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Inflation and Output Growth in Turkey, 1963-1999

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An unresolved issue in macroeconomics centers on the relationships among inflation, inflation uncertainty, and real output growth. Starting with Friedman (1977), many economists have suggested that there should be a positive relationship between inflation and inflation uncertainty, since monetary policy becomes more erratic and unpredictable during periods of high inflation. Ball (1992) develops a model that predicts a positive link between the level of inflation and the degree of uncertainty about future inflation. Friedman and others suggest that greater inflation uncertainty will adversely affect real economic activity, because inflation uncertainty reduces the information content of prices, distorts relative prices and therefore lowers economic efficiency. Empirical evidence, although somewhat mixed, has generally supported a positive relationship between inflation and inflation uncertainty and a negative relationship between inflation uncertainty and real output growth [see Golob (1993) for a comprehensive review of the existing empirical literature].

Although both relationships (inflation-inflation uncertainty, and inflation uncertainty-output) are closely related theoretically, previous empirical research has investigated them separately. Most research on inflation uncertainty has been done on low inflation countries like the U.S., and high inflation countries have received much less attention. The contribution of this paper is to investigate both relationships simultaneously in the high inflation country of

Turkey. Following the methodology of Grier and Perry (2000), we use a bivariate GARCH-M system to estimate inflation, inflation uncertainty, and output growth simultaneously in a

system of equations to test the potential links between inflation-uncertainty and uncertainty-real output in Turkey from 1963-1999. We find strong statistical support that inflation significantly raises inflation uncertainty in Turkey and that inflation uncertainty significantly lowers real output growth in Turkey over the sample period.

The historical record of inflation and output growth in Turkey from 1963-1999 is presented in Section I. Section II introduces a bivariate GARCH-M model, empirical results are discussed in Section III, and Section IV contains a summary of our main findings.

I. Background on Turkish Inflation and Output Growth, 1963-1999

Turkish inflation grew from single digit levels in the 1960s and reached its first peak in 1980 at more than 80% (see Figure 1). After reaching a second peak of 125% in 1994, inflation started a downward trend in response to a series of stabilization measures that were introduced in the same year. Throughout the second half of the 1990s, inflation continued to fluctuate within a 70 to 100% range. However, after the introduction of the 1999 Disinflation and Fiscal Adjustment Program and the three-year stand-by agreement signed with the International Monetary Fund (IMF), inflation dropped significantly. Under the three-year stand-by arrangement, the year end inflation was targeted at 25% in 2000 and 10-12% by the end of 2001. Turkey today is still

considered a high inflation country with an inflation rate just under 30%.

A combination of internal and external factors starting in the late 1970s was responsible for Turkey's record of high inflation. Throughout the 1960s and the 1970s, Turkey followed an inward-looking growth strategy driven by import substitution policies. During the earlier stages of this strategy inflation was relatively low and the expansionary effects of macro policies were moderate. The public sector, which was the driving force behind the growth strategy, relied heavily on domestic savings and foreign exchange receipts to meet borrowing requirements. However, as public sector borrowing requirements reached unmanageable levels due to excessive spending during the 1973-74 oil crisis, Turkey resorted to external borrowing and intensified its aggressive short-term borrowing practices. A balance of payments crisis followed and led to the debt crisis of 1978. Rising monetary aggregates exacerbated the inflation situation; that, and supply limitations resulting from shortages of imported inputs, caused inflation to accelerate significantly toward the end of the 1970s.

In 1980, Turkey introduced drastic measures to stabilize the economy, encourage export promotion, and gradually remove trade barriers and foreign exchange restrictions. The main goals of these measures were to lower inflation from the peak of more than 80%, improve the balance of payments, and through further restructuring transform Turkey into an outward looking export driven economy. Inflation initially fell to 30% in 1981, but gradually then began to rise and fluctuate within a 40 to 70 percent range during the rest of the 1980s.

