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# Macroeconomic Uncertainty and Economic Performance for Germany

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**Summary.** This study finds that uncertainties in interest rates, commodity prices and money aggregate affect economic outcomes for Germany. Both interest rate and monetary policy uncertainty measures are positively correlated with interest rates, while commodity price uncertainty is negatively correlated with the output level. However, uncertainties in exchange rate, price and income do not have a statistically significant predictive power for income, prices or the interest rate.

**Key words:** Macroeconomic Uncertainty, Economic Performance and Multivariate GARCH-M Models.

## 1. Introduction

This study tests whether uncertainties in various macroeconomic aggregates, both financial and goal variables, affect German economic performance for the period 1964:12 to 1989:12. Previous studies mostly concern whether inflation uncertainty has a negative effect on economic performance, although some studies do investigate the possible effect of uncertainty surrounding exchange rate, monetary policy, interest rate and foreign trade (both export and import) on economic performance. Even if this negative relationship between inflation uncertainty and economic performance is observed for so me of the OECD countries, this negative relationship is not observed for Gennauy (see Froyen and Waud, 1987; Sauer and Bohara, 1995). This study tests whether other macroeconomic uncertainty variables beside inflation uncertainty have an explanatory power for the economic performance. This study, first, combines all these different macroeconomic aggregate uncertainties in a single study, and second, tests whether controlling for certain aggregates affects the nature of these correlations between various uncertainty measures and economic outcomes. This is important because assuming only the uncertainty surrounding inflation but not other aggregates like interest rates, exchange rates and money demand matters might be a too restrictive assumption, one that could lead to a misspecified model. Furthermore, variolis uncertainties might be proxying another variable, such as inflation uncertainty proxying inflation. Controlling this variable may show that a particular uncertainty variable does not statistically significant explanatory power.

One risk variable that economist s follow is inflation uncertainty. They observe the effect of inflation uncertainty on output and on inflation itself. Okun (1971), for example, observed a positive association between inflation and inflation uncertainty. He suggests that when the inflation level is low, the public knows that the government prefers to keep inflation at low levels; however, if infiation is high, then the public does not know whether the government is willing to bear the cost of recession to decrease the level of infiation. (On the similar positive relatianship between infiation and the measure of infiation uncertainty, see Jansen, 1989; Ball and Cecchetti, 1990; Evans, 1991; Evans and Wachtell, 1992; Holland, 1993.)

Literature is not dear about the effect of infiation uncertainty on output. Marshall (1886), Okun (1971) and Friedman (1977) argue that uncertainty about future prices does negatively affect output. Friedman (1977) notes that uncertainty about future prices can have real effects because, first, the need for new and costlier contractual arrangements will increase transactian costs, and second, the effect of volatility of relative prices increases information costs. On the other hand, Cukierman and Meltzer (1986) claim that greater uncertainty about money growth and infiation makes it easier for the government to create unanticipated infiation to increase not only output but also the infiation rate. Hence, Cukierman and Meltzer suggest that there is a positive relationship between infiation uncertainty and output.

Empirical evidence on the relationship between infiation uncertainty and output is not well established. Both Froyen and Waud (1987) and Sauer and Bohara (1995) find mixed results for different countries. Furthermore, Huizinga (1993), Jansen (1989) and Shen (1991) cannot find statistically significant evidence that uncertainty about future infiation decreases the output level for the U.S. Jansen explains this weak evidence by noting that the infiation rate may be highly predictable, thus observing the infiation uncertainty is difficult. However, Coulson and Robins (1985) find that the conditional infiation variance decreases unemployment and increases output level. Hafer (1986) and Mullineaux (1980) also find that infiation uncertainty is positively correlated with unemployment. Overall, the empirical evidence is mixed for the possible negative relationship between the infiation risk and output.

