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# THE EFFECT OF MONETARY POLICY ON ASSET PRICES: EVIDENCE FROM GERMANY AND UK

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## Introduction

The main objective of this work is to study the effect of monetary policy on asset prices and in particular on the stock market. While in the past, the studies did not often support the belief that the behaviour of the stock prices was linked with monetary policy shocks, in the recent years researchers have led to the evidence of the existence of a strong connection between monetary policy variables and the stock market (Thorbecke (1995), Bomfim (2000), Rigobon and Sack ((2003), (2004)) among others). If from one hand monetary policy exerts an impact on the stock market, from the other hand stock price movements might affect monetary decisions. This evidence motivates empirical analysis to develop a better and clearer understanding of this relationship.

The recent empirical research which found support for a strong connection between the stock market and monetary decisions by the policy makers (Rigobon and Sack (2003, 2004), Bomfim (2000), Thorbecke (1995),...) test for the existence of this link focusing on the US economy, as this state has been proved to be the dominant capital market capable of influencing developing markets. The countries we here examine are instead Germany and the UK, chosen because of the important economic role played by these countries in the European context. Beside the link between monetary policy and the stock market studied by Rigobon and Sack for US, we focus the analysis on the relation of monetary policy and other asset prices: the bond price, the bond yield and the exchange rate. These variables as well might be affected by monetary changes.

Differently from the more traditional literature, in order to test the effect of German and British monetary policy on asset prices, we apply a technique which allows to estimate a model in which the variables behave simultaneously and are endogenously defined relying on a new set of assumptions. This approach, which has been called "heteroskedasticity based approach", as it relies on heteroskedasticity in the data, has been recently suggested by Rigobon and Sack (2003, 2004). The methodology we are going to use differs from the traditional literature as it makes these estimates relying on an innovative set of assumptions and on some restrictions which we believe to be weaker than those characterizing the previous literature. The heteroskedasticity based approach achieves identification of the parameters relying on the comovement of the variables of the model when the variance of one shock to the system is known to shift. In particular, we only need to divide our estimating period in at least two samples, depending on the behavior of one shock of the model.

Thus, to verify whether monetary policy had an impact on asset prices, we divide the period of analysis in at least two samples assuming heteroskedasticity of monetary shocks during the monetary policy announcement days, which is a plausible assumption, and we divide the period in "announcement" day (corresponding to the day of the monetary policy announcement) and "non announcement" day (which is taken to be alternatively one day, two days or five days prior to the announcement).

In order to compare the estimates obtained with the heteroskedasticity based approach to those found with a more traditional approach, we test an event study analysis, which is based on estimating the model focusing on periods immediately surrounding changes in the policy variable.

The structure of the work proceeds as follows. We first describe in details the heteroskedasticity based approach, underlying its assumptions and its main features. Then, we apply this methodology and the event study analysis in order to capture German and British effect of monetary policy on asset prices. We finally present the results.

# 1 The methodology

## 1.1 The identification problem

In order to evaluate the link between monetary policy and asset prices, we study the basic following model:

(1)

$$\Delta i_t = \beta \Delta s_t + \varepsilon_t$$

(2)

$$\Delta s_t = \alpha \Delta i_t + \eta_t$$

where $\Delta i_t$ is the change in the short-term interest rates and $\Delta s_t$ is the change in the asset price. Equation (1) represents a monetary policy reaction function that captures the expected response of policy to the asset price. Equation (2) is the asset price equation, which allows the asset price to be influenced by the interest rate.

The traditional literature has largely estimated eq. (2) of the model above, focusing in particular, on the impact of interest rate changes on the stock market around policy dates or including lagged terms, without estimating the contemporaneous link between the variables and thus obtaining incorrectly signed coefficients ( Roley *et al* ((1995), (1998)), Thorbecke (1997), Kuttner (2000), Bomfim (2000), Crowder (2004)).

We are here interested on the contemporaneous effect between the variables. In estimating the link, we must take into account that the model described by equation (1) and (2) has the features of including endogenous variables as regressors. The question of identification when the model includes endogenous variables has been studied for a long period now. The problem refers to a system of simultaneous equations where the parameters cannot be directly estimated.

Several difficulties arise. First, monetary variable proxy like short-term interest rates are simultaneously influenced by the behaviour of asset prices, resulting in a difficult endogeneity problem. While asset prices are influenced by short-term interest rates, the short-term interest rate is simultaneously affected by asset prices. Second, a number of other variables, including news about the economic situation of the country which is analyzed and variables that contribute to give information about the macroeconomic outlook or changes in risk preferences, likely have an impact on both short-term interest rates and asset prices.

These two considerations complicate the issue of identification of the link between asset prices and policy actions to the point that no procedures have been developed to cope with all problems at the same time.

To see the econometric problem formally, consider running an OLS regression on equation below (2). The estimated coefficient will be biased because the shock term $\eta_t$ is correlated with the regressor *i* as a result of the response of the interest rate to the asset price, as determined by parameter $\beta$ in equation (1). Without imposing restriction in the model, the parameters of interest cannot be estimated by any method. The problem originates from the fact that the only statistics that can be computed in a system of *n* simultaneous equations is the covariance matrix of the residual form. However, the covariance matrix only provides three equations (the variance of the residuals to the interest rates, the variance of the residuals to the stock market and their covariance) while there are four unknowns to derive $\alpha$ , $\beta$ , $\sigma_\varepsilon^2$ , $\sigma_\eta^2$ . Therefore, to solve for the original parameters more information is required; this implies the necessity to impose constraints in the model itself.

