)	0.33 (0.45)	0.83*** (0.25)	-0.65*** (0.17)	2.09 (1.45)	0.10 (1.48)
Sample post-break	-2.74** (1.32)	0.37 (0.36)	0.85 (0.55)	-0.29 (0.40)	0.54 (0.95)	-0.88 (0.63)

Numbers in parentheses are standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table IV.3 - Individual Coefficients of the Interest Rate Equation

3-equation VAR with Output Gap

Canada			
regime1	rate	inf.	gap
const	-0.01		
	(0.03)		
lag1	1.20*	-0.05*	0.17*
	(0.03)	(0.05)	(0.12)
lag2	-0.15*	0.19*	0.07
	(0.04)	(0.05)	(0.26)
lag3	-0.03	0.09*	-0.12
	(0.04)	(0.05)	(0.24)
lag4	-0.03*	0.00	-0.09
	(0.03)	(0.05)	(0.11)
sigma	0.02		
Σ coefficients	0.98	0.23	0.03
Long Run Responses		1.36	2.24
regime2	rate	inf.	gap
const	1.25*		
	(0.66)		
lag1	1.11*	5.53*	-0.95*
	(0.22)	(1.14)	(0.68)
lag2	-0.59*	-1.34*	0.15
	(0.52)	(0.81)	(0.53)
lag3	-1.78*	-0.50	1.63
	(0.70)	(0.79)	(1.63)
lag4	2.12*	-3.82*	-0.65
	(0.44)	(1.38)	(1.05)
sigma	0.15		
Σ coefficients	0.86	-0.14	0.18
Long Run Responses		-0.08	1.29

Sweden			
regime1	rate	inf.	gap
const	0.05*		
	(0.02)		
lag1	1.47*	-0.08*	0.01
	(0.07)	(0.05)	(0.09)
lag2	-0.44*	0.14*	-0.15
	(0.07)	(0.04)	(0.17)
lag3	-0.04*	0.01	0.40*
	(0.03)	(0.05)	(0.26)
lag4	-0.01	-0.01	-0.26*
	(0.02)	(0.06)	(0.14)
sigma	0.02		
Σ coefficients	0.98	0.05	-0.01
Long Run Responses		0.21	-0.34
regime2	rate	inf.	gap
const	-0.21		
	(0.65)		
lag1	0.76*	0.74*	-0.15
	(0.12)	(0.37)	(0.62)
lag2	-0.06	0.60	1.69
	(0.13)	(0.65)	(2.28)
lag3	0.01	0.97*	-4.36*
	(0.17)	(0.71)	(3.56)
lag4	0.26*	-0.86*	2.76*
	(0.12)	(0.37)	(1.85)
sigma	0.40		
Σ coefficients	0.96	1.46	-0.06
Long Run Responses		2.43	-1.38

United Kingdom			
regime1	rate	inf.	gap
const	0.01		
	(0.03)		
lag1	0.99*	-0.02	0.04
	(0.04)	(0.03)	(0.17)
lag2	0.02	0.01	0.06
	(0.06)	(0.02)	(0.36)
lag3	0.02	0.02	-0.20
	(0.06)	(0.03)	(0.32)
lag4	-0.05*	-0.04*	0.10
	(0.04)	(0.03)	(0.14)
sigma	0.01		
Σ coefficients	0.98	-0.03	0.00
Long Run Responses		-0.14	0.09
regime2	rate	inf.	gap
const	0.14*		
	(0.11)		
lag1	1.31*	0.15*	1.24*
	(0.11)	(0.10)	(0.34)
lag2	-0.24*	0.34*	-2.96*
	(0.19)	(0.10)	(0.69)
lag3	0.01	0.09*	2.85*
	(0.24)	(0.08)	(0.67)
lag4	-0.14	0.28*	-1.05*
	(0.14)	(0.09)	(0.35)
sigma	0.10		
Σ coefficients	0.94	0.85	0.08
Long Run Responses		1.14	1.29

3-equation VAR with Unemployment

Canada			
regime1	rate	inf.	unemp.
const	0.47*		
	(0.09)		
lag1	0.97*	0.39*	-0.07*
	(0.00)	(0.09)	(0.01)
sigma	0.03		
Σ coefficients	0.97	0.39	-0.07
Long Run Responses		1.03	-2.40
regime2	rate	inf.	unemp.
const	2.55*		
	(1.52)		
lag1	0.70*	0.19	-0.04
	(0.07)	(0.24)	(0.12)
sigma	0.25		
Σ coefficients	0.69	0.19	-0.04
Long Run Responses		0.05	-0.12

Sweden			
regime1	rate	inf.	unemp.
const	0.03		
	(0.05)		
lag1	1.50*	-0.04	-0.08*
	(0.06)	(0.07)	(0.06)
lag2	-0.51*	0.07*	0.08*
	(0.06)	(0.05)	(0.06)
sigma	0.03		
Σ coefficients	0.99	0.03	0.00
Long Run Responses		0.22	-0.06
regime2	rate	inf.	unemp.
const	1.08*		
	(0.67)		
lag1	0.86*	0.34*	1.04*
	(0.09)	(0.25)	(0.64)
lag2	0.02	0.64*	-1.13*
	(0.09)	(0.46)	(0.68)
sigma	0.57		
Σ coefficients	0.89	0.97	-0.09
Long Run Responses		0.68	-0.79

