IMPERFECT INFORMATION IN MACROECONOMICS

Paul Hubert
Sciences Po OFCE
Giovanni Ricco
University of Warwick and OFCE

This article presents some recent theoretical and empirical contributions to the macroeconomic literature that challenge the perfect information hypothesis. By taking into account the information frictions encountered by economic agents, it is possible to explain some of the empirical regularities that are difficult to rationalise in the standard framework of full information rational expectations. As an example, we discuss how the sign, size and persistence of the estimated effects of monetary and fiscal policies can change when the informational frictions experienced by economic agents are taken into account.

Keywords: informational frictions, imperfect information, economic policy.

How do economic agents form their expectations and make their decisions? How can these processes be modelled in a macroeconomic framework and what conclusions can be drawn from the analysis of economic time series? These methodological issues have long been among the most fundamental questions in macroeconomics. The dominant approach – since the work of Lucas, Sargent and their co-authors in the early 1970s – has adopted the joint hypotheses of model-consistent or rational expectations, and of full information.[1] Under these assumptions, economic agents know the structure of the economy precisely and can perfectly observe and process all economic information in real-time.

1. "Model-consistent or rational expectations".

These assumptions can be viewed as a theoretical benchmark whose introduction has enormously increased the sophistication of macroeconomic models. However, over time, there has been an accumulation of convincing evidence about phenomena that would be "anomalous" in the standard framework. Recently, models that incorporate deviations from the full information hypothesis in the form of "sticky information", "noisy information" or "dispersed information" have been proposed to explain some of the empirical regularities that are difficult to accommodate in the standard framework, such as the persistence of the response of macroeconomic variables to supply or demand shocks, the delayed response of inflation to economic policy shocks, and the autocorrelation of agents' forecast errors.

This article presents some of the ideas proposed to incorporate deviations from the hypothesis of full information in the standard framework. We also discuss some of the implications of models of imperfect information for the estimation of the impact of macroeconomic policy actions.

1. The Perfect Information Rational Expectations Framework

In his *General Theory* (1936), Keynes pointed out that private expectations can affect macroeconomic variables. Since then, it has been acknowledged that the expectations of private agents, households and firms are of fundamental importance in many macroeconomic models. In the 1960s, the direct introduction of expectations into macroeconomic models became widespread and led to efforts in ad-hoc modelling of the process through which agents were forming their forecasts. Among others, a common representation of this process was the adoption of "adaptive expectations", where agents are assumed to form expectations based on past experience. In contrast to this approach, Muth (1961) proposed modelling agents' expectations as being "model-consistent", i.e. as coherent with the economy model implied probability.

The experience of stagflation in the 1970s led to a reconsideration of the assumptions of the Keynesian models of the 1960s. In fact, these models, often supplemented with adaptive expectations, implied that macroeconomic stabilisation policies based on fiscal and monetary expansions could be used to reduce unemployment and increase

output at the cost of higher inflation (a relationship summarized by a causal interpretation of the Phillips curve).

To explain why policy actions were not delivering the expected results, Lucas (1972) proposed a schematic model of islands in which policy makers are not able to systematically exploit the relationship between inflation and real activity (the Phillips curve). What became known as the "Lucas critique" suggested that the use of parameters based on past experience is a misguided way of assessing the effects of changes in macroeconomic policies (Lucas, 1976). Indeed, when policies are changed agents incorporate the policy shift in their expectations. This in turn implies that policy analysis obtained from models calibrated with past data can deliver inconsistent results. Lucas and Sargent (1979) incorporated this intuition in a general equilibrium model featuring forward-looking agents with model-consistent rational expectations and perfect information. In such a setting, economic agents react to policy changes by re-optimising their decisions in light of the policy change. Since then, the hypothesis of full information rational expectations has become a fundamental building block in macroeconomic models supporting the assumption of market efficiency, the permanent income hypothesis, the "Ricardian" equivalence, and standard asset pricing models.

This revolution has not been limited to the academic sphere, and macroeconomic policy makers have also relied on the assumptions of full information and rational expectations in the macroeconomic policy models employed by central banks and finance ministries.