Starting in 1988, Turkey began to follow populist measures that caused inflation to accelerate in the following years. As a result of excessive spending, rapid expansion of public sector credits, and expansionary monetary policies motivated by local and general elections, inflation rose significantly in the 1990s. Inflation reached its all time high of 125% in 1994, and Turkey experienced a severe financial crisis.

In response to the rising inflation and the widening budget deficits, the government tried to keep interest rates low and switched from domestic borrowing to foreign debt and monetization. This policy, which was intended to reduce inflation without giving up economic growth, led instead to higher interest rates, higher deficits, and continued high inflation. The austerity plan introduced in 1994 did eventually succeed in bringing inflation down temporarily, but did not eliminate the macroeconomic imbalances. The year-end inflation, after surging to 125%, declined to 72% in 1995 but rose to almost 100% again by 1997. Efforts to reduce the interest burden on the budget continued, but that did not prevent the noninterest expenditures from rising. Thus, one primary source of inflation, excessive spending and the resulting budget deficits, remained in effect, and inflation continued to dominate Turkey's macroeconomic environment in the later 1990s.

One of the real, potential costs that high levels of inflation imposes on the economy, is the accompanying increase in uncertainty about future inflation. An empirical analysis of Turkish inflation by Nas and Perry (2000) confirms that the course of future inflation became much harder to predict during the episodes of high inflation, leading to the close link between the level of inflation and uncertainty about future inflation shown in Figure 2. The figure reveals that annual inflation uncertainty, measured by the conditional variance of inflation using GARCH techniques, rose significantly during the periods of high inflation.

The effects of inflation on real output growth (measured by the growth rate in industrial production) are also considerable (see Figure 3). Generally, the periods of high inflation are associated with declining growth rates of industrial output. From the mid-1960s to 1980, the growth rate of industrial output fluctuated in a downward trend as inflation rose. Especially after the 1973-74 oil crisis when inflation began its steep rise, output growth moved in the opposite

direction, declining almost 11% in 1979, about the same time when inflation peaked. A subsequent decline in inflation was followed by a decline in output, but thereafter, as inflation began an upward trend during the 1980s and 1990s, output growth fluctuated for the most part in the opposite direction. During the 1994 financial crisis, in particular, industrial production growth hit another yearly low of -7.5%, as inflation rose sharply. Thus, over the 1963-1999 period, output growth rates were negative and lowest when inflation reached its highest levels during the 1979 and 1994 crises.

As depicted in Figure 4, at the highest levels of inflation uncertainty, output growth rates were also negative and at their lowest levels.[1] Although during the 1979 debt crisis the decline in real output slightly preceded the increase in inflation uncertainty, for the most part, rising inflation uncertainty was accompanied by declining output growth rates on an annual basis (e.g., during the 1994 crisis).

Clearly, an analysis of the historical record and graphical evidence of annual data indicates that inflation, inflation uncertainty, and real output growth are closely related in Turkey. To further investigate these relationships more formally, we next develop a bivariate GARCH-M system of equations to simultaneously investigate in a single model the relationships between a) monthly inflation and inflation uncertainty and b) monthly inflation uncertainty and real output growth.

II. Bivariate GARCH-M Model of Inflation, Inflation Uncertainty and Output Growth A multi-equation GARCH-M model allows equations for the conditional means, conditional variances and covariances of both inflation and output growth to be jointly estimated. The level of inflation is included as an exogenous variable in the equation for the conditional variance of inflation to determine whether average inflation affects the level of inflation uncertainty. The conditional variance of inflation generated from a GARCH(1,1) specification of inflation is used as a time-series measure of inflation uncertainty and appears as a regressor in the output equation to test for the effects of inflation uncertainty on real output in Turkey.[2]