United Kingdom			
regime1	rate	inf.	unemp.
const	0.05*		
	(0.03)		
lag1	1.01*	0.01	-0.26*
	(0.05)	(0.03)	(0.16)
lag2	0.07	0.02	0.09
	(0.07)	(0.02)	(0.26)
lag3	-0.08*	0.03	0.16
	(0.05)	(0.03)	(0.16)
sigma	0.01		
Σ coefficients	0.99	0.06	-0.01
Long Run Responses		0.53	-0.76
regime2	rate	inf.	unemp.
const	-0.12		
	(0.13)		
lag1	1.31*	-0.01	-0.67*
	(0.10)	(0.10)	(0.43)
lag2	-0.19*	0.25*	0.08
	(0.15)	(0.10)	(0.76)
lag3	-0.12*	0.17*	0.57*
	(0.09)	(0.09)	(0.41)
sigma	0.11		
Σ coefficients	1.00	0.42	-0.01
Long Run Responses		5.72	-3.08

Standard errors are in parentheses. * p < 0.3. The long run response for inf. is annualized to match the annual rate of interest.

Table IV.4 - Matrix of markovian transition probabilities P[i,j]

Canada	Sweden	UK
Output gap	Output gap	Output gap
0.93 0.73	0.90 0.39	0.68 0.49
0.07 0.27	0.10 0.61	0.32 0.51
Unemployment	Unemployment	Unemployment
0.95 0.40	0.93 0.27	0.73 0.38
0.05 0.60	0.07 0.73	0.27 0.62

Table IV.5 - Long Run Policy Responses

	Canada	Sweden	UK
Regime 1			
Responses of R to			
inflation - β_π	1.36	0.21	-0.14
output gap - β_y	2.24	-0.34	0.08
*Kuttner (2004)**			
Responses of R to			
inflation forecast - β_π	na	1.97	-0.47
output gap - β_y	na	-0.55	0.32
*Muscatelli et al. (2002)***			
Responses of R to			
expected inflation - β_π	1.32	0.77	1.40
output gap - β_y	1.41	ns	0.57
Seyfried and Bremmer (2003)			
Responses of R to			
inflation - β_π	-0.12	na	-0.45
output gap - β_y	1.45	na	0.37
Valente (2004)			
Responses of R to			
inflation - β_π	na	na	0.69
output gap - β_y	na	na	0.13

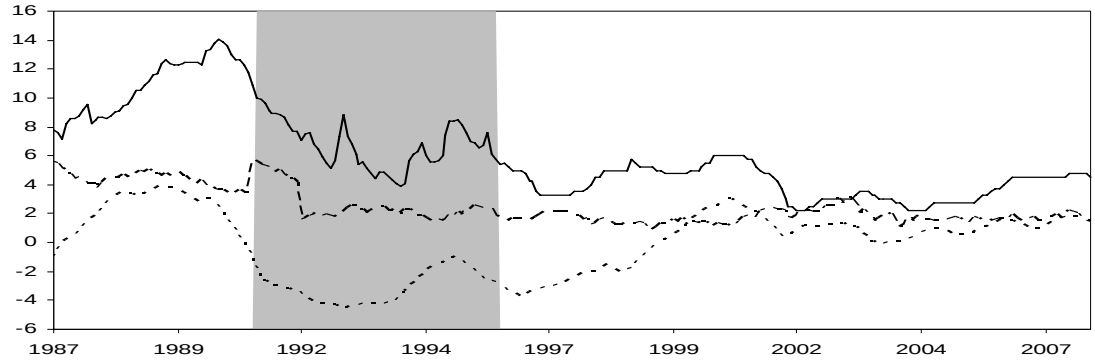
*: estimations including growth forecast (not reported)
**: estimations giving the lowest standard error and including other regressors (money growth, exchange rate, etc.: not reported)
ns: not significant; na: not available

Table IV.6 - Long Run Policy Responses - Unemployment

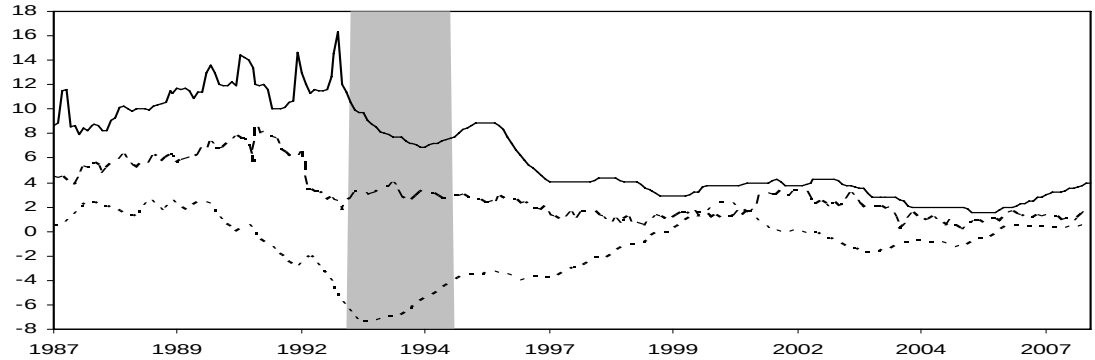
	Canada	Sweden	UK
Regime 1 Responses of R to			
inflation - β_π	**1.03**	**0.21**	**0.52**
unemp. - β_y	-2.40	-0.06	-0.76
Regime 2 Responses of R to			
inflation - β_π	0.05	0.68	5.71
unemp. - β_y	-0.12	-0.79	-3.07

