IMF Working Paper

WP/98/161

INTERNATIONAL MONETARY FUND

Western Hemisphere Department

Inflation, Uncertainty, and Growth in Colombia[1]

Prepared by Henry Ma

Authorized for distribution by Olav Gronlie

November 1998

Abstract

It has been argued that higher levels of inflation lead to greater uncertainty about future inflation and to greater dispersion of relative prices. In either case, inflation could reduce the efficiency of market prices in coordinating economic activities. This paper shows that the rise of inflation in Colombia, from low levels in the 1950s to average rates of 18–22 percent since the 1970s, has been accompanied by increased uncertainty and relative price dispersion; and that inflation has had a negative and persistent effect on real GDP growth.

JEL Classification Numbers: E3, O5

Keywords: inflation, inflation uncertainty, relative price dispersion, VAR

Author's E-Mail Address: hma@imf.org

[1]The author thanks Alvaro Almeida, Peter Christoffersen, Olav Gronlie, Wayne Lewis, Evan Tanner, John Thornton, and Tarik Yousef (all at the IMF), and Marta Misas (Banco de la República, Colombia), for comments on an earlier version of this paper.

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SUMMARY

It has been argued that inflation has a negative effect on economic efficiency and growth because higher levels of inflation lead to greater uncertainty about future inflation and to greater relative dispersion of prices. In either case, the allocative signals sent by the price system become "muddled," and economic agents find it more difficult to optimize. This paper investigates whether these hypotheses apply to Colombia, which has experienced a rise in inflation from low levels in the 1950s to moderate (i.e., 18–22 percent) and persistent levels since the 1970s.

Historical data show that there is a positive correlation between the level of inflation in Colombia and its observed variability. However, because the observed variability of inflation could well have been forecast by economic agents, it could be a misleading measure of inflation uncertainty. Consequently, a generalized autoregressive conditional heteroscedastic (GARCH) model of inflation was estimated, and the conditional variance of the model's forecast errors was extracted and used as a measure of uncertainty. The results suggest that higher inflation is also associated with greater uncertainty about future inflation. A GARCH model of relative price dispersion also shows that both trend inflation and inflation uncertainty are associated with greater relative price dispersion

The final section of this paper investigates whether either the increased inflation uncertainty or the relative price dispersion associated with inflation has deterred investment and growth. A vector autoregression (VAR) analysis shows that there is weak evidence for the negative effects of uncertainty or dispersion. However, there is strong evidence that the level of inflation has had a negative and persistent effect on growth.

I. INTRODUCTION

Between 1955 and 1972, inflation in Colombia was relatively low. Since 1973, however, Colombia has experienced inflation averaging 18–22 percent (see Figure 1), making it the "moderate-inflation country par excellence" (Dornbusch and Fischer, 1993).[2] Yet, Colombia has also been known for its prudent macroeconomic policies, to which have been attributed its record of sustained economic growth and manageable external debt, in contrast to the experience of other Latin American countries. Fiscal deficits were kept low (before widening somewhat in the 1990s), while monetary authorities have kept an eye toward an alarm signal of 30 percent inflation: When inflation exceeds that level (as in 1977 and 1990), monetary policy counteracts it (Echeverry, 1996).

Perhaps because moderate inflation has been accompanied by sustained growth, there has not been much demand for stronger measures to reduce inflation. But inflation is now higher than the rest of the region. In the 1980s, inflation averaged 24 percent in Colombia, vs. 437 percent in Argentina, 340 percent in Brazil, 20 percent in Chile, and 65 percent in Mexico. In 1997, however, inflation was 18 percent in Colombia, whereas it was 0.6 percent in Argentina, 8 percent in Brazil, 6 percent in Chile, and 13 percent in Mexico. Perhaps not coincidentally, Colombia's growth rate now also lags. In the 1980s, real GDP growth in Colombia averaged 3.4 percent, vs. -1 percent in Argentina, 1.5 percent in Brazil, 3 percent in Chile, and 2.2 percent in Mexico. In 1997, real GDP growth was 3 percent in Colombia, 8 percent in Argentina, 3.5 percent in Brazil, 6 percent in Chile, and 7 percent in Mexico.

This paper investigates whether persistent moderate inflation has had a detrimental effect on Colombia's economic growth. It has been argued that inflation has a negative effect on economic efficiency and growth because higher levels of inflation lead to: (i) greater uncertainty about future inflation and (ii) greater dispersion of relative prices. In either case, the allocative signals sent out by the price system become "muddled," and economic agents find it more difficult to make optimal decisions. To the extent that uncertainty depresses investment and growth, the persistence of moderate inflation in Colombia could help explain why Colombia's economic performance now lags other Latin American countries that have sharply reduced inflation.

II. INFLATION AND UNCERTAINTY: THEORY

A. Mechanisms

There are two ways in which high inflation could be associated with price uncertainty.

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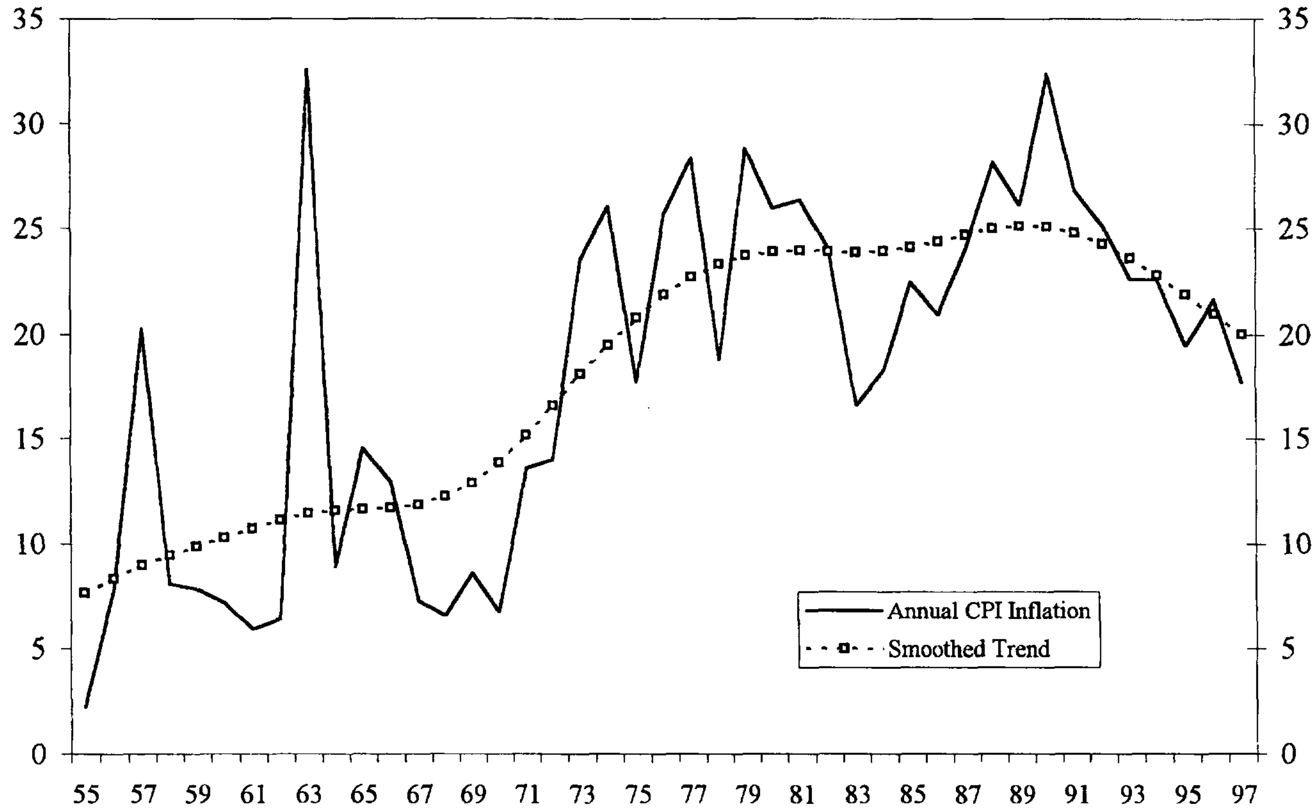
[2]Several reasons why inflation has persisted in that range have been: the crawling peg exchange rate adopted in 1967; the indexation of the system of housing finance (UPACs); the indexation of tax brackets; and informal partial indexation of wages.

