

# Recent Developments in Experimental Macroeconomics

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- Experimental macroeconomics is a relatively new approach to investigating important macroeconomic questions.
- The experimental approach is well suited for studying the implications of different public policies and for inferring unobservable behaviour such as expectations formation.
- The Bank of Canada has started using experimental macroeconomics to examine important monetary policy issues such as the relative efficacy of inflation targeting versus price-level targeting, and the nature of inflation expectations.
- Although only suggestive, results to date indicate that experimental macroeconomics is a useful tool in central bank research.

Canada's public institutions have a responsibility to continuously review their policy frameworks, ensuring that they are contributing as best as they can to the standard of living of Canadians. Part of this review includes re-examining important questions through a new lens. In this article, we describe research being conducted at the Bank of Canada and elsewhere in which, in a novel approach, experimental economics is used at the macro level to gain new insights into key monetary policy issues.

Experimental economics is the application of experimental methods to study and answer economic questions. The approach is similar to a scientific experiment, where a controlled environment is created and different factors are manipulated to assess their impact on a variable of interest. Unlike experiments in the sciences, however, people, rather than chemicals or organic matter, for example, are used as the reactants.

Early applications of experimental methods tended to focus on micro-economic debates surrounding issues such as individual and group behaviour, and on how to effectively design contracts, incentive structures and market platforms. In one of the first applications of an experimental approach to an economic question, Thurstone (1931) considered the problem of determining an individual's preferences over a range of goods

(i.e., indifference curves). In his experiments, each subject was asked to make a large number of hypothetical choices between commodity bundles consisting of three different combinations—hats and coats, hats and shoes, or shoes and coats. Upon examining the data, Thurstone concluded that choice data could be adequately represented by indifference curves.

In another early example that had enormous influence on how economists think about interactive behaviour, Flood (1958) conducted an experiment analyzing an economics game known as the prisoner's dilemma. In contrast to theoretical results, Flood found evidence against the general hypothesis that players tend to choose non-co-operative (Nash equilibrium) strategies.<sup>1</sup> Instead, the results reinforced the hypothesis that a co-operative “split the difference” principle is a more effective way to organize the data from games of this type. From these early roots, the literature of experimental economics experienced exponential growth in the decades that followed, and Vernon Smith was recognized in 2002 with a Nobel Prize in economics for his contributions to this field.

With respect to issues related to monetary policy, laboratory-generated data possess several advantages over naturally occurring macroeconomic data. First, experimental methods are useful for studying factors that cannot be readily observed or measured. The formation of inflation expectations is an important example from the perspective of a central bank. Indeed, a better understanding of how households and firms form inflation expectations would be helpful across a broad range of important monetary policy decisions, such as predicting inflation dynamics, calibrating interest rate movements to fluctuations in the economy and choosing an appropriate monetary policy regime. Since the process according to which inflation expectations are generated is unobservable, making it a difficult subject to study using standard economic methods, experimental economics is well suited to help researchers infer how people form these expectations.

Second, the laboratory provides an opportunity to “experiment” with policies in a controlled manner. In the laboratory—unlike the real world—there is no need to fear unintended or irreversible consequences of unexpectedly “bad” policies. Experiments, therefore, can inform policy-makers on which policies may be more or less desirable. Moreover, in a laboratory, aggregate outcomes can be easily scrutinized and linked to parameters of the experiment, including those that are difficult to identify from macroeconomic data, such as preferences, expectations and non-fundamental variables (or “sunspots”).<sup>2</sup> Finally, an experiment can be run many times to produce more data, while we cannot “rerun” an economy to produce multiple versions of macroeconomic data.<sup>3</sup>

Experimental economics has been used recently, with some success, to explore topics central to macroeconomics, such as optimal lifetime consumption and savings decisions, theories of money, strategic behaviour, coordination issues, commitment versus discretion, and fiscal and tax

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1 The Nash equilibrium describes a situation where each player does the best that he or she can, given the behaviour of the other players in the game.

2 Sunspots include phenomena such as asset-price bubbles, self-fulfilling prophecies and animal spirits. These sunspots do not affect economic fundamentals directly but may have an effect on outcomes because they influence expectations.