### 1.1.1 The VAR analysis

A technique used in this literature to estimate a model like that of equation (1) and (2) has been the estimate of a VAR which includes the stock market return and a monetary policy variable. The VAR framework allows the innovations in the variables to be interpreted as the unanticipated shocks. To capture the estimates of the parameters in a VAR structure, we need to impose one of the following constraints:

1) Exclusion restrictions: this refers to constraint either $\alpha$ or $\beta$ to be equal to zero. In a structural VAR context, typical identification is based on zero restrictions that in this case rules out simultaneous responses between interest rate and stock market variables.
   Unfortunately, this type of restriction implies a specific contemporaneous relationship among the endogenous variables that is often incompatible with economic theory. Looking at model described by equation (1) and (2), if we constrain $\alpha$ or $\beta$ to be equal to zero, we would obtain bias coefficients because of the endogenous variables present in the model.
2) Sign restrictions. The imposition of the sign on the slopes of the structural equations can allow partial identifications because the two inequalities imply a region of admissible parameters.
3)Long run constraints. When the structural form includes lagged dependent variables, it is possible to constraint the long run behaviour of a particular shock. This hypothesis is equivalent to impose that the sum of lag coefficients is equal to zero. Because economic theory generally has more specific implications for long-run behavior, Blanchard and Quah (1989) suggested imposing a long-run neutrality restriction on the VAR system. The form of this restriction in the current analysis implies for example that shocks to stock returns have no long run effect on the federal funds rate. This means that the Fed will only respond in a temporary way to innovations in the equities markets (Crowder (2004)).
4) Finally, constraints on the variances.

### 1.1.2 The event study approach

Recently, researchers have typically solved the problems of identification of model described by equation (1) and (2) by focusing on periods immediate surrounding changes in the policy variable. This approach has been called the "event study" approach. The theoretical explanation of the event study approach is that the bias in the OLS estimate $\alpha$ or $\beta$ will be limited if we include only periods in which the innovations to the system are primarily due to one shock of the economic model. The event study methodology focuses on the effects immediately after a policy announcement. It was believed that these announcements, using daily or weekly data, rather than monthly or quarterly as the earlier studies, could be viewed as exogenous to the subsequent reactions on the event day.

The bias in the OLS estimate for $\alpha$ will be limited if the sample contains periods in which the innovations to the system are driven primarily by the policy shock $\varepsilon$.

To show this consider to estimate an OLS regression of a little extension of the model described by equation (1) and (2). We consider the following model:

(1')

$$\Delta i_t = \beta \Delta s_t + \gamma z_t + \varepsilon_t$$

(2')

$$\Delta s_t = \alpha \Delta i_t + z_t + \eta_t$$

which allows for the presence of a possible common shock affecting both the interest rate and the asset price. The estimated parameter $\hat{\alpha}$ of this model would be given by:

(3)

$$\hat{\alpha} = \alpha + (1 - \alpha\beta) \frac{\beta\sigma_\eta + (\beta + \gamma)\sigma_z}{\sigma_\varepsilon + \beta^2\sigma_\eta + (\beta + \gamma)^2 \sigma_z}$$

where $\sigma_\eta$, $\sigma_\varepsilon$ and $\sigma_z$ represent the variance of asset prices shocks, monetary policy shocks and other relevant shocks respectively (Rigobon and Sack (2004)).

Looking at equation (3) we can see that the estimate $\alpha$ is biased because of the simultaneity problem (if $\beta \neq 0$ and $\sigma_\eta > 0$) and the omitted variable problem (if $\gamma \neq 0$ and $\sigma_z > 0$).

To reduce the bias, thus, the event study approach considered a period in which the innovations to the system of equations (1') and (2') are driven primarily by the policy shock. In particular, this methodology requires here that:

$$\sigma_\varepsilon >> \sigma_z$$

$$\sigma_\varepsilon >> \sigma_\eta$$

So that $\hat{\alpha} \cong \alpha$.

In the limit, if the variance of the monetary policy shock becomes infinitely large relative to the variances of the other shocks, thing that for example can happen around policy dates, the bias goes to zero, and the OLS estimate is consistent. This property of the OLS estimate is what Fisher (1976) referred to as "near identification".

This literature largely followed Cook and Hahn (1989), whose approach was to regress daily changes in the market rates on changes in the federal fund rate for a sample of dates on which the Fed announced changes in the monetary policy decisions.

The problem with this estimation procedure, however, still remains since the basis of the approach which consists in estimating OLS regressions on dates of monetary decisions meetings or policy moves- has remained the same. Unfortunately, the event-study analysis does not give any empirical support about whether the necessary conditions to reduce the bias hold, and thus the magnitude of the bias that still remains in those estimates cannot be tested with the event-study approach.

### 1.2 The heteroskedasticity based approach: a description

To solve the issue of identification and study a system of equations where the variables behave simultaneously and are endogenously defined, we assume heteroskedasticity in the data. The explanation behind this identification technique relies on the role of the covariance matrix when one shock of the model is assumed to shift. The intuition behind the identification is that shifts in the variance change the region in which the errors are distributed, enlarging the ellipse along the two equations of the model. This change in the ellipse can be estimated from the reduced form covariances allowing to obtain the slopes of the schedules and thus the identification of the parameters.