Figure IV.1 –Data

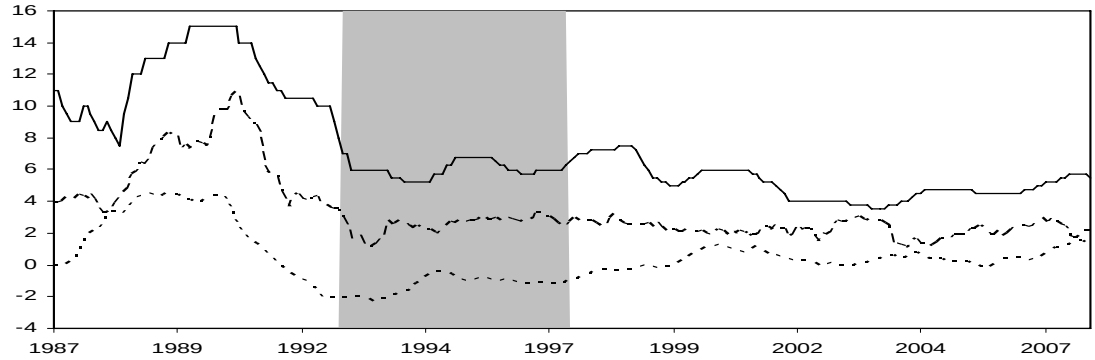
Canada



Sweden



United Kingdom

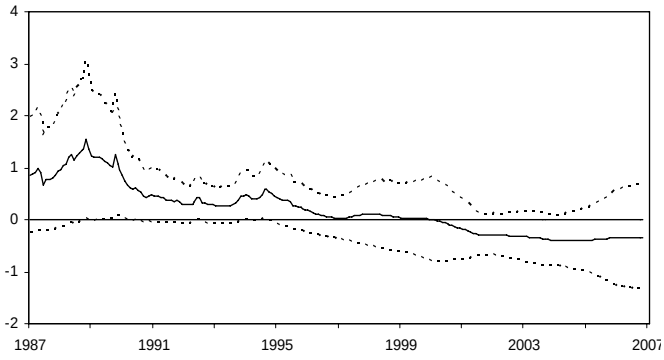


The implementation period between the adoption of IT and its completion in final form has been represented by a grey area. The solid line is the central bank reference interest rate, the dashed line is the inflation rate targeted by the central bank, and the dotted line is the output gap.

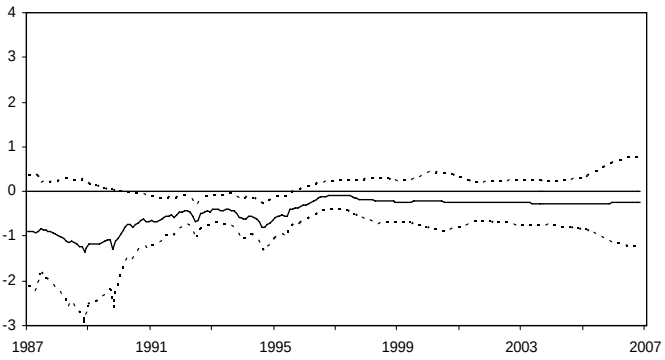
Figure IV.2 – Time-Varying Responses to Inflation and Output Gap with $h_\pi = h_y = 9$, a Noise-to-Variance ratio = 0.01 and 1 S.E. bands