3 Surveys of professional forecasters have been useful for studying the dynamics of expectations in response to past economic fluctuations. See, for example, Coibion and Gorodnichenko (2012), Kozicki and Tinsley (2012), and Jain (2013). While the survey approach is based only on expectations formed at a point in history and cannot be replicated, the experimental approach is based on many artificial histories and can be replicated many times.

policies.<sup>4</sup> The usefulness of experiments in addressing macroeconomic problems naturally makes them an attractive tool for central bankers; however, before discussing this line of research, it is important to understand how these experiments are conducted.

This article first describes a generic economics experiment, noting several limitations to the approach. It then provides examples of where experimental economics has been used to examine a number of macroeconomic issues. Recent contributions of experimental macroeconomics to monetary policy are then highlighted, followed by concluding remarks.

## Experiments in Economics

An economics experiment, like any other scientific experiment, involves the creation of a controlled and simplified environment to examine a question of interest. Control helps to isolate features of the experimental economy that have a material effect on the behaviour of participants (subjects). Control factors often include information available to participants, a set of possible decisions, and how those decisions translate into outcomes and monetary payoffs for subjects. In practice, control factors are individually manipulated to gauge their effect on economic behaviour. An experiment could, for example, study how changes in the monetary policy regime influence a participant's ability to forecast inflation, as will be explored later in the article.

Once an economics experiment has been designed, it is usually conducted in a computer laboratory at a university or research institute. Participants are given detailed oral and written instructions on their experimental environment and the decisions they will be making. Most importantly, they are informed on how their decisions would translate into monetary payoffs. Depending on the complexity of the experiment, subjects may have the opportunity to practise making decisions and to ask the experimenter for clarifications.

Sessions typically last for one to two hours, but may be shorter or longer, depending on the nature of the experiment. An experiment may involve participants making a single decision or it may involve many repeated decisions. After the session is complete, participants are paid according to the rule specified in the instructions. For example, in experiments where participants are asked to forecast inflation, their payoff could depend on the accuracy of their forecasts. Higher payoffs are given for more accurate forecasts, creating an incentive for participants to make an effort throughout the experiment.

Despite its potential efficacy, the experimental approach has certain limitations. First, laboratory-generated data are frequently subject to the concern of "external validity"; that is, individuals may behave differently in the simplified laboratory environment than they would in their everyday environment. For example, individual decisions can be affected by the amount and complexity of relevant information; in addition, individuals' efforts in processing information may be sensitive to the incentives. Such concerns about the external validity of experiments could be addressed, to some extent, by changes in the reward scheme, information parameters, decision options, the composition and size of the subject pool, and other features of experimental design.<sup>5</sup> Nevertheless, experimental data should be viewed as supplementary to macroeconomic data rather than as a replacement.

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<sup>4</sup> Chakravarty et al. (2011), Cornand and Heinemann (2014), and Duffy (2014) provide surveys of the experimental macroeconomics literature.

<sup>5</sup> For example, Cheremukhin, Popova and Tutino (2011) find that subjects in the experiments differ dramatically in their ability to process information; Caplin and Dean (2014) show that subjects respond to higher incentives by spending more time and effort processing information.

A second limitation is that macroeconomic experiments often involve fewer than 10 participants, causing speculation about whether sample sizes are large enough to study economy-wide phenomena. Perhaps surprisingly, evidence indicates that they are. Macroeconomics experiments can study outcomes for a group of participants in a non-co-operative setting by choosing a group large enough to limit the impact of individual effects. Since in such a setting each participant is aware that his or her decisions do not affect the outcomes for the group as a whole, those outcomes can be given macroeconomic interpretation. Indeed, early experiments of market exchange show that, even with a small number of subjects, experimental outcomes are similar to those in the competitive market (Smith 1962).