Some other studies have also examined the effects of uncertainty factors other than infiation uncertainty. Table 1 _summarizes some of these studies. The first column lists the study, the second column indicates the uncertainty variable, the third column shows the variable affected by the uncertainty variable, and the last column indicates how the macroeconomic aggregate in the third column is affeded by the uncertainty variable in the second column. Overall. the table suggests that all the economic uncertainty variables negatively affect the economic activity.

| Study | Uncertainty Variable | Level Variable | Direction |
|---|---|---|---|
| Kormendi and Meguire (1985) | Money | Growth | Negative |
| Conway (1988) | Real Interest Rate | Investment | Negative |
| Lopez (1989) | Real Exchange Rate | İnvestment and Real income | Negative |
| Glezakos (1973), Voivodas (1974), and Ocler and Harrihan (1988) | Export | Growth | Negative |
| Helleiner (1986) | Import | Growth | Negative |
| Caballero and Cobra (1988), and Celasun and Rodrik (1989) | Exchange Rate | Export | Negative |
| Devarajan and de Mello (1987) | Currency | Growth | Negative |
| Huizinga (1993) | Real Wage | Investment | Negative |
| Aizenman and Marion (1993) | Government Consumption and Taxes | Private Investment | Negative |

Table 1 Studies of Relationship Between Various Uncertainty Variables and Economic Activity

Various methods can be used to measure uncertainty. These are sample variance of the crosssection of the data set, a sample variance of survey data for each time period, moving average variances and conditional variance. This study uses conditional variances to measure uncertainty. Here, conditional variance is the prediction, one month in advance, of the price level. Using the conditional variances allows us first, to measure uncertainty as a time-dependent variable and second, to measure uncertainties for the future value of the infiation rate.

On the other measures of uncertainty measures, Okun (1971) uses sample variance to measure infiation uncertainty by using a particular time interval for each observation. Mullineaux (1980), however, measures the infiation uncertainty by using standard errors of the survey data that this generated by asking questions to the specialists for each time period. Katsimbris (1985) allows the mean and variance of infiation to change over time by using moving averages. These measures may, however, fail to capture time dependent infiation uncertainty for the future. Okun's method fails to deliver a time-dependent uncertainty measure. Even if using survey data or moving averages gives time dependent uncertainty measures, these methods may not measure the uncertainty for the future value of a variable. Survey data measures uncertainty by observing the difference between point estimates of individual specialists, where uncertainty effect is already incorporated into the specialists' forecast. Hence if every specialist is uncertain about inflation and has a similar forecast, this method may still indicate that inflation uncertainty is low. The moving average method uses the unpredicted part of a current value to measure uncertainty about the future value. In sum, these methods may not necessarily measure uncertainty about the future value of a particular variable (see Jansen, 1989, for details). The conditional variability of various macroeconomic aggregates is also be used as a measure of uncertainty (see, Jansen, 1989, for a summary of these studies). This method employs all information available to farecast the time-dependent variance of a variable that can be used as a measure of uncertainty.

In sum, to avoid the problems introduced by sample variance of cross section-time series data, survey data and moving average- variance methods, this study uses conditional variances as a measure of uncertainty. In order to allow for the possibility that not only the inflation uncertainty but also other types of Juncertainties matter, we use a more general form of conditional variability, the Multivariate Generalized Autoregressive Conditional Heteroscedastic, models (MGARCH) to measure uncertainty. We will allow the uncertainty measure to affect the level of the predicted future path of the series; this set of models is called MGARCH in Means models (MGARCH-M). The following section discusses the methodology of MGARCH-M modeling. Section three introduces the data. The empirical evidence is presented in section four. The last section offers conclusions.

## 2. Econometric Methodology

Assume a relationship between certain macroeconomic variables and the measures of uncertainty for these variables. Let $z_t$ be a $N \times 1$ vector for the macroeconomic variables and $H_t$ be a $NxN$ vector as a measure of uncertainties. Here the diagonal elements of $H_t$ measure the uncertainty of each variable and the off-diagonal elements measure the correlations among these variables Furthermore, $\varepsilon_t$ is the $N \times 1$ matrix of error terms at time $t$. The error term shows the unexplained part of the vector $z_t$ by the systematic part of the economic variables. This relationship can be, represented in the form of (1) where A's and G are $NxN$ matrices of estimated coefficients. Here the coefficients of the matrix G are our concern. G measures whether any of these uncertainty factors has predictive power for the macroeconomic aggregates:

$$z_t = A_0 + \sum_{i=1}^{p} A_{t-i} z_{t-i} + GH_t + \varepsilon_t \tag{1}$$

Importantly, here $H_t$ is both a measure of uncertainty and the time-dependent conditional variance-covariance matrix of $\varepsilon_t$ Here it is assumed that the agents' forecast for the $E(\varepsilon_t \varepsilon_t')$ by using all available information ( that is, $z_{t-1}, z_{t-2}, ...$) equals its conditional expectation.

