Beyond Rational Expectations: Learning and Monetary Policy

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Abstract:

The rational expectations assumption that magically gifts economic agents with perfect knowledge of the economic system, policy goals and parameters has been a workhorse of economic research. Current research has focused on the relaxing of the rational expectations assumption and has introduced learning into the system. The following paper summarizes several key research papers in the field of learning and monetary policy choices. The paper draws together several key results that are common among the research presented here. Additionally the paper offers several avenues of research to expand this promising field of economic theory.

Introduction

The challenges that central bankers face with the implementation of monetary policy are complex and varied. Should the central bank follow a rules based policy or a discretionary monetary policy? Should the policy focus on output stabilization or should the policy focus on the maintenance of price stability or a combination of the two? The answers to these and many other economic questions are difficult to define and in many instances economists are unable to form a consensus regarding the set of policy parameter choices.

Despite the challenges faced by central banks, the goal of the bank is to choose the monetary policy with an optimal solution that minimizes the negative effects on the economy. The central bank faces a trade off between output stabilization and price stability. Faced with this trade off, monetary policy seeks to minimize the output gap and maintain price stability when faced with exogenous shocks to the economy.

The role that expectations play is a crucial variable of concern to central banks. A critical assumption is to endow economic agents with rational expectations, where these agents intuitively know the parameters of the policy, can accurately predict the central banks moves, and know how the economy will be affected. Rational expectations is a quantum leap of faith assuming economic agents know the policy parameters and the optimal policy solution when the central bank itself struggles to accurately define policy parameters as well as the optimal policy solution.

This paper examines recent research that moves beyond the rational expectations assumption and analyzes the effects when learning is introduced. James Bullard summarizes the process of learning stating that economic agents do not initially know the policy parameter but have a perceived equilibrium law of motion (PLM). The agents use information generated by the economy itself to update their perceived law of motion using learning algorithms such as least squares. If the agent's perceived law of motion converges with the actual law of motion (ALM), rational expectations equilibrium (REE) will be attained (Bullard 2006). By relaxing the rational expectations assumption and instead providing economic agents with the ability to learn, policy analysis has taken a large step toward a realistic economic environment.

The paper will perform a literary review of economic papers that focus on the effects of expectations and learning on monetary policy rules. The review format is chosen due to the variety of models and methods used. The format will allow the reader to make a clear connection of results to the specific model. Each paper will be reviewed in turn and each review will contain a short paper summary, a brief outline of the model used in the paper with the mathematical equations omitted for brevity, the methods used to analyze the model, and a review of key findings. After the literary review, the conclusion will summarize finding that are consistent among the papers and highlight any conflicting results. Finally the paper will offer several possible avenues of exploration that may lead to the creation of models that more closely represent the real world economic environment.

Literary Reviews

Simplicity Versus Optimality

Tetlow and von zur Muehlen analyze the affects of learning and the choice of monetary policy. The paper focuses on the effects of memory on learning time, the role that policy parameter choices play on expectations and policy learnability, and how the complexity of the monetary policy rule affects the private economic agent's ability to learn the changing policy parameters.

Tetlow and von zur Muehlen (1999) create a small forward looking New Keynesian macroeconomic model to represent the economy. The Phillips curve plays a central role in the model and inflation is assumed to be "sticky" or has the tendency to persist. The model parameters are set so that monetary policy affects on demand and prices occur with a lag. Economic agents are endowed with recursive least squares and discounted learning least squares algorithms.

The methods the authors use to analyze the dynamic effects on the model economy involve several key parameters. The optimal policy rule is simplified and constraints are placed on the number of arguments. The policy is set to minimize the loss function. Economic agents are assumed to be attempting to learn the coefficients for the output gap and the inflation gap. The authors measure the effects of two distinct monetary policy rules. One rule is a strong inflation targeting rule where weight of 0.8 is placed on inflation stabilization and 0.1 on output stabilization. The second rule or weak inflation targeting rule places the weight of 0.1 on inflation and 0.8 on output. The authors provide economic agents with three levels of memory: a full recursive least squares (RLS) or full memory with a memory coefficient of 1, a discounted recursive least squares (DRLS) model or long memory with a memory coefficient of 0.95, and a second DRLS model or short memory with a memory coefficient 0.85. With the model and method described above, the author performed a simulation to analyze the effects of memory on learning time, the role of policy parameter choices, and how complexity affects learning.

The simulation found that learning is a slow process. Learning occurs fastest for agents with short memory. Even with short memory, agents took over 10 years to learn new policy parameters. Fast learning does not necessarily improve economic performance due to two important factors. First, to actively teach agents the central bank must introduce variability to the state variable. Second, the early gains are given back when learning ultimately slows with time.

The economic cost incurred by policy changes vary with the form of monetary policy followed. The costs of changing strong inflation targeting rules are high. This finding indicates that the central bank should actively communicate policy changes to economic agents to reduce learning time and thus minimize the costs. Alternatively, changes in the parameters of weak inflation target policies benefit from agent misconceptions and slow learning.