However, over time many empirical regularities at odds with the perfect information framework have been reported. Examples include the slow adjustment of prices, money non-neutrality, the delayed and smoothed links between macroeconomic time series and the booms and busts in financial asset prices. In addition, surveys of the expectations of households, firms and private forecasters have provided direct evidence against the full information rational expectations hypothesis (e.g. Pesaran and Weale, 2006).

One of the most striking implications of the rational expectations hypothesis concerns the Phillips curve. As private agents anticipate the effects of economic policy decisions (changes in money supply or in the policy interest rate for instance), they adjust their expectations (of future inflation in this example). Hence the impact of these policies is not real but only nominal. However, empirical work has shown that

monetary and fiscal policies can have real transitional effects. Various avenues for explaining these results have been proposed, including models of non-rational expectations and staggered contract models in which prices and wages are fixed for a given period.[2] As we discuss in the next section, a different approach has been to challenge the hypothesis of perfect information to explain the empirical findings.

2. Models of Imperfect Information

The lack of empirical support for the predictions of models of full information rational expectations has provided motivation to explore models in which rational agents are rational albeit limited in their ability to acquire and process information.

In models of "sticky information", proposed by Mankiw and Reis (2002), private agents cannot update their information at all times, but only infrequently. However, when they do, they can acquire full information. Alternative approaches, called "noisy information" or "rational inattention", assume that agents can only observe signals about economic variables polluted by observational errors (Woodford, 2002), or have limits in their ability to process information in real-time and hence have to rationally choose what information to monitor (Sims, 2003; Maćkowiak and Wiederholt, 2009; Paciello and Wiederholt, 2014).

The hypothesis of imperfect information in models with sticky information and noisy information may be micro-founded and linked to the inattention of economic agents to new information. This behaviour can be explained by the cost of accessing information (see, for example, Reis, 2006a, b) or by limited information-processing capabilities (see among others Sims, 2003; Matějka, 2016; Matějka and McKay, 2012).[3]

A common feature of all these models of imperfect information is that economic agents absorb and respond to new information only gradually. The response of economic variables to economic policy shocks or other structural shocks is therefore slow. This contrasts

2. Although private agents in neo-keynesian models form rational expectations and suffer no money illusion, the theory has simply shifted the non-neutrality of private agents' behavior to the constraints private agents are facing: the different types of frictions.

3. The central idea of rational inattention models is that private agents have limited attention and therefore need to decide how to allocate their attention on the vast amount of information available. In this theory of rational inattention, however, private agents make their decision optimally.

sharply with the predictions of full information rational expectations models in which economic agents can process and respond to new information immediately.

Other classes of models proposing deviations from the hypothesis of rational expectations with full information have been proposed. One of these alternatives is the "bounded rationality" model proposed by Sargent (1999), where agents are limited in their knowledge of the economic model but are rational in their decision-making. Similarly, Gabaix (2014) proposed a model in which the economic agents adopt a simplified model of the economy and pay attention only to some of the relevant variables. This approach is motivated by the limited capacity of agents to monitor and understand macroeconomic variables and their interactions. The "natural expectations" model of Fuster *et al.* (2010) proposes a framework where economic agents use simplified models to predict a complex reality. Along the same line, "diagnostic expectations" refer to a different approach in which economic agents have imperfectly defined models of the economy. This type of expectations is justified by the representation heuristics of Kahneman and Tversky (1972), which describes the non-Bayesian tendency of economic agents to overestimate the probability of a characteristic in a group when this characteristic is representative or symptomatic of the group. Gennaioli and Shleifer (2010) and Bordalo *et al.* (2016) describe the formation of expectations based on this behavioural bias. Economic agents with diagnostic expectations overweight future events that become more likely based on the most recent data, which may explain both the excessive volatility of some markets and an excessive reaction to new information.

Finally, learning models (Evans and Honkapohja, 2012) offer a complementary approach to the issue. In these models, economic agents are rational and have full access to new economic information, however they don't know the parameters that govern the economic model. Agents thus act as econometricians and try to learn about the relations describing the economy's dynamics over time, given the observed data. Expectations are then formed by using tentative estimates. This type of model helps to explain the persistence of inflation expectations (Orphanides and William, 2005; Milani, 2007; Branch and Evans, 2006).

3. Empirical Evidence for Models of Imperfect Information

Models of sticky information, noisy information and rational inattention provide common emerging predictions, empirically documented by Coibion and Gorodnichenko (2012) using survey data.

