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Least squares learning and the US Treasury bill rate

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ABSTRACT

Understanding how agents formulate their expectations about Fed behavior is important for market participants because they can potentially use this information to make more accurate estimates of stock and bond prices. Although it is commonly assumed that agents learn over time, there is scant empirical evidence in support of this assumption. Thus, in this paper we test if the forecast of the three month T-bill rate in the Survey of Professional Forecasters (SPF) is consistent with least squares learning when there are discrete shifts in monetary policy. We first derive the mean, variance and autocovariances of the forecast errors from a recursive least squares learning algorithm when there are breaks in the structure of the model. We then apply the Bai and Perron (1998) test for structural change to a forecasting model for the three month T-bill rate in order to identify changes in monetary policy. Having identified the policy regimes, we then estimate the implied biases in the interest rate forecasts within each regime. We find that when the forecast errors from the SPF are corrected for the biases due to shifts in policy, the forecasts are consistent with least squares learning.

1. Introduction

Much prior research (for example, Goyenko et al., 2011; Chen, 2007; Chordia et al., 2005; Balduzzi et al., 2001, etc.) has established that macroeconomic factors such as inflation, economic recession,

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and monetary policy impact the capital markets. This is because macroeconomic factors are important determinants of stock and bond prices. In this study, we focus on the US Treasury bill rate (T-bill rate), which is one of the key macroeconomic variables.

The T-bill rate directly affects stock and bond prices because it is an important component of asset pricing models to determine the cost of capital.[1] Keeping other factors constant, if the T-bill rate rises, it increases the cost of capital by directly increasing the cost of equity and the cost of debt. This leads to a higher discount rate and, consequently, a lower estimate of firm value. Seen from a different perspective, if the risk-free rate rises, it signals a greater amount of risk associated with long-term government bonds. Thus, in the face of a rising risk-free rate, investors may deem stocks to be even more risky and demand a greater equity risk premium for investing in stocks.

T-bill rates are extremely important from the standpoint of determining firm value. If T-bill rates rise, it affects different types of stocks differently. Specifically, mature, low growth stocks are not significantly affected because these stocks typically have fewer growth assets. In contrast, growth stocks are adversely affected because a significant portion of their assets are growth assets and are hence discounted to a greater degree, reducing their valuations significantly. Under these situations, forecasting T-bill rates becomes critical for managers of firms wishing to raise fresh capital. Investors can also benefit from the knowledge of future T-bill rates because they can use this information to time their stock purchases.

In order to forecast the T-bill rate, agents require information about factors that determine the T-bill rate. Early researchers have assumed that agents have rational expectations (REH, henceforth), i.e., they acquire and process information rationally (see Muth, 1961; Fischer, 1977, etc.). When agents have complete knowledge of the structure of the model, forecast errors have mean zero, constant variance and no serial correlation. Empirical tests based on surveys of expectations often reject the REH (Carlson, 1977; Urich and Wachtel, 1984; Caskey, 1985; Zarnowitz, 1985; Milani, 2007, etc.) because survey forecast errors are serially correlated. This implies that the forecasts are not efficient in that they omit relevant information available to forecasters.

Due to the accumulated evidence rejecting the REH, researchers have proposed that agents may not have access to all information about the structure of the economy but that they learn about it over time. This assumption is referred to as "adaptive learning". Agents behave like econometricians when making forecasts and adjust their forecast rule as new data become available over time. In fact, a large volume of research has demonstrated theoretically the stability of monetary policy under learning (see, for example, Evans and Honkapohja, 2001, 2003a,b, 2006; McGough et al., 2005; Preston, 2006, etc.).

While these studies use least squares learning in theoretical macro models, they do not show whether agents show learning behavior.[2] In this study, therefore, we conduct a formal direct test of whether agents' forecasts of the three month T-bill rate are consistent with least squares learning when there are changes in monetary policy. We specifically examine the one quarter ahead median three month T-bill forecasts from the SPF.

We first derive the theoretical conditional mean, variance and autocovariances of the forecast error of the short-term interest rate from the SPFs assuming there are discrete shifts in policy and least squares learning. We show that when the optimal weights associated with the parameters of the forecasting model changes due to structural shifts, under least squares learning the forecast error will not have zero mean and constant variance. Then we apply the Bai and Perron (1998, 2003) test to identify the number and dates of the breaks in the optimal weights for the information set of the short-term interest rate forecasting model.[3] Next, we estimate the optimal weights for the agents' information set in each policy regime and empirically estimate the conditional mean and variance of the forecast error. Then we standardize the median forecast error from the SPFs with the estimated mean and variance. Finally, we test the standardized residuals for serial correlation. If agents have the

[1] The proxy for the risk-free rate used in asset pricing models is the US T-bill rate.

[2] In fact, the one exception is Branch and Evans (2006), who conduct an indirect test of whether agents show learning behavior by using different learning algorithms to try and reproduce the SPFs' forecasts for inflation and output growth. Our study differs from Branch and Evans (2006) in that we employ a more direct test of learning in our paper.

[3] We use the Bai and Perron (1998, 2003) test because it is the most widely used in the literature for finding structural breaks in the US T-bill rate.