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Transmission of the European Central Bank Monetary Policy across Regional Stock Markets *

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Transmission of the European Central Bank Monetary Policy across Regional Stocks Markets

Abstract:

In this paper we estimate the transmission of common euro area monetary policy shocks across the euro area main stock markets. To do so, we develop global SVAR models in which the ECB monetary policy is modeled as a function of euro area aggregate variables and the US variables that define the FED monetary policy shocks. Our results suggest, in line with economic theory, that the transmission of monetary policy across Eurozone stocks markets displays heterogeneity driven by differences in the listed firms' characteristics but also by the distance between the actual ECB stance and the obtained by applying a Taylor rule implied in the ECB policy to country-specific macroeconomic data. These results highlight the need for a corrective fiscal policy on the undesirable effects of the common monetary policy and may allow policymakers to check the effects of their fiscal policies when any.

1. Introduction

The European Monetary Union has faced numerous economic and political challenges. Among them, like in US states and economic regions, is the different respond of the economies of member countries to the (common) actions of the European Central Bank (ECB). Before euro and BCE common monetary policy adoption in January 1999, authors as Bayoumi and Eichengreen (1993) and Carlino and DeFina (1998 and 2000) point out that in presence of heterogeneous sovereign nations, likely differences in monetary policy responses will arise. Moreover, Mihov (2001) notes that a common monetary policy may fail in stabilizing macroeconomic fluctuations in country members when its effects exhibit heterogeneity across countries, even in the presence of a high degree of integration of the national business cycles in the common one. However, those differences did not make it difficult to form the European Monetary Union, contrary to what Carlino and DeFina (1998) foretold, or its management until today.

Nevertheless, it has not been until more recently that empirical analyses of these differences, as in Ciccarelli *et al*. (2013), Barigozzi *et al*. (2014), Georgiadis (2015), Cavallo and Ribba (2015) and Mandler *et al.* (2016), have been done. In this sense, Cavallo and Ribba (2015) argue that previously not enough data to study the influence of ECB's monetary policy stance on Eurozone countries were available. Note that all these analyses employ monthly or quarterly data, focusing exclusively on data after the introduction of the euro, i.e., from 1999 onward. As Mandler *et al*. (2016) note, we find in the literature other works based on data from the pre-euro period.[1] This fact requires carefully modeling the monetary policy country reaction functions and the monetary

[1] Examples of these works that use country-level data are Ehrmann (2000), Mihov and Scott (2001), Rafiq and Mallick (2008) and Boivin et al. (2009).

policy shock, as in Mojon and Peersman (2001) and Ciccarelli and Rebucci (2006), to control for the differences in the country's monetary policy reaction function, which describes how the national monetary policy endogenously reacts to shock-induced movements in variables.

Ciccarelli et al. (2013) use a restricted panel VAR model for two groups of euro area countries: countries that came under stress in the financial and sovereign debt crises and those that did not; and find significant differences in the output and inflation responses to ECB monetary policy shocks between 2003 and 2007. Barigozzi et al. (2014) use a structural dynamic factor model and show that there are significant differences between North and South Europe in the response of prices and unemployment to ECB monetary policy. Georgiadis (2015) develops a global VAR model and shows that euro area economies in which a higher share of aggregate output is accounted for by sectors servicing interest rate sensitive demand exhibit a stronger transmission of monetary policy to real activity. Cavallo and Ribba (2015), using a near-SVAR approach, investigate in eight Eurozone countries if the dominant source of macroeconomic fluctuations at the national level is represented by exogenous Eurozone shocks or, alternatively, by local shocks. They report evidence against asymmetric effects of monetary shocks but only attribute the Eurozone shocks as the dominant source of the business cycle to the four biggest economies. Mandler et al. (2016) using a Bayesian VAR analyze whether the ECB monetary policy has heterogeneous effects on these four countries and find output to respond less negatively in Spain than in the other three countries, the drop in the price level is less pronounced in Germany relative to France, Italy and Spain, and bond yields rise more strongly and persistently in France and Germany than in Italy and Spain.

