On the existence or absence of a variance relationship: a study of macroeconomic uncertainty

MENELAOS KARANASOS*
Busines School
Brunel University
Middlesex, UK

JINKI KIM†
Gangwon Development Research Institute
Chuncheon-si, South Korea

Abstract: - In this paper we employ the BEKK parameterization of a bivariate GARCH model and we perform Granger causality tests to examine the link between the variability of inflation and of output growth. This approach provides a simple way to illustrate the existence or absence of a variance relationship. Our results are supportive of a unidirectional feedback between nominal and real uncertainty with the line of causation running from the former to the latter. In particular, in Japan and the USA inflation volatility has a positive impact on output volatility as predicted by Logue and Sweeney (1981). On the other hand, in Germany there is mild evidence that increased nominal uncertainty lowers real uncertainty, confirming the theoretical prediction made by Taylor (1979). Finally, in Japan and Germany, although in the sixties and seventies there is a lack of causal effect from output variability to inflation variability a positive effect begins to exist in the eighties and nineties. This result gives support to the Devereux (1989) hypothesis.

Key-words: -Causality tests, Conditional heteroscedasticity, Inflation-output variability relationship.

1 Introduction

The issue of the nature of the relationship between the levels of inflation and output growth has been one of the most researched topics in macroeconomics both at the theoretical and empirical front. Considerable ambiguity surrounds the link between inflation uncertainty and nominal uncertainty. A number of arguments advanced over the last 30 years predict a positive or negative association between the two. In particular, Logue and Sweeney (1981) point out that there are two reasons to suspect that greater uncertainty of inflation leads to greater uncertainty in production, investment, and marketing decisions, and greater variability in real growth. First, relative price variation creates additional producer uncertainty. Hence, the real growth in investment, and all other economic activity, will be more variable because of the inability to distinguish real shifts in demand from 'nominal' shifts. Second, models with a stable inflation-unemployment trade-off imply a positive relationship between the variability of inflation and the variability of real activity. Moreover, in Devereux's (1989) model, inflation uncertainty and the mean rate of inflation are positively correlated because the variability of real shocks is the predominant cause of inflation uncertainty. In particular, more variable shocks cause a reduction in the degree of indexation and increase the benefits to the government of creating surprise inflation. More recently, the relationship between nominal and real uncertainty has been analyzed by using intertemporal general equilibrium models. The models developed by Goodfriend and King (1997), King and Wolman (1998) and Rotemberg and Woodford (1998) show that inflation targeting, by keeping the inflation rate constant, also minimizes the output gap variability. Bean (1998) develops a model in which an optimal monetary policy is defined as the policy that minimizes the variances of output and of inflation (for a recent brief survey of this literature see Arestis et al., 2002). In sharp contrast, Taylor (1980, 1994) argues that the existence of the short-run output-inflation trade-off

*Address for correspondence: M. Karanasos, Business School, Brunel University, Uxbridge, Middlesex, UB8 3PH; tel: +44 (0)1895 274000, fax: +44 (0)1895 269770.

†We would like to thank M. Karanassou for her helpful comments and suggestions. This research was conducted while both authors were at the University of York.

implies a long-run trade-off in variances. In other words, if policy-makers wish to reduce nominal uncertainty in the face of demand and supply shocks they must vary real output a great deal in order to stabilize inflation. On the other hand, in order to lower the variability of output the policy-makers must allow shocks that affect inflation to persist, thus increasing the nominal uncertainty.

The empirical evidence to date is also rather mixed. In particular, Logue and Sweeney (1981), using cross-sectional tests and data from 24 countries that are members of the OECD, find that the variability in real growth is strongly and positively related to the variability in inflation. Similarly, Batini and Haldane (1998) for the UK and Amano et al. (1999) for Canada show that inflation targeting lowers both real and nominal uncertainty. In sharp contrast, Fuhrer (1997) estimates an efficient set of weighted combinations of inflation and output variances and finds that when monetary policy attempts to make output (inflation) variation too small there is a dramatic increase in inflation (output) variance. Clarida et al. (1999) also show that a trade-off in variances exists and is less favorable the higher the degree of inflation persistence becomes.