Canada

Response to inflation

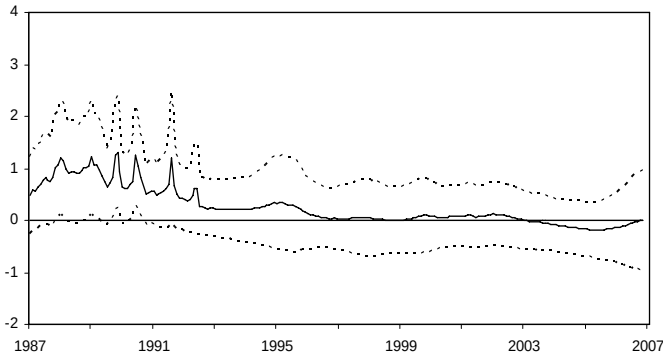


Response to output gap

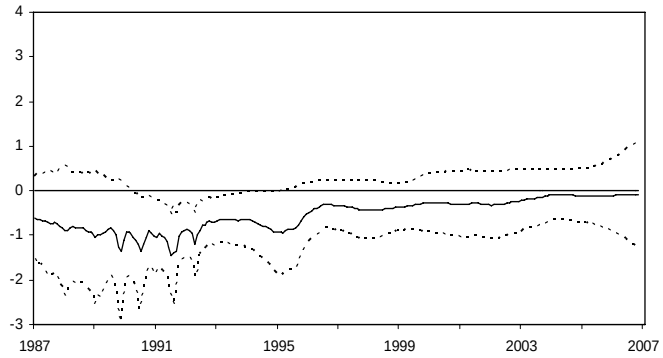


Sweden

Response to inflation

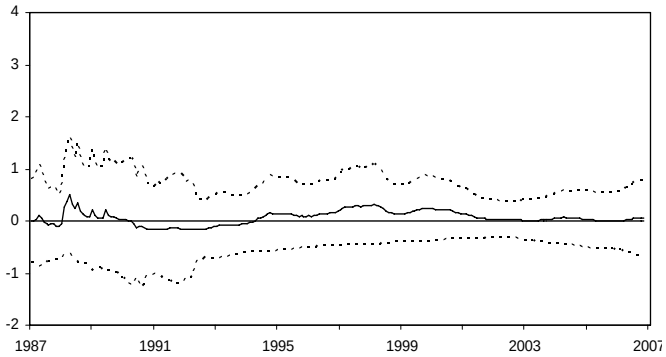


Response to output gap



United Kingdom

Response to inflation



Response to output gap

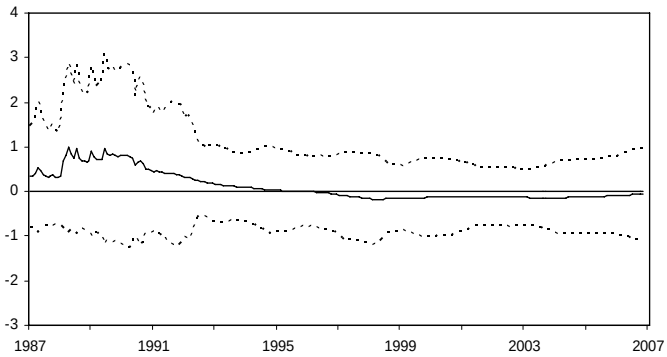
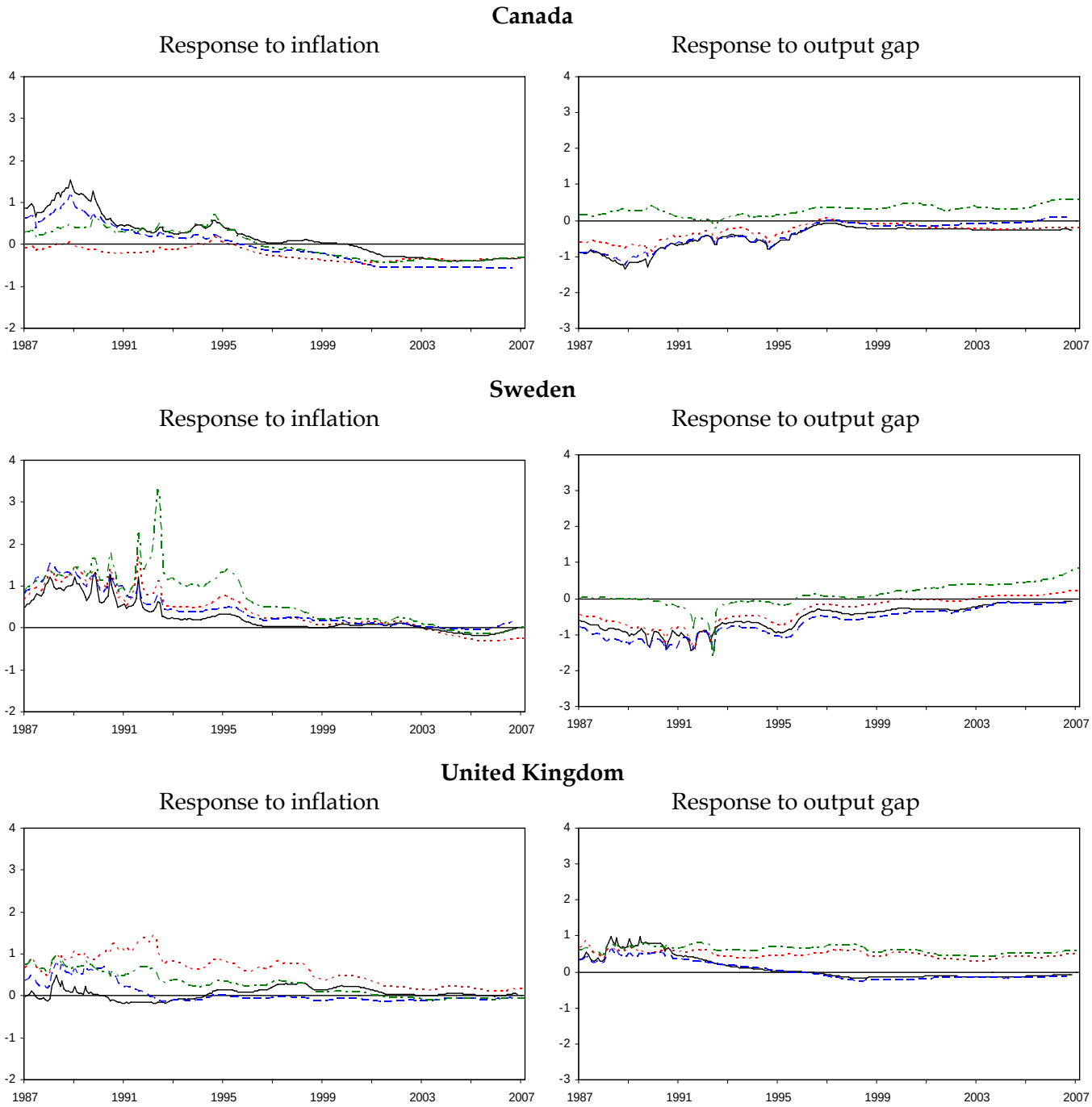
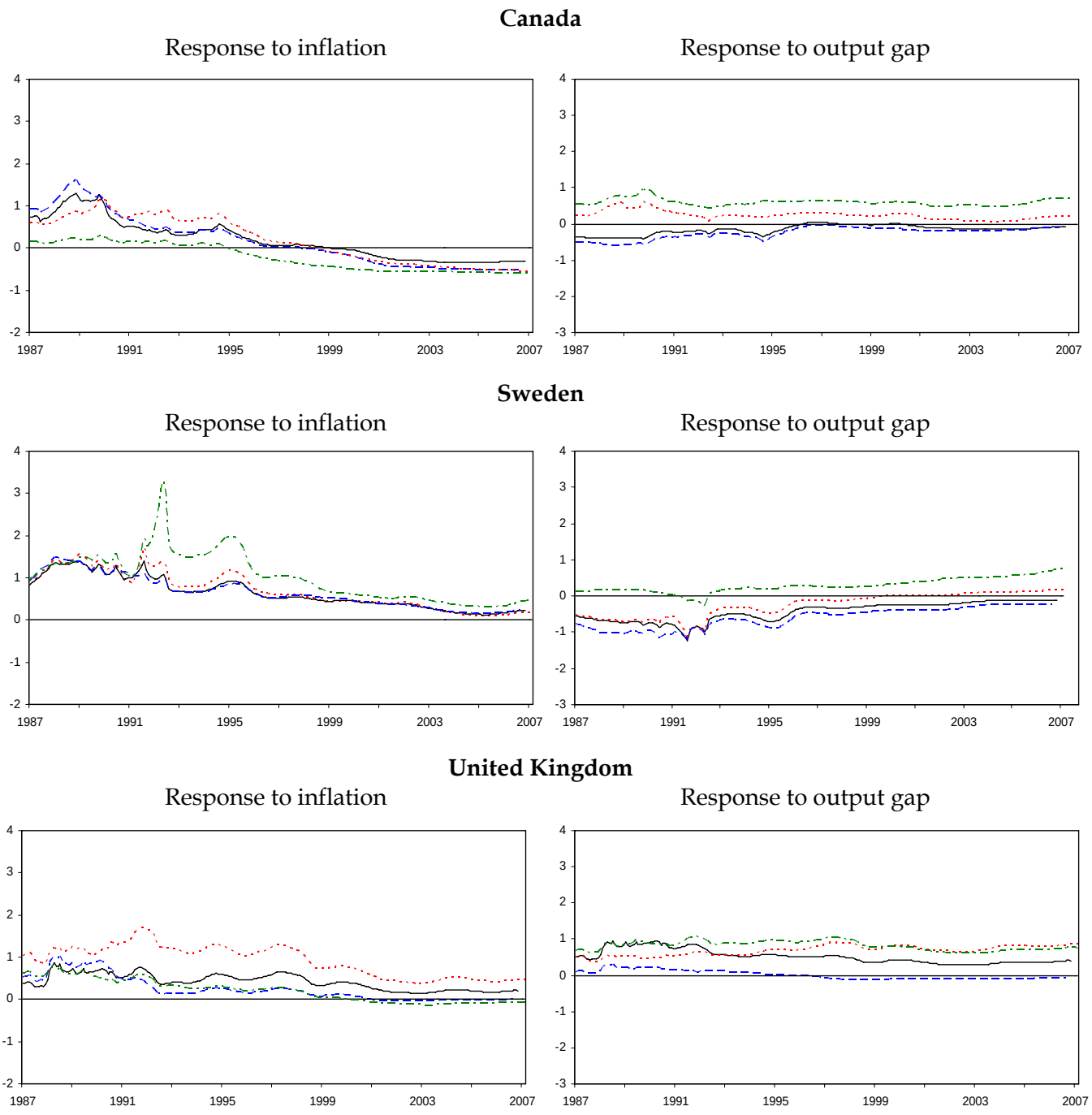