$$(2) \qquad H_t = E(\varepsilon_t \varepsilon_t' \ / \ z_{t-1}, z_{t-2}, ...)$$

Engle and Kroner (1993) suggested modeling vector generalization of $H_t$ as a $MGARCH(q, w)$ where

$$\begin{aligned}(3) \qquad H_t &= \Delta_0 + \Delta_1 H_{t-1} \Delta_1' + \Delta_2 H_{t-2} \Delta_2' + ... + \Delta_q H_{t-q} \Delta_q' \\ &+ D_1 \varepsilon_{t-1} \varepsilon_{t-1}' D_1' + D_2 \varepsilon_{t-2} \varepsilon_{t-2}' D_2' + ... + D_w \varepsilon_{t-w} \varepsilon_{t-w}' D_w'\end{aligned}$$

Here $\Delta_0, \Delta_s$ and $D_s$ for $s = 1, 2...$ denote $(NxN)$ parameter matrices. This modeling technique generates $H_t$ as a positive definite matrix if $\Delta_0$ is a positive definite matrix.

For a relative large $N$, it is necessary to restrict the $MGARCH(q, w)$ specification to decrease the number of parameters to be estimated. One such restriction is to assume both $\Delta_s$ and $D_s$ to be diagonal matrices for $s = 1, 2, ...$ . In such a specification, the conditional covariance between $\varepsilon_{i,t}$,and $\varepsilon_{j,t}$ depends on the past values of $\varepsilon_{i,t-s} \ \varepsilon_{i,t-s}$, not the products or squares of other residuals

Bollerslev (1990) also assumes that the conditional correlations among the elements of $\varepsilon_t$ are constant over time, and the conditional variances are modeled where $h_{i,t} = E(\varepsilon_{it}^2 \ / \ z_{t-1}, z_{t-2}, ...)$ Hence, the conditional variance could be modeled as a univariate Generalized Autoregressive Conditional Heteroscedastic ($GARCH$) models for each equation where the process is modeled by its squared lag innovations and lag conditional variances with constant covariances among N variables. Here, $GARCH(1, 1)$ specification can be written for $N$ equations as

$$(4) \qquad h_{i,t} = \delta_{0i} + \delta_{1i} h_{i,t-1} + \delta_{2i} \varepsilon_{i,t-1}^2 \quad \text{for } i = 1, 2, ...N$$

Hence, the number of parameters to be estimated decrease considerably. The estimation methoc of the model is aIready worked out by Engle, lto and Lin (1990), and the modeling methodology this paper uses will be discussed in the following sections.

## 3. Data

We first estimate a Vector Autoregressive- (VAR) type macroeconomic model which includes six variables such that these six variables incorporate both Keynesian-Monetarist and Real Busines Cycles features. Then the second moments of the residuals are modeled as a GARCH process individually and are then incorporated into the VAR process as a weakly exogenous variable. At the second stage, (1) and (4) are estimated jointly.

The six macroeconomic variables we include in the unconstrained VAR model are the same as those in Sims's (1992) paper. These variables are call rate as interest rate, Deutsche marks per SDR as exchange rate, world export commodity price index as the commodity price index, $M1$ as money aggregate, $CPI$ as prices, and industrial produetion as income. All the data is obtained from International Monetary Fund-International Financial Statistics, and each variable is seasonally adjusted. The data set includes monthly observations from 1964:12 to 1989:12 for Germany; the sample is ended at 1989:12 to avoid distortion from the effeet of unification.

The advantage of including this set of variables is that it includes both the standard ıs and Real Business Cycles features. The standard assumption of the $IS-LM$ framework is that money aggregate or unexpected change in money aggregate affects the output. In a multivariate time series model, including nominal interest rates makes the effect of monetary policy smaIler. Hence, we include both money aggregate and interest rate in the multivariate setting to explain the behavior of income. For the Real Business Cycle- ($RBC$) style models, monetary policy has little real effect.