A bivariate GARCH(1,1)-M model consists of the following equations:

$$\Pi_t = \beta_0 + \sum_{i=1}^n \beta_i \Pi_{t-i} + \sum_{i=n+1}^m \beta_i \varepsilon_{t-i} + \varepsilon_t \quad (1)$$

$$\sigma_{\varepsilon_t}^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \sigma_{\varepsilon_{t-1}}^2 + \alpha_3 \Pi_t \quad (2)$$

$$Y_t = \Theta_0 + \sum_{i=1}^n \Theta_i Y_{t-i} + \sum_{i=n+1}^m \Theta_i v_{t-i} + \Theta_{m+1} \sigma_{\varepsilon_t}^2 + v_t \quad (3)$$

$$\sigma_{v_t}^2 = \alpha_3 + \alpha_4 v_{t-1}^2 + \alpha_5 \sigma_{v_{t-1}}^2 \quad (4)$$

$$\text{COV}_t = \rho_{\varepsilon v} \sigma_{\varepsilon_t} \sigma_{v_t} \quad (5)$$

Inflation (Π_t) and output growth (Y_t) in equations (1) and (3) follow an autoregressive-moving average (ARMA) process, and are a function of autoregressive lags and moving average terms. Equations (2) and (4) are GARCH(1,1) specifications for the conditional variances of inflation ($\sigma_{\varepsilon_t}^2$) and output growth ($\sigma_{v_t}^2$) respectively, implying that the conditional variance at

time t depends on the squared residuals at time $t-1$ (ϵ_{t-1}^2) from the conditional mean equations (1) and (3) and the lagged conditional variances. The constant conditional correlation model of the covariance between ϵ_t and v_t is represented in equation (5).[3]

III. Empirical Results

In applying the GARCH-M model to the Turkish case, inflation is calculated as the log of the monthly difference in the producer price index (PPI), on an annualized basis [$\Pi_t = \log(PPI_t / PPI_{t-1}) * 1200$]. Real output growth is likewise the log of the monthly difference in industrial production (IP): [$Y_t = \log(IP_t / IP_{t-1}) * 1200$] on an annualized basis. The sample period is monthly from 1963.01 to 1999.12 using data from the Turkish Central Bank.

Assuming that Turkish inflation and output growth follow standard ARMA processes, we first specify single equation OLS models for each variable.[4] With standard Box-Jenkins techniques, we determine that the best fitting time-series models for inflation is eight autoregressive lags and a twelfth-order moving average term. The output equation also contains eight autoregressive lags and a twelfth-order moving average term.

The bivariate GARCH-M system of equations (1-5) is next estimated using a nonlinear maximum likelihood technique and the results are reported in Table 1.[6] Estimates for the conditional mean and conditional variance of inflation are reported in equations (1) and (2). The GARCH(1,1) coefficients in equation (2) are both significant at the 1% level, and sum to less than one which is a requirement for stationarity of the conditional variance process.[5] The estimated coefficient for inflation in the conditional variance of inflation equation is positive and significant at the 1% level (t-statistic = 2.94), indicating that inflation significantly raises inflation uncertainty in Turkey over this period.

Equations (3) and (4) report the estimates of the conditional mean and conditional variance of real output growth. The GARCH(1,1) parameters in the conditional variance equation (4) are stable (they sum to less than one), and the coefficient for the lagged, squared residuals (v_{t-1}^2) is significant at the 1% level (t=2.66). The coefficient on the lagged error variance (σ_{vt-1}^2) in the output equation is insignificant, indicating that output growth shocks have no persistent effect on output growth uncertainty. The estimated coefficient for inflation uncertainty (σ_{et}^2) in the output equation is negative (-.760) and significant at the 1% level (t-stat = -3.30), indicating that inflation uncertainty significantly lowers average output growth in Turkey. The conditional correlation coefficient in equation (5) is not significantly different from zero, suggesting that the residual covariance between equations is not significant.

A series of diagnostic tests on the residuals and squared residuals are reported at the bottom of Table 1. Ljung-Box Q-tests for 12 lags show that the errors and squared errors are serially uncorrelated (at the 5% level) for the inflation and output equations, indicating that our GARCH(1,1)-M system adequately captures both the conditional variance and the joint distribution of the residuals.