In this class of model, following a macroeconomic shock the average forecast in the economy will respond less than the actual variable being forecast. Hence if, for example, a shock lowers inflation over a number of periods, economic agents' average expectation of inflation will not decline immediately as much as actual inflation does. In a sticky information model, this is due to the fact that some of the agents are unaware that the shock has occurred and do not change their expectations. In noisy information models, private agents receive signals indicating higher inflation but change their expectations only gradually because of their uncertainty about whether the higher signals represent noise or real innovations. In models of rational inattention, agents can only pay limited attention to inflation data hence do not fully adjust their expectations on impact.

Another prediction, common to all of these models, is that the average of the ex-post forecast errors is predictable from the ex-ante revisions of the average forecast. This contrasts with the full information case in which ex-post forecast errors cannot be predicted. In the sticky information model, this reflects the fact that some agents do not update their information and therefore their forecasts remain unchanged, which creates a correlation between the average forecasts at different times. In the noisy information model, the economic agents update their forecasts only gradually because of the presence of noise in the signals they receive.

Coibion and Gorodnichenko (2015) test these predictions on US data and Andrade and Le Bihan (2013) on European data, and they provide evidence of empirical regularities compatible with models featuring informational frictions.

Recent empirical research has also highlighted omnipresent and systematic deviations from the predictions of rational expectations models with full information using survey data. This empirical evidence is consistent with the predictions of imperfect information models. Among other contributions, Mankiw, Reis and Wolfers (2004), Dovern *et al.* (2012) and Andrade *et al.* (2016) use the dispersion of responses in survey data to assess the extent to which the persistent informational model can replicate some of the characteristics of the

expectations of private forecasters and consumers. Using epidemiological models, Carroll (2003) suggested that information is transferred from professional forecasters to consumers over time through the forecasters' publications. Carvalho and Nechio (2014) found that many households report expectations that are inconsistent with monetary policy measures.

Gourinchas and Tornell (2004), Bacchetta, Mertens and van Wincoop (2009), and Piazzesi and Schneider (2011) in turn identify the potential links between systematic forecast errors in survey expectations and empirical puzzles in asset markets.

Adam and Padula (2003) have shown that empirical estimates of the slope of the neo-Keynesian Phillips curve have the expected sign when using survey measures of inflation expectations, while this is not generally the case when one adopts empirical specifications based on full information assumptions. More recently, Coibion and Gorodnichenko (2015) and Coibion *et al.* (2017) tried to explain the missing disinflation following the Great Recession by the partial de-anchoring of consumers' and producers' inflation expectations between 2009 and 2011 due to large oil shocks.

4. Imperfect Information and the Identification of Structural Shocks

Most of the macroeconometric literature studying the effects of policy shocks – monetary and fiscal – is based on mechanisms and insights derived from models of full information and rational expectations. However, a number of empirical studies have argued that the presence of informational frictions could modify the identification problem along several dimensions.[4]

In an economy without informational frictions, the econometrician has to align the econometric model's information set to the representative agent's. Conversely, when the economic agents do not observe the structural shocks in real time, the econometrician, faced with the same data as the economic agents, may not be able to identify the shocks correctly (Blanchard *et al.*, 2013). In fact, in such a case, in order to

4. Introducing too many variables into the model can be problematic because of the number of parameters to be estimated and the risk of collinearity. The literature suggests using factor models or Bayesian analysis to minimize these issues. While this method attempts to identify structural shocks in economic policy, a different but related issue is to analyze the consequences of forecasting errors by policy makers.

correctly identify structural shocks, the econometrician has to employ a superior information set. Also, crucially, when the economic agents have different sets of information, the concept of a representative agent could most definitely be misleading. Finally, the absence of a fully informed representative agent implies that economic policy decisions can reveal the policy maker's information about the state of the economy and transmit information to the economic agents. This mechanism is called the signalling channel of economic policy actions (see Romer and Romer, 2000, and Melosi, 2017).[5]

In models of rational expectations and full information, the economic agents immediately process new information and, consequently, their forecast errors are linear combinations of the contemporaneous structural shocks only. In contrast, in cases where information is imperfect, new information is only partially absorbed by the agents over time and, therefore, the average forecast errors are a combination of present and past structural shocks. This implies that the forecasting errors can no longer be considered as being in themselves a good proxy for structural shocks.