Figure IV.3 – Time-Varying Responses to Inflation and Output Gap with Alternative Forecasting Horizons h_π and h_y, and a Noise-to-Variance ratio = 0.01



The dot-dashed green line stands for [$h_\pi = h_y = 0$], the dotted red line for [$h_\pi = h_y = 6$], the solid black line for [$h_\pi = h_y = 9$] and the dashed blue line for [$h_\pi = h_y = 12$].

Figure IV.4 – Time-Varying Responses to Inflation and Output Gap with an Alternative Noise-to-Variance ratio = 0.001

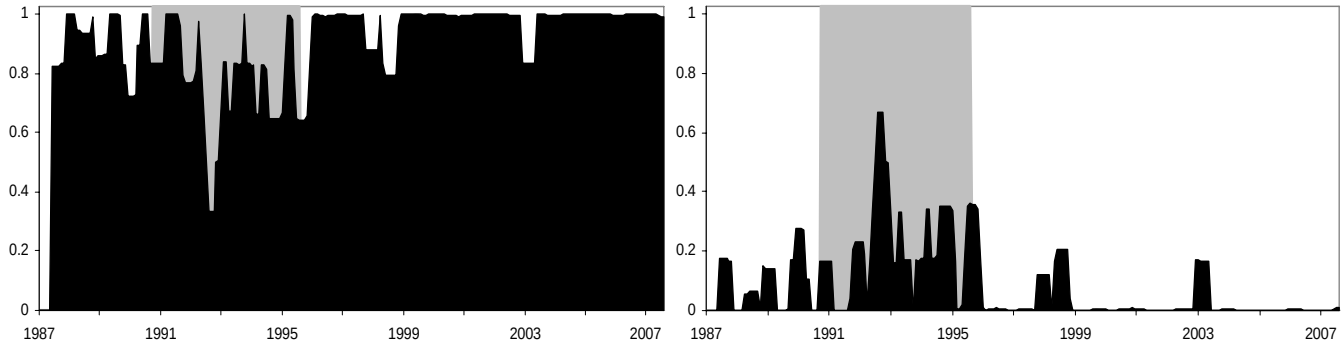


The dot-dashed green line stands for [$h_\pi = h_y = 0$], the dotted red line for [$h_\pi = h_y = 6$], the solid black line for [$h_\pi = h_y = 9$] and the dashed blue line for [$h_\pi = h_y = 12$].