Figure 1. Colombia: Consumer Price Inflation
(In percent)



First, high inflation could be associated with *inflation uncertainty*; that is, increased uncertainty regarding future inflation.[3] For an economy to function efficiently, economic agents require clear signals from markets when making decisions regarding consumption and investment because many decisions are dependent on the formation of expectations regarding prices. However, inflation uncertainty causes the real value of future payments and earnings to be uncertain. It causes sellers to become uncertain about real profits, employees about real wages, and tenants and proprietors about real rents, and could thereby distort these agents' decisions regarding the allocation of goods and labor. Inflation uncertainty also increases the riskiness of the real returns on financial instruments. Consequently, investors would attach a larger inflation risk premium to financial instruments, thus raising nominal interest rates, and to the extent that the inflation risk premium exceeds actual inflation, the real interest rate as well; this, in turn, would make it more difficult for otherwise viable projects to pass rate-of-return hurdles.[4] Finally, to avoid the risks arising from inflation uncertainty, economic agents could put off or alter their decisions. For instance, business could postpone capital formation, households could put off housing investment, or savers could pursue costly hedging strategies.[5]

Second, high inflation could reduce the informational efficiency of the price system by raising the *relative dispersion of prices*. The relative price of a good is its price relative to the price of another good, or alternatively, to the composite price of a basket of goods (e.g., the consumer price index). The relative prices of goods affect the decisions of economic agents and, ideally, should be determined solely by demand and supply conditions. Although some degree of relative price dispersion is unavoidable in a market economy, large changes in relative prices that are unrelated to fundamental demand and supply conditions could generate inefficiencies and reduce economic welfare by "muddling" economic agents' expectations, thereby fostering suboptimal decisions.

B. Theoretical Explanations

Ball (1992) provides a theoretical rationale for a positive relationship between high inflation and inflation uncertainty. As inflation increases, the public could become more uncertain about the central bank's attitude toward inflation. Because of a presumed short-run trade-off between inflation and unemployment, when inflation is low, everybody wants to keep it low, but at higher levels, central banks that are committed to low inflation would try to reduce it, whereas those with a weaker commitment may be deterred by the lower growth and higher

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[3]Okun (1971) and Friedman (1977) were among the first to postulate the relationship.

[4]For the U.S., according to Campbell (1995), the effect of inflation uncertainty on real interest rates could be as high as 1.25 percentage points. Also see Wardlow (1994).

[5]These cases have to do with the *ex ante* effects of inflation uncertainty. *Ex post*, if actual inflation differs from expected inflation and if contracts are denominated in nominal terms, unanticipated income redistribution would occur.

unemployment that disinflation could entail. Hence, the central bank's response to inflation becomes less certain when inflation is high. In a nutshell: Inflation creates a situation in which major policy changes become more likely and the outcomes of such changes become more uncertain.[6]

On the other hand, two alternative hypotheses could explain the positive relationship between inflation and relative price dispersion. First, there could be fixed costs to changing prices ("menu costs"). In this environment, it has been suggested that a firm would practice an (S, s) pricing rule: It would hold its nominal price constant until inflation brings the real price down to some lower threshold, s, at which point it would adjust the nominal price to bring the real price back up to S. If fixed costs vary across firms or firms face shocks specific to themselves, then price changes in the economy would be staggered and higher inflation would increase the dispersion of relative prices. Second, the increased inflation uncertainty associated with higher inflation brings with it "signal extraction problems." The greater is inflation uncertainty, the less do firms adjust output in response to shocks (even fundamental demand and supply shocks). Consequently, in each market, prices have to move more in order to ensure equilibrium between demand and the now less-variable supply, and thus relative price dispersion increases. The first hypothesis implies a positive relationship between the *level* of inflation and relative price dispersion, while the second implies such a link between *inflation uncertainty* and relative price dispersion. (These alternative hypotheses are tested in Section III.B.)

C. Consequences

In an environment characterized by uncertainty (whether arising from inflation uncertainty, relative price dispersion, or macroeconomic volatility in general), economic agents become more likely to make mistakes or to incur large transactions costs (e.g., the cost of inflation hedges), making economic welfare lower than it would otherwise have been.[7] Furthermore, it would seem intuitive that the uncertainty generated by inflation (and uncertainty in general)

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[6]Other explanations have been suggested. Devereux (1989) suggests that greater uncertainty about real disturbances increases inflation uncertainty and reduces the degree of wage indexation; the latter makes it more tempting for the monetary authorities to exploit the short-run trade-off between inflation and unemployment, by creating surprise inflation. Holland (1993) points to forecasters' uncertainty about the impact of monetary growth on prices as the link between inflation and inflation uncertainty.

[7]Also, Ball and Romer (1993) point out that if customers and suppliers form long-term relations, then customers use current prices as signals of future prices. However, inflation reduces the informativeness of current prices, causing customers to make costly mistakes. In addition, the reduced informativeness of prices makes demand less price-elastic, thereby increasing markups. Both negative effects on welfare could be quantitatively significant even at moderate inflation rates.

would depress capital formation and, in turn the rate of economic growth.[8] However, it should be noted that economic theory does not provide clear predictions regarding the net effect of uncertainty on investment. As Servén (1996) points out, if the marginal revenue product of capital is a convex function of the output price and if the evolution of the output price is uncertain, then higher uncertainty could in fact raise the desired capital stock and hence investment. Furthermore, even if uncertainty deters investment at the level of individual firms, the impact on aggregate investment could differ, due to the nonlinearity of investment policies. Likewise, Caballero (1991) shows that a negative relationship between price uncertainty and investment is not theoretically robust. Ultimately, this relationship is a matter for empirical verification and could likely differ from one case to another.

III. Inflation and Uncertainty: Evidence

A. Inflation Uncertainty

Historical Evidence

Early studies on inflation and inflation uncertainty employed the observed variance or standard deviation of inflation as the measure of uncertainty.[9] Figure 2a shows the relationship between the annual average of quarterly inflation and the corresponding standard deviation for the year; both are calculated over non-overlapping four-quarter periods, covering 1955Q1–1997Q4.[10] The least-squares regression line drawn through the points indicates a positive relationship between the two variables. However, if long-term nominal contracts are more likely to be subject to the costs of unanticipated inflation, then long-run uncertainty would matter more to economic agents, and hence one should average over longer periods than four quarters. Accordingly, Figures 2b–2d show inflation and its standard deviation over

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[8]Aizenman and Marion (1993a, 1993b, and 1998) investigate the effects on growth of policy uncertainty; Pindyck and Solimano (1993) and Ramey and Ramey (1995), of macroeconomic volatility; and Mendoza (1997), of terms-of-trade volatility.

[9]Golob (1994) surveys 21 studies of inflation and its variability and finds that 17 of the studies suggest a positive relationship. Hess and Morris (1996) reach a similar conclusion, using cross-section samples of 47 low-to-moderate inflation countries and 21 OECD countries. Joyce (1997) shows that during the post-war period, higher inflation in the U.K. has been associated with greater variability.

[10]Inflation for each quarter is measured as the percentage change between the final-month CPI for that quarter and that for the previous quarter.

non-overlapping six-quarter, eight-quarter, and twelve-quarter periods.[11] The positive relationship holds even over longer horizons.

Nevertheless, observed variability may not be a valid proxy for uncertainty (which is not directly observable) because it could well have been forecast by economic agents. It has therefore become standard to estimate a forecasting equation of inflation, from which the conditional variance of forecast errors is extracted and used as a measure of uncertainty.[12] In this regard, ARCH (autoregressive conditional heteroskedasticity) models of inflation are well-suited for deriving inflation uncertainty.[13] An ARCH model of inflation assumes that inflation uncertainty (the conditional variance of inflation) depends on the size of past squared errors in forecasting inflation. This assumption is appropriate where both large and small forecasting errors are clustered, which has been observed to be the case with inflation.

A GARCH Model of Inflation

A general model of inflation with conditional heteroscedasticity assumes that the conditional mean and variance of inflation are generated as follows:

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[11]The corresponding OLS regressions are as follows (T-statistics are in parentheses):

Figure 2a:	Av SD = 0.35 + 0.42*Av inflation (0.82) (4.50)	AdjR^2=0.31, DW=1.89
Figure 2b:	Av SD = 0.87 + 0.34*Av inflation (1.82) (3.19)	AdjR^2=0.25, DW=1.45
Figure 2c:	Av SD = 0.81 + 0.36*Av inflation (1.43) (2.93)	AdjR^2=0.27, DW=1.43
Figure 2d:	Av SD = 1.03 + 0.29*Av inflation (1.32) (1.74)	AdjR^2=0.14, DW=2.46

[12]Earlier studies using the forecasting approach include Evans (1991), Batchelor and Dua (1993), Brunner and Hess (1993), and Joyce (1997). A more direct way of measuring inflation uncertainty is to ask economic agents how uncertain they are about inflation or to measure the dispersion of inflation forecasts by survey respondents. In the U.S., this can be done with data from the ASA-NBER or Livingston surveys, but as of this writing there are no such data available for Colombia. See Batchelor and Dua (1993, 1996) for a comparison of the two methods.

