METU Studies in Development, 24 (3) 1997, 319-327

Inflation, inflation risk and interest rates: A case study for Turkey

Hakan Berument*
Department of Economics, Bilkent University, 06533 Bilkent, Ankara Turkey

Nuray Güner
Department of Management, Middle East Technical University, 06533 Ankara Turkey

Abstract

There is a growing interest in how economic uncertainty affects economic growth. The overall macroeconomic uncertainty might be proxied by inflation risk and the interest rate can be taken as a transmission mechanism. In this paper, the effect of inflation instability on the three-month interest rate on time deposits in Turkey is examined. Following Bollerslev (1986), the variability of inflation is modeled as a GARCH(1,1) process. It is found that the level of inflation and inflation uncertainty increase the three-month time deposit interest rate for Turkey over the period 1987:03 to 1997:06 at the 99% significance level.

1. Introduction

New developments in macroeconomic policy emphasize the effects of macroeconomic uncertainty on economic growth and investment (see Rodrik 1991; Barro, 1991; Aizenman and Marion, 1993; Aizenman and Hausmann, 1994; and Dornbush and Edwards, 1995). Despite the general acknowledgment

* We wish to thank Richard Froyen, Valerie Ginter, Miguel Herce, Michael Salemi, Serdar Sayan, John Wood and an anonymous referee for their comments.

that economic uncertainty affects economic growth negatively, economists have not yet assessed a transmission mechanism through which the uncertainty associated with government's macroeconomic policy influences economic performance. In this paper, following the approach taken by Fisher (1993), we assume that inflation uncertainty proxies for overall macroeconomic uncertainty and the interest rate can be taken to be a transmission mechanism. We then examine the impact of inflation uncertainty on the interest rate in Turkey.

Turkey provides a unique environment to study the effect of inflation uncertainty on interest rates because of historically high and volatile inflation rates. Since investors are risk averse, they prefer to have a higher return for a given level of risk, or a lower risk for a given level of return.[1] Risky assets, therefore, should offer a higher return to investors as compensation for assuming higher risk. Hence, higher inflation uncertainty must be associated with higher returns.

Riskiness of a variable is generally measured by the standard deviation (or variance) which is the long run estimate of volatility. On the other hand, investors are more concerned about the variability of inflation over the period that they hold the assets (i.e., the conditional standard deviation). This is especially important when there is a big difference between conditional (over the holding period) and unconditional (in the long run) standard deviations. Therefore, we proxy the uncertainty of inflation with the conditional standard deviation of inflation. Recent advances in econometric methods allow us to estimate the conditional variability. Following these developments, we estimate the conditional variance of inflation using a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model.

In this paper, the three-month time deposit interest rate is modeled as a function of expected inflation and of uncertainty associated with inflation. The empirical analyses indicate that the level of inflation and the inflation risk have a positive effect on the interest rate for Turkey during the period 1987:3 to 1997:6. This finding has important implications for the effectiveness of governments' macroeconomic policies and the validity of asset pricing models.

The plan of the paper is as follows: The next section develops and outlines the methodology used in this paper and describes the data. The findings are reported in Section 3. The last section summarizes the findings and concludes the paper.

[1] See, Markowitz (1952), Sharpe (1964), Lintner (1965), Black (1972) and Ross (1976).

2. Expectations, risk and GARCH models

After the introduction of the rational expectations hypothesis, economists have emphasizes the importance of developing new tools to identify the relevant information set used by agents to form their expectations. Most of the research is devoted to identifying the mean of variables in the information set of agents. However, Engle (1982) and Bollerslev (1986) introduce tools to model the second moments. The following subsection introduces the model used in this paper to measure the expected inflation (mean) and the inflation risk (second moment). The second subsection incorporates the expected inflation and inflation risk into the interest rate equation. Finally, the last subsection identifies the data sources and describes the data used in the analysis.