When both variances of the shocks shift, then there is an expansion along both schedules. If the relative importance of all shocks remains the same, the two ellipses are proportional and not additional information is obtained from the heteroskedasticity, other than the magnitude of the shift. On the contrary, if the relative importance of one shock changes, so that one is more important in magnitude than the others, then the ellipse widens more along one of the schedules and the problem of identification is solved.

Thus, to estimate the model described by equation (1) and (2) the heteroskedasticity based approach relies on looking at changes in the co-movements of interest rates and asset prices when the variance of the monetary policy shock is known to shift.

To implement this approach, we only need to identify at least two sub samples.

We need to identify a period of time in which the variance of the monetary policy shock is higher than at other times but the variances of the other shocks in the system remains unchanged.

In order to estimate $\alpha$, the response of asset prices to monetary policy shocks, we assume that the variance of monetary policy shocks is higher on days of monetary decision meetings, when a larger portion of news hitting markets is about monetary policy. This enables us to identify two subsamples: a "policy date" and a "non policy date" regime; and in each subsample we compute the variance and covariance matrix. The identification of the parameter is achieved by the change in the covariance matrix between the two regimes. A covariance matrix provides $\frac{n(n+1)}{2}$ different equations (where $n$ indicates the number of endogenous variables), whereas the parameters to be identified are *the n* variances and the *n(n-1)* coefficients[1]. Under the assumptions of heteroskedasticity, thus, every regime features a different covariance matrix, each providing $\frac{n(n+1)}{2}$ new equations and *n* new variances to be estimated. This assumption implies that 2 different regimes are sufficient to identify all coefficients, providing the extra equations necessary to solve the model and achieve identification. The shift in the variance of the policy shocks on the monetary announcements dates is sufficient to capture the impact of monetary policy on asset prices.

The shift in the variance is the element that makes the difference with the assumption made by the traditional literature which we have mentioned above. It is here assumed that the form of the heteroskedasticity is known: in particular, it is supposed that the change in the variance of the observed variables is explained by a change in the variance of one of the shocks which affects the system. Contrary to the event study analysis, this identification approach does not need that the variance of one shock becomes infinitively large, but instead is based on the change in the covariance of interest rates and asset prices at times when the variance of a shock increases.

The procedure described is feasible and it can be justified in the real world where there exist several situations in which the assumption of the shift in the heteroskedasticity can be reasonable. For example, shift in exchange rate regime, stock market crash, policy shocks can be interpreted both as changes in structural parameters as well as changes in the variance of one shock of the model.

## 1.3 The model

The model we study is that one described by equation (1') and (2') which we remind is represented by the following system of equations:

(1’)

$$\Delta i_t = \beta \Delta s_t + \gamma z_t + \varepsilon_t$$

(2’)

$$\Delta s_t = \alpha \Delta i_t + z_t + \eta_t$$

where *i* is the short-term interest rate and *s* is the asset price. Equation (1') represents a monetary policy reaction function; equation (2') is the asset price equation. The variable $\varepsilon_t$ is

[1] In our case (model (1) and (2)) *n* is two, the interest rate and the stock market price. The covariance matrix provides three equations (the variance of *i*, the variance of *s* and their covariance) and the parameters to be estimated are $\alpha$ and $\beta$ plus the variances).

the monetary policy shock, $\eta_t$ is a shock to the asset price and $z_t$ is an unobservable common shock whose variance is $\sigma_z^2$. The disturbances are assumed to have no serial correlation and to be uncorrelated with each other.

We are here interested in $\alpha$ which measures the impact of a change in the short-term interest rate $\Delta i$ on the asset price $\Delta s$.

The parameter $\alpha$ is estimated assuming heteroskedasticity in the data. This identification relies on the change in the covariance of interest rates and asset prices at times when the variance of the policy shock increases. To implement this approach we only need to identify two subsamples, denoted as $F$ and $\tilde{F}$, for which the following assumptions are valid: the parameters of equations (1') and (2') are stable; the "importance" of policy shocks increases in the subsample *F*.

$$\sigma_\varepsilon^F > \sigma_\varepsilon^{\tilde{F}}$$

$$\sigma_\eta^F = \sigma_\eta^{\tilde{F}}$$

$$\sigma_z^F = \sigma_z^{\tilde{F}}$$

We make the distinction between the "policy dates" related to the subsample *F*, in which the variance of the policy shock is elevated, and the "non policy" dates which are taken to be alternatively the "one day", "two days", and "five days" before each policy day, in which the policy shocks are low.

The "policy" date is the day of the policy announcement as it is plausible that during these days the major determinant of the variance hitting the economy comes from the monetary policy shocks.

Thus, we assume that the monetary policy shocks are higher on policy dates. There are two regimes, one with high variance (*F*) and one with low variance ($\tilde{F}$).