The theoretical and empirical ambiguity surrounding the link between nominal and real uncertainty provides us with the motivation to expand on the empirical aspects of this issue. The empirical evidence on the inflation-output variability relationship remains scant, as pertains, in particular to international data in industrialized countries. The studies of Lee (1999), Arestis et al. (2002), Fountas et al. (2002, 2005), Grier et al. (2004) and Karanasos and Kim (2005a, 2005b) are some attempts to investigate the inflation-output variability relationship using measures of conditional volatilities. In particular, Lee (1999) and Karanasos and Kim (2005a) estimate the BEKK parameterization of a bivariate GARCH process and find evidence of a relationship between nominal and real uncertainty. Grier et al. (2004) estimate a general model that allows them to reject not only the diagonality but also the symmetry restrictions commonly imposed upon the variance-covariance matrix for output growth and inflation. However, as Arestis et al. (2002) point out, the reduced form of the BEKK model allows only for a positive relationship. Subsequently, Arestis et al. (2002) utilized a stochastic volatility model to analyze the possible effects of inflation targeting on the trade-off between output-gap variability and inflation variability. They found that the adoption of inflation targets, in countries like Canada and the UK, results in a more favorable monetary policy trade-off.

Consequently, this paper adopts a two-step procedure. First, we employ the BEKK parameterization of the bivariate GARCH model and measure inflation and output uncertainty by the estimated conditional variances of inflation and output growth, respectively. Then we perform Granger causality tests to examine the bidirectional causal relationships between the two variables. Doing so allows us to test for a possible trade-off in variances. The two step approach has been employed among others by Grier and Perry (1998) and Fountas et al. (2002, 2005). In particular, Fountas et al. (2005) examined the link between the variability of inflation and output in the G7 and found that in most of the countries there is no causal relation between nominal and real uncertainty. In sharp contrast, Karanasos and Kim (2005b) estimate a vector-diagonal bivariate GARCH model for the G3 and find evidence of a unidirectional variability relationship with the line of causation running from nominal uncertainty to real uncertainty.

Our approach provides a simple way to illustrate the existence or absence of a variance relationship. Several results stand out for the entire sample period. First, nominal uncertainty significantly affects real uncertainty in all three countries but not all in the same manner. In Japan and the USA increased inflation variability does lead to an increased output variability, a result which is in line with the hypothesis advanced by Logue and Sweeney (1981). In contrast, in Germany there is mild evidence that increased nominal uncertainty lowers real uncertainty, confirming the theoretical predictions made by Taylor (1979). Second, in the USA output volatility has a mild negative effect on inflation volatility as predicted by Taylor (1979). In Japan and Germany real uncertainty does not Granger-cause nominal uncertainty. Taken as a whole our results are supportive of a unidirectional feedback between nominal and real uncertainty with the line of causation running from the former to the latter.

The four decades under investigation are characterized by persistent high inflation, as was the case from late 1960s through the early 1980s, followed by the relatively shock-free 1990s where both inflation and real growth were more stable than they were in the 1980s. Therefore, we thought it necessary to partition the total sample period into two subperiods. The first subperiod goes from the beginning of the sample to the end of 1979. The second subperiod starts in 1980 and continues till to the end of the sample. In the USA the subsamples for the 1980 breakpoint are defined a priori as corresponding to the periods before and after the nonborrowed reserves operating procedure. The effect of nominal uncertainty on real uncertainty is negative in the sixties and seventies but turns to positive in the 1980s and 1990s. On the other hand, there is a lack of a causal effect of output variability on inflation variability in the 1960s and 1970s. However, a strong effect begins to exist in the eighties and nineties.

The layout of the paper is as follows. Section 2 describes the theoretical model used for estimation and then presents the empirical analysis and the results from the Granger causality tests. Concluding remarks are in section 3.