The main implication of our empirical study is that we find strong statistical support for Friedman's hypotheses in Turkey during the 1963-1999 period. Using bivariate GARCH-M methods to simultaneously estimate inflation, inflation uncertainty and output growth in a single system of equations, we find that the level of inflation significantly **raises** inflation uncertainty in Turkey (at the 1% level), and that inflation uncertainty significantly **lowers** real output growth (at

the 1% level).

Figure 5.

The average monthly inflation shock occurs at month zero. The maximum effect of inflation on both output growth and inflation uncertainty occurs two months after the shock, and the effect of inflation lasts for about 6-7 months before gradually disappearing. At the maximum effect two months after the shock, real output growth is decreased by about 7 percentage points (on an annualized basis), and inflation uncertainty is increased by almost 10 percentage points (annualized).

IV. Summary and Conclusions

In this paper, we present a GARCH-M system of equations to simultaneously examine the inflation-inflation uncertainty and inflation uncertainty-real output growth relationships empirically in Turkey using monthly data. The evidence shows that Turkish inflation *significantly raises* inflation uncertainty and *lowers* real output growth during the 1963-1999 period. Further investigation indicates that the adverse effects of inflation and inflation uncertainty on real output growth in Turkey are nontrivially large and persistent.

Based on the empirical evidence that we uncover, real output growth in Turkey will improve significantly if inflation continues its downward trend. The 1999 Disinflation and Fiscal Adjustment Program (supported by the stand-by agreement with the IMF) is designed to lower inflation into single digits and achieve real output growth of 5.8% by 2002. Recent macroeconomic data indicates that the program's performance is in line with expectations. Inflation has declined considerably and industrial production rose sharply during the first half of 2000. Based on these encouraging outcomes and the predictions of our model, the strict implementation of the 1999 program, by lowering inflation and inflation uncertainty, should lead to the realization of target growth rates for real output during the next three years.

Endnotes

1. Inflation uncertainty is measured here, as in Figure 2, as the annualized conditional variance of inflation, using a single equation GARCH(1,1) model for Turkish inflation.
2. Before the introduction of ARCH and GARCH models, ad-hoc measures of inflation uncertainty were used previously including the moving standard deviation of the inflation rate and the cross-sectional dispersion of individual forecasts from survey data. GARCH methods are statistically superior to ad-hoc methods, because by estimating the conditional variance of inflation, an actual parametric, time series measure of inflation uncertainty is constructed.
3. Several parameterizations of the general multivariate GARCH model are possible, including the constant conditional correlation model outlined in Bollerslev (1990). In the constant conditional correlation model, the conditional covariance matrix is allowed to be time-varying but the conditional correlation across equations is assumed to be constant. The assumption of a constant correlation matrix represents a major reduction in terms of computational complexity and is commonly used in multivariate GARCH estimation.
4. Using Dickey-Fuller and Phillips-Peron tests, we first investigate whether inflation and real output growth in Turkey are stationary variables. The null hypothesis of a unit root is rejected at

the 1% level for both variables at various lag lengths using both tests, indicating that both inflation and output growth are clearly stationary.

5. Other specifications besides a GARCH(1,1) model of the conditional variance are possible and were considered, but the GARCH(1,1) model provided the best-fitting model.

6. The software used to estimate the GARCH system of equations is a FORTRAN program called MGARCH, which is available from the University of California-San Diego.

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Table 1. INFLATION AND OUTPUT GROWTH IN TURKEY: GARCH(1,1)-M System

$$\begin{aligned}
(1) \Pi_t = & 7.64 + .55 \Pi_{t-1} - .06 \Pi_{t-2} + .13 \Pi_{t-3} - .001 \Pi_{t-4} - .02 \Pi_{t-5} + .006 \Pi_{t-6} + .009 \Pi_{t-7} \\
& (3.66) \quad (7.11) \quad (0.90) \quad (2.03) \quad (0.02) \quad (0.37) \quad (0.11) \quad (0.02) \\
& + .15 \Pi_{t-8} + .13 \varepsilon_{t-12} + \varepsilon_t \\
& (2.66) \quad (3.36)
\end{aligned}$$