Indeed, the only statistics that can be measured is the covariance matrix of the reduced form. We substitute equation (1') into equation (2'); we obtain the following reduced form equations:

$$\Delta i_t = \frac{1}{1-\alpha\beta}\left[(\beta+\gamma)z_t + \beta\eta_t + \varepsilon_t\right]$$

$$\Delta s_t = \frac{1}{1-\alpha\beta}\left[(1+\alpha\gamma)z_t + \eta_t + \alpha\varepsilon_t\right]$$

We next derive the reduced covariance matrix of the system at time t which is equal to:

(4)

$$\Omega_F = \frac{1}{(1-\alpha\beta)^2}\begin{bmatrix} \beta^2\sigma_\eta^2 + \sigma_\varepsilon^2 + (\beta+\gamma)^2\sigma_z^2 & \beta^2\sigma_\eta^2 + \alpha\sigma_\varepsilon^2 + (\beta+\gamma)(1+\alpha\gamma)\sigma_z^2 \\ & \sigma_\eta^2 + \alpha^2\sigma_\varepsilon^2 + (1+\alpha\gamma)^2\sigma_z^2 \end{bmatrix}$$

The same for regime $\tilde{F}$ .

As we assume that the variance in the policy dates is given by the monetary policy shocks, the difference between the two covariance matrices does not depend on the two terms explaining respectively $\sigma_z^2$ and $\sigma_\eta^2$ but it is given by:

(5)

$$\Delta\Omega_t = \Omega_F - \Omega_{\tilde{F}} = \frac{\sigma_\varepsilon^F - \sigma_\varepsilon^{\tilde{F}}}{(1-\alpha\beta)^2}\begin{bmatrix} 1 & \alpha \\ \alpha & \alpha^2 \end{bmatrix}$$

From equation (5) we derive the identification for $\alpha$ :

(6)

$$\alpha = \frac{\Delta\Omega_{12}}{\Delta\Omega_{11}}$$

(7)

$$\alpha = \frac{\Delta\Omega_{22}}{\Delta\Omega_{21}}$$

The two estimates of $\alpha$ should be identical. Differences in the estimates could indicate that the parameters of the equations are not stable across the sub samples or that the variance of other shocks increased on policy dates. In this case in fact, when we compute the difference of the covariance matrices, also other shocks enter in the equations as the variance of the policy dates does not depend in this case only from the monetary policy shocks.

## 1.4 Procedure: Instrumental Variable technique

As shown in Rigobon and Sack (2004), an interesting feature of the methodology described is that it can be implemented by an instrumental variable technique.

To get at an instrumental variable interpretation of the estimator we have to define:

(8)

$$\Delta i = \{\Delta i_t, \forall t \in F\} \cup \{\Delta i_t, \forall t \in \tilde{F}\}$$

(9)

$$\Delta s = \{\Delta s_t, \forall t \in F\} \cup \{\Delta s_t, \forall t \in \tilde{F}\}$$

and the following two instruments:

(10)

$$\omega_i = \{\Delta i_t, \forall t \in F\} \cup \{-\Delta i_t, \forall t \in \tilde{F}\}$$

(11)

$$\omega_s = \{\Delta s_t, \forall t \in F\} \cup \{-\Delta s_t, \forall t \in \tilde{F}\}$$

where F and $\tilde{F}$ are the two regimes which have been defined in the model.

It turns out that the estimates of $\alpha$ can be derived regressing the change in $\Delta s$ on $\Delta i$ using both sets of days and the instrumental variable approach. The IV estimator is:

(12)

$$\hat{\alpha}_2 = (\omega_i \Delta i)^{-1} (\omega_i \Delta s)$$

(13)

$$\hat{\alpha}_1 = (\omega_s \Delta i)^{-1} (\omega_s \Delta s)$$

which can be written as:

(14)

$$\hat{\alpha}_2 = \frac{\{\Delta i_{F,} - \Delta i_{\tilde{F}}\}' \{\Delta s_{F,} - \Delta s_{\tilde{F}}\}}{\{\Delta i_{F,} - \Delta i_{\tilde{F}}\}' \{\Delta i_{F,} \Delta i_{\tilde{F}}\}} = \frac{Cov(\Delta i_{F,} \Delta s_F) - Cov(\Delta i_{\tilde{F},} \Delta s_{\tilde{F}})}{Var(\Delta i_F) - Var(\Delta i_{\tilde{F}})}$$

(15)

$$\hat{\alpha}_1 = \frac{\{\Delta s_{F,} - \Delta s_{\tilde{F}}\}' \{\Delta s_{F,} \Delta s_{\tilde{F}}\}}{\{\Delta s_{F,} - \Delta s_{\tilde{F}}\}' \{\Delta i_{F,} \Delta i_{\tilde{F}}\}} = \frac{Var(\Delta s_F) - Var(\Delta s_{\tilde{F}})}{Cov(\Delta i_{F,} \Delta s_F) - Cov(\Delta i_{\tilde{F},} \Delta s_{\tilde{F}})}$$

which is identical to the estimator (6) and (7) above.

Rigobon and Sack (2004) have shown that both $\omega_i$ and $\omega_s$ are valid instruments for estimating $\alpha$ under the assumptions that the parameters are stable and that the policy shocks are heteroskedastic.

### 1.5 Hypothesis test

In order to comment the results found with the heteroskedasticity based approach, and see whether they are robust to different specifications, we have also estimated the impact of monetary policy on asset prices using the event study methodology which is based on testing the relation between the variables around policy dates. We have tested whether the two results obtained with the heteroskedasticity based approach are significantly similar and then we have used the Hausmann test, which we are going to describe, to compare the results obtained with the heteroskedasticity assumption with those found with the event study analysis. Looking at the difference between the two estimates, this test can be used to estimate the bias deriving from the event study methodology.