Some of these ideas have been applied to the empirical study of technology news shocks and non-fundamental fluctuations in the economic cycle (see for example Barsky and Sims, 2012; Blanchard *et al.*, 2013; and Forni *et al.*, 2013) and of the effects of conventional monetary policy shocks (Hubert, 2017; Hubert and Maule, 2016; Miranda-Agrippino and Ricco, 2017) and unconventional monetary policy shocks (Andrade and Ferroni, 2017), as well as of fiscal shocks (Ricco, 2015; Ricco *et al.*, 2016).

In the remainder of this section, we provide some empirical examples of how imperfect information may change the empirical identification problem, taken from the work of the authors of this article.

In the case of monetary policy actions, the information sets of the central bank and of private agents may differ. When the latter are surprised by a monetary policy decision, they have to consider whether this surprise is due to the central bankers' assessment of macroeconomic conditions or to a deviation from the monetary policy rule – i.e. a monetary policy shock. For example, a hike in the central bank's policy rate may signal to private agents that an inflationary shock will

5. When private agents have different beliefs because of differences in their information sets, aggregation issues may arise and some caution is required to avoid aggregation bias.

affect the economy in the future, pushing private expectations of inflation up. Conversely, the same increase in the central bank's policy rate could be interpreted as a preference shock indicating that central bankers want to be more hawkish, which would reduce future inflation and output. More generally, whenever the central banker and private agents have different information sets, the monetary policy decision can transmit private central bank information about future macroeconomic developments to the agents.

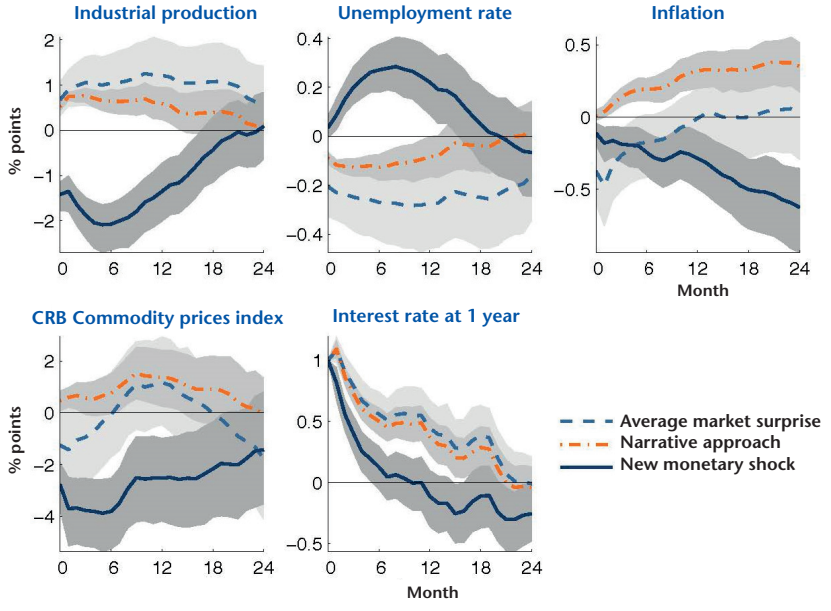
Importantly, despite extensive research, there is still much uncertainty about the effects of monetary policy shocks (see Ramey, 2016). In particular, several studies have highlighted a counter-intuitive increase in production or in prices following a monetary tightening – also called output and price puzzles. In Miranda-Agrippino and Ricco (2017), the authors observe that the lack of robustness in the empirical results in the existing literature can be due to the implicit assumption that both the central bank and private agents enjoy perfect information about the state of the economy. Importantly, the transfer of macroeconomic information from the central bank to private agents can generate the price puzzle highlighted in the literature.