[13]Although ARCH models are now used most often in econometric analyses of financial variables, they were in fact first used by Engle (1982) to model U.S. inflation and test whether its variance had changed over time. A good survey of ARCH models can be found in Bollerslev, Chou, and Kroner (1992).

Figure 2a. Non-Overlapping Four-Quarter Periods, 1955Q1-1997Q4

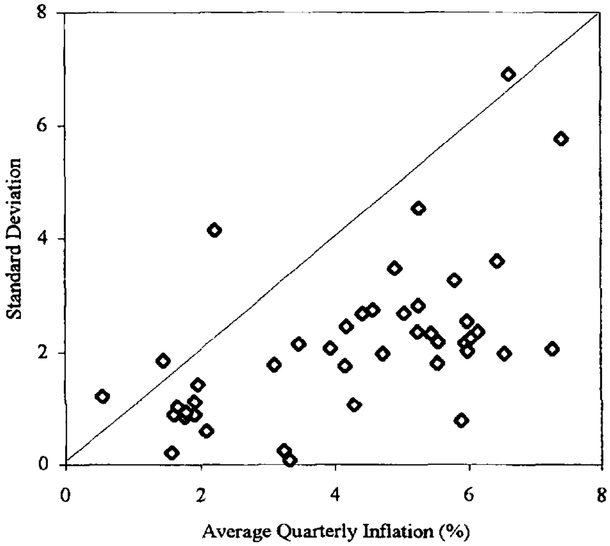


Figure 2b. Non-Overlapping Six-Quarter Periods, 1954Q3-1997Q4

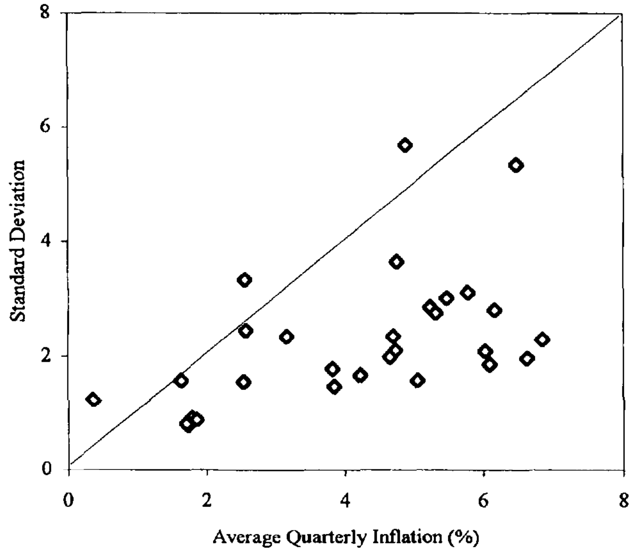


Figure 2c. Non-Overlapping Eight-Quarter Periods, 1956Q1-1997Q4

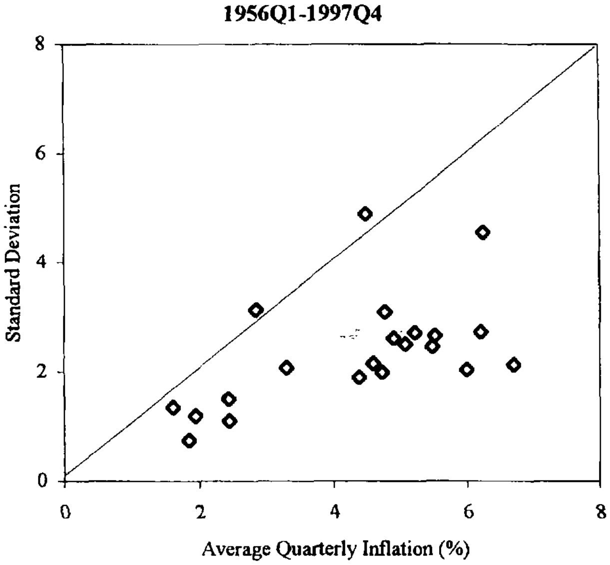
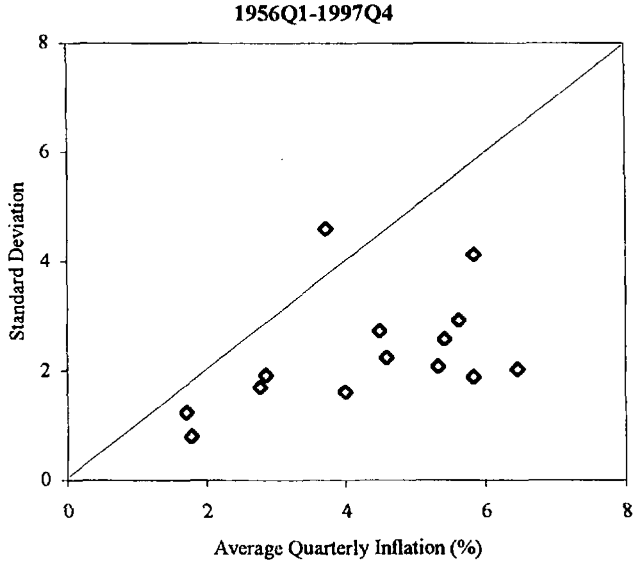


Figure 2d. Non-Overlapping Twelve-Quarter Periods, 1956Q1-1997Q4



$$\pi_t = x_t\beta + u_t$$

$$u_t \sim N(0,\sigma_t^2)$$

$$\sigma_t^2 = z_t\alpha$$

where π_t is the rate of inflation, x_t is a vector of explanatory variables contributing to the conditional mean of inflation, u_t is a heteroscedastic error term with conditional variance σ^2_t, and z_t is a vector of variables contributing to the conditional variance σ^2_t.

This paper uses a GARCH (1,1) model of the conditional variance of inflation (Bollerslev, 1986). It specifies that the variance depends on three factors, a constant; the previous period's news about the variance of inflation, which is taken to be the squared residual from the previous period (the ARCH term); and the previous period's forecast variance (the GARCH term).

$$\sigma_t^2 = \varpi_0 + \varpi_1\varepsilon_{t-1}^2 + \varpi_2\sigma_{t-1}^2$$

The above specification assumes that an economic agent forecasts the variance of inflation by forming a weighted average of the following: a long-term average (the constant term), the forecast from the previous period, and what was learned the previous period about the variance. It implies that large variances are more likely to be followed by large changes in π_t than by small changes.

A simple autoregressive model of inflation with a GARCH (1,1) specification of the conditional variance was chosen, as it did reasonably well on statistical criteria (see Table 1). Figure 3a shows the extracted measure of inflation uncertainty. There seem to have been three periods when inflation uncertainty was particularly high: the mid-1960s, the late 1970s, and the late 1980s. As Figure 3b shows, these periods have also approximately been periods when inflation levels have peaked. To confirm the visual impression obtained from Figure 3b, an OLS regression was estimated, with inflation uncertainty as the dependent variable and lagged inflation as an explanatory variable (see Table 2). The results allow us to infer that a 10 percent increase in lagged inflation leads to a 4.6 percent increase in inflation uncertainty, which is a substantial effect.