2.1. Expectations and the GARCH process

Assume that inflation, π_t, follows an invariable autoregressive process

$$\pi_t = i_0 + \sum_{j=1}^{q} i_j \pi_{t-j} + \epsilon_t \tag{1}$$

where i_t is the coefficient of the i^{th} lag of inflation, and ϵ_t is the discrete-time real valued stochastic process with a normal conditional distribution given by

$$\epsilon_t / \Omega_{t-1} \sim N(0,h_t) \tag{2}$$

Here, the conditional variance of ϵ_t with a given information set at time t-1 is h_t with a mean of zero and Ω_{t-1} includes all the information available to the agents at time t-1. Then, the conditional expectation of the inflation rate at time t with the given information set at time t-1 is

$$E_t(\pi_t/\Omega_{t-1}) = i_0 + \sum_{j=1}^{q} i_j \pi_{t-j} \tag{3}$$

Engle [1982] introduces the Autoregressive Conditional Heteroscedasticity (ARCH) model that allows the forecast variance of the inflation series to vary systematically over time. In ARCH models, h_t is assumed to depend on the past squared residuals from the π_t equation.

$$h_t = d_0 + \sum_{j=1}^{p} d_j \epsilon^2_{t-j} \tag{4}$$

Bollerslev (1986) then introduces the GARCH process, which extends the ARCH model to make h_t a function of lagged values of h_t as well as the lag values of ϵ_t^2. In this case, h_t, the conditional variance, is estimated by

$$h_t = d_0 + \sum_{j=1}^{p} d_{1j} \epsilon^2_{t-j} + \sum_{j=1}^{q} d_{2j} h_{t-j} \tag{5}$$

Bollerslev (1986) requires all estimated coefficients to be positive to ensure that the conditional variance is never negative. Furthermore, the sum of all d_{1j} and d_{2j} coefficients has to be less than one in order for the process to be stationary.

2.2. Estimation Process

Fisher (1907) argues that nominal interest rates must move with the expected inflation rate. Even if the nominal rate of return from an investment could be known in advance, the expost real return is subject to inflation risk. Hence, the inflation risk could also affect the interest rate. Equations 3 and 5 are used to estimate the expected inflation and the inflation risk. We then measure the effect of these variables on interest rates. In this paper, the nominal interest rate is assumed to be affected by the expected inflation, π^e_t, as well as the inflation risk, square root of h_t, and modeled as shown in the following equation:

$$r_t = c_0 + c_\pi \pi_t + c_h \sqrt{h_t} + \eta_t \tag{6}$$

The residual terms, η_t, and ϵ_t, have means of zero and constant variances. We assume that η_t and ϵ_t are distributed as

$$\begin{bmatrix} \epsilon_t \\ \eta_t \end{bmatrix} \sim N \left[\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} h_t & e_0 \\ e_0 & f_0 \end{bmatrix} \right] \tag{7}$$

where f_0 is the time-invariant variance of the residual η_t, and e_0 is the time-invariant covariance between η_t and ϵ_t. Both e_0 and f_0 will be estimated from the model.

Notice that h_t in equation 6 is a generated regressor. Pagan (1984) notes that using regressors generated by a stochastic model may lead to biased estimates of the parameters' standard errors. As a solution to this problem, Hoffman (1987) suggests using the generalized least square method to estimate the model. We estimate the parameters of the interest rate equation by using the Full Information Maximum Likelihood estimation technique.

2.3. Data and Sample

The sample includes monthly observations from 1987:03 to 1997:06 for Turkey. The consumer price index *(CPI)* and the interest rate are obtained from the International Monetary Fund-International Financial Statistics Data Base. The interest rate is the three-month time deposit rate since it is the longest continuous time series available for Turkey.

Since the three-month time deposit rate is used in the analysis, the inflation rate over the holding period will be important to investors. The continuously compounded three-month inflation rate is calculated as:

$$\pi_t = \log(CPI_{t+3}) - \log(CPI_t) \tag{8}$$

This is then a forward looking inflation rate rather than a backward looking one.