2 The Theoretical Model and Empirical Analysis

2.1 Model

We use bivariate VAR models to estimate the conditional means of the rates of inflation and output growth. Let π_t and y_t denote the inflation rate and real output growth respectively, and define the residual vector ε_t as $\varepsilon_t = (\varepsilon_{\pi t}, \varepsilon_{yt})'$. Note that a general bivariate VAR(p) model can be written as

$$x_t = \Phi_0 + \sum_{i=1}^{p} \Phi_i x_{t-i} + \varepsilon_t, \qquad (1)$$

with

$$\Phi_0 = \begin{bmatrix} \phi_{\pi 0} \\ \phi_{y0} \end{bmatrix}, \quad \text{and} \quad \Phi_i = \begin{bmatrix} \phi_{\pi\pi,i} & \phi_{\pi y,i} \\ \phi_{y\pi,i} & \phi_{yy,i} \end{bmatrix},$$

where x_t is a 2×1 column vector given by $x_t = (\pi_t \ y_t)'$, Φ_0 is the 2×1 vector of constants and Φ_i, $i = 1, \ldots, p$, is the 2×2 matrix of parameters. In our empirical work, we estimate several bivariate VAR specifications for inflation and output growth. We used the optimal lag-length algorithm of the Akaike information criterion (AIC) to determine the order of the VAR process. Regarding ε_t, we assume that it is conditionally normal with mean vector 0 and variance-covariance matrix H_t, where $\text{vech}(H_t) = (h_{\pi t}, h_{\pi y,t}, h_{yt})'$. That is, $(\varepsilon_t | \Omega_{t-1}) \sim N(0, H_t)$, where Ω_{t-1} is the information set up to time $t-1$. We have also estimated VAR models where the Φ_i matrix was either lower triangular ($\phi_{\pi y,i} = 0$), or upper triangular ($\phi_{y\pi,i} = 0$), or diagonal ($\phi_{y\pi,i} = \phi_{\pi y,i} = 0$). Our choice between the three models was based on the use of Granger causality tests (Wald tests). Following Engle and Kroner (1995), these Granger causality tests were performed on the assumption that the conditional covariance matrix follows the BEKK representation.[1] That is, H_t is parametrized as

$$H_t = CC' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}B', \qquad (2)$$

with

$$A = \begin{bmatrix} \alpha_{\pi\pi} & \alpha_{\pi y} \\ \alpha_{y\pi} & \alpha_{yy} \end{bmatrix}, \quad B = \begin{bmatrix} \beta_{\pi\pi} & \beta_{\pi y} \\ \beta_{y\pi} & \beta_{yy} \end{bmatrix}.$$

Because of the presence of a paired transposed matrix factor for each of these three matrices nonnegative definiteness of the conditional matrix is assured. Also, in the above BEKK model, $\{\varepsilon_t\}$ is covariance stationary if and only if all the eigenvalues of $A \otimes A + B \otimes B$ (where $\otimes$ stands for Kronecker product) are less than one in modulus (see Engle and Kroner, 1995). We estimate the system of equations (1) and (2) using the Berndt et al. (1974) numerical optimization algorithm (BHHH) to obtain the maximum likelihood estimates of the parameters.

2.2 Data and Empirical Results

The data set comprises monthly Producer Price Index (PPI) and Industrial Production Index (IPI) series for the USA, Japan and Germany. In our empirical analysis we use the PPI and the IPI as proxies for the price level and output respectively. The index for the USA and Japan covers the period of February 1957 to August 2000 and consists of 523 observations for each series. For Germany the sample is February 1958 to July 2000. Inflation is computed as $[1200 \times (\log(\text{PPI}_t) - \log(\text{PPI}_{t-1}))]$ where PPI_t and PPI_{t-1} are monthly Producer Price Indices at time t and $t-1$ respectively. Real output growth is measured by the annualized monthly difference in the