Third, while the use of a simplified environment allows experiments to mimic the key features of the real world, simplicity is a double-edged sword, since it forces researchers to interpret their results with caution. If, for instance, participants in an experiment are found to form better inflation forecasts when the central bank switches from inflation targeting to price-level targeting, this result may not necessarily apply outside of the laboratory, since experiments are not able to capture or even identify all the features and uncertainties associated with the real world. Nonetheless, if the underlying experimental design is able to capture the key features of an economic issue, the experimental evidence may provide useful guidance for what we can expect to observe outside of the laboratory.

◀ *Even with a small number of subjects, experimental outcomes can be given macroeconomic interpretation*

## Experimental Macroeconomics

Laboratory experiments addressing macroeconomics and policy issues have become increasingly popular over the past two decades. Experiments have provided a means to evaluate important assumptions embedded into modern macroeconomic models; study macroeconomic phenomena such as bank runs, currency attacks, asset bubbles, episodes at the zero lower bound, moral hazard in the banking sector and the importance of non-fundamental variables (sunspots); and examine the implications of different types of public policy.

Laboratory experiments have studied, for example, the importance of sunspots for determining aggregate outcomes.<sup>6</sup> Duffy and Fisher (2005) design a market experiment in which buyers and sellers trade a commodity under two alternative market settings, observing transaction prices in real time or only at the end of trading. The sunspot variable, introduced at the beginning of trading, is an announcement of the market-price forecast, chosen at random between “the forecast is high” or “the forecast is low.” Duffy and Fisher find that the expectations of subjects regarding the market price—and therefore their supply and demand decisions—are more likely to be influenced by a sunspot variable in the market with less information. They therefore provide evidence that sunspots can play an important coordinating role when the ability to coordinate by other means is hindered by limited information.

In another example, Arifovic and Sargent (2003) study issues of credibility and time inconsistency within an experiment based on a model developed by Barro and Gordon (1983). In this experiment, private agents attempt to accurately forecast inflation. After seeing these forecasts, the policy-maker chooses the socially optimal inflation rate. As in Barro and Gordon’s

<sup>6</sup> Lucas (1986) proposes using experiments to provide predictions for phenomena on which macro-economic theory is silent, such as the nature of sunspots or outcomes of macro-coordination problems.

framework, the policy-maker has an incentive to create surprise inflation, because it leads to a lower level of unemployment. Forecasters, however, recognize the policy-maker's bias for inflation and anticipate higher and higher levels of inflation, leading to a situation of both high inflation and high unemployment (the Nash equilibrium). If, instead, the central bank can credibly commit to low inflation, the economy will experience a situation of low inflation and low unemployment (the commitment equilibrium). In most sessions of their experiment, Arifovic and Sargent observe that inflation is initially close to the Nash equilibrium; however, with a credible commitment to low inflation by the central bank, inflation gradually converges toward the commitment equilibrium, providing support for one of the key predictions of the Barro and Gordon model.

Other experiments have explored the effects of monetary policy as well as the ability of monetary policy and lending regulations to work together to stabilize asset markets.<sup>7</sup> In addition, experiments have shed light on the aggregate effects of income taxation to finance unemployment insurance (Riedl and van Winden 2007) and public goods (Huber, Shubik and Sunder 2011).

## Experimental Macroeconomics, Monetary Policy and Expectations Formation

In conducting monetary policy, central bankers face the difficult task of taking into account the complex nature of economic behaviour and uncertainty. A central element of this behaviour is how economic agents form their expectations about the future course of the economy. Boivin (2011) emphasized the importance for policy-makers to understand how expectations affect the conduct of monetary policy, and vice versa.<sup>8</sup> Empirical evidence regarding the formation of inflation expectations is sparse, however, so researchers have applied experimental economics to help fill this important gap (see, for example, Pfajfar and Zakelj (2014a, 2014b) and Assenza et al. (2013)).

Original research on expectations formation involved predicting the path of a stochastic process for an asset price (Schmalensee 1976; Smith, Suchanek and Williams 1988). The objective is to elicit subjects' forecasts while presenting them with period-by-period information about the data-generating process. Typical findings from this approach are that forecast errors are biased and persistent, or correlated with other variables. Most of these early experiments, however, did not allow expectations of future outcomes to play any role in determining current outcomes—the so-called “self-referential” feature that is essential in modern macroeconomic models.