3. Empirical evidence and discussion

First, we try to fit an AR(p) model to the inflation rate. We obtain a parsimonious representation using an AR(12) process. To account for annual seasonalities in inflation rates, we include additive monthly dummies in equation 1 while performing the econometric analysis.[2] After finding the AR model that fit the data, we test for ARCH effects in the square of error terms

---

2 Ljung-Box Q-statistics for various lag lengths indicate that the residual series appear to be white noise at the 5% level. Furthermore, Akaike and Schwarz criteria are the lowest for this model across the different autoregressive orders that are considered.

from that model using the test statistic suggested by Engle (1982). To conduct this test, the square of the error terms are regressed on its first twelve lags and the TR^2 value is calculated. The test statistic is 25.44 and the critical value is 21.03 at the 95% level of confidence. Since this test statistic indicates the presence of autoregressive conditional heteroscedasticity components in squared error terms, we model the variance of inflation rate using GARCH(p,q) models.

Following Bollerslev (1986), we estimate the conditional variance of the inflation rate in Turkey using a GARCH(1,1) process. To test the implication of the hypotheses, we perform the maximum likelihood estimation of equations 3, 5 and 6. The parameter estimates are as follows;

$$
\begin{aligned}
\pi_t &= \pi_t^e + \epsilon_t \\
h_t &= \underset{(2.47)}{0.15} + \underset{(2.89)}{0.03}\,\epsilon_{t-1}^2 + \underset{(95.21)}{0.96}\,h_{t-1} \\
r_t &= \underset{(0.25)}{0.98} + \underset{(3.94)}{7.49}\sqrt{h_t} + \underset{(2.49)}{0.12}\,\pi_t^e + \eta \\
cov(\epsilon_t,\eta_t) &= \underset{(5.61)}{5.05} \\
\sigma_\eta^2 &= \underset{(1.99)}{0.57}
\end{aligned}
\qquad (9)
$$

where numbers in parentheses are the t-statistics. To save space, the coefficients of the inflation equation are not reported. The joint null hypothesis that the coefficients of the autoregressive variables of the inflation equation are statistically significant, and the hypothesis that the coefficients of the monthly dummies are jointly significant could not be rejected.

In the conditional variance equation, all the coefficients are positive and statistically significant at the conventional significance levels. These estimates suggest that the conditional variance estimates will never be negative. Furthermore, the sum of the coefficients of ϵ_{t-1}^2 and h_{t-1} is less than one, indicating a stationary process. Diagnostic tests did not indicate the need to include other lags in the GARCH(1,1) model.

In this model, all the coefficients in the interest rate equation are statistically significant at 99% except the intercept. Empirical evidence suggests that both the expected inflation rate and the variability of inflation have positive and statistically significant effects on the interest rate in Turkey. Furthermore, parameter estimates indicate that the effect of inflation risk on interest rates is much higher than that of the inflation rate. Given the highly volatile inflation rates experienced in Turkey, this result may not be surprising. Our findings indicate that the higher the variability of inflation and the level of inflation, the higher will be the three-month Turkish time deposit rate.

4. Conclusions

Investors are risk averse and, therefore, want to be compensated for assuming higher risks. As a result, the estimation of risk becomes an important issue. Risk is generally measured by standard deviation (or variance). Since investors are more concerned about the variability of returns over investors' holding period, the conditional standard deviation, not the unconditional one, should be known. The current advances in econometric methods allow the estimation of the conditional volatility of variables.

This paper analyzes the effect of inflation uncertainty on the risk-free interest rate in Turkey. The inflation risk is modeled as a GARCH(1,1) process. The empirical evidence shows that both uncertainty about inflation rate and the level of inflation are important in determining the interest rates. Moreover, the variability of the inflation rate increases the interest rate.

The three-month time deposit rate can be considered as the risk-free rate because of hundred percent deposit insurance provided by the government of Turkey, implicitly or explicitly. Since the risk-free rate is expected to affect the required rate of return on other investments and assets, finding an increase in the risk-free interest rate, as a result of changes in the volatility of inflation, implies that the required rate of return on other assets will be higher as well. Since a higher inflation risk increases the required rate of return and, in turn, higher interest rates discourage investment, this finding has important implications for effectiveness of government policies. Furthermore, since the current asset pricing models do not consider the inflation uncertainty, the validity of these asset pricing models should also be questioned.