Figure 3a. Inflation Uncertainty
(In percent)

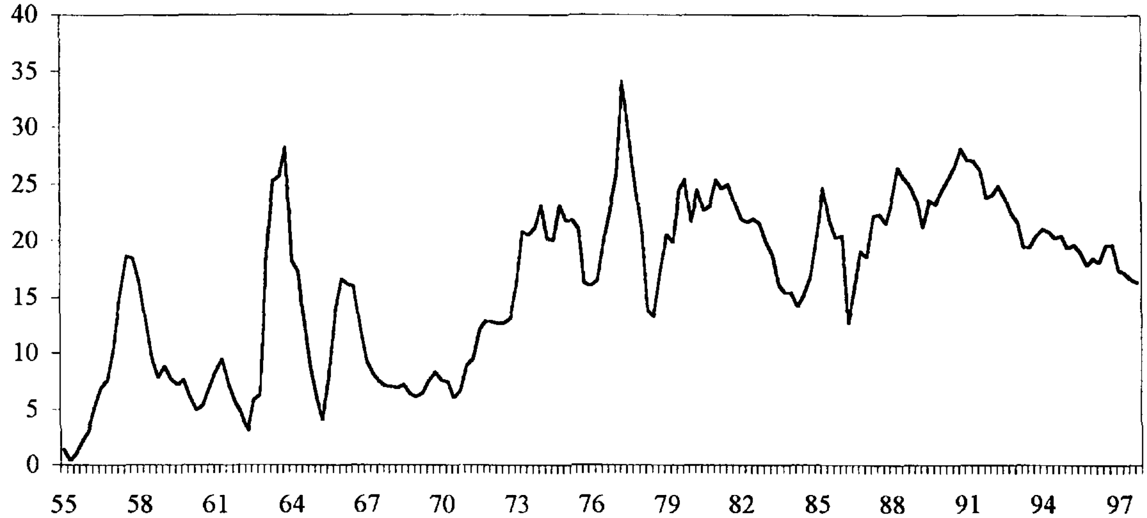
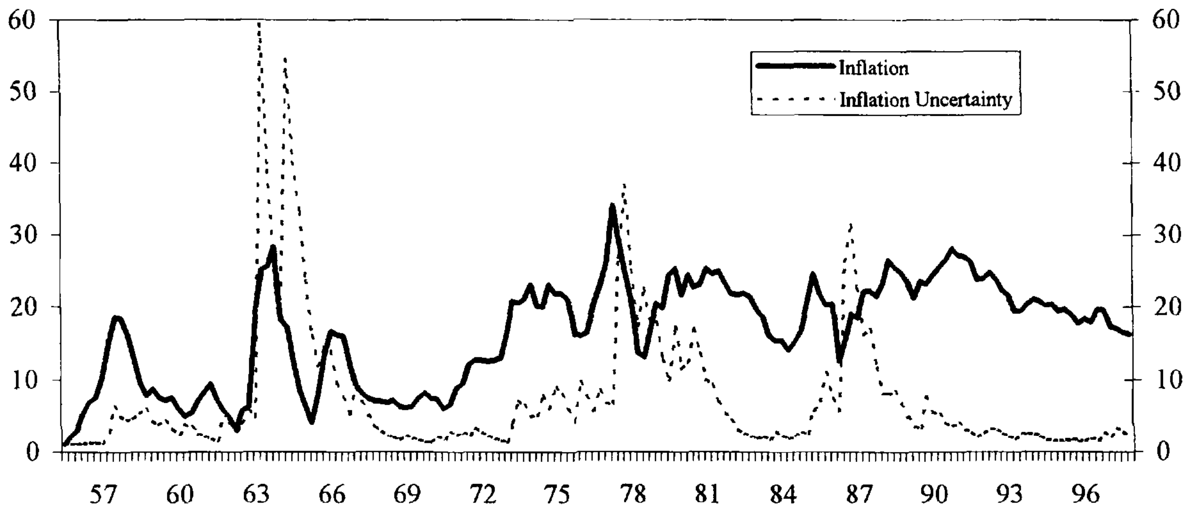


Figure 3b. Inflation and Inflation Uncertainty
(In percent)



B. Relative Price Dispersion

A typical measure of relative price dispersion is

$$RPD_t = \sum_{i=1}^{n} \omega_i (\pi_{it} - \pi_t)^2$$

where π_t is the aggregate inflation rate, π_{it} is the rate of change in the ith group of commodities comprising the aggregate price index, and ω_i is the weight of the ith group. Figure 4 shows the behavior over time of relative price dispersion in Colombia, using the actual weights used by the Colombian statistics authority in constructing the consumer price index.[14] There appears to be a positive relationship between the two variables, and this can be confirmed using the same GARCH methods as in Section III.A. This involves two steps. First, a GARCH forecasting model of monthly inflation is estimated, from which a measure of inflation uncertainty is extracted. Second, relative price dispersion is modeled as a GARCH process, with both the level of inflation and inflation uncertainty as explanatory variables. This way, as Grier and Perry (1996) point out, the two hypotheses discussed in Section II.B. regarding inflation and relative price dispersion can be tested. Table 3 shows the results.

It is evident that both lagged squared inflation and lagged inflation uncertainty are statistically significant, indicating that both hypotheses regarding the effect of inflation and inflation uncertainty on relative price dispersion have some validity in the case of Colombia. Nevertheless, one should also note that the value and significance level of the coefficient on trend inflation are lower than for inflation uncertainty. This would seem to indicate that although "menu costs" have had a role in generating relative price dispersion, inflation uncertainty, by making it difficult for economic agents to extract information from price signals, has had a larger role. The differing roles may be explained as follows. Given the persistence of moderate inflation in Colombia, pricing rules could have adapted, so that firms find ways to reduce the fixed costs of changing prices in order to keep up with inflation.[15]

IV. A VAR Analysis of Uncertainty, Investment, and Growth

This section investigates whether the increased uncertainty associated with inflation has deterred investment and growth. There have been several studies on the relationship between

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[14]The component groups and their weights are food (35 percent), housing (33 percent), clothing (9 percent), and miscellaneous items (23 percent). In order to filter out the seasonality of these indices, the 12-month inflation rates are used.

[15]One way to verify this hypothesis is to apply this approach to a country that has experienced much higher rates of inflation. Price adjustments in Brazil, for instance, were extremely rapid during its periods of high inflation, indicating low "menu costs" in relation to the cost of not keeping up with inflation.

Figure 4. Monthly Relative Price Dispersion

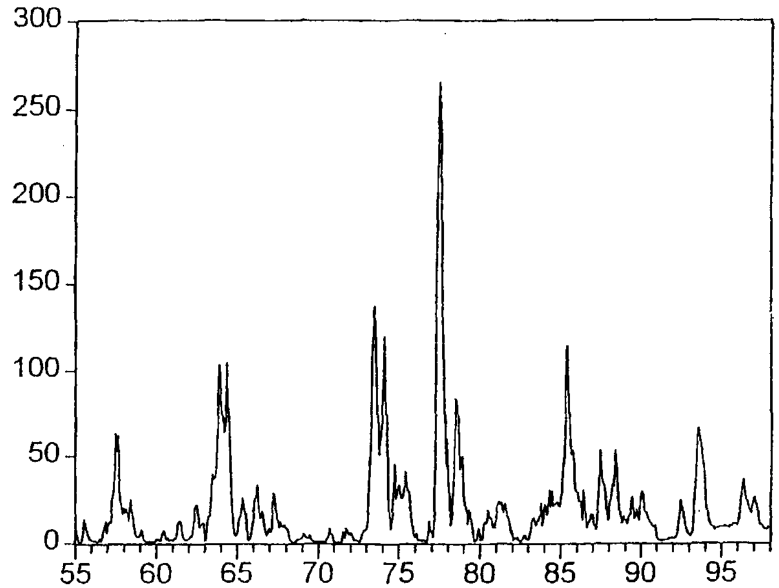


Figure 5. Growth Rates of Real Gross Domestic Product

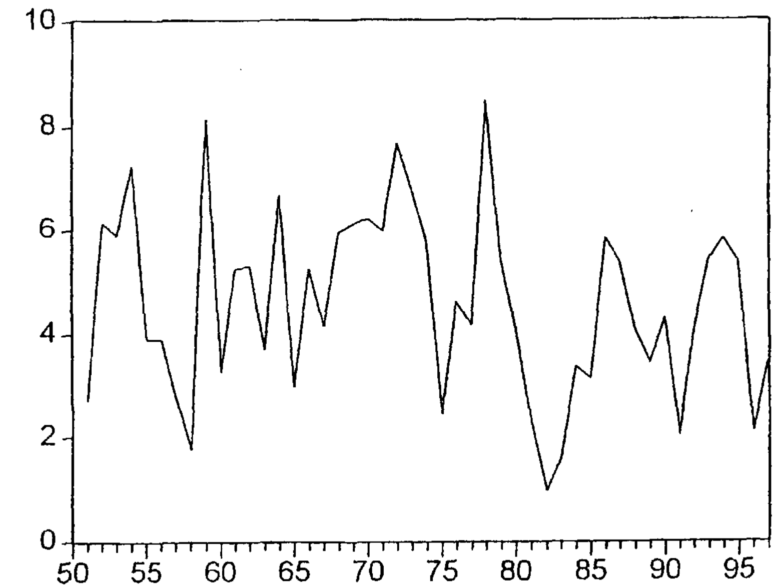
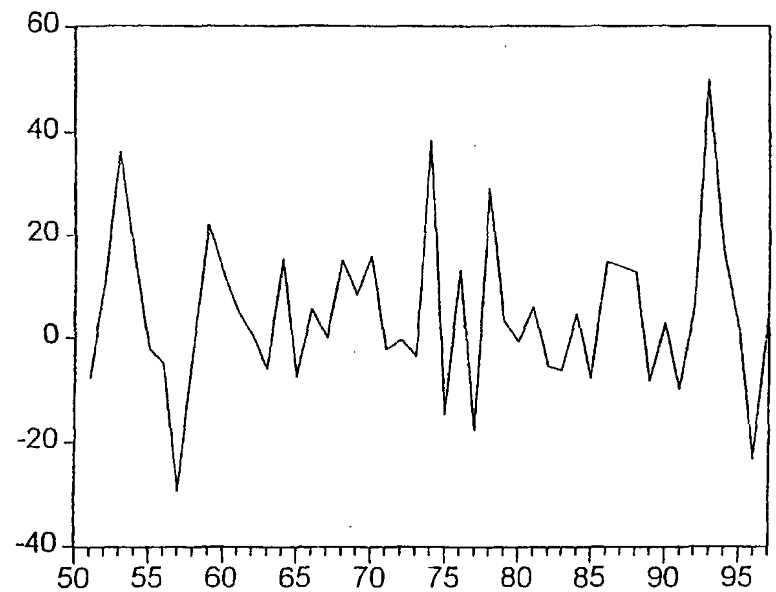