[1] In the presence of conditional heteroskedasticity, Vilasuso (2001) investigates the reliability of causality tests based on least squares. He demonstrates that when conditional heteroskedasticity is ignored, least squares causality tests exhibit considerable size distortion if the conditional variances are correlated. In addition, inference based on a heteroskedasticity and autocorrelation consistent covariance matrix constructed under the least squares framework offers only slight improvement. Therefore, he suggests that causality tests be carried out in the context of an empirical specification that models both the conditional means and conditional variances. Accordingly, Grier and Perry (2000) use bivariate GARCH models to simultaneously estimate the conditional means, variances and covariance of inflation and output growth.

log of the IPI [$1200\times(\log(\text{IPI}_t)-\log(\text{IPI}_{t-1}))$]. To test for a second unit root in PPI and IPI, we apply the augmented Dickey-Fuller and Phillips-Perron unit root tests to the monthly inflation and output growth. With all inflation and output growth series we find (results are not reported) that there is evidence against a second unit root.

Table 1 reports parameter estimates for the three BEKK GARCH(1,1) models.[2] The parameter $\alpha_{\pi y}$ suggests a cross-effect running from the lagged output error to the inflation variance whereas the parameter $\alpha_{y\pi}$ depicts a cross-effect in the opposite direction. The off diagonal elements in B depict the extent to which the conditional variance of one variable is correlated with the lagged conditional variance of the other variable.

Table 1. Parameter estimates for the BEKK GARCH(1,1) models (Entire Sample).

	USA	JAPAN	GERMANY
$c_{\pi\pi}$	1.505 (6.22)	3.637 (10.12)	1.916 (4.94)
$c_{\pi y}$	0.912 (0.65)	0.573 (0.29)	0.744 (0.27)
c_{yy}	6.139 (12.37)	2.454 (1.72)	6.162 (3.74)
$\alpha_{\pi\pi}$	0.478 (11.97)	0.564 (11.21)	0.401 (6.41)
$\alpha_{y\pi}$	0.042 (0.51)	0.038 (0.22)	0.176 (0.46)
$\alpha_{\pi y}$	−0.024 (0.68)	−0.027 (1.03)	−0.006 (0.45)
α_{yy}	0.724 (13.13)	0.200 (4.73)	0.304 (4.85)
$\beta_{\pi\pi}$	0.852 (36.85)	0.531 (5.21)	0.733 (6.84)
$\beta_{y\pi}$	−0.069 (0.88)	0.048 (0.28)	0.245 (0.58)
$\beta_{\pi y}$	0.005 (0.12)	−0.009 (0.28)	−0.005 (0.39)
β_{yy}	0.395 (5.43)	0.965 (52.13)	0.903 (24.0)

This table reports parameter estimates for the BEKK(1,1) models. The numbers in parentheses are t-statistics.

With all countries, the hypothesis of uncorrelated standardized and squared standardized residuals is well supported. The bivariate AR(12)-GARCH(1,1) models seem to fit the means and variances of both inflation and output growth well. To test for volatility transmissions between inflation and output we perform joint tests under the null hypothesis that $\alpha_{ij} = \beta_{ij} = 0$ for $i \neq j$. Based on the likelihood ratio test statistic (not reported) the null hypothesis of no cross effects is accepted. In other words, in all three cases the likelihood ratio test shows the lack of any association between the variability of inflation and output growth.

2.3 Granger causality tests

In the previous section the relationship between nominal and real uncertainty is estimated in a simultaneous approach using the BEKK model, which allows each h_{it} ($i = \pi, y$) to depend on lagged squared residuals and past variances of both variables in the system. The simultaneous approach suffers from the disadvantage that it does not allow for a trade-off between the variability of output and of inflation. In other words, the reduced form of the BEKK model restricts the relationship between nominal and real uncertainty being positive (see, for example, Karanasos and Kim, 2004a). In this section we employ a two-step approach where the estimates of the two conditional variances are first obtained from our bivariate GARCH models and then causality tests are run to test for bidirectional effects. We first perform Wald tests and then we report the F statistics of Granger causality tests using four, eight, and twelve lags, as well as the sign of the sums of the lagged coefficients in case of statistical significance. The two-step approach provides a simple way to investigate the relationship between the variability of inflation and of output.