Our findings imply that, as long as governments try to have a stable inflation rate, as well as a low inflation rate, they can achieve lower interest rates and, hence, stimulate economic growth. This is an important finding for countries that have high macroeconomic instability, especially for those that try to decrease their inflation rates to stimulate their economic growth, such as Turkey. Our findings imply that governments can stimulate economic growth as long as they have stable and credible macroeconomic policies even if the level of policy variables are outside the desired range for these variables.

The role of inflation risk in determining interest rates for developed countries and countries with stable macroeconomic policy should also be studied. If it is an important factor for these countries, the asset pricing models that are used extensively in finance may need to be modified to incorporate inflation risk. If inflation risk is not an important factor for developed countries, the asset pricing models may need to be modified when applied to countries with unstable macroeconomic policies. Furthermore, these models should be able to explain the role played by inflation risk in pricing securities for at least countries with unstable macroeconomic environments.

References

AIZENMAN, J. and HAUSMANN, R. (1994), "Why Is Inflation Skewed? A Debt and Volatility Story", NBER Working paper 4837.

AIZENMAN, J. and MARION, N. (1993), "Policy Uncertainty, Persistence and Growth", *Review of International Economics*, 1(2), 145-163.

BARRO, R. (1991), "Economic Growth in a Cross-section Countries", *Quarterly Journal of Economics*, 106(2), 407-43.

BLACK, F. (1972), "Capital Market Equilibrium with Restrictive Borrowing", *Journal of Business*, 45, 444-455.

BOLLERSLEV, T. (1986), "Generalized Autoregressive Conditional Heteroscedasticity", *Journal of Econometrics*, 31 (3), 307-27.

DORNBUSH, R. and EDWARDS, E. (1995), *Reform, Recovery and Growth.*, Chicago: University of Chicago Press.

ENGLE, R. (1982), "Autoregressive Conditional Heteroscedasticity with estimates of the variance of United Kingdom inflation", *Econometrica*, 50(4), 987-1007.

FISHER, I. (1907), *The Rate of Interest.* New York: Macmillan.

FISHER, S. (1993), "The Role of Macroeconomic Factors in Growth", *Journal of Monetary Economics*, 32(3), 485-512.

HOFFMAN, D. (1987), "Two-step Generalized Least Squares Estimators in Multi-equation Generated Regressor Models", *Review of Economics and Statistics*, 69(2), 336-46.

HOLT, M. and SATHEESH, V. (1990), "Price Risk in Supply Equations: an Application of GARCH Time-series Models to the U.S. Broiler Market", *Southern Economic Journal*, 57(1), 230-242.

LINTNER, J. (1965), "The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets", *Review of Economics and Statistics*, 47, 13-47.

MARKOWITZ, H.M. (1952), "Portfolio Selection", *Journal of Finance*, 7, 77-91.

PAGAN, A. (1984), "Econometrics Issues in the Analysis of Regressions with Generated Regressors", *International Economic Review*, 25(1), 221-47.

RODRIK, D. (1991), "Policy Uncertainty and Private Investment in Developing Countries", *Journal of Development Economics*, 36, 229-42.

ROSS, S. A. (1976), "The Arbitrage Theory of Capital Asset Pricing", *Journal of Economic Theory*, 13, 341-60.

SHARPE, W. F (1964), "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk", *Journal of Finance*, 19, 425-42.

TOBIN, J. (1965), "Money and Economic Growth", *Econometrica*, 33, 671-84.

Özet

Enflasyon, enflasyon riski ve faiz oranları: Türkiye için bir çalışma

Son zamanlarda ekonomik verilerdeki belirsizliğin ekonomiyi nasıl etkilediği incelendi. Bu çalışma enflasyondaki belirsizliğin üç-aylık Türkiye Cumhuriyeti devlet hazine bonolarının faiz oranlarını nasıl etkilediğini araştırmaktadır. Bollersev'in (1986) modellemesini takiben enflasyon riski GARCH(1,1) süreçli olarak tanımlandı. Enflasyondaki risk, faiz denklemine dahil edildiğinde, bu çalışma 1987: 03-1997:06 dönemi için faiz hadlerinin enflasyon riski ile positive bir ilişki içinde olduğunu buldu.