Starting with the innovative work by Marimon and Sunder (1993, 1994), the literature on expectations formation has incorporated the self-referential feature, letting subjects' expectations—usually in the form of their combined forecasts—feed directly into the experimental outcomes. This literature has yielded a variety of useful insights for monetary policy, to which we now turn.

Hommes et al. (2007) study forecasting behaviour in a supply-and-demand cobweb model. In their experiment, subjects predict market-equilibrium prices without knowledge of the process by which they are determined, relying mostly on past observations. Remarkably, the subjects' forecasts are correct, on average, although with a higher variance than predicted by the model. The work of Hommes et al. illustrates how individuals, given

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<sup>7</sup> Bosch-Domènech and Silvestre (1997); Lian and Plott (1998); Fenig, Mileva and Petersen (2013); Petersen (2014).

<sup>8</sup> Cunningham, Desroches and Santor (2010) take stock of work on inflation expectations.

sufficient time and a stationary environment, can learn to make fairly accurate forecasts, even without knowledge of the underlying economic structure.<sup>9</sup>

Adam (2007) conducts an experiment based on a standard two-equation New Keynesian model, asking participants to forecast inflation and output. Like Hommes et al., Adam finds that, over time, participants learn a reasonably efficient forecasting rule. Importantly, he finds that this forecasting rule differs from the “correct” econometric forecast specification, giving rise to unduly persistent movements in inflation and output. This example demonstrates that, among the key determinants of macroeconomic fluctuations—such as people’s preferences, firms’ technologies, resources and information—expectations are also important.

Aside from being a factor in macroeconomic outcomes, what makes expectations a focal point of monetary policy? In forming expectations, households and firms are not likely to blindly extrapolate their past experience into the future, behaving entirely in a backward-looking fashion. Rather, they combine past experience with their understanding of the economy to form a more accurate outlook for the economy, thus forming *forward-looking* expectations. An important element in forming such an outlook is the ability of individuals to anticipate future monetary policy actions and their effect on the economy. For example, when buying a house, a household takes into account the cost of a mortgage, which, in turn, depends on the future path of interest rates. Therefore, monetary policy that is predictable and transparent can affect economic decisions through expectations.<sup>10</sup>

Staff at the Bank of Canada have used experimental macroeconomics to shed light on important questions regarding the design of the monetary policy framework. One ongoing issue is the efficacy of price-level targeting relative to inflation targeting. For price-level targeting to deliver its noted benefits, private agents need to understand how price-level targeting works, believe the regime is stable and then incorporate these perceptions into their inflation expectations. In fact, if these conditions are not satisfied, price-level targeting may deliver results that are inferior to inflation targeting.<sup>11</sup>

Since evidence regarding the formation of inflation expectations under price-level targeting is sparse, Amano, Engle-Warnick and Shukayev (2011) study, in an experimental laboratory, whether inflation expectations adjust in a manner that is consistent with price-level targeting. Their results indicate that inflation-forecasting behaviour changes across inflation-targeting and price-level-targeting regimes. In particular, in forming their inflation forecasts, subjects appear to shift from relying on the inflation target under inflation targeting to assuming that the price level will revert to its target under price-level targeting. Although this shift in expectations is in the right direction, subjects do not forecast optimally under price-level targeting, relying only partially on the target-reverting nature of the price level to generate their inflation forecasts.

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9 One branch of macroeconomic literature examines how individuals, given time and a stationary environment, can learn the correct econometric forecast specification. See Evans and Honkapohja (2001).

10 Woodford (2003) and Galí (2011) provide extensive reviews of theories of monetary policy and its interaction with economic expectations.

11 See, for example, Kryvtsov, Shukayev and Ueberfeldt (2008).



This evidence suggests that, all else being equal, the benefits of price-level targeting would not be fully realized if a central bank implemented a price-level-targeting regime. It should be noted, however, that the shift to price-level targeting was explained only once to subjects in the experiments. In the real world, a central bank would likely undertake an ongoing communication strategy to explain and remind the public about the implications of price-level targeting, thereby helping agents to more accurately adjust their expectations in such a regime.