Private agents' interpretation of monetary policy surprises is therefore crucial in determining the sign and magnitude of the effect of monetary policies. Based on this intuition, Miranda-Agrippino and Ricco (2017) propose a new approach to study the effects of monetary policy shocks that takes into account the problem that agents face following central bank policy announcements. In the United States, after five years the Fed releases the macroeconomic forecasts of its economists (the Greenbook forecasts) that were used to inform past monetary policy decisions. This makes it possible to ex-post separate the reactions of the financial markets to information about the state of the economy (as reported by the Greenbook forecasts) revealed to the public through the central bank's action, from reactions to monetary policy shocks. The authors use these responses to study the effects of monetary policy on the US economy in a flexible econometric model that is robust to misspecifications.

In Chart 1, the approach described above is compared to methods that do not take into account the transfer of information between the central bank and the private agents. While these latter methods generate the price puzzle, the approach taking into account the

information transfer implies that monetary tightening simultaneously reduces both prices and output.

Chart 1. Responses of different macroeconomic variables to a restrictive monetary shock

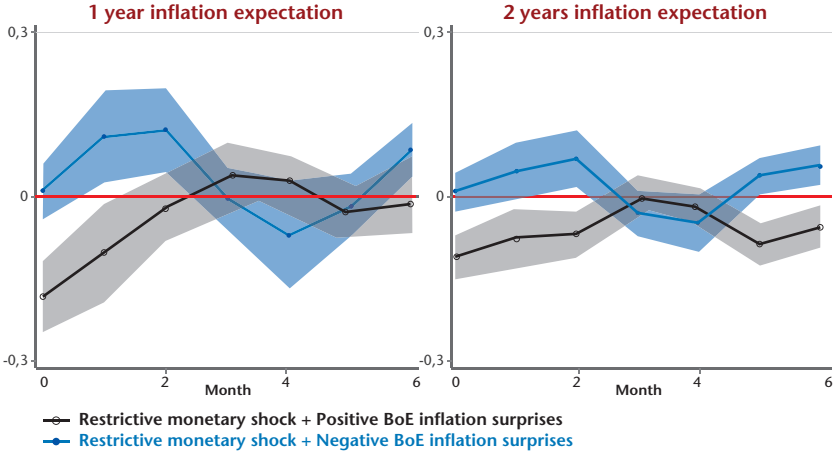


Reading note: The graph shows the impulse response of several variables, over 24 months, to a contractionary monetary shock. This monetary shock is identified in three different ways: via the average surprise of market operators on the day of the announcement (blue dots), via a narrative approach that consists of extracting the unexplained component of the central banks' forecasts of a change in interest rates (orange dots), and using the method of Miranda-Agrippino and Ricco (2017), which takes into account the transfer of information (blue line).
Source: Authors' calculations.

On the basis of these results and in order to study whether private agents' interpretation of monetary policy surprises depends on the information at their disposal, Hubert (2017) assesses whether the central bank's publication of its macroeconomic forecasts could affect how private agents understand monetary policy surprises, and therefore ultimately affect the impact of monetary policy decisions. More specifically, this work assesses whether the term structure of inflation expectations responds differently to decisions by the Bank of England (BoE) based on first whether these are accompanied by the publication of its macroeconomic forecasts (of inflation and growth) and second whether they are corroborated or contradicted by its forecasts.[6]

On average, private inflation expectations respond negatively to restrictive monetary shocks, as expected given the transmission mechanisms of monetary policy. The main result of Chart 2, however, is that central bank inflation forecasts modify the impact of monetary shocks. Monetary shocks (in this example, restrictive) have more negative effects when they interact with a positive surprise about the central bank's inflation forecasts. On the other hand, a restrictive monetary shock, which interacts with a negative surprise on inflation forecasts, has no effect on private inflation expectations.

Chart 2. Responses to a restrictive monetary shock



Reading note: The graph shows the 6-month change in 1 and 2-year inflation expectations following a restrictive monetary shock, when (a) it is corroborated by a positive surprise on the central bank inflation forecasts (black line) (b) when it is contradicted by a negative surprise on inflation forecasts (blue line).
Source: Authors' calculations