$$\begin{aligned}
(2) \sigma_{\varepsilon_t}^2 = & 179.4 + .347 \varepsilon_{t-1}^2 + .309 \sigma_{\varepsilon_{t-1}}^2 + 2.65 \Pi_t \\
& (4.57) \quad (6.60) \quad (4.66) \quad (2.94)
\end{aligned}$$

$$\begin{aligned}
(3) Y_t = & 36.5 - .57 Y_{t-1} - .27 Y_{t-2} - .17 Y_{t-3} - .19 Y_{t-4} + .19 Y_{t-5} - .13 Y_{t-6} - .17 Y_{t-7} - .16 Y_{t-8} \\
& (4.99) \quad (10.55) \quad (4.52) \quad (3.10) \quad (3.33) \quad (3.49) \quad (2.34) \quad (2.88) \quad (3.71) \\
& + .22 v_{t-12} - .760 \sigma_{\varepsilon_t}^2 + V_t \\
& (4.56) \quad (3.30)
\end{aligned}$$

$$\begin{aligned}
(4) \sigma_{v_t}^2 = & 1599 + .205 V_{t-1}^2 + .247 \sigma_{v_{t-1}}^2 \\
& (2.25) \quad (2.66) \quad (0.94)
\end{aligned}$$

$$\begin{aligned}
(5) \text{COV}_t = & -.039 \sigma_{\varepsilon_t} \sigma_{v_t} \\
& (0.65)
\end{aligned}$$

	Inflation Eqn.	Output Eqn.	Cross-Eqn.
Q(12)	13.82	16.28	18.66
Q ² (12)	8.00	8.28	-

Log Likelihood Function = -4367

Sample period is 1963.01 - 1999.12. Π_t is the inflation rate calculated from the Producer Price Index and Y_t is the growth rate of industrial production (seasonally adjusted). T-statistics are in parentheses. Q(12) is the Ljung-Box statistic for twelfth-order serial correlation in the residuals. Q²(12) is the Ljung-Box statistic for twelfth-order serial correlation in the squared residuals. The critical value for both Q-statistics is 21.0 at the .05 level.

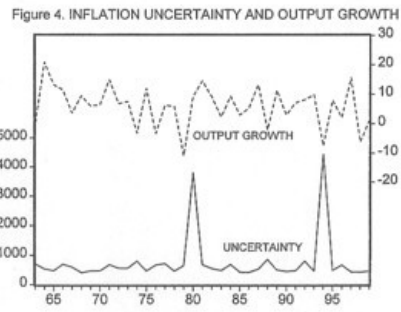
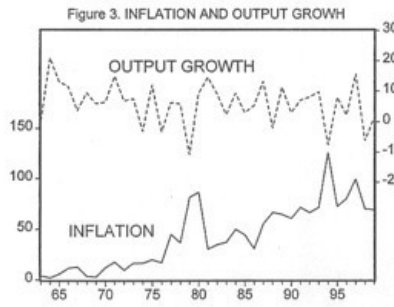
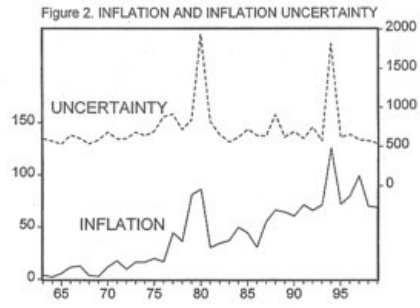
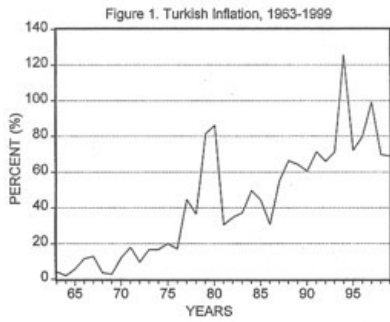


FIGURE 5. The Effect on an Average Positive Inflation Shock on Inflation Uncertainty and Output Growth