The work by Amano, Engle-Warnick and Shukayev (2011) points out that the extent to which expectations are forward-looking provides central bankers with an additional lever that can be used to keep inflation on target and stable. Yet, the work by Hommes et al. (2007) and Adam (2007) provides experimental evidence that, in forming expectations, individuals tend to rely on history without having an understanding of the future course of the economy or monetary policy; i.e., they form backward-looking expectations. So what is the relative importance of the forward- and the backward-looking components in expectations? And, given their relative importance, how much macroeconomic stabilization can be achieved by monetary policy through its influence on expectations?

Kryvtsov and Petersen (2013) design an experiment to answer these two questions. Unlike most previous experimental researchers, they provide subjects with detailed information about the data-generating model, including linkages between inflation, output and the interest rate; the monetary policy rule; the nature of the exogenous shock; and the full history of inflation, output and the interest rate. In each period, subjects observe the state of the economy and nominal interest rate, and then provide their forecasts for inflation and output in the next period, which are, in turn, used to calculate current inflation and output. The novelty of the Kryvtsov and Petersen set-up is that it allows them to estimate the extent to which expectations rely only on history (are backward-looking), as opposed to being driven by anticipation of future policy actions (forward-looking).

Kryvtsov and Petersen find that subjects' expectations contain a significant backward-looking component, attributing approximately half of the weight to history and the remaining half to anticipations of future monetary policy responses. The authors estimate that, without the forward-looking component of expectations, volatility in inflation and output would be twice as large as when the forward-looking component is present. Therefore, despite the sizable backward-looking component in expectations, monetary policy is found to be very potent in stabilizing inflation and output through its effect on the forward-looking portion of subjects' inflation expectations.

Experimental macroeconomics can also help to develop and refine our understanding of central bank communication. Engle-Warnick and Turdaliev (2010) conduct an experiment in which subjects play the role of central bankers by choosing the level of the nominal interest rate to stabilize fluctuations in inflation and output. They find that, despite limited knowledge of the underlying model or prior experience as central bankers, subjects made interest rate decisions that kept the economy stable. Thus, the basic principles of monetary policy may come naturally to the public and, therefore, may not be difficult to communicate.<sup>12</sup>

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<sup>12</sup> Carvalho and Nechio (2014) use data from the Thomson Reuters/University of Michigan Surveys of Consumers to show that some households are aware of the basic principles of monetary policy when forming their expectations about interest rates, inflation and unemployment.

Low interest rates in the post-crisis world have led central banks to expand their set of policy tools. For example, communication of future monetary policy, or forward guidance, has become more frequent (Carney 2012). In ongoing work, Arifovic and Petersen (2014) use experiments to study the effects of central bank communication at the zero lower bound. They find that forward guidance is more effective in shortening the duration of the zero lower bound than communicating only the inflation target. Kryvtsov and Petersen (2013) also explore the idea of providing the public with a central bank's conditional projection of future nominal interest rates. They observe that subjects initially coordinate their expectations with the central bank's announced future path of the interest rate. Over the duration of the experiment, however, if central bank interest rate projections are not consistently aligned with realized interest rates, subjects reduce the weight they place on subsequent central bank announcements. This result adds to the debate about whether a central bank should publish its forecast for future policy rates, as discussed in Svensson (2006).

## Conclusion

The experimental macroeconomics literature, although relatively new, has provided useful insights into questions close to the hearts of macroeconomists and central bankers. The experimental approach has a clear niche in providing evidence on economic phenomena that cannot be observed directly or that are difficult to measure. Regarding monetary policy, initial experimental work has shed light on a number of important issues. Evidence suggests, for example, that it may be difficult to fully exploit the gains associated with a price-level-targeting regime relative to an inflation-targeting one. Moreover, research at the Bank of Canada that attempts to garner a better understanding of the formation of inflation expectations has found that the backward-looking component of expectations is not trivial, which has important implications for the conduct of monetary policy. Finally, it is not certain from recent work using experimental macroeconomics that more information about a central bank's actions and intentions is always beneficial.

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