When changing policy regimes, costs are reduced by simplifying the policy model. Additionally agents have great difficulty in learning models with complex and multiple conditioning variables.

Learning About Monetary Policy Rules

Mitra and Bullard (2000) focus on several aspects of macroeconomic system stability and the effects of learning on several monetary policy rules. In particular, the paper concentrates on system determinacy where a solution is attainable and indeterminacy where no or multiple solutions exist. The ability of agents to learn the monetary policy rule is also examined. The policy is learnable if the agents are able to coordinate and converge on REE. Additionally, the paper looks at active versus passive monetary policy as well as the affect of an aggressive active monetary policy regime.

The model system is a small forward looking macroeconomic model used by Woodward (1999). Monetary policy regimes are based on a form of the Taylor rule. The model consists of four policy variants. The first is the Contemporaneous Data (CD) form where nominal interest rates (I*) are set by current deviations of inflation (π) and output (y*) from their respective targets. Second is the Lagged Data (LD) form where I* reacts to lagged (π) and (y*). The third form is Forward Looking (FL) where I* responds to the future forecast of (π) and (y*). The final form is Contemporaneous Expectations (CE) where I* reacts to current expectations of (π) and (y*). In the CD form policy makers react to current information only and agents form expectations. In the LD form both policy makers and private agents react to t-1 (π) and (y*) gaps. For the FL form, the monetary authority form forecasts based on t-1 and t data. Finally, in the CE form, policy is set by current expectations of (π) and (y*) gaps based on t-1 information.

The method employed to simulate the model economy follows. Economic agents do not possess RE. Economic agents use adaptive learning algorithms derived from information generated from within the system they operate. Expectational Stability (E-Stability) is then calculated. E-Stability is defined as the convergence of PLM to the ALM as a differential equation in notional time. The stability of the differential equation governs the stability of the system under real-time recursive learning (Bullard, 2006). If E-Stability holds then RLS learning is locally convergent to REE. Agents are provided with the PLM that coincides with the minimal state variables (MSV) making convergence to ALM much easier.

The model and method found the determinacy alone is not sufficient to induce private agents to learn the policy parameters and converge on REE. Rules that are unlearnable in this model should be avoided, given that agents are assumed to have the correct variables and relationships and are still unable to succeed. Active monetary policy rules that respond to CD output and inflation data are determinate and learnable. Conversely, passive policies that use this same data are indeterminate and unstable. Rules that follow the CE model converge to the same learnable and determinate region as above. The author asserts that the CE policy is the most desirable for learnability and determinacy. Aggressive response to LD rules lead to determinacy however they may be unlearnable under RE assumptions. In the FL model, indeterminacy rises with response aggressiveness. Across all models the paper found that active policies outperformed passive in the generation of E-Stability conditions and that aggressive responses to π tend to associate with REE and lead to determinacy and E-Stability.

Imperfect Knowledge, Inflation Expectations, and Monetary Policy

Orphanides and Williams (2002) use model simulations to illustrate how learning affects inflation expectations, inflation and output. The authors create a simple linear model to represent the U.S. economy. The model assumes that private economic agents know the economy's parameters and use this information when forming expectations. Under the RE assumption, the output/inflation trade off results in a one parameter optimal policy rule that targets inflation. Model inflation is determined by a Lucas supply function with some level of inflation persistence. The model uses a "perfect knowledge benchmark" to compare the simulation results under imperfect knowledge.

The method of analysis was to run computer simulations using the model parameters above to generate results in four areas. First, the model is used to evaluate the performance of inflation forecasts by economic agents. Second, the model is used to generate the dynamic response to 1970's style shocks, comparing outcomes when agents are endowed with imperfect knowledge and use a RLS learning under three policy regimes: a) The inflation dove that places more weight on output stability, b) the balanced preference with equal weights on output and inflations stabilization, and c) the inflation hawk that place the most weight on inflation stability. Third, the simulation is run under the perfect knowledge assumption but economic agents are given imperfect information. Finally, the policy assumes imperfect knowledge and agents learn and adjust to the policy as necessary.

The simulation addressed the first area of concern finding that finite memory forecasts performed well when the greatest weight is placed on inflation and finite learning outperformed infinite least squares learning and increases as the weight on inflation increases. With nearly efficient inflation expectations, imperfect information distorts the inflation/output trade off and leads to inflation persistence. With these distortions present, policies that appear to be efficient under the RE assumption can show significantly worse performance with imperfect information.

Where 70's type shocks occur, the simulations found that the inflation hawk policy outperforms the dove policy when agents are endowed with perfect information. The hawk policy resulted in a 2.5% rise in inflation for 10 periods while the dove policy found a 4.5% rise for 20 periods. Additionally, by changing to the imperfect knowledge assumption, the deviations are exaggerated even more. The simulation results reveal that through inflation targeting, the likelihood of stagflation is reduced.