Figure IV.5 – Regimes' Probabilities over time
for 3-equation VAR with Output gap

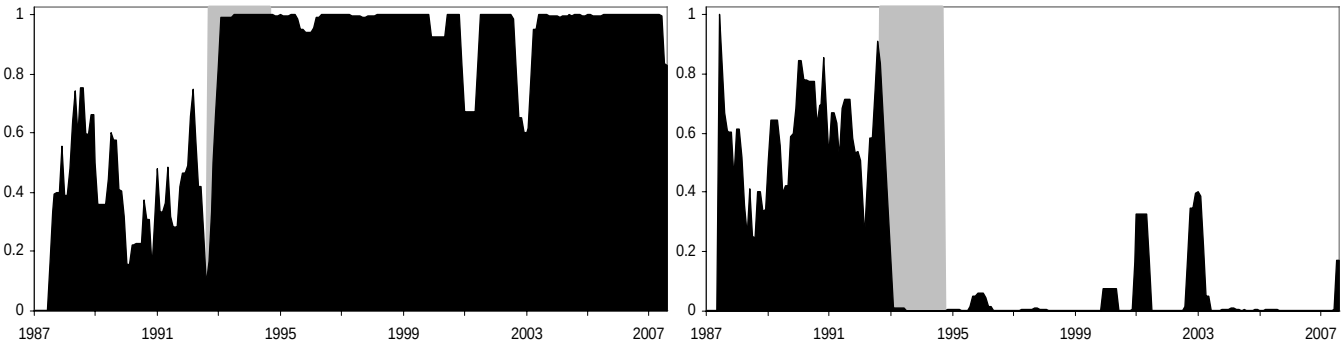
Canada

Regime 1 - $\rho = 0.98$, $\beta_\pi = 1.36$, $\beta_y = 2.24$ | Regime 2 - $\rho = 0.85$, $\beta_\pi = -0.08$, $\beta_y = 1.29$



Sweden

Regime 1 - $\rho = 0.98$, $\beta_\pi = 0.21$, $\beta_y = -0.34$ | Regime 2 - $\rho = 0.95$, $\beta_\pi = 2.43$, $\beta_y = -1.37$



United Kingdom

Regime 1 - $\rho = 0.98$, $\beta_\pi = -0.14$, $\beta_y = 0.08$ | Regime 2 - $\rho = 0.94$, $\beta_\pi = 1.14$, $\beta_y = 1.29$

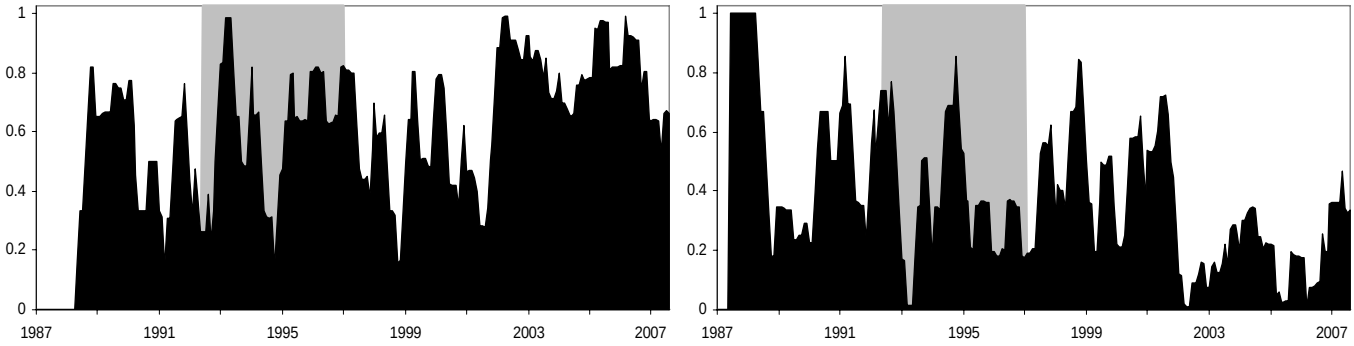
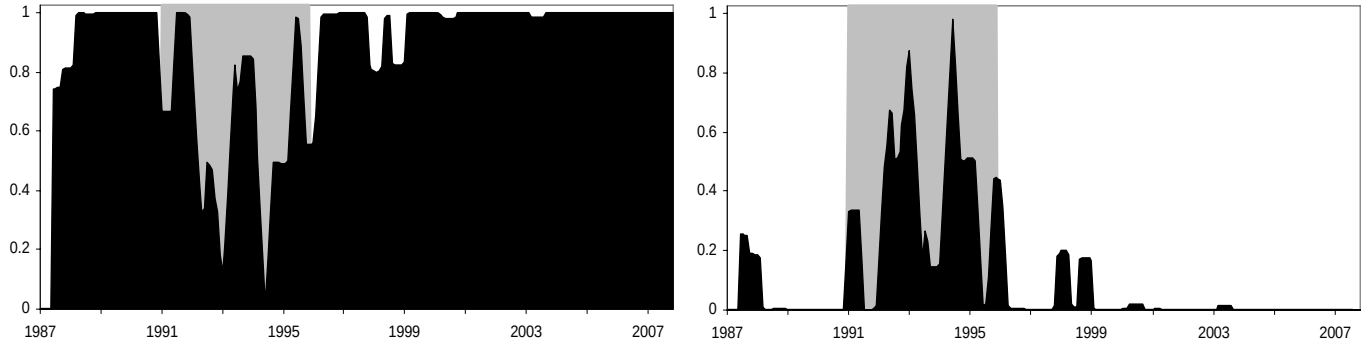


Figure IV.6 - Regimes' Probabilities over time
for 3-equation VAR with Unemployment