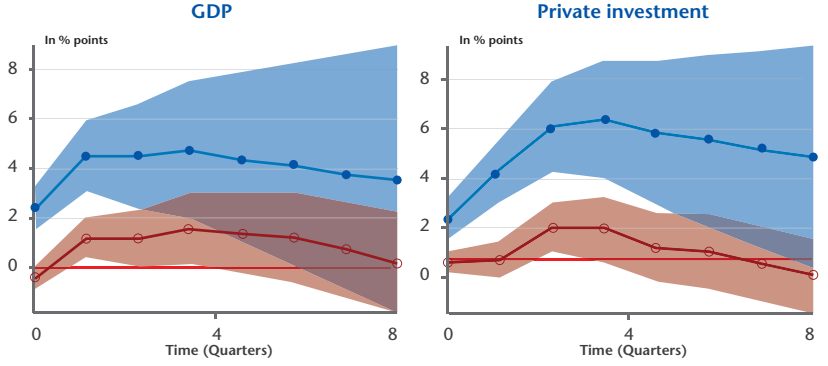
This suggests that, when monetary shocks and forecast surprises corroborate one another, monetary shocks have a greater negative impact on private inflation expectations, possibly because private agents can deduce the preference shock of the central bank and respond more strongly. When monetary shocks and forecast surprises

6. This paper focuses on data UK because BoE projections have a specific feature that makes it possible to identify econometrically their own effects. Indeed, the research question studied requires that the central bank's projections are not a function of the current policy decision, so that monetary surprises and projection surprises can be identified separately. BoE projections are conditional on the market interest rate and not the policy rate, so the BoE projections are independent of monetary policy decisions.

contradict one another, monetary shocks have no impact (or less), possibly because private agents receive conflicting signals and are unable to determine the direction of monetary policy. They therefore also respond to the macroeconomic information disclosed.

These results show that informational questions, and in particular the central banks' publication of its macroeconomic information, which helps private agents to process the signals they receive, modify the responses to monetary policy decisions.

Chart 3. Responses of GDP and private investment to expansionary fiscal announcements conditional on the disagreement among private agents



Reading note: Impact of budget announcements in a situation of high (red) and low (blue) disagreement. The shock corresponds to a difference of one standard deviation from the revisions of the 3-quarter forecast of public expenditure. The responses to the impulse have been normalized to have a similar increase in public spending over 4 quarters. The estimates are provided with a 68% confidence interval.
Source: Authors' calculations.

Imperfect information can also play a role in the transmission of fiscal shocks. For example, Ricco *et al.* (2016) propose a study of the effects of the communication of fiscal policy with respect to public expenditure shocks. To do this, they calculated an index measuring the coordination effects of policy makers' announcements on private agents' expectations. This index is based on the dispersion of the 3-quarter ahead public expenditure forecast of professional forecasters in the United States. The basic intuition is that communications about the future path of fiscal policy can act as a focal point for expectations and reduce informational frictions and thus the dispersion of forecasts among economic agents. The results (Chart 3) indicate that in times of low disagreement, the response of output to public expenditure shocks is positive and significant, mainly because of the strong response of private investment. Conversely, periods of high disagreement are

characterized by a low or no response of output. These results indicate that informational frictions can modify the effects of economic policy decisions.

5. Conclusion

Models with imperfect information have been widely used to study, among other questions, how economic agents make decisions on consumption and investment or select their asset portfolios. Another active area of research concerns the design of optimal policies in the presence of informational frictions. It is noteworthy that the implications of these models of imperfect information can be of great policy relevance.

For example, Ball, Mankiw and Reis (2005) show that a price level target is optimal in models with sticky information, while inflation targeting is optimal in models where the prices are sticky. Paciello and Wiederholt (2014) document how models of rational inattention modify the optimal monetary policy. Branch, Carlson, Evans and McGough (2009) examine how monetary policy decisions affect the optimal frequency for updates of information sets. They show that if the central bank is more concerned with inflation than with growth, firms' inflation expectations may be better anchored and this may decrease output and inflation variability. This mechanism may partially explain the 'Great Moderation'. Angeletos and Pavan (2007) examined issues of efficiency and optimal policy in the presence of imperfect information and the externalities that the use of the information by an agent imposes on other agents. Angeletos and La'O (2011) studied optimal monetary policy in an environment in which firms' pricing and production decisions are subject to informational frictions. They show that perfect price stability is no longer optimal. In this context, the optimal policy is to 'lean against the wind', that is to say, to target a negative correlation between the price level and real economic activity.