The answer to areas three and four are two sides of the same coin. The simulation results are dramatic and a strike against the output stabilization policies. The simulation results find that economic losses are exaggerated by a failure to account for imperfect knowledge when pursuing an output stabilization regime. Conversely, an inflation stabilization policy yields superior output and inflation performance. Thus, inflation targeting appears to moderate the negative affects of imperfect knowledge. A common theme in the finding of all four areas is that policies that focus on inflation stabilization lead to greater leaning performance in the finite learning models.

Expectations and the Stability Problems for Optimal Monetary Policies

Evans and Honkapohja (2003) explore the relationship between optimal monetary policy regime that assume RE, an agents ability to learn within the system and the negative effects of expectational errors during the learning process. A central goal of the paper is to solve the negative effects of expectational errors by finding an optimal, learning-stable discretionary monetary policy. The optimal rule must converge on REE over time and be E-Stable under learning. Further, the requirements must hold as the policy makers themselves learn the parameters of the system.

The authors provide a model economy with a log linear framework containing two essential equations: 1) a dynamic IS curve and 2) a new Phillips curve created with monopolistically competitive pricing decisions. The interest rate (I*) is adjusted to neutralize shocks to the IS curve. Price shocks present the monetary authority with the classic output/inflation tradeoff.

The method used to run simulation of the described model economy follows. Agents use least squares (LS) learning to forecast and update state variable rules. The model simulation is run with and without the RE assumption to compare the effects of the assumptions on policy performance.

A primary finding of the model is that RE should not be assumed. With small expectation errors from the outset, the model will fail to converge to REE if the optimal RE policy is followed. The divergence can be overcome if the model supplements the conditioning variable with observed private expectations. Through this discretionary monetary policy that uses observed expectations, the model economy will converge to REE over time. The above results hold when both private agents and the monetary authority are learning the structural parameters through LS learning simultaneously. The performance of the model is contingent on accurate private expectations. This result indicates that central bankers need to place a high priority on accurately defining private expectations.

Timing and Real Indeterminacy in Monetary Models

Carlstrom and Fuerst (2001) analyze the affects of forecast timing on the implementation of monetary policy. The model economy is a money-in-the-utility endowment economy. The authors use two economic timing models to represent the affect of timing assumptions on central bank policy decisions: 1) Cash in Advance (CIA) timing with the previous period time element of (t-1) and 2) Cash When I'M Done (CWID) with the current time element of time (t).

The paper finds that the CWID timing generally leads to determinacy. There are exceptions in extreme cases where indeterminacy occurs when real interest rates are unaffected by inflation expectations. The CIA timing leads to a different result. The CIA timing model leads to sunspot equilibria. Sunspots are non-fundamental equilibria that are extrinsic and do not matter for the economy. However, agents that are attempting to converge on equilibrium erroneously focus on the wrong target, the sunspot equilibrium. Sunspots occur when the system is indeterminate. (Bullard, 2006) A thorough discussion of sunspot equilibria is beyond the scope of this paper but the possible negative consequences of economic agents focusing on the sunspot target are clear. If agents focus on the wrong target, any policy choice of the monetary authority is doomed to failure. The conclusion of the paper is that the element of timing of expectations matter. Central banker must account for the timing issues and determinacy when choosing a monetary policy regime.

The review of recent economic research into the roles that expectations and learning plays in the implementation of monetary policy reveals several common findings. First, central bankers should focus on inflation stabilization rather than output stabilization. Active, discretionary monetary policies that involve an aggressive approach to inflation stabilization creates a determinate, learnable system that improves the probability that REE will be reached. In the models discussed in this paper, the monetary authority stands the greatest chance of success by acknowledging that economic agents have imperfect information. Learning models show that if the central bank assumes rational expectations when agents actual have imperfect information, success is far from guaranteed. Several papers focused on the timing of expectational assumption. The timing element is critical to the success of the monetary policy regime. The central bank must place a premium on determining the expectations of agents and the timing of the expectations before choosing a policy. The wrong choice of policy coupled with the wrong timing assumptions lead to indeterminacy and instability in several learning models.

Direct contradictions of results do not exist in this group of papers. There are findings that are not common among the papers but the results do not directly conflict. The multitude of model and methods of simulation insure result variability.

The concepts and theories in this paper are a new area of economic research. New areas of exploration could include the expansion of the learning model. The current research uses a single algorithm that apparently describes the mean economic agent. Knowing that in reality there are nearly an infinite number of algorithms that describe all economic agents, a system of equations could be used simultaneously and the dynamics of the learning system examined. A second opportunity may lie in the assumption that system parameters are know or nearly known by economic agents. In the real world, few if any economic players can define system parameters. In many cases the existence of the system itself may be unknown to many. By relaxing the parameter assumptions more, the system may be a closer reflection of reality. An intriguing area of research is in the area of sunspot fluctuations. Again, system parameters and system solutions are unknown and the targeting of sunspots by agents is real. The effect of targeting the wrong outcome may have profound effects on learning algorithms used in the models. With many possibilities and an improved reality based system, the future is bright for expectations and learning research.

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