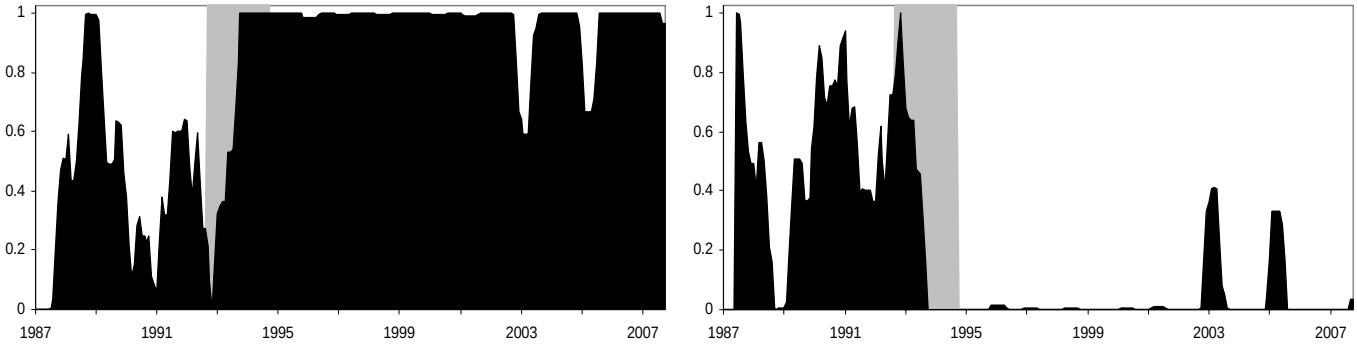
Canada

Regime 1 - $\rho = 0.97$, $\beta_\pi = 1.03$, $\beta_y = -2.40$ Regime 2 - $\rho = 0.69$, $\beta_\pi = 0.05$, $\beta_y = -0.12$



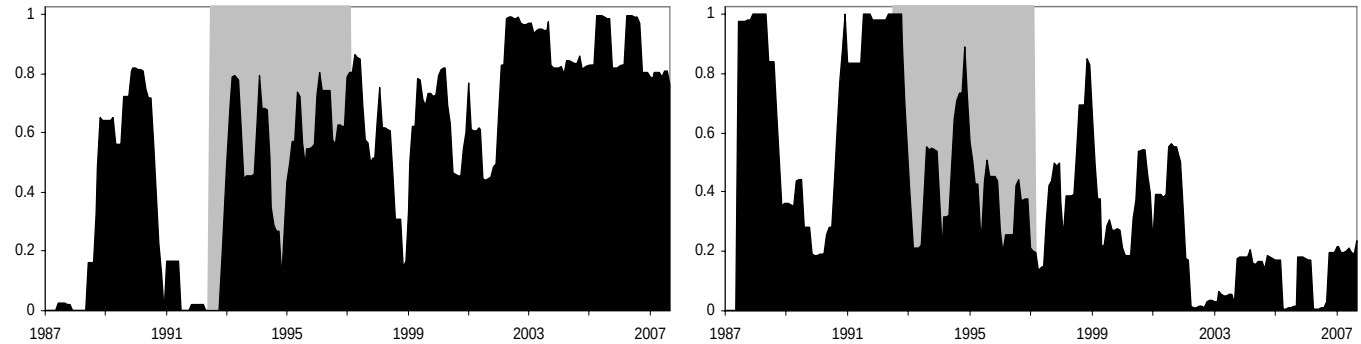
Sweden

Regime 1 - $\rho = 0.98$, $\beta_\pi = 0.21$, $\beta_y = -0.06$ Regime 2 - $\rho = 0.88$, $\beta_\pi = 0.68$, $\beta_y = -0.79$



United Kingdom

Regime 1 - $\rho = 0.99$, $\beta_\pi = 0.52$, $\beta_y = -0.76$ Regime 2 - $\rho = 0.99$, $\beta_\pi = 5.71$, $\beta_y = -3.07$



General Conclusion

If this thesis contributes to the monetary policy literature with some new conceptual, empirical, theoretical elements on the competence and influence ability of communicating central banks, it does not constitute an outcome by itself and calls for extensions and deepenings of its results and implications. In this conclusion, we will first recall the main contributions and results of this work and propose directions for future research.

This thesis explores the implications of competence and communication for monetary policymaking in a context of imperfect information. It considers the central bank as coordinator of expectations because of its competence rather than its commitment. By competence, we intend to say the ability to correctly forecast the future state of the economy. The central point has been to show that competence (together with communication) enables influence, and that central bank influence of private expectations enables to loose monetary policy constraints to reach stabilizing policies. Competence along with communication acts as a second instrument in addition to the short-term interest rate for monetary policy to influence private agents and reach its macroeconomic objectives. It provides a way to evade the Tinbergen (1952)'s constraint of one instrument for one objective.

The first two chapters evaluate the competence of different central banks: the Federal Reserve, which publishes its forecasts after five years, in the first one and a set of five communicating central banks which publish their forecasts in real-time in the second one. The second chapter also assesses the influence of these communicating central banks and conceptualizes the link between competence and influence. The third chapter explores the theoretical implications of endogenous influence (i.e. influence ability due to competence), while the fourth one tests the outcomes of the previous model for countries in which central banks have a high degree of transparency and publish their forecasts in real-time.