In the wake of the financial crisis, the attention was mainly focused on incorporating financial frictions in macroeconomic models. However, it is also important not to underestimate the importance of informational frictions. This article has tried to show that informational frictions have important implications for macroeconomic models' predictions as well as the measurement of economic policy shocks and their effects. If these frictions are not properly taken into account, then economic policy recommendations may be misleading.

References

Adam K. and M. Padula, 2011, "Inflation Dynamics and Subjective Expectations in the United States", *Economic Inquiry*, 49(1): 13-25.

Andrade P. and H. Le Bihan, 2013, "Inattentive professional forecasters", *Journal of Monetary Economics*, 60(8): 967-982.

Andrade P., R. Crump, S. Eusepi and E. Moench, 2016, "Fundamental disagreement", *Journal of Monetary Economics*, 83(C): 106-128.

Andrade P. and F. Ferroni, 2017, "Delphic and Odyssean monetary policy shocks: Evidence from the euro-area", *mimeo*.

Angeletos G.-M. and A. Pavan, 2007, "Efficient Use of Information and Social Value of Information", *Econometrica*, 75(4): 1103-1142.

Bacchetta P., E. Mertens and E. van Wincoop, 2009, "Predictability in financial markets: What do survey expectations tell us?", *Journal of International Money and Finance*, 28(3): 406-426.

Ball L., G. Mankiw and R. Reis, 2005, "Monetary policy for inattentive economies", *Journal of Monetary Economics*, 52(4): 703-725.

Barsky R. and E. Sims, 2012, "Information, Animal Spirits, and the Meaning of Innovations in Consumer Confidence", *American Economic Review*, 102(4): 1343-77.

Blanchard O., J.-P. L'Huillier and G. Lorenzoni, 2013, "News, Noise, and Fluctuations: An Empirical Exploration", *American Economic Review*, 103(7): 3045-3070.

Bordalo P., N. Gennaioli and A. Shleifer, 2016, "Diagnostic Expectations and Credit Cycles", *NBER Working Paper*, No. 22266.

Branch W., J. Carlson, G. Evans and B. McGough, 2009, "Monetary Policy, Endogenous Inattention and the Volatility Trade-off", *Economic Journal*, 119, 123-157.

Carroll C., 2003, "Macroeconomic Expectations of Households and Professional Forecasters", *Quarterly Journal of Economics*, 118(1): 269-298.

Carvalho C. and F. Nechio, 2014, "Do people understand monetary policy? », *Journal of Monetary Economics*, 66(C): 108-123.

Clarida R., J. Gali and M. Gertler, 2000, "Monetary policy rules and macroeconomic stability: evidence and some theory", *Quarterly Journal of Economics*, 115(1): 147-180.

Coibion O. and Y. Gorodnichenko, 2012, "What Can Survey Forecasts Tell Us about Information Rigidities?", *Journal of Political Economy*, 120(1): 116-159.

————, 2015a, "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts", *American Economic Review*, 105(8): 2644-2678.

———, 2015b, "Is the Phillips Curve Alive and Well after All? Inflation Expectations and the Missing Disinflation", *American Economic Journal: Macroeconomics*, 7(1): 197-232.

Coibion O., Y. Gorodnichenko and R. Kamdar, 2017, "The Formation of Expectations, Inflation and the Phillips Curve", *NBER Working Paper*, No. 23304.

Dovern J., U. Fritsche and J. Slacalek, 2012, "Disagreement Among Forecasters in G7 Countries", *Review of Economics and Statistics*, 94(4): 1081-1096.

Evans G. W. and S. Honkapohja, 2012, *Learning and Expectations in Macroeconomics*, Princeton University Press.

Forni M., L. Gambetti, M. Lippi and S. Luca, 2013, "Noisy News in Business cycles", *CEPR Discussion Papers*, No. 9601.

Fuster A., D. Laibson and B. Mendel, 2010, "Natural Expectations and Macroeconomic Fluctuations", *Journal of Economic Perspectives*, 24(4): 67-84.

Gabaix X., 2014, "A Sparsity-Based Model of Bounded Rationality", *Quarterly Journal of Economics*, 129(4): 1661-1710.

Gennaioli N. and A. Shleifer, 2010, "What Comes to Mind", *Quarterly Journal of Economics*, 125(4): 1399-1433.