Figure 6. Growth Rates of Real Gross Fixed Capital Formation, Private



inflation and growth in Colombia, but the results have not been conclusive. Uribe (1994) studies the period 1951–1992 and finds that neither the level nor the variability of CPI inflation have had a statistically significant effect on growth. He attributes this to the fact that whereas inflation was low but relatively volatile in the 1950s and 1960s, it has been high but relatively stable since the 1970s. By contrast, Partow (1995), using a VAR framework to study the same period covered by Uribe (1994) finds that inflation has had a negative and statistically significant effect on real GDP growth, and that it takes about 10 years for the negative effect of inflation to wear off. In a related study, Partow (1996) uses the standard deviation of the marginal productivity of capital as a measure of uncertainty and finds that it is negatively associated with real private investment—interestingly, she also finds that the standard deviation of inflation has a positive and statistically significant effect on private investment. Given these differing results, it would be worthwhile to reexamine the relationship by employing the perhaps more appropriate measure of uncertainty derived in the previous section.

VAR (vector autoregression) models were estimated using two macroeconomic data sets: annual data for the period 1955–1997; and quarterly data, which are only available for the period 1977:1–1997:3. VAR modeling is an alternative, non-structural approach to modeling the relationships between macroeconomic variables when economic theory is not rich enough to provide a tight specification of the dynamic relationships among the variables.

The macroeconomic variables employed are: INF (the 12-month percentage change of the CPI); either UNCER or RPD (the measure of inflation uncertainty derived above or the relative dispersion of consumer prices); DGFCFPRV (the annual real growth of private gross fixed capital formation); and DGDP (the annual real growth of gross domestic product).[16] Figure 1 shows the behavior over time of INF; Figure 3a of UNCER; and Figure 4 of RPD. Figures 5 and 6 show DGFCFPRV and DGDP. The data were first analyzed to determine the existence of unit roots, using the conventional battery of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. For the annual data (see Table 4a), both the ADF and PP tests strongly reject the null hypothesis that unit roots are present in the DGFCFPRV and DGDP series. Although the tests split as regards INF, UNCER, and RPD, this study leaned toward the PP test results, which indicate stationarity. With stationary variables, the VAR can be estimated in levels, which facilitates interpretation of the estimation results. As Table 4b shows, the tests give mixed results regarding the presence of unit roots in quarterly data; nevertheless the PP tests do consistently show rejection of the null hypothesis of nonstationarity at varying significance levels. Consequently, the quarterly VAR was also estimated in levels.

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[16]Public investment is excluded from the analysis, consistent with Aizenman and Marion's (1998) findings that the detrimental impact of uncertainty on investment and growth is best seen using disaggregated data and that in some cases, public investment is positively correlated with volatility.

For each data set, two VAR models were estimated: the first, with UNCER as a regressor; the second, with RPD. Hence, a total of four models were estimated. Because the coefficients estimated with a VAR model are usually hard to interpret, the results of main interest are the variance decompositions and impulse response functions. Hence, the estimated coefficients are not presented; instead, Tables 5–8 show the variance decompositions, while Figures 7–10 show the impulse response functions. The variance decomposition for each variable shows the contributions to its forecast error variance of (i) innovations of the variable itself and (ii) shocks to other variables in the model. Impulse response functions show how a one-standard-deviation shock to a variable affects the other variables in the model.

The variance decompositions were estimated using the causal ordering: INF, UNCER (or RPD), DGFCFPRV, and DGDP. This ordering is based on the hypothesis that: (i) higher levels of inflation lead to higher inflation uncertainty or relative price dispersion, (ii) uncertainty deters private investment; and (iii) lower private investment lowers the rate of growth.

Table 5 shows that practically all of the forecast error variance in DGFCFPRV is due to its own innovations, and this holds even for a 10-year horizon, which is quite long. Hence, the other variables in the system evidently are not important in explaining DGFCFPRV. Interestingly, innovations in INF explain a larger part of the forecast error variance of UNCER than do innovations in UNCER itself. This result lends strong support to the hypothesis of a relationship between the level of inflation and inflation uncertainty. The results also show that, over the 10-year horizon, innovations in INF explain approximately 16 percent of the forecast error variance of DGDP, while innovations in DGFCFPRV explain a larger share, with 28 percent. The contribution of innovations in UNCER is minuscule.

By contrast, Table 6, which is derived from a VAR system that uses RPD as a regressor, shows that innovations in RPD contribute 13 percent of the variance of DGDP, exceeding the share of INF. Also, RPD's share in the variance of DGFCFPRV is much larger than the share of UNCER in Table 5 (12 percent versus 4 percent). Taken together, Tables 5 and 6 indicate that RPD has been more important than UNCER as a determinant of investment and growth.

Table 7 is the quarterly analogue of Table 5. The forecast error variance of INF and DGFCFPRV are mainly due to their own innovations, with little contribution from the other variables. Approximately in line with the results from annual data, innovations in INF explain 9 percent of the variance of DGDP, while innovations in DGFCFPRV explain 21 percent. The overall impression obtained from Table 7 is that UNCER is not an important determinant of investment and growth, and that INF has some contribution to growth and of investment. Table 8 conveys the same message with regard to the contributions of INF and RPD.

Overall, Tables 5–8 suggest the following: First, inflation has consistently been an important determinant of growth in Colombia. Second, RPD has had some role in explaining growth. Third, UNCER has not had a major role in explaining either investment or growth.

Figures 7–10 show how innovations in INF, UNCER, and RPD have affected investment and growth. The impulse response functions employ the same causal ordering as the variance decompositions, and the figures of particular interest are the ones in the lower left hand corner, which show the responses of investment and growth to one standard deviation shocks to INF and UNCER (or RPD). Results derived from annual data (Figure 7) show that, in general, increases in either INF or UNCER depress investment growth within one year, but modestly stimulate it within two years, and have a negative impact thereafter. The time pattern of the effect of an increase in UNCER on DGDP is also somewhat similar. On the other hand, increases in INF have a persistent negative effect on growth, with the negative effect being most pronounced in the fourth year. The magnitudes are slightly different when RPD is used as a regressor (Figure 8), but the overall story is similar.

Figures 9 and 10 show the impulse response functions for quarterly data. With regard to investment, increases in either INF, UNCER, or RPD have an erratic but generally negligible effect. With regard to GDP growth, an increase in UNCER has a negligible effect, but an increase in RPD leads to growth being around 0.3 percent higher than the baseline within 5-7 quarters after the shock. Figure 9, consistent with Figures 7 and 8, shows that increases in INF negatively affect growth throughout the entire horizon, but Figure 10 shows a positive effect on growth by the sixth quarter.

Although the results are rather divergent, one result is quite strong: *The effect of inflation on real GDP growth is negative and persistent*. From Figure 7, nine years after a one standard deviation increase in the rate of inflation, real GDP growth remains below the baseline (this is consistent with Partow's (1995) results). From Figure 9, however, the negative effect lasts for only around seven quarters. The coverage of the quarterly data (1977–97) could be the reason why the estimated negative effect of inflation on growth is less persistent. During this period, as Uribe (1994) has noted, inflation has been high but relatively stable, as compared to the 1950s and 1960s, when inflation was low but volatile. The relative stability of inflation during this period could have made economic agents relatively insensitive to inflation shocks.

V. Conclusions

The level of inflation in Colombia has been associated with increased variability and increased uncertainty regarding future inflation. High inflation also contributes to uncertainty by increasing the relative dispersion of prices. In either case, price signals are "muddled," decreasing economic welfare and, potentially, economic growth as well.