Empirical evidence als o suggests that price levels moves counter cyclically to disturbances of all kinds. In the Sims (1992) specification, RBC models do not directly compete with the $IS-LM$ interpretations that can rationalize the behavior of interest rates, money, income and prices. We also include two other variables, the exchange rate (to account for the effect of the foreign sectar) and commodity prices (to resolve the price puzzle).[1]

We first examine whether there is a unit root in these series. Table 2 reports the Augmented Dickey-Fuller unit root tests for these six series. $\tau_t$ tests the unit root of levels of variables with a constant and a time trend. $\tau_\mu$ tests the unit roots using the first difference of the variables. All the variables except the interest rates are in their logarithmic forms. The table suggests that for all the variables but the interest rates, we cannot reject the null hypothesis of unit roots at the 5% level. However, for all of the series, when their first difference is taken, the null hypothesis of the unit root at the 5% level can be rejected.[2] suggests that all the variables except the interest rate are nonstationary. Unless there is a linear combination of these five variables such that this linear combination is stationary, the multivariate analysis upon these nonstationary variables cannot be performed. In other words, these five series mu st be cointegrated.

We next examine the existence of cointegrating relationships among these five nonstationary variables. If there is a cointegrating relationship among them, then there is at least one stationary relationship among them as well, and these five nonstationary variables and the interest rates can be used at their levels

[1] Omitting the commodity prices could indicate that tight monetary policy leads to high pricesee Christiano, Eichenbaum and Evans (1996).

[2] We also tested the unit root of these series at their levels with a constant; the results are simil;to those for the unit root of these series with a constant and a time trend.

for multivariate analyses. Table 3 reports Johansen's cointegration tests for the five nonstationary series.

| Variables | $\tau_1$ | $\tau_2$ |
|---|---|---|
| Interest Rates | -3.65* | -3.50* |
| Exchange Rate | -2.08 | -8.78* |
| Money | -1.85 | -7.33* |
| Commodity Prices | -1.77 | -6.03* |
| Prices | -0.11 | -5.51* |
| Industrial Production | -2.36 | -5.89* |

[a] *Significant at the 5% level.

Table 2 Augmented Dickey-Fuller Tests[a]

Panel A reparts the Maximum Eigenvalue tests and Panel B reports the Trace tests. The first column of each panel reports the $\lambda$ statistics, while the second and third columns specify the null and alternatiye hypotheses, respectively. The fourth columns of each panel report the critical values for the $\lambda$ statistics at the 90% level from Johansen and Juselius (1990, Table 2). Both statistics reported in Table 3 suggest that there are three independent cointegrated vectors at the 10% level of significance; stationary relationships exist among these five nonstationary macroeconomic variables. Hence, (1) and (4) can be estimated jointly to observe the effects of uncertainty measures on these six macroeconomic variables when the levels of the series are used.

| Panel A: Maximum Eigenvalue Tests | | | | Panel B: Trace Tests | | | |
|---|---|---|---|---|---|---|---|
| $\lambda_{\max}$ | Null | Alternative | $\lambda_{\max,90}$ | $\lambda_{trace}$ | Null | Alternative | $\lambda_{trace,90}$ |
| 40.72* | r=0 | r=1 | 20.90 | 85.67* | r=0 | r$\geq$1 | 67.74 |
| 20.19* | r=1 | r=2 | 17.15 | 44.96* | r$\leq$1 | r$\geq$2 | 43.84 |
| 16.94* | r=2 | r=3 | 13.39 | 24.77* | r$\leq$2 | r$\geq$3 | 26.70 |
| 6.46 | r=3 | r=4 | 10.60 | 7.83 | r$\leq$3 | r$\geq$4 | 13.31 |
| 1.36 | r=4 | r=5 | 2.71 | 1.36 | r$\leq$4 | r=5 | 2.71 |

[a] *Significant at the 10% level.

Table 3 Johansen's Cointegration Tests[a]

## 4. Emfirical Evidence

This section discusses how the conditional varianee of the six macroeconomic aggregates affects the variables at their levels. In order to observe the effects of conditional variances on their levels.

(1) and (4) are first specified and then estimated. Because Sims (1992) has aIready discussed the relationship among these six variables, the author will not cover that aspect here, but the author refer interested readers to his research for more details.