Chapter 1 proceeds to an empirical review of the vast literature dealing with the relative forecasting performance of the Federal Reserve, a central bank which publishes its forecasts with a 5-year lag, and for which evidence is mixed. The contribution of this chapter is to identify the opposite results and their causes. We assess this question by confronting the different methods, data and samples used previously and obtain unambiguous results. We use unconditional comparisons, conditional comparisons through regressions, in the spirit of Fair and Shiller (1989, 1990), a pooling method of forecasts, and a factor analysis and confirm that the Fed has a superior forecasting performance on inflation but not on real GNP/GDP. In addition, we show that the longer the horizon, the more pronounced the advantage of Fed on inflation and that this superiority seems to decrease but remains prominent in the more recent period when the Fed has increased its transparency. The second objective of this chapter is to underline the potential sources of this superiority. It appears that it may stem from better information rather than a better model of the economy. The policy implication of this chapter is to support large investment of central banks in their forecasting ability through information about future state of the economy.

Chapter 2 focuses on central banks which publish their forecasts in real-time. This allows for emphasizing the expectations channel of monetary policy and the question of credibility through the link between relative forecasting performance and influence of central banks. We propose to define endogenous credibility as the capacity to influence arising from a superior forecasting performance, in opposition to exogenous credibility for which central

banks need not a forecasting advantage to be influential. We find that one out of five central banks, in Sweden, has a superior forecasting performance over private agents. This reveals a puzzle as information is supposed to be symmetric since central banks' forecasts are available to private agents. It appears that the Riksbank benefits from a specific competence in gathering new private information between each forecast's release. A superior forecasting performance is therefore compatible with forecasts' communication. We then find that three out of five central banks, in Sweden, the UK and Japan, influence private agents, while there is no evidence of influence of private agents on central banks. Sweden therefore seems to experience endogenous credibility and the UK and Japan exogenous credibility. This chapter thus offers conceptual and empirical contributions and its main policy implication is that communication of forecasts should be at the forefront of the central bank policies as it enables central banks to signal their commitment or competence.

Chapter 3 investigates the theoretical implications of endogenous influence for monetary policymaking through a New-Keynesian economy with adaptive learning (i.e. non rational expectations) in which there are simultaneously heterogeneity of forecasts, information asymmetry in favour of and influence of the central bank. The model, based on incomplete information and knowledge of households and firms, introduces adaptive learning for both private agents and the central bank. Central bank influence is considered as endogenous because the central bank has a better forecasting record than private agents and the latter are therefore naturally prone to follow central bank forecasts. We find that the central bank must only respect the Taylor principle and need not be more restrictive to ensure macroeconomic stability, in contrast to exogenous influence (when central banks are influential due to their *type* credibility and leader position rather than because of a better forecasting record) as studied by Muto (2008). This result calls for an increase of the *competence* credibility of central banks and reinforces the case for enhancing forecasting performance of central banks. The final objective is thus to attain endogenous influence in order to reach macroeconomic stability at a lower cost. In other words, a direct policy implication of this chapter is that when central banks are influential, they should invest enough resources in forecasting to guide private expectations.

Chapter 4 constitutes somewhat an empirical investigation of the theoretical outcome of the third chapter, when keeping in mind that the chapter 2 shows Canada does not experience *influence* credibility, while the UK has exogenous credibility and Sweden endogenous credibility. These three countries have adopted inflation targeting in the nineties. Chapter 4 thus assesses the monetary policy preferences of these central banks which have adopted the inflation targeting framework and therefore communicate their forecasts in real-time. The literature on inflation targeting has up to now focused on its impact on macroeconomic performance or private expectations. We test the hypothesis that inflation targeting has constituted a switch towards a greater focus on inflation as conventional wisdom suggests. We use three complementary methods: a structural break analysis, time-varying parameters and Markov-Switching VAR which make possible to estimate linear or nonlinear, and forward or backward looking specifications, to account for heteroskedasticity and not to assume a date break *ex ante*. Our main result is that inflation targeting has not led to a stronger response to inflation. The inflation targeting *paradigm* (an inflation target at 2% would produce macroeconomic stability) should not be confounded with the inflation targeting *framework*. Beyond this common result, it appears that the most significant evidence of a change in the direction of a lower response to inflation has to be credited to Sweden.

We now present some research projects to extend the present analysis. First, while the existing literature has focused on the link between institutional transparency and dispersion of private forecasts and this work on the link between central bank forecasts and the level of private forecasts, it would be interesting to complement the empirical analysis on central bank influence by assessing the central bank ability to directly manage expectations, taking into account the information set of macroeconomic news that also influences private forecasts, the institutional transparency of the central bank, the time elapsed since the publication of central bank forecasts, whether central bankers have communicated in a qualitative way during the period and the distance of the central bank forecasts to the central bank inflation target. This work would enable to characterize more precisely central bank influence and to identify the sources of influence.

Second, the theoretical outcome calls for two extensions. As more communication of public information makes monetary policy neutral, central banks face a trade-off in its communication policy. Based on the seminal work of Walsh (2006) and Cornand and Heinemann (2008) in situations of imperfect information and coordination games, the first theoretical extensions would be to analyze the optimal level of information that central banks should reveal in order to influence private expectations. This project would investigate the trade-off between the quality of information disclosed (in order to influence private agents) and the maximum level of information disclosed to enable the central bank to influence private agents in a way that makes stabilizing policies possible.

The second theoretical extensions would be to compare the features of both forms of credibility and their implications for policymaking. Confronting *influence* credibility and *type* credibility in a simple Barro and Gordon (1983)'s framework would allow for prioritizing behaviours and decisions that central banks should have, according to the criteria of implementing efficient monetary policy to stabilize the economy. In other words, is it more important for a central bank to signal its commitment or its competence? Furthermore, what are the strategic games and their implications that could arise from a situation where private agents know that central banks could signal one or the other?

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