An empirical investigation of the effects of inflation and its accompanying uncertainty on private investment and economic growth produced ambiguous results. Although there is no conclusive evidence to support the hypothesis that inflation uncertainty and relative price dispersion depress investment and real GDP growth, the evidence is strong that the level of inflation has a negative and persistent effect on growth. This result highlights the negative effect of inflation on Colombia's economy, even at moderate and relatively stable levels, and argues for stronger efforts to reduce inflation on the part of the monetary authorities.

Figure 7. Impulse Responses, Annual VAR, Inflation Uncertainty and Growth
Response to One S.D. Innovations ± 2 S.E.

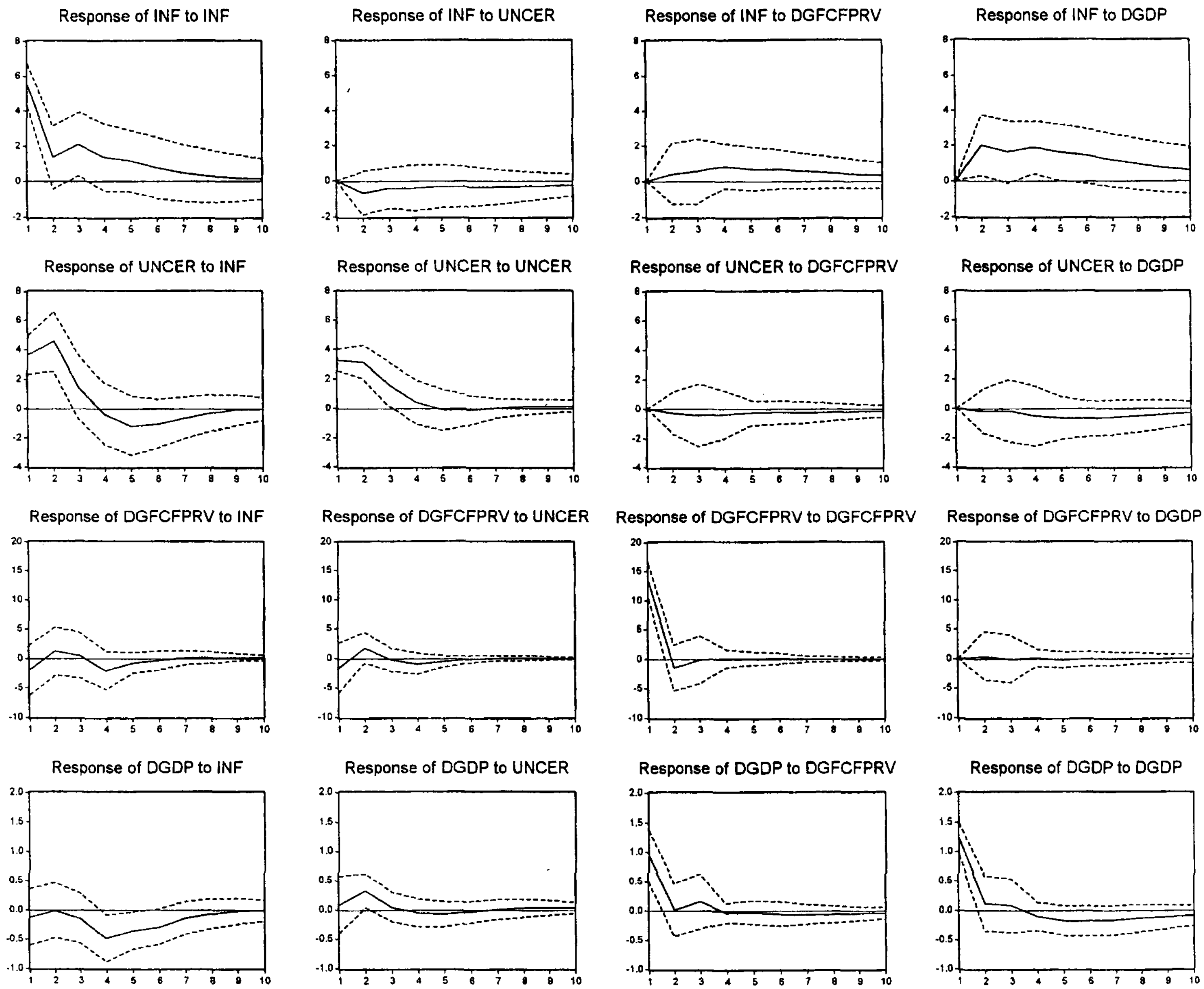

Figure 8. Impulse Responses, Annual VAR, Relative Price Dispersion and Growth
Response to One S.D. Innovations ± 2 S.E.

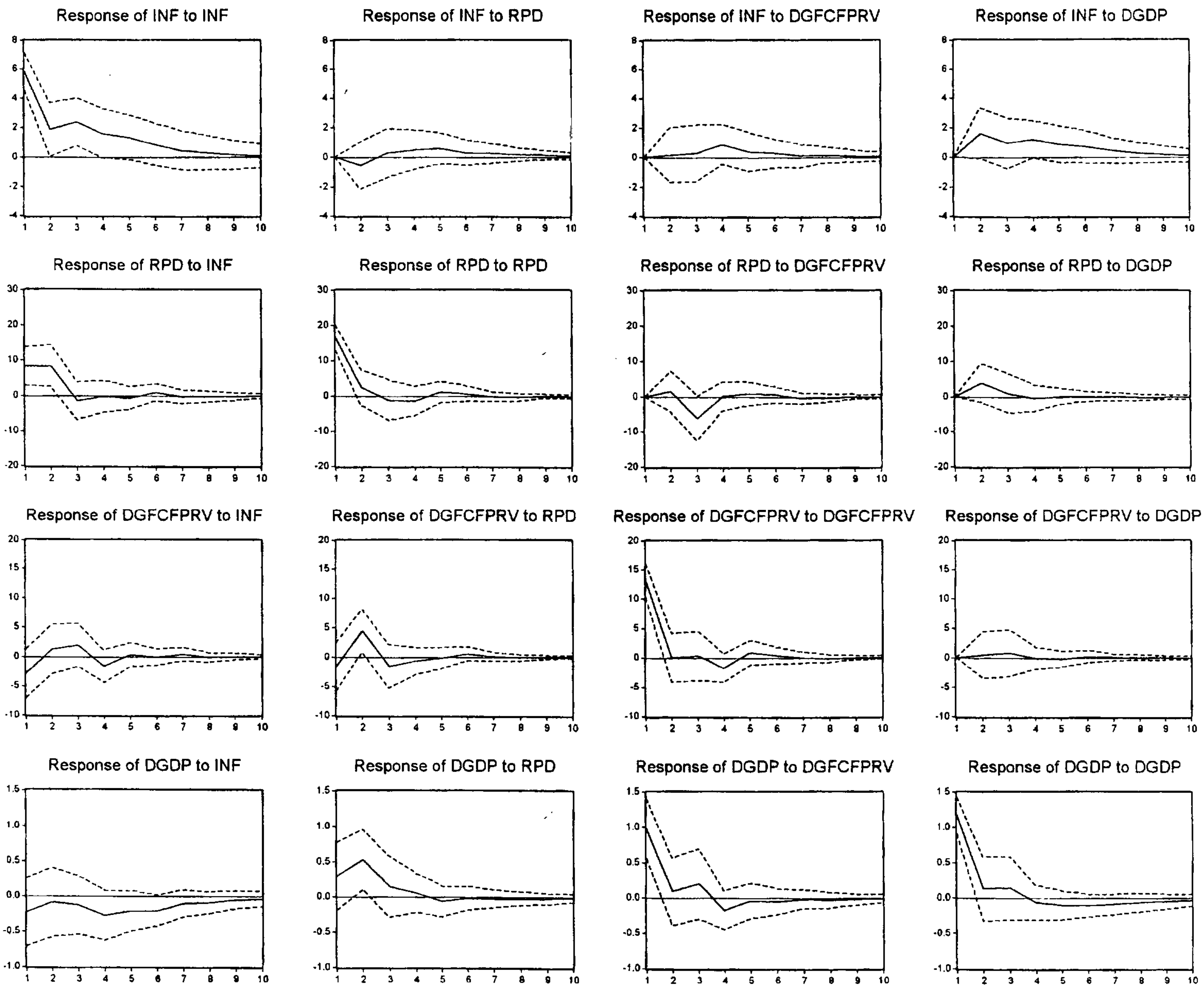

Figure 9. Impulse Responses, Quarterly VAR, Inflation Uncertainty and Growth
Response to One S.D. Innovations ± 2 S.E.