In order to specify the model, we first determine the lag structure of the VAR system. We used the Bayesian Information Criteria that suggest the order of the VAR process, which is one. We could alsa have used the Final Predictian Error Criteria to determine different lag structures for each equation within the VAR system, but we avoided these criteria to preserve the symmetry of the system. Second, we modeled the variances of the residual terms for each single equation in the VAR system as a $GARCH(1,1)$ process. Here we model the conditional variances as a function of the unexpected movement of each variable from (1) and the lag value of the conditional variance itself. The model also incorporates the conditional variance of the residuals. which could affect the variable itself. Incorporation of the conditional variances to the VAR process allows us to see how the measure of the uncertainties for each variable influences other variables To avoid overparameterizing the model, we also assumed that the covariance between each residua is constant. Finally, the two sets of (1) and (4) are estimated jointly to test the basic hypotheses of the paper.[3]

Table 4 presents the empirical evidence for (1) and (4), where only the effects of the various uncertainty variables on the variable itself are reported. The table reports the estimatec coefficients as well as the p-values. The p-values are the marginal significance levels of particular variable uncertainty factors on levels.

Before starting to interpret the estimates, we should state that to save space we will discuss only the statistically significant coefficients.[4] Interest rate uncertainty and money demand uncertaint} both positively correlate with interest rates. Interest rate uncertainty may discourage agents from holding currency. Therefore, money demand or loanable funds decrease. Hence, interest rate: increase. Note also that there is a negative and statistically significant correlation that will be discussed below between interest rate uncertainty and money demand. This result is consisten with the hypothesis that risk-averse agents like to avoid risky assets; greater uncertainty about money demand discourages agents from holding money, and this may further decrease the interest rates.

Exchange rate is influenced by interest and exchange rate uncertainties. Interest rate uncertainty decreases, while exchange rate uncertainty increases, the exchange rate. Note that the exchang rate is the foreign exchange value of domestic currency. An increase in the exchange rate indicate the appreciation of domestic curreney. Again, for risk averse agents, as the interest rate uncertainty increases, holding domestic currency becomes riskier, demand for foreign currency increases and/or demand for domestic currency decreases and the domestic currency depreciates.

[3] After specifying the MGARCH-M process with its first lags, we also included additionallagHowever, the Bayesian Information Criteria stili indicated that additionallags are not needed.

[4] The level of significance is 10% unless otherwise noted.Abbreviations.

| Effect of Uncertainty Variable | On Levels | Estimated Coefficients | p-values |
|---|---|---|---|
| Interest Rate | Interest Rate | 0.1736 | 0.0000** |
| Exchange Rate | Interest Rate | 5.9057 | 0.3490 |
| Commodity Prices | Interest Rate | -2.7156 | 0.1435 |
| Money | Interest Rate | 20.9584 | 0.0297** |
| Prices | Interest Rate | -41.8722 | 0.3227 |
| Income | Interest Rate | -9.2580 | 0.6916 |
| Interest Rate | Exchange Rate | -0.0433 | 0.0263** |
| Exchange Rate | Exchange Rate | 1.3569 | 0.0022** |
| Commodity Prices | Exchange Rate | 0.3118 | 0.1677 |
| Money | Exchange Rate | -0.6891 | 0.3082 |
| Prices | Exchange Rate | -3.2462 | 0.1578 |
| Income | Exchange Rate | -0.8124 | 0.5421 |
| Interest Rate | Money | -0.0224 | 0.0034** |
| Exchange Rate | Money | -0.0621 | 0.7673 |
| Commodity Prices | Money | 0.1536 | 0.0620* |
| Money | Money | -0.2762 | 0.3295 |
| Prices | Money | 0.7981 | 0.3848 |
| Income | Money | 0.2519 | 0.5866 |
| Interest Rate | Commodity Prices | 0.1123 | 0.0001** |
| Exchange Rate | Commodity Prices | -0.5581 | 0.5411 |
| Commodity Prices | Commodity Prices | -1.0774 | 0.0017** |
| Money | Commodity Prices | 0.3464 | 0.5728 |
| Prices | Commodity Prices | -0.8212 | 0.8195 |
| Income | Commodity Prices | -1.9245 | 0.3105 |
| Interest Rate | Prices | 0.0037 | 0.0146** |
| Exchange Rate | Prices | -0.0771 | 0.2804 |
| Commodity Prices | Prices | -0.0512 | 0.0347** |
| Money | Prices | -0.0400 | 0.6506 |
| Prices | Prices | -0.4702 | 0.1088 |
| Income | Prices | -0.0593 | 0.5852 |
| Interest Rate | Income | 0.0090 | 0.4161 |
| Exchange Rate | Income | 0.2487 | 0.2257 |
| Commodity Prices | Income | -0.1591 | 0.0837* |
| Money | Income | 0.1483 | 0.6451 |
| Prices | Income | -1.4593 | 0.2231 |
| Income | Income | -0.5702 | 0.1825 |