The test of the overidentifying restrictions which compares the two estimates $\hat{\alpha}_1$ and $\hat{\alpha}_2$ obtained with the heteroskedasticity based methodology is as follows:

(18)

$$\hat{\delta}_{all,i} = \frac{1}{K} | \hat{\alpha}_1 - \hat{\alpha}_2 | M_{all,i}^{-1} | \hat{\alpha}_1 - \hat{\alpha}_2 |$$

where $M_{all,i}$ is the difference of the variance of the estimators.

This test statistic has an *F* distribution and *K*, *K(t-1)* degrees of freedom, where *K* is the number of assets and *t* is the number of policy dates.

A rejection of the hypothesis that the two estimates are equal would can mean that at least one of the assumptions of stability of the parameters or of homoskedasticity of the other shocks of the model is rejected.

With the Hausmann test we compare the results found with the heteroskedasticty based approach ($\alpha_1$ and $\alpha_2$) to the event study estimates $\alpha_{es}$ obtained by running an OLS regression around policy dates. This enables us to test whether the stronger assumptions that the event study approach needs are valid.

The Hausman specification test is described by the following equation:

(19)

$$\hat{\delta}_{es,all} = \frac{1}{K} | \hat{\alpha}_1 - \hat{\alpha}_{es} | M_{es,all}^{-1} | \hat{\alpha}_1 - \hat{\alpha}_{es} |^2$$

This test statistic has an F distribution with *K, K(T-1)* degrees of freedom. A significant test statistic would indicate a rejection of the assumption that the variance of the policy shock on policy dates is sufficiently large for near identification to hold.

## 2 Data and results

The data used in the study are all drawn on line from Datastream. The stock market return is the daily return on the FTSE 250 index for the UK and on the DAX 100 index for the market in Germany. The interest rate is the short term interest rate for both countries. The rest of the financial variables which we have examined are the price index of a 10 years Government bond, the corporate bond yield and the British and German exchange rate with the dollar.

The estimated period we have considered goes from 1/1/1988 to 31/12/1998 for Germany and goes from January 1987 to December 2003 for the UK. The policy days for the UK are available on the Bank of England webpage, the dates for Germany are available on request at the Bundesbank.

As already reminded, we consider two subregimes: regime *F*, which includes the date of policy announcements, and regime $\tilde{F}$ which selects alternatively, one day, two days, or five days prior to the announcement. In regime F it is reasonable to assume monetary policy shocks to be more volatile; in regime $\tilde{F}$ for contrast, we presume lower heteroskedasticity. We apply both the heteroskedasticity based approach and the event study analysis and compare the results found with the two methodologies.

We start considering Germany. When we estimate the effect of German monetary policy on the mentioned financial variables of the country, we do not find any significant effect of changes of interest rates on these variables. Table 1 presents the results of the effects of monetary policy on the dax index.

Both the event study and the heteroskedasticity based approach find a negative relationship between monetary policy and the stock market. An interest rate increase decreases the future equity cash flows thus depressing equity prices. This effect, however, is not significant, suggesting that monetary policy has been neutral on the stock market and indicating that monetary changes do not affect the expected profits of the firm. The sign of the estimate is in line with Rigobon and Sack' findings and with the more traditional literature. Rigobon and Sack's findings suggest that increases in the short term interest rate have a negative and significant impact on stock prices. Thorbecke (1995) and Bomfim (2000) who, as most of these works, studied the US market, also find a significant response of the stock prices, although smaller in magnitude than Rigobon's response, while other papers, including Bomfim and Reinhart (2000) and Roley and Sellon (1998) find no statistically significant response. These last works, as we have noted above, rely on the event study approach.

Even in our analysis both in the event study and in the heteroskedasticity based approach results, the estimate of the parameter appears not significant. This suggests that monetary decisions followed by the Bundesbank do not play a significant impact on the behavior of the stock market. This result could be explained by monetary policy being procyclical some times, and anticiclical other times, causing a general neutral effect on German stocks.

There can be other reasons which might explain this finding. We are here considering firms belonging to the Dax index. Because most of these firms are based on export it is easy that these companies are not affected by changes in the Bundesbank monetary policy but might be instead influenced by monetary decisions taken by the country where they export. An other possible explanation of the result found can be reasoned in terms of German peculiar financial system where we have a strong evidence of cross share holdings.

Table 1

| **Germany** | $\alpha_1$ | | $\alpha_2$ | $\alpha_{es}$ |
|---|---|---|---|---|
| **Effect of call money on dax** | **One day** | | | |
| | -0.544 | | -0.447 | -0.052 |
| | (0.757) | | (0.833) | (0.973) |
| Test of OI Restrictions | | | | |
| | 0.0585 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.469 | 0.021 | | |
| | **Two days** | | | |
| | -0.385 | | -0.384 | -0.052 |
| | (1.282) | | (1.28) | (0.973) |
| Test of OI Restrictions | | | | |
| | 0.00034 | | | |
| Test of E.S. Assumptions | | | | |
| | 1.69 | 0.019 | | |
| | **Five days** | | | |
| | -0.497 | | -0.497 | -0.052 |
| | (1.455) | | (1.457) | (0.973) |
| Test of OI Restrictions | | | | |
| | 0.007 | | | |
| Test of E.S. Assumptions | | | | |
| | 1.693 | 0.019 | | |

T statistics in parenthesis
The F statistics at 95% is 3.23
$\alpha_1$ and $\alpha_2$ are the estimates obtained with the het. based approach
The estimate $\alpha_{es}$ is obtained with the event study approach

The estimated response of the stock indexes under the heteroskedasticity based method are always larger than the corresponding estimates obtained under the event study approach, in some cases by a considerable amount. This difference probably reflects the bias in the event study estimates.