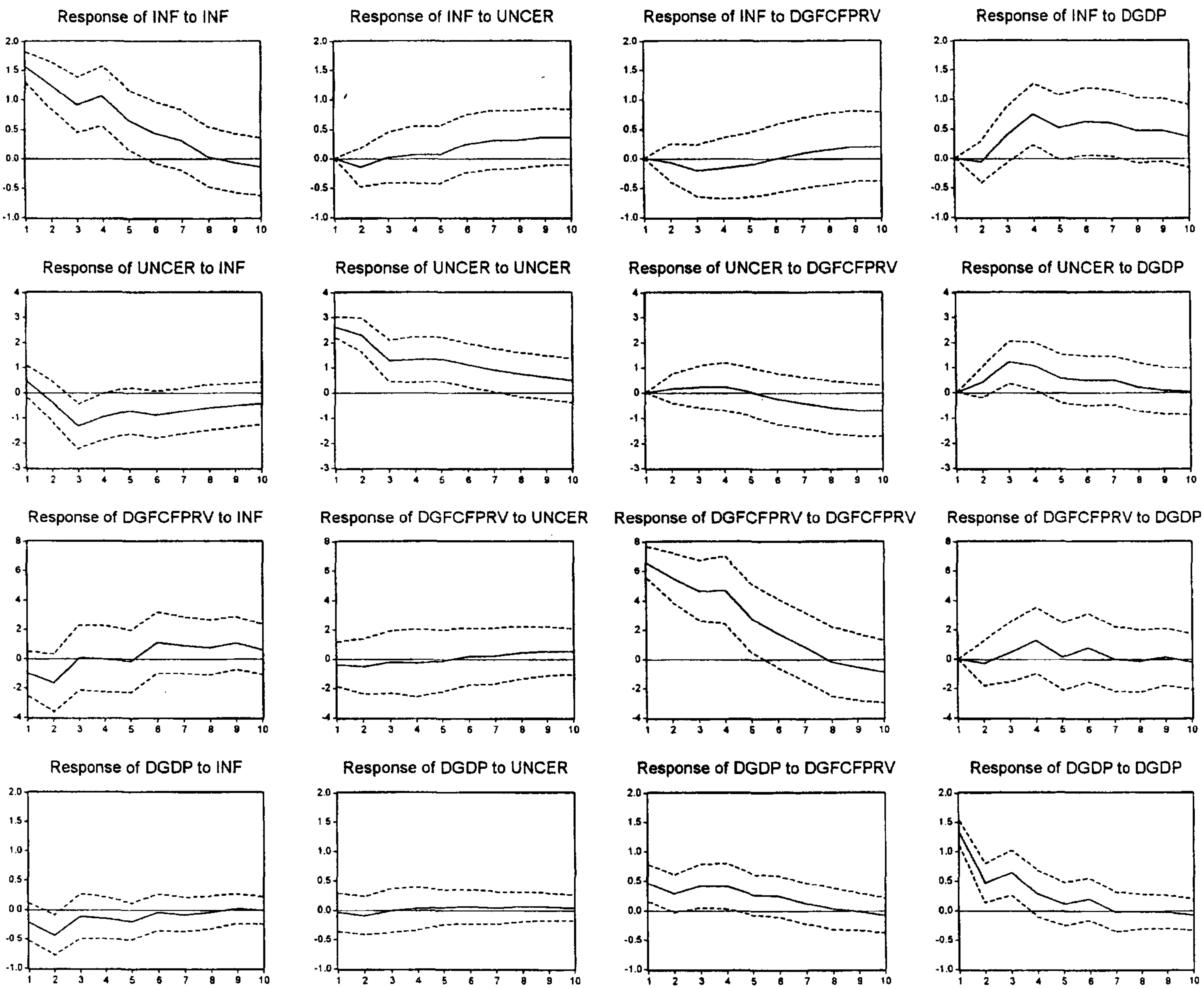

Figure 10. Impulse Responses, Quarterly VAR. Relative Price Dispersion and Growth
Response to One S.D. Innovations ± 2 S.E.

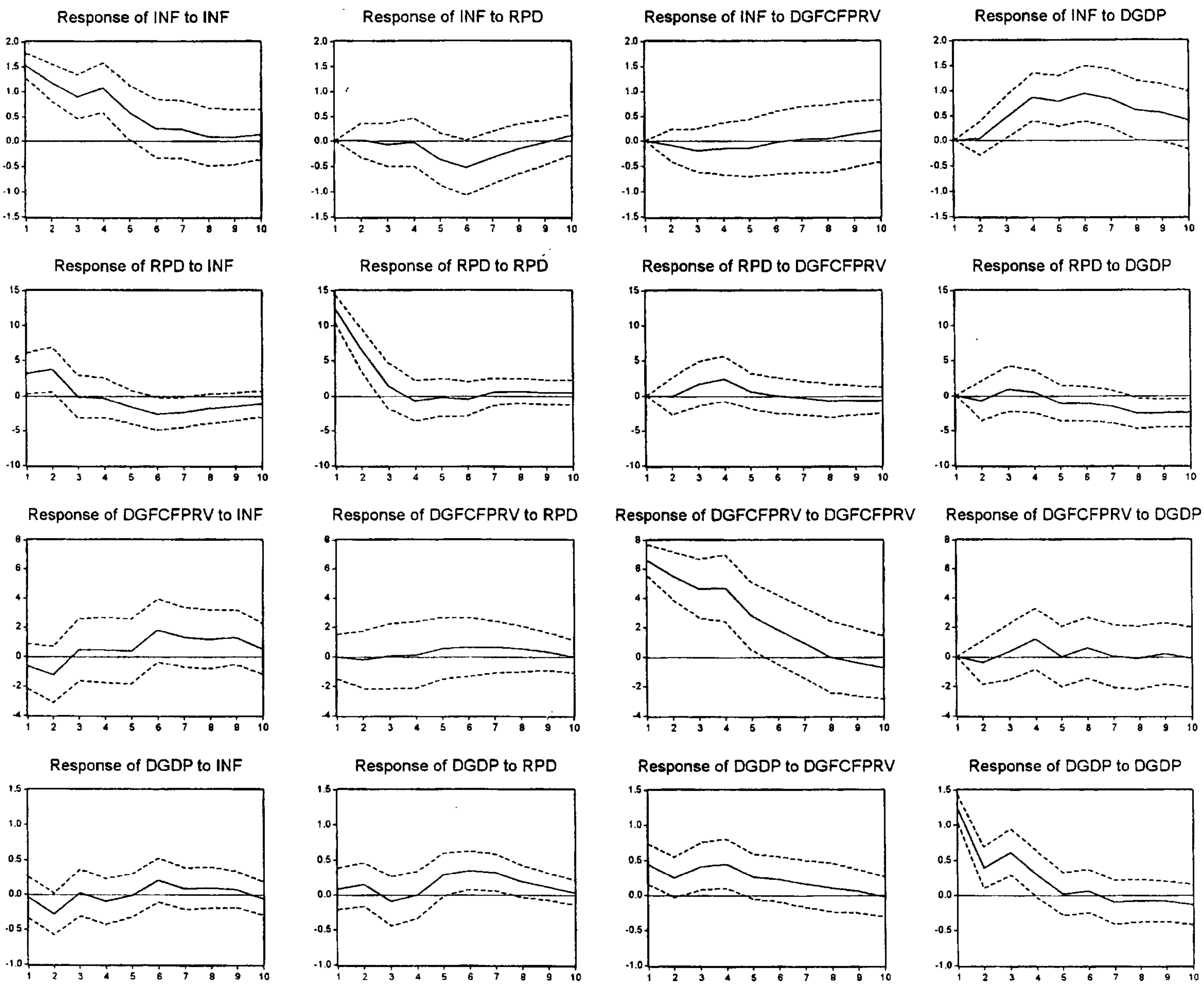

Table 1. GARCH (1,1) Model of Quarterly CPI Inflation

I. Dependent Variable: Quarterly CPI Inflation

Explanatory Variable	Coefficient	T statistic
Constant	1.033	2.831 ***
Inflation, Lagged One Quarter	1.366	13.795 ***
Inflation, Lagged Two Quarters	-0.430	4.649 ***
II. Dependent Variable: Conditional Variance of Quarterly Inflation		
Constant	0.354	1.614
ARCH(1)	0.388	2.919 ***
GARCH(1)	0.646	5.967 ***
Adjusted R squared	0.879	
Durbin-Watson Statistic	2.355	
Sample Period	1955Q3-1997Q4	

Table 2. OLS Regression of Inflation Uncertainty on Inflation

Dependent variable: Log of Inflation Uncertainty

Explanatory Variable	Coefficient	T statistic
Constant	0.379	0.768
Log of Lagged Inflation	0.458	3.508 ***
AR(1)	0.919	29.422 ***
Adjusted R squared	0.867	
Durbin-Watson Statistic	2.05	
Sample Period	1956Q1-1997Q4	

Source: Fund staff estimates.