[a] **Significant at the 5% level.

[a] *Significant at the 10% level.

Table 4 Effects od Various Economic Uncertainties on Macroeconomic Variables for Germany[a]

Similarly, as foreign currency becomes risky, as indicated by higher uncertainty in foreign exchange, then demand for foreign curreney decreases and/or demand for domestic currency increases. Domestic interest rate then increase as the demand for domestic currency increases.

Money demand decreases with higher levels of interest rate uncertainty and increases with commodity price uncertainty. The reason for this type of relationship could be that higher interest rate uncertainty discourages agents from holding money and agents try to hold alternative assete. However, the risk of higher commodity prices increases the money demand possible because of the precautionary demand for money. Here, it is interesting to note that even if both the consumer price index uncertainty and commodity prices uncertainty are positively associated with money demand, the commodity price index, not the consumer price index, explains the behavior of the money demand in a statistically significant fashion.

Commodity prices are positively affected by interest rate risk and are negatively affected by their own risk. The positive effect of interest rate risk on commodity prices may suggest that higher interest-rate risk discourages firms from producing primary products, and this relationship may increase commodity prices. The negative effect of commodity prices uncertainty on the commodity prices is admittedly puzzling. However, this result may mean that commodity price risk increases the import demand so that commodity prices decrease.

Prices are positively associated with interest rate uncertainty and negatively associated witl commodity price risk. This relationship can be explained as first, the interest rate uncertainty increasing aggregate consumption, a result consistent with the lower money demand, and second higher aggregate demand increasing the price level. Interest rate uncertainty also increases income; however, the evidence is not statistically significant. Lastly, commodity price uncertainty decrease: prices and income, possibly because of higher imports or because the risk premium decreases the aggregate demand.

Note that the estimated coefficient on the effect infiation uncertainty has on output is negative as Friedman and others suggest. However, the estimated coefficients for the income equation o all the uncertainty measures except the commodity price uncertainty measure are not statistically significant. Two explanations may exist for the insignificant coefficients for these uncertainty measures. First, the interest rate is the transmission mechanism such that higher money demand and interest rate uncertainties decrease the economic performance due to higher interest rates. Next both money aggregate and interest rate are more readily available for corresponding month than price levels. German agents may prefer not to monitor the monthly price uncertainty for the cur rent month, but their decisions were mostly influeneed by the monetary aggregate or interest rate uncertainty measure, ceteris paribus

## 5. Conclusian

This study uses a Multivariate GARCH-M model to see how the various macroeconomic variable uncertainties affect the macroeconomic outeomes for Germany for the monthly sample from 1964:1: to 1989:12. We tested whether uncertainty surrounding interest rate, exchange rate, commodity prices, money demand, prices and income affect their own levels. We chose Germany as the country for whieh to observe these uncertainty effects because earlier studies could not find that inflation uncertainty had affected the economic performance of this country. However, uncertainty surrounding other variables beside inflation could affect economic performance. Like other studies, this study could not find supporting evidence for the hypothesis that inflation uncertainty affects the output This paper did find, though, that money and interest rate uncertainties affect the interest rate positively, and commodity price uncertainty decrea.ses income. Hence, uncertainty beside inflation could have an effect on economic performance. that earlier univariate studies could not perceive.

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MGARCH: Multivariate Generalized Autoregressive Conditional Heteroscedastic models.
MGARCH-M: Multivariate Generalized Autoregressive Conditional Heteroscedastic in Mean models.
GARCH: Generalized Autoregressive Conditional Heteroscedastic models.
VAR: Vector Autoregressive models.
RRC: Real Business Cvcle models.