When we focus on the effect of ECB monetary policy on the stock market returns we find in the literature earlier works as those of Angeloni and Ehrmann (2003), Bredin *et al.* (2007), Bohl et al. (2008), Kholodilin *et al.* (2009), and Hussain (2011). In this context, high frequency data permit to apply specific methodologies, as the seemingly unrelated regression model of Pearce and Roley (1983), the heteroscedasticity-based approach of Rigobon and Sack (2004) and the event study approach of Bernanke and Kuttner (2005), where samples of long time periods are not required. More recent papers, as those of Wang and Mayes (2012), Fiordelisi *et al.* (2014), Ricci (2015), Rogers *et al.* (2014) and Haitsma *et al.* (2016), also use these specific financial market methodologies. However, all these approaches are focus on the simultaneous response of the stock market to monetary policy shocks. When, in the spirit of Patelis (1997), the aim is not only to analyze the simultaneous response but also the long-run dynamic of the response and/or the cumulative response of the stock market to monetary policy shocks, as Chatziantoniou et al. (2013) and Ruiz (2015) do for the German and the Spanish stock markets respectively, VAR methodologies, that require long enough data time series, become optimal again.

In that context, this paper focuses on the different transmission of common euro area monetary policy shocks across the euro area main regional stock markets, and on explaining that heterogeneity. Note that, as Rodriguez-Fuentes and Dow (2003) point out, this paper is "concerned with the effects of a single European monetary policy across countries of the Euro-zone, which became ‘regions’ of this Euro-zone” as in the mostly current research.

In line with the seminal paper of Carlino and DeFina (1998), we are interested in measure the whole effect of monetary policy shocks in each regional stock market and therefore we use VAR models to do it. Following these authors, we introduce the hypothesis of the differences in the industry composition of the stock markets to explain the heterogeneity of these effects. Additionally, we introduce the hypothesis of the differences between country-specific and euro-specific monetary policy macroeconomic objective variables to explain the heterogeneity of the effects of monetary policy shocks across the stock markets after controlling by the differences in their industry composition.

To do so, we develop global SVAR models in which the common monetary policy is a function of euro area aggregate variables and the US macroeconomic variables that define the Fed monetary policy shocks. In these models the euro area country members are considered small open economies and we only add the returns of their stock markets. Previous evidence in Cavallo and Ribba (2015) support that alternative VAR models in which a full interaction between the Eurozone and local variables is allowed report similar results. We also use this global SVAR model to analyze the effect of monetary policy shock on the whole euro stock market and on its industries.

Our results suggest, in line with economic theory, that the transmission of monetary policy across Eurozone stock markets displays heterogeneities driven by differences in the listed firms' characteristics. However, controlling by the industrial structure of the different markets, results also permit to relate the impacts of ECB monetary policy on country stock markets to the distance between the actual ECB stance and the obtained by applying a simple Taylor rule implied in the ECB policy to the country-specific macroeconomic data.

These results support the increasingly widespread hypothesis that the monetary policy per se would have a sufficiently strong effect to promote the bubbles generation (and pop them) if significantly affects risk appetite in asset markets. This argument applies a fortiori to country stock markets within a currency area where the common monetary policy stance may be far from their actual needs. In this sense, this work has potentially important policy implications: In addition to highlighting the need for a corrective common monetary and fiscal policies on the undesirable effects of the conventional monetary policy when significant regional heterogeneity exist (Fraser et al., 2014), the results may allow policymakers to check the effects of their common fiscal policies when any.

This paper is structured as follows. After this introduction, Section 2 presents the factors involved in the models and data used in the estimations. Section 3 describes the models, the SVAR methodology on which they build and the alternative schemes used for their identification. In Section 4, we report and comment on the results. Finally, Section 5 summarizes the main results and concludes.

2. Factors, variables, sample and data

The beginning of our analysis period is bounded by the start of the third phase of the European Economic and Monetary Union, in January 1999, with the transition from the local currencies to the euro along with the start of the common monetary policy run by the ECB, as Fahr *et al.* (2013) properly describe. Our sample runs to the most current data available, October 2016. Thus, our whole sample covers 214 observations of monthly data.

We classified the nine factors involved in the later SVAR analyses into three groups: (i) one that include the factors that define the global monetary policy shocks; (ii) a second group with the factors that define the Eurozone monetary policy shocks; and (iii) the third that collect country-specific factors that, obviously, include the country-specific stock market behavior. We summarize in Table 1 these factors and the basic variables used as their proxy along the further empirical analyses. In the same Table 1 we indicate the sources of data.

Subsequently, we introduce two additional regression analyses. The first to control by the industrial structure of the different markets using the impact of the ECB monetary policy shocks on industry-specific euro indices. We also estimate these industry-specific responses from SVAR models. The second one to relate the impacts of ECB monetary policy on country stock markets to the distance between the actual ECB monetary policy stance and the obtained by applying a simple Taylor rule implied in the ECB policy to the country-specific macroeconomic data.