The Overidentifying (OI) restrictions test concludes that the two heteroskedasticity estimators are not statistically different indicating that the assumptions of the model hold. Finally, the Hausmann test (test of E.S. Assumptions) does not reject the hypothesis that $\alpha_{es} = \alpha_{het}$ .

No significant effect appears when we evaluate the effect of monetary policy changes on the exchange rate. Table 2 shows that to an increase of German interest rates corresponds an appreciation of the currency. When interest rates rise, because of the higher interest rates, we assist to a capital movement towards German economy. The effect of the monetary change, however, is not significant. The fact that the DM is not responding to German monetary policy in a significant way could suggest to take into account other factors in the transmission process such as international interest rates. An other possible explanation of this result could reflect the objective of the Bundesbank not to appreciate the exchange rate.

In all the three cases, the overidentifying restriction test does not reject the hypothesis that the two heteroskedasticity based estimators are not different. The Hausmann test does not reject the null hypothesis $\alpha_{het} = \alpha_{es}$ .

Table 2

| **Germany** | $\alpha_1$ | | $\alpha_2$ | $\alpha_{es}$ |
|---|---|---|---|---|
| **Effect of call money on DM-US exchange rate** | **One day** | | | |
| | -2.016 | | -1.48 | 0.009 |
| | (0.237) | | (0.268) | (0.267) |
| Test of OI Restrictions | | | | |
| | 0.064 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.056 | 0.15 | | |
| | **Two days** | | | |
| | -9.98 | | -9.04 | 0.009 |
| | (0.066) | | (0.07) | (0.267) |
| Test of OI Restrictions | | | | |
| | 0.004 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.0043 | 0.0034 | | |
| | **Five days** | | | |
| | 13.009 | | -1.926 | 0.009 |
| | (0.059) | | (0.157) | (0.267) |
| Test of OI Restrictions | | | | |
| | 0.0029 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.0029 | 0.004 | | |

T statistics in parenthesis
The F statistics at 95% is 3.23
$\alpha_1$ and $\alpha_2$ are the estimates obtained with the het. based approach
The estimate $\alpha_{es}$ is obtained with the event study approach

Finally, we estimate the effects of interest rates changes on the 10 years bond price index. As evident from Table 3, an increase in German interest rates leads to a reduction of bond prices. The result is not significant. The sign of the estimate is in line with what we should expect. Its not significance can be due to the fact that we are here focusing on a long term bond.

Both the Hausmann and the OI test are not rejected, validating the assumptions of the model.

Table 3

| **Germany** | $\alpha_1$ | | $\alpha_2$ | $\alpha_{es}$ |
|---|---|---|---|---|
| **Effect of call money on 10 years bond price index** | **One day** | | | |
| | -0.092 | | -0.094 | -0.002 |
| | (0.938) | | (0.949) | (0.002) |
| Test of OI Restrictions | | | | |
| | 0.857 | 0.021 | | |
| Test of E.S. Assumptions | | | | |
| | 0.036 | | | |
| | **Two days** | | | |
| | -0.267 | | -0.275 | -0.002 |
| | (0.369) | | (0.369) | (0.002) |
| Test of OI Restrictions | | | | |
| | 0.134 | 0.0004 | | |
| Test of E.S. Assumptions | | | | |
| | 0.00014 | | | |
| | **Five days** | | | |
| | -0.195 | | -0.194 | -0.002 |
| | (0.93) | | (0.906) | (0.002) |
| Test of OI Restrictions | | | | |
| | 0.8 | 0.019 | | |
| Test of E.S. Assumptions | | | | |
| | 0.0002 | | | |

T statistics in parenthesis
The F statistics at 95% is 3.23
$\alpha_1$ and $\alpha_2$ are the estimates obtained with the het. based approach
The estimate $\alpha_{es}$ is obtained with the event study approach

We now look at the UK. Table 4 evaluates the effects of monetary policy on the exchange rate. As for Germany, to an increase of the interest rate corresponds an appreciation of the currency. Differently from Germany, however, the effect is here significant both in the event study and in the heteroskedasticity based approach estimators and the magnitude of the effect is similar in the two tests.

When the UK interest rate increases, higher rewards in the UK market shift capital towards British economy; this has the effect of appreciating the currency with a significant estimate of the parameter.

Table 4

| **UK** | $\alpha_1$ | | $\alpha_2$ | $\alpha_{es}$ |
|---|---|---|---|---|
| **Effect of libor on exchange rate** | **One day** | | | |
| | 0.005 | | 0.0051 | -0.0121 |
| | (0.002) | | (1.38) | (4.91)* |
| Test of OI Restrictions | | | | |
| | 0.404 | | | |
| Test of E.S. Assumptions | | | | |
| | 6.58 | 0.33 | | |
| | **Two days** | | | |
| | -0.0148 | | -0.0015 | -0.012 |
| | (4.51)* | | (4.65)* | (4.91)* |
| Test of OI Restrictions | | | | |
| | 0.21 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.85 | 1.59 | | |
| | **Five days** | | | |
| | -0.013 | | -0.014 | -0.012 |
| | (5.91)* | | (6.38)* | (4.91)* |
| Test of OI Restrictions | | | | |
| | 13.3 | | | |
| Test of E.S. Assumptions | | | | |
| | 15.5 | -1.12 | | |

T statistics in parenthesis
The F statistics at 95% is 3.23
$\alpha_1$ and $\alpha_2$ are the estimates obtained with the het. based approach
The estimate $\alpha_{es}$ is obtained with the event study approach

We find another important significant effect when we test the response of the FTSE index to changes in interest rates (Table 5).