Table 2. Granger causality tests between inflation uncertainty and output growth uncertainty. BEKK GARCH(1,1) models (Entire sample).

	USA	JAPAN	GERMANY
Panel A H0: $h_{\pi t} \nrightarrow h_{yt}$			
4 lags	1.09	3.24***(+)	0.35
8 lags	2.38**(+)	3.74***(+)	0.75
12 lags	2.11**(+)	2.69***(+)	3.00***(-)
Panel B H0: $h_{yt} \nrightarrow h_{\pi t}$			
4 lags	1.73▲(-)	1.24	1.48
8 lags	0.72	1.18	0.58
12 lags	2.11**(-)	0.69	0.38

$h_{\pi t} \nrightarrow h_{yt}$: Inflation uncertainty does not Granger-cause output growth uncertainty. $h_{yt} \nrightarrow h_{\pi t}$: Output growth uncertainty does not Granger-cause inflation uncertainty. ***, **, *and ▲denote significance at the 0.01, 0.05, 0.10 and 0.15 levels, respectively. A + (-) indicates that the sum of the lagged coefficients is positive (negative).

Table 2 reports the results of causality tests between nominal and real uncertainty for our bivariate GARCH model. Panel A tests the null hypothesis that inflation volatility does not cause output volatility. The results show that nominal uncer-

[2] The BEKK estimates of the inflation and output uncertainty are based upon a bivariate VAR(12) model. On the basis of the AIC and the requirement of white residuals we decide to include twelve lags in the VAR. We do not report the estimated results for the mean equation for space considerations.

tainty significantly affects real uncertainty in all three countries, but not all in the same manner. In Japan and the USA inflation variability has a positive impact on output variability. The evidence is very strong in Japan and strong in the USA. These results support the hypothesis advanced by Logue and Sweeney (1981). By contrast, in Germany there is mild evidence (at lag 12) that increased nominal uncertainty lowers real uncertainty, confirming the theoretical predictions made by Taylor (1979). In other words the Taylor hypothesis is verified by the Granger causality tests only for Germany whereas the data for Japan and the USA support Logue-Sweeney's theory.

Panel B tests the null hypothesis that output volatility does not cause inflation volatility. The results show that in Germany and Japan at each lag length the null hypothesis that real uncertainty does not Granger-cause nominal uncertainty is accepted at the 0.01 level. Hence, for these two countries we find no support for the Devereux hypothesis on the positive association between the variability of output and the inflation variability. In the USA the null hypothesis is rejected at the 0.05 level using 12 lags. We take this as mild evidence in favor of Taylor's theory since the sum of the coefficients on lagged real uncertainty in the nominal uncertainty equation is negative.

In sum, Logue-Sweeny's (1981) hypothesis regarding the positive effect of nominal uncertainty on real uncertainty receives support in the USA and Japan whereas in Germany there is mild evidence suggesting a negative impact as hypothesized by Taylor (1979). Evidence in favor of the Taylor hypothesis that output volatility affects inflation volatility negatively applies in the USA. In Germany and Japan we find no effect of real uncertainty on nominal uncertainty.

2.4 Subsample analysis

In this section we examine whether the transition from the high inflation of the sixties and seventies to an era of low inflation during the 1980s and 1990s affects the inflation-output variability relationship by dividing the whole sample period into two subperiods and conducting causality tests for each subperiod separately. In particular, the full sample, which runs from 1957:02 through 2000:08, is broken into two subsamples, corresponding to assumed shifts in the monetary policy regime. The first subperiod goes from the beginning of the sample to the end of 1979. The second subperiod starts in 1980 and continues till to the end of the sample. In the USA the subsamples for the 1980 breakpoint are defined a priori as corresponding to the periods before and after the nonborrowed reserves operating procedure. Considering the structural changes that the three economies have undergone over the past four decades the Granger causality tests are applied to each of the two subperiods.