1/ Indicates statistical significance at the 99 percent significance level.

Table 3a. GARCH (1,1) Model of Monthly CPI Inflation

I. Dependent Variable: Monthy CPI Inflation

Explanatory Variable	Coefficient	T statistic
Constant	0.214	2.158 ***
Inflation, Lagged One Month	1.365	26.134 ***
Inflation, Lagged Two Months	-0.098	2.097 ***
II. Dependent Variable: Conditional Variance of Monthly Inflation		
Constant	0.025	3.018 ***
ARCH(1)	0.114	6.139 ***
GARCH(1)	0.878	46.255 ***
Adj. R squared	0.981	
Durbin-Watson Statistic	1.855	
Sample Period	1955:04-1997:12	

Table 3b.GARCH (1,1) Model of Monthly Relative Price Dispersion

I. Dependent variable: Relative Price Dispersion

Explanatory Variable	Coefficient	T statistic
Constant	0.046	0.151
Inflation, Lagged One Month	0.001	2.671 ***
Uncertainty, Lagged One Month	0.591	3.278 ***
Relative Price Dispersion, Lagged One Month	0.776	32.218 ***
MA(1)	0.336	9.146 ***
II. Dependent Variable: Conditional Variance of Relative Price Dispersion		
Constant	1.959	6.016 ***
ARCH(1)	1.283	13.978 ***
GARCH(1)	0.336	14.633 ***
Adjusted R squared	0.856	
Durbin-Watson Statistic	1.345	
Sample Period	1955:05-1997:12	

Source: Fund staff estimates.

1/ Indicates statistical significance at the 99 percent significance level.

Table 4a. Unit Root Tests on Annual Data

		Levels		First Differences	
		ADF	PP	ADF	PP
INF	1955-97	-2.54	-4.77 ***	-3.41 **	-11.16 ***
UNCER	1955-97	-3.91 **	-3.03	-4.45 ***	-4.74 ***
RPD	1955-97	-2.45	-5.13 ***	-3.78 ***	-10.99 ***
DGDP	1951-96	-4.27 ***	-5.38 ***	-6.44 ***	-11.84 ***
DGFCFPRV	1951-96	-6.18 ***	-6.89 ***	-6.48 ***	-13.45 ***

Table 4b. Unit Root Tests on Quarterly Data

		Levels		First Differences	
		ADF	PP	ADF	PP
INF	1977:1-1997:4	-1.99	-3.21 *	-6.69 ***	-8.97 ***
UNCER	1977:1-1997:4	-2.85	-3.58 **	-3.87 ***	-8.14 ***
RPD	1977:1-1997:4	-3.55 **	-5.98 ***	-5.23 ***	-16.48 ***
DGDP	1977:1-1997:4	-2.77	-3.96 **	-4.67 ***	-14.39 ***
DGFCFPRV	1977:1-1997:4	-2.51	-3.28 **	-4.38 ***	-9.38 ***

Source: Fund staff estimates.

Notes:
ADF: Augmented Dickey-Fuller Test
PP: Philips-Perron Test
All regressions in levels contain a constant and a linear trend.
All regressions in differences contain only a constant and four lags.
For annual data, three lags of the dependent variable are used.
For quarterly data, four lags of the dependent variable are used.
(*), (**), and (***) indicate rejection of the null hypothesis of a unit root at significance levels of 10, 5, and 1 percent, respectively.

Table 5. Variance Decompositions, Annual Data

Variable	Lags	INF	UNCER	DGFCFPRV	DGDP
INF	1	100.0	0.0	0.0	0.0
	2	87.1	1.3	0.4	11.2
	4	75.6	1.6	2.4	20.5
	8	65.8	2.0	4.4	27.9
	10	64.4	2.1	4.7	28.8
UNCER	1	55.2	44.8	0.0	0.0
	2	62.1	37.7	0.2	0.1
	4	60.0	38.6	0.7	0.6
	8	60.1	35.7	1.1	3.1
	10	59.7	35.5	1.2	3.5
DGFCFPRV	1	2.2	1.4	96.5	0.0
	2	2.8	3.0	94.1	0.1
	4	5.2	3.4	91.3	0.1
	8	5.5	3.6	90.8	0.1
	10	5.6	3.6	90.8	0.1
DGDP	1	0.6	0.3	36.4	62.6
	2	0.6	4.5	34.7	60.2
	4	10.1	4.2	31.7	54.0
	8	16.6	4.0	28.3	51.1
	10	16.4	4.0	28.2	51.3

Source: Fund staff estimates.

Note: Ordering is INF, UNCER, DGFCFPRV, DGDP.

Table 6. Variance Decompositions, Annual Data

Variable	Lags	INF	RPD	DGFCFPRV	DGDP
INF	1	100.0	0.0	0.0	0.0
	2	92.7	0.8	0.0	6.5
	4	87.7	1.2	1.7	9.4
	8	84.8	2.0	2.0	11.3
	10	84.7	2.0	2.0	11.3
RPD	1	20.4	79.6	0.0	0.0
	2	32.3	63.9	0.5	3.3
	4	29.8	58.6	8.4	3.2
	8	29.8	58.4	8.6	3.2
	10	29.8	58.4	8.6	3.2
DGFCFPRV	1	4.5	1.4	94.1	0.0
	2	4.8	10.9	84.2	0.1
	4	7.5	11.7	80.5	0.4
	8	7.6	11.7	80.3	0.4
	10	7.6	11.7	80.3	0.4
DGDP	1	2.1	3.5	39.0	55.4
	2	2.7	13.1	34.9	49.8
	4	5.1	13.0	34.8	47.1
	8	8.3	12.5	33.3	45.8
	10	8.5	12.5	33.2	45.8

Source: Fund staff estimates.

Note: Ordering is INF, RPD, DGFCFPRV, DGDP.

Table 7. Variance Decompositions, Quarterly Data

Variable	Lags	INF	UNCER	DGFCFPRV	DGDP
INF	1	100.0	0.0	0.0	0.0
	2	99.2	0.6	0.1	0.1
	4	87.7	0.4	1.1	10.7
	8	73.8	3.2	1.3	21.7
	10	68.5	5.6	2.0	23.8
UNCER	1	2.7	97.3	0.0	0.0
	2	2.7	95.7	0.2	1.4
	4	14.3	72.1	0.6	13.0
	8	17.9	67.4	2.4	12.4
	10	18.1	64.9	5.4	11.6
DGFCFPRV	1	2.4	0.3	97.3	0.0
	2	5.0	0.5	94.3	0.1
	4	3.2	0.5	94.9	1.5
	8	4.8	0.6	92.9	1.8
	10	5.8	0.9	91.5	1.8
DGDP	1	2.4	0.1	10.5	87.0
	2	9.8	0.5	11.6	78.2
	4	8.3	0.4	18.8	72.6
	8	9.2	0.6	21.4	68.8
	10	9.2	0.7	21.4	68.7

Ordering is INF, UNCER, DGFCFPRV, DGDP.

Table 8. Variance Decompositions, Quarterly Data

Variable	Lags	INF	RPD	DGFCFPRV	DGDP
INF	1	100.0	0.0	0.0	0.0
	2	99.7	0.0	0.2	0.0
	4	94.3	0.1	1.0	14.6
	8	59.3	5.4	0.9	34.4
	10	56.4	5.3	1.4	36.9
RPD	1	6.2	93.8	0.0	0.0
	2	11.1	88.7	0.0	0.2
	4	10.5	84.9	3.8	0.8
	8	16.3	75.0	3.7	5.0
	10	16.7	70.5	3.8	9.0
DGFCFPRV	1	1.1	0.0	98.9	0.0
	2	2.8	0.1	97.0	0.2
	4	2.0	0.1	96.6	1.4
	8	6.2	1.0	91.4	1.4
	10	7.4	1.0	90.1	1.4
DGDP	1	0.1	0.4	11.3	88.1
	2	4.1	1.4	12.7	81.8
	4	3.2	1.3	21.9	73.6
	8	4.4	11.0	22.8	61.8
	10	4.5	11.2	22.6	61.7

Source: Fund staff estimates.

Note: Ordering is INF, RPD, DGFCFPRV, DGDP.

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