The values we find, however, represent a result different from that one just found for Germany and with the results of the traditional literature. We would have expected that a monetary tightening would lead to a decrease in the stock market index as an increase in the market rates decreases the expected cash flows of a firm, with negative consequences on the price of its stocks. We instead find that a rise in interest rates leads to an increase of the FTSE index. This positive and significant link between the interest rate and the stock market price is difficult to explain. This result seems to suggest that the market is expecting an improvement of the firm profits causing a rise on the price of its stocks. The positive and significant effect of monetary policy on the stock market, together with the positive and significant effect of monetary policy on the exchange rate, means that when interest rate increases, the exchange rate and stock price increase as well, characterizing a prociclical policy.

Table 5

| UK | $\alpha_1$ | | $\alpha_2$ | $\alpha_{es}$ |
|---|---|---|---|---|
| **Effect of libor on FTSE** | **One day** | | | |
| | 0.105 | | 0.013 | 0.012 |
| | (0.563) | | (0.273) | (1.838) |
| Test of OI Restrictions | | | | |
| | 0.358 | | | |
| Test of E.S. Assumptions | | | | |
| | 1.22 | 1.01 | | |
| | **Two days** | | | |
| | 0.015 | | 0.02 | 0.012 |
| | (2.21)* | | (2.81)* | (1.838) |
| Test of OI Restrictions | | | | |
| | 3.9 | | | |
| Test of E.S. Assumptions | | | | |
| | 4.13 | 1.54 | | |
| | **Five days** | | | |
| | 0.012 | | 0.0113 | 0.012 |
| | (2.2)* | | (2.13)* | (1.838) |
| Test of OI Restrictions | | | | |
| | 4.29 | | | |
| Test of E.S. Assumptions | | | | |
| | 4.29 | -0.002 | | |

T statistics in parenthesis
The F statistics at 95% is 3.23
$\alpha_1$ and $\alpha_2$ are the estimates obtained with the het. based approach
The estimate $\alpha_{es}$ is obtained with the event study approach

In order to make a distinction between the effect which can be attributed to the expected component of monetary change to the "surprise" effect, we verify whether stock market prices react to the unexpected component of monetary policy, which we have constructed as the difference between the three months future rate and the three months Treasury Bill rate on the day prior to the change.

The conclusions we obtain from the heteroskedasticity based approach and the event study analysis (Table 6) show that stock prices are negatively linked to interest rate surprises and that this relation is not significant. These results suggest that the unexpected component of monetary policy has been neutral on the stock market behavior. If the unexpected component of monetary policy does not exert an impact on the stock prices, it means that monetary policy does not influence the expected profits of the firms. This can be explained by monetary policy stabilizing the expected profits of the firms. It could be also explained by the fact that we are here studying the effect of monetary policy on the ftse index. This stock market index includes many multinationals which are not affected by monetary policy changes of their country, but are possibly influenced instead by policy changes of the country where they export.

We can also think that the surprise component of monetary policy does not have an effect on the stock market because some time the transmission mechanism is procyclical, other times anticiclical, causing a general neutral effect on the stocks. These results can be some starting points to understand the monetary policy transmission mechanism.

Table 6

| **UK** | $\alpha_1$ | | $\alpha_2$ |
|---|---|---|---|
| **Effect of the "surprise" component of MP on FTSE** | **One day** | | |
| | -26.78 | | -27.04 |
| | (0.865) | | (0.9) |
| Test of OI Restrictions | | | |
| | 0.007 | | |
| Test of E.S. Assumptions | | | |
| | 0.067 | 7.85 | |
| | **Two days** | | |
| | -9.734 | | -58.08 |
| | (0.07) | | (0.41) |
| Test of OI Restrictions | | | |
| | 0.005 | | |
| Test of E.S. Assumptions | | | |
| | 0.014 | 0.005 | |
| | **Five days** | | |
| | -49.9 | | -224.01 |
| | (0.77) | | (2.45)* |
| Test of OI Restrictions | | | |
| | 0.63 | | |
| Test of E.S. Assumptions | | | |
| | 0.95 | 0.86 | |

T statistics in parenthesis
The F statistics at 95% is 3.23
$\alpha_1$ and $\alpha_2$ are the estimates obtained with the het. based approach
The estimate $\alpha_{es}$ is obtained with the event study approach

For what concerns the other variables, table 7 and 8 represent the effects of the UK monetary policy changes respectively on a 10 years government bond index and on the corporate index yields.

As for Germany, an increase in interest rates leads to a decline of bond prices. These results, however, are not significant (Table 7). Again, this result can be explained by the fact that we have considered the effect on a long term bond. The estimates obtained with the event study methodology are similar to those obtained with the heteroskedasticity based approach. Both the Hausmann and the OI test are not rejected.