Table 3a. Parameter estimates for the BEKK GARCH(1,1) models (Subsample: 1957-1979).

	USA	JAPAN	GERMANY
$\alpha_{\pi\pi}$	0.513 (8.26)	0.604 (4.94)	0.425 (4.29)
$\alpha_{y\pi}$	0.033 (0.19)	0.310 (0.95)	0.233 (0.50)
$\alpha_{\pi y}$	0.028 (0.60)	0.044 (1.10)	0.001 (0.03)
α_{yy}	0.718 (7.52)	0.133 (1.41)	0.336 (3.38)
$\beta_{\pi\pi}$	0.811 (16.08)	0.663 (4.82)	0.756 (5.69)
$\beta_{y\pi}$	−0.159 (0.94)	−0.242 (1.08)	0.324 (0.73)
$\beta_{\pi y}$	−0.054 (0.83)	−0.036 (0.78)	−0.009 (0.77)
β_{yy}	0.316 (2.16)	0.964 (22.57)	0.941 (21.70)

The numbers in parentheses are t-statistics.

Table 3 reports parameter estimates for the BEKK parameterizations of the three bivariate GARCH(1,1) models. Table 3a reports the results for the pre-1980 period. In all three countries all the off-diagonal estimates in A and B are statistically insignificant. The results for the post-1979 period are reported in table 3b. The picture is different to that of the pre-1980 period. In the USA the estimate of $\beta_{y\pi}$, which depicts the extent to which the conditional variance of output growth is correlated with the lagged conditional variance of inflation, is statistically significant. In Japan the estimate of $\beta_{\pi y}$, which depicts a cross-effect in the opposite direction, is highly statistically significant.

Table 3b. Parameter estimates for the BEKK GARCH(1,1) models (Subsample: 1980-2000).

	USA	JAPAN	GERMANY
$\alpha_{\pi\pi}$	0.423 (4.24)	0.169 (1.90)	−0.061 (0.20)
$\alpha_{y\pi}$	0.235 (2.50)	0.191 (0.82)	−0.159 (0.08)
$\alpha_{\pi y}$	−0.070 (0.81)	−0.107 (2.55)	0.013 (0.37)
α_{yy}	0.197 (2.07)	0.309 (2.34)	0.368 (2.06)
$\beta_{\pi\pi}$	0.825 (12.78)	0.930 (8.49)	0.783 (3.35)
$\beta_{y\pi}$	−0.139 (1.62)	−0.401 (1.00)	−2.172 (0.79)
$\beta_{\pi y}$	0.017 (0.45)	0.086 (2.48)	−0.062 (0.76)
β_{yy}	0.958 (23.26)	0.819 (7.00)	0.346 (0.36)

The numbers in parentheses are t-statistics.

Table 4 reports the results of causality tests between nominal and real uncertainty for the three countries. Panel A reports the results of applying the Granger causality tests for the pre-1980 period. For Japan and Germany we find strong evidence of a negative unidirectional variability relationship with the line of causation running from inflation volatility to output volatility. No effect in either direction is present for the USA. The results for the post-1979 period are reported in Panel B. The picture is different to that of the pre-1980 period. In Japan there is a lack of a causal effect of nominal uncertainty on real uncertainty whereas in the other two countries the effect is positive. The evidence is strong in the USA and very weak in Germany. Panel B also shows that in all three countries output variability Granger causes inflation variability. The effect is positive in Japan and Germany and negative in the USA. Comparing the results of the entire period with those of the pre-1980 and post-1979 periods the following observations are noted. The (weak) evidence in Germany that the Taylor hypothesis holds reflects the pre-1980 period whereas in the USA the extensive evidence of a bidirectional feedback between real and nominal uncertainty reflects the post-1979 period. That is, the results for the USA over the period which followed the changes in operating procedures in 1979 support both the Taylor and the Logue-Sweeney hypotheses. In sharp contrast, in the pre-1980 period there is no causal relation between inflation and output volatility.