Gourinchas P.-O. and A. Tornell, 2004, "Exchange rate puzzles and distorted beliefs", *Journal of International Economics*, 64(2): 303-333.

Hubert P., 2017, "Central bank information and the effects of monetary shocks", *Bank of England working papers,* No. 672, Bank of England.

Hubert P. and B. Maule, 2016, "Policy and macro signals as inputs to inflation expectation formation", *Bank of England working papers*, No. 581, Bank of England.

Kahneman D. and A. Tversky, 1972, "Subjective Probability: A Judgment of Representativeness", *Cognitive Psychology*, 3(3): 430-454.

Lucas R., 1972, "Expectations and the Neutrality of Money", *Journal of Economic Theory*, 4(2): 103-124.

Lucas R., 1976, "Econometric Policy Evaluation: A Critique", *Carnegie-Rochester Conference Series on Public Policy*, 1: 19-46.

Lucas R. and T. Sargent, 1979, "After Keynesian Economics", *Federal Reserve Bank of Minneapolis Quarterly Review*, 3(2): 1-16.

Lorenzoni G., 2009, "A Theory of Demand Shocks", *American Economic Review*, 99(5): 2050-84.

Maćkowiak B. and M. Wiederholt, 2009, "Optimal Sticky Prices under Rational Inattention", *American Economic Review*, 99(3): 769-803.

Mankiw G. and R. Reis, 2002, "Sticky Information versus Sticky Prices: A Proposal to Replace the New Keynesian Phillips Curve", *Quarterly Journal of Economics*, 117(4): 1295-1328.

Mankiw N. G., R. Reis and J. Wolfers, 2004, "Disagreement about Inflation Expectations", NBER Chapters, in: *NBER Macroeconomics Annual 2003*, 18: 209-270.

Matějka F., 2016, "Rationally Inattentive Seller: Sales and Discrete Pricing", *Review of Economic Studies*, Oxford University Press, 83(3): 1125-1155.

Matějka F. and A. McKay, 2012, "Simple Market Equilibria with Rationally Inattentive Consumers", *American Economic Review*, American Economic Association, 102(3): 24-29, May.

Melosi L., 2017, "Signalling Effects of Monetary Policy", *Review of Economic Studies*, Oxford University Press, 84(2): 853-884.

Miranda-Agrippino S. G. and Ricco, 2017, "The transmission of monetary policy shocks", *Bank of England Working Papers,* BoE, No. 657.

Muth J., 1961, "Rational Expectations and the Theory of Price Movements", *Econometrica*, 29(3): 315-335.

Paciello L. and M. Wiederholt, 2014, "Exogenous Information, Endogenous Information, and Optimal Monetary Policy", *Review of Economic Studies*, Oxford University Press, 81(1): 356-388.

Pesaran H. and M. Weale, 2006, "Survey expectations", *Handbook of economic forecasting*, 1: 715-776.

Piazzesi M. and M. Schneider, 2011, *Trend and cycle in bond premia*, manuscrit, Stanford University.

Ramey V., 2016, "Macroeconomic shocks and their propagation", *Handbook of Macroeconomics*, 2: 71-162.

Reis R., 2006a, "Inattentive Producers", *Review of Economic Studies*, 73(3): 793-821.

———, 2006b, "Inattentive consumers", *Journal of Monetary Economics*, 53(8) : 1761-1800.

Ricco G., G. Callegari and J. Cimadomo, 2016, "Signals from the government: Policy disagreement and the transmission of fiscal shocks", *Journal of Monetary Economics*, 82(C): 107-118.

Ricco G., 2015, "A new identification of fiscal shocks based on the information flow", *ECB Working Paper*, No. 1813.

Romer C. D. and D. H. Romer, 2000, "Federal Reserve Information and the Behavior of Interest Rates", *American Economic Review*, 90(3): 429-457.

Sims C., 1992, "Interpreting the macroeconomic time series facts: The effects of monetary policy", *European economic review*, 36(5): 975-1000.

Sims C., 2003, "Implications of Rational Inattention", *Journal of Monetary Economics*, 50(3): 665-690.

Woodford M., 2002, "Imperfect Common Knowledge and the Effects of Monetary Policy", In *Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps*, editors P. Aghion, R. Frydman, J. Stiglitz, and M. Woodford, Princeton: Princeton University Press.