Table 8 presents the results of the impact of monetary policy on corporate bond yields. The effect is not significant and the sign of the estimates is sometimes positive, sometimes negative. Again, both the Hausmann and the OI test are not rejected.

Table 7

| UK | $\alpha_1$ | | $\alpha_2$ | $\alpha_{es}$ |
|---|---|---|---|---|
| **Effect of libor on bond price** | **One day** | | | |
| | 0.005 | | 0.015 | 0.002 |
| | (0.028) | | (0.463) | (0.95) |
| Test of OI Restrictions | | | | |
| | 0.058 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.074 | 0.043 | | |
| | **Two days** | | | |
| | 0.079 | | 0.0015 | 0.002 |
| | (0.697) | | (0.664) | (0.95) |
| Test of OI Restrictions | | | | |
| | 0.47 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.47 | 0.016 | | |
| | **Five days** | | | |
| | 0.152 | | 0.001 | 0.002 |
| | (0.974) | | (0.854) | (0.95) |
| Test of OI Restrictions | | | | |
| | 0.92 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.92 | -0.058 | | |

T statistics in parenthesis
The F statistics at 95% is 3.23

$\alpha_1$ and $\alpha_2$ are the estimates obtained with the het. based approach

The estimate $\alpha_{es}$ is obtained with the event study approach

Table 8

| UK | $\alpha_1$ | | $\alpha_2$ | $\alpha_{es}$ |
|---|---|---|---|---|
| **Effect of libor on corporate bond yield** | **One day** | | | |
| | -0.113 | | -0.12 | 0.011 |
| | (0.064) | | (0.0067) | (0.095) |
| Test of OI Restrictions | | | | |
| | 0.0005 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.009 | 0.005 | | |
| | **Two days** | | | |
| | 0.054 | | 0.054 | 0.011 |
| | (0.33) | | (0.34) | (0.095) |
| Test of OI Restrictions | | | | |
| | 0.00078 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.002 | 0.154 | | |
| | **Five days** | | | |
| | -0.028 | | -0.028 | 0.011 |
| | (0.219) | | (0.219) | (0.095) |
| Test of OI Restrictions | | | | |
| | 0.00002 | | | |
| Test of E.S. Assumptions | | | | |
| | 0.0001 | 0.62 | | |

T statistics in parenthesis
The F statistics at 95% is 3.23

$\alpha_1$ and $\alpha_2$ are the estimates obtained with the het. based approach

The estimate $\alpha_{es}$ is obtained with the event study approach

## Conclusions

According to the results we obtain from the analysis, Germany seems not to react to policy decisions of its own country: German monetary policy seems to exert a neutral effect on German stocks. An unexpected increase in the market interest rate depresses equity prices. This negative relation is not significant. This result is in line with some of the traditional literature which focuses on US economy and differs from other studies including Rigobon and Sack' whose findings suggest that an increase of the federal funds rate has a negative and significant effect on the US stock market. There can be at least two different reasons which might explain this finding. First, we are here considering firms belonging to the dax index. Most of these firms are based on export and for this reason they might be affected by monetary decisions taken in the country where they export.

An other possible explanation of the result found can be reasoned in terms of German peculiar financial system where we have a strong existence of cross share holidings.

The increase of German interest rates leads to the appreciation of the DM. This result, however, is not significant probably suggesting the Bundesbank' desire to target the exchange rate.

In contrast with German economy, when we focus on the effects of British monetary policy on stock prices we find that an increase of interest rates in the UK leads to a significant increase of British stock market prices and to a significant appreciation of the currency. These results all together can be a sign of a prociclical policy.

The positive and significant link between the interest rate and the stock market price is difficult to be explained. This result seems to suggest that the market is expecting an improvement of the firm profits. In order to separate the effect derived from the expected component of monetary policy to the surprise effect, we have checked whether the stock prices react to the surprise component of monetary decisions. The conclusions we obtain now from the heteroskedasticity based approach and the event study analysis show that stock prices are negatively linked to interest rate surprises; this relation is not significant. These results suggest that the unexpected component of monetary policy has been neutral on the stock market behavior. If the unexpected component of monetary policy doesn't exert an impact on the stock prices, it means that monetary policy doesn't influence the expected profits of the firms. This can be explained by monetary policy stabilizing the expected profits of the firms. It could be also explained by the fact that we are here studying the effect of monetary policy on the ftse index. This stock market index includes many multinationals which are not affected by monetary policy changes of their country, but are possibly influenced instead by policy changes of the country where they export.

These results can be some starting points to understand the monetary policy transmission mechanism.

As we have noted, UK's monetary policy variable plays an other important significant effect on the exchange rate. An increase of the libor appreciates the sterling. This effect is statistically significant and means that the higher rewards of the market attract capital from the outside economy, appreciating the currency. While the results for Germany seem to suggest that the Bundesbank is willing to target the exchange rate, this evidence is not true for the UK.

For what concerns the methodology used in the analysis, the results show that in most of the analysis the results obtained with the heteroskedasticity based approach are larger than those obtained with the event study analysis. This suggests the bias of this traditional approach, which is due to the stronger assumption on the monetary policy shocks it requires. The heteroskedasticity based approach thus appears an innovative and useful technique capable to capture more reliable estimates of the relation between monetary policy and asset prices.

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