Table 4. Granger causality tests between inflation uncertainty and output growth uncertainty. Subperiods: 1957-1979 and 1980-2000.

	USA	JAPAN	GERMANY
Panel A: Subperiod 1957-1979			
H_0: $h_{\pi t} \nrightarrow h_{yt}$			
4 lags	0.67	15.53***(-)	2.71**(-)
8 lags	0.82	9.39***(-)	1.93*(-)
12 lags	0.60	4.94***(-)	3.14***(-)
H_0: $h_{yt} \nrightarrow h_{\pi t}$			
4 lags	0.72	0.56	0.17
8 lags	0.44	0.70	0.14
12 lags	0.49	0.23	0.26
Panel B: Subperiod 1980-2000			
H_0: $h_{\pi t} \nrightarrow h_{yt}$			
4 lags	3.00**(+)	0.76	2.10*(+)
8 lags	2.20**(+)	1.17	1.05
12 lags	2.90***(+)	1.05	0.75
H_0: $h_{yt} \nrightarrow h_{\pi t}$			
4 lags	5.64***(-)	3.59***(+)	46.88***(+)
8 lags	3.23***(-)	2.01**(+)	24.03***(+)
12 lags	2.58***(-)	1.77**(+)	15.43***(+)

$h_{\pi t} \nrightarrow h_{yt}$: Inflation uncertainty does not Granger-cause output growth uncertainty. $h_{yt} \nrightarrow h_{\pi t}$: Output growth uncertainty does not Granger-cause inflation uncertainty. ***, **, *and ▲ denote significance at the 0.01, 0.05, 0.10 and 0.15 levels, respectively. A + (-) indicates that the sum of the lagged coefficients is positive (negative).

3 Conclusions

In this paper we employed bivariate GARCH models to generate the conditional variances of monthly inflation and output growth for the G3. We then used these variances as proxies of nominal and real uncertainty and performed Granger causality tests to examine the bidirectional relationship between the two variables. The following observations, among other things, are noted about the inflation-output variability relationship. First, in the entire sample period, nominal uncertainty significantly affects real uncertainty in all three countries but not all in the same manner. In Japan and the USA increased inflation variability leads to an increased output variability, a result which is in line with the hypothesis advanced by Logue and Sweeney (1981). By contrast, in Germany there is mild evidence that increased nominal uncertainty lowers real uncertainty, confirming the theoretical predictions made by Taylor (1979).

Second, in the USA output volatility has a negative effect on inflation volatility as predicted by Taylor. Third, for the USA over the period 1980-2000, which followed the changes in operating procedures, the effect of nominal uncertainty on real uncertainty is positive, whereas output uncertainty has a negative impact on inflation uncertainty. The former finding is in agreement with Logue-Sweeney's theory whereas the latter supports Taylor's hypothesis. However, there is no causal relation between nominal and real variability over the period 1957-1979. Fourth, for Germany and Japan in the pre-1980 period there is evidence of causality running only from inflation volatility to output volatility. The effect is negative leading support to the Taylor hypothesis. However, the effect disappears in the post-1979 period. Finally, although in the sixties and seventies there is a lack of a causal effect from real uncertainty to nominal uncertainty a positive effect begins to exist in the eighties and nineties. This result gives support to the Devereux theory. We conclude that, though substantial progress has been made, our understanding of the relation between nominal and real uncertainty is still at a relatively primitive stage, with a considerable amount of territory that is worth exploring.

[1] Amano, R., Coletti, D., Macklem, T., 1999. Monetary rules when economic behavior changes. Bank of Canada, Working Paper, 99-8.

[2] Arestis, P., Caporale, G. M., Cipollini, A., 2002. Does inflation targeting affect the trade-off between output-gap and inflation variability? Manchester School, 70, 528-545.

