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Adaptive learning, endogenous uncertainty, and asymmetric dynamics ☆

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ABSTRACT

I present a simple model where forecasting confidence affects aggregate demand. It is shown that this model has similar stability properties, under statistical and evolutionary learning, as a model without a confidence affect. From this setup, I introduce "Expectational Business Cycles" where output fluctuates due to learning, heterogeneous forecasting models and random changes in the efficient forecasting model. Agents use one of two forecasting models to forecast future variables while heterogeneity is dictated via an evolutionary process. Increased uncertainty, due to a shock to the structure of the economy, may result in a sudden decrease in output. As agents learn the equilibrium, output slowly increases to its equilibrium value. Expectational business cycles tend to arrive faster, last longer and are more severe as agents possess less information.

1. Introduction

Forecast uncertainty plays an important role in output fluctuations as it is common knowledge, among economists, that uncertainty is greater in a recession than it is during an expansion. For example, even among well informed professional forecasters, the median forecast error and the dispersion of GDP forecasts in the Survey of Professional Forecasters tend to increase during a recession. Uncertainty probably has the greatest effects on consumption and investment decisions. Cogley (2005) shows that during a recession, due to higher uncertainty, agents may be unable to distinguish between permanent and transitory shocks to their income. As a result, agents may be unsure how to smooth their consumption and thus adjust it more than they would under greater certainty. Potter (1999) shows that firms may also be less certain about returns to

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investments during a recession. He finds that investors may take a stand of "wait and see" during times of uncertainty leading to a decrease in investment. Finally, recent papers by Jaimovich and Rebelo (2009), Bloom (2009), and Bloom et al. (2010) suggest uncertainty as an important determinant of business cycles. They model a change in uncertainty as an exogenous increase in the variance of some underlying process which causes firms to cut investment and employment.

In this paper, I propose a mechanism to generate endogenous fluctuations in uncertainty. A simple model is presented where uncertainty has a negative feedback effect on aggregate demand. It turns out that bounded rationality plays a key role for the business cycle dynamics as it creates uncertainty in forecasting. If the economy experiences a structural shock and all agents have rational expectations, then there is not enough forecast uncertainty to create business cycle dynamics. However, as agents become boundedly rational, a structural shock will lead to a higher level of uncertainty (due to adaptive learning) and lower levels of output. As agents learn the new equilibrium, uncertainty will decrease and output will return to previous levels. Therefore, bounded rationality may be an important propagation mechanism for business-cycle like dynamics after a simple structural shock to the economy.

Several papers have discussed the role expectations play as an endogenous propagation mechanism for the business cycle. Many of these models focus on providing an explanation of the well-known fact that the average business cycle is asymmetric where the arrival of the recession is quite prompt and the recovery is more drawn out.[1] In Chalkley and Lee (1998), agents learn from their predecessors on the state of the economy with some noise. These agents decide whether to put in high or low effort based on their knowledge. If agents believe that they are in a "bad" state and see an aggregate increase, they may believe that the increase was from a stochastic shock and not from a shift to the "good" state. Therefore, agents will adjust quickly in the bad state, but, due to risk aversion, the agents will slowly adjust in the "good" state. In González (1997), agents learn from others in good times creating informational economies of scale. During bad times, agents focus on their microeconomic activity rather than learning about macroeconomic activity. When there is a shock to the "bad" state, agents see this shock due to the informational economies of scale and react to the shock quickly. When the shock to the "good" state occurs, agents are unaware of this shock due to the loss of the informational economies of scale. The author suggests that in order for others to believe that they are back in the "good" state, some agents must experiment which could further increase aggregate activity. Finally, Nieuwerburgh and Veldkamp (2006) consider an RBC-like model with a Markov technology shock and informational economies of scale through production. They conclude that low production creates noisy estimates of recovery leading to a slower recovery. These papers have assumed that a recession occurs due to a shock to the economy and not directly due to a change in expectations. In this paper, I examine a model in which a Markov process or technology shocks will not directly create a business cycle. A recession will only occur if agents lose confidence in their ability to make future forecasts.

A natural way to model changes in uncertainty is to assume that agents act like econometricians and form expectations based on some adaptive learning mechanism. Recently, many papers have included predictor choice in models that include an expectations feedback effect. Brock and Hommes (1997) and Hommes (2009) discuss an approach called Adaptively Rational Equilibrium Dynamics (ARED) where predictor choice is modeled using a multinomial logit. This approach has been used in other papers such as De Grauwe and Grimaldi (2005, 2006) to discuss the role predictor choice has on exchange rate dynamics and in Branch and Evans (2006) and Berardi (2011) who combine the ARED with adaptive learning discussed in Evans and Honkapohja (2001). Evolutionary game theory as presented by Weibull (1995) has also been used to model predictor choice in learning models. This has been discussed in papers by Sethi and Franke (1995), Branch and McGough (2008), and Guse (2010). In this paper, I follow the second set of papers and model predictor choice using the imitation dynamics, a common tool used in evolutionary game theory.

This paper introduces the concept of "Expectational Business Cycles" where fluctuations in an aggregate output are caused by a shock to fundamentals that lead to a short term reduction in forecasting efficiency. In this case, predictor choice dynamics (from the game theory literature) and adaptive learning act as the propagation mechanisms for the expectational business cycle. Suppose that the economy is near its equilibrium level of output and there is a shock to fundamentals. This shock may lead to another forecasting model (FM) becoming more efficient than the current FM used by most agents. With agents now using a relatively inefficient FM, there may be less investment and a decline in consumer confidence due to an increase in uncertainty. This may lead to a decline in output moving the economy into a recession. During this time, a small amount of agents may discover that the current FM is inefficient and switch to using the new efficient FM. Agents forecasting using the inefficient model may see this and decide to change to the other FM while others may follow later. When individuals learn, they tend to make large initial mistakes (large increase in uncertainty) and then learn how to minimize these mistakes (slower decline in uncertainty). If output is affected by changes in uncertainty, then output would decline quickly due to the large increase in uncertainty and return slowly to its equilibrium due to the slow process of learning. As a result, learning is a prime candidate for an explanation of asymmetry in the business cycle.

The key ingredient to an expectational business cycle is that forecast confidence affects aggregate demand. Therefore, I introduce a simple model where forecasting confidence positively feeds back to aggregate demand. I show that this model has the same local stability properties under statistical and evolutionary learning as a model without a confidence effect. Using the results from the stability analysis, I consider two states: one where the efficient FM is of a simple minimum state variable form and one where the efficient FM is an AR(1). In either state, output may decline with an increase in uncertainty

[1] Asymmetry in the business cycle has been discussed in Neftci (1984), Hamilton (1989), and Sichel (1993).