[3] Batini, N., Haldane, A., 1998. Forward looking rules for monetary policy. Bank of England, Discussion Paper.

[4] Bean, C., 1998. The new UK monetary arrangements: a view from the literature. Economic Journal 108, 1795-1809.

[5] Berndt, E., Hall, B., Hall, R., Hausman, J., 1974. Estimation and inference in nonlinear structural models. Annals of Economic and Social Measurement 3, 653-665.

[6] Clarida, R., Gallí, J., Gertler, M., 1999. The science of monetary policy: a new Keynesian perspective. Journal of Economic Literature 37, 1661-1707.

[7] Devereux, M., 1989. A positive theory of inflation and inflation variance. Economic Inquiry 27, 105-116.

[8] Engle, R., Kroner, K. F., 1995. Multivariate simultaneous generalized ARCH. Econometric Theory 11, 122-150.

[9] Fountas, S., Karanasos, M., Kim, J., 2002. Inflation and output growth uncertainty and their relationship with inflation and output growth. Economics Letters 75, 293–301.

[10] Fountas, S., Karanasos, M., Kim, J., 2005. Inflation uncertainty, output growth uncertainty, and macroeconomic performance. Oxfoed Bulletin of Economic and Statistics, forthcoming.

[11] Fuhrer, J., 1997. Inflation output variance trade-offs and optimal monetary policy. Journal of Money, Credit, and Banking 29, 214-234.

[12] Goodfriend, M., King, R., 1997. The new neoclassical synthesis and the role of monetary policy. NBER Macroeconomics Annual 1997, MIT press, Cambridge, 233-283.

[13] Grier, K. B., Perry, M., 1998. On inflation and inflation uncertainty in the G7 countries. Journal of International Money and Finance 17, 671-689.

[14] Grier, K. B., Perry, M., 2000. The effects of real and nominal uncertainty on inflation and output growth: Some GARCH-M evidence. Journal of Applied Econometrics 15, 45-58.

[15] Grier, K. B., Henry, Ó. T., Olekalns, N., Shields, K., 2004. The asymmetric effects of uncertainty on inflation and output growth. Journal of Applied Econometrics, 19, 551-565.

[16] Karanasos, M., Kim, J., 2005a. The inflation-output variability relationship in the G3: a bivariate GARCH (BEKK) approach. Risk Letters, forthcoming.

[17] Karanasos, M., Kim, J., 2005b. The link between the variability of inflation and of output and the transition from the high inflation of the sixties and seventies to an era of low inflation during the 1980s and 1990s. Brunel University, Unpublished manuscript.

[18] King, R. G., Wolman, A. L., 1998. What should monetary authority do when prices are sticky? In Taylor, J. (ed.), Monetary Policy Rules, University of Chicago Press, Chicago.

[19] Lee, J., 1999. The inflation and output variability trade-off: evidence from a GARCH model. Economics Letters 62, 63-67.

[20] Logue, D., Sweeney, R., 1981. Inflation and real growth: some empirical results. Journal of Money, Credit, and Banking 13, 497-501.

[21] Rotemberg, J., Woodford, M., 1998. An optimization based econometric framework for the evaluation of monetary policy. In NBER Macroeconomics Annual, MIT Press, 297-346.

[22] Taylor, J., 1979. Estimation and control of a macroeconomic model with rational expectations. Econometrica 47, 1267-86.

[23] Taylor, J., 1980. Aggregate dynamics and staggered contracts. Journal of Political Economy 88, 1-23.

[24] Taylor, J., 1994. The inflation/output variability trade-off revisited. In Goals, Guidelines and Constraints Facing Monetary Policymakers, Federal Reserve Bank of Boston, Conference Series, No. 39, 152-214.

[25] Vilasuso, J., 2001. Causality tests and conditional heteroscedasticity: Monte Carlo evidence. Journal of Econometrics 101, 25-35.