2.1 Global monetary policy shocks

As a global monetary policy factor we use the Fed monetary policy. The monetary policy of the Fed is measured using the (less noisy) target interest rate on the last day of the month.[2] As Bernanke and Blinder (1992) and Bernanke and Mihov (1998) argue, FFR is a good proxy for the Fed policy actions. Moreover, it tends to adjust relatively fast to the Fed funds target rate as Fama (2013) shows. Therefore, it has been also widely used in the previous literature, as in Patelis (1997), Thorbecke (1997), Goto and Valkanov (2002), Jensen and Mercer (2002), Chen (2007), among others, adding the interbank market noise. On the other hand, Maio (2014) points out, in the VAR framework a regular time-series is needed, and so this framework is not compatible with some of the other proxies that are used in the context of specific financial market methodologies.

For a definition of the global monetary policy shock we also include the US inflation rate and a US business cycle measure. The US inflation rate is measured as the US consumer price index (US-CPI) inter-annual variation rate. The US business cycle is measured by US industrial production index (US-IPI) inter-annual growth rate. In order to complete our global factor, we include the stock market return which is computed using data of the benchmark stock market index S&P500. We use the last day of the month data to compute monthly continuous compounding returns.

2.2 Eurozone monetary policy shocks

Euro area monetary policy is measured by the stance of the monetary authority. We use the nominal target interest rate on the last day of the month set by the ECB.[3] To

[2] Concretely, we use the target for the federal funds rate. This is the rate that commercial banks charge between themselves for overnight loans. A meeting of the members of the Federal Open Market Committee (FOMC), which normally occurs eight times a year about seven weeks apart, specifies the target. The committee may also hold additional meetings and implement target rate changes outside of its normal schedule.

[3] The Governing Council of the ECB sets the key interest rates for the Eurozone. The Governing Council meets twice a month. At its first meeting of the month, as a rule, the Governing Council assesses the economic situation and the stance of the monetary policy. Decisions on the key interest rates are normally taken during that meeting. The target interest

correctly define the ECB monetary policy shocks we add: the Eurozone inflation measured as the monthly inter-annual variation rate of the harmonized consumer price index (HICP); and the Eurozone business cycle approximated by the monthly growth rate of the Eurozone industrial production index (IPI). Finally, we have included the Euro STOXX index returns as a proxy for the euro area stock market return when a Eurozone analysis is performed.

2.3 Country-specific variables

We include in our analysis the eleven countries that initially formed the European Monetary Union in January 1999. Specifically: Germany, Austria, Belgium, Spain, Finland, France, Netherlands, Ireland, Italy, Luxembourg and Portugal. For each of the countries, we have used the specific country business cycle measure, which is measured by industrial production index inter-annual growth rate computed as the difference with the corresponding variable for the Eurozone.

We have included the return of the stock markets computed from data of the country-specific benchmark stock market index. Concretely, we have used the following stock market indexes: DAX30 (Germany), ATX (Austria), BEL20 (Belgium), IBEX35 (Spain), OMXH25 (Finland), CAC40 (France), AEX (Netherlands), ISEQ20 (Ireland), FTSE MIB (Italy), FTSE LUX (Luxembourg) and PSI20 (Portugal). We use the last day of the month data to compute monthly continuous compounding returns.

2.4 Industrial analysis

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rate is the rate of the "main refinancing operations" (MRO), which provide the bulk of liquidity to the banking system.

To control by the industrial structure of the different markets, we use the sectorial stock market returns computed using data of the Euro STOXX Industry Indices. From the last day of the month data we compute monthly continuous compounding returns. Specifically, we have used the 10 Industries according the Industry Classification Benchmark: Euro STOXX Oil & Gas, Euro STOXX Basic Materials, Euro STOXX Industrials, Euro STOXX Consumer Goods, Euro STOXX Health Care, Euro STOXX Consumer Services, Euro STOXX Telecommunications, Euro STOXX Utilities, Euro STOXX Financials, Euro STOXX Technology. Data have been obtained from Thomson Reuters Eikon database.

2.5 An implicit Taylor's rule of the ECB monetary policy stance.

We estimate a Taylor's rule using Eurozone historical data. Concretely we estimate the following equation:

$$TR_{Euro,t} = a + r^{*} + \dot{p}^{*} + b\left(\dot{p}_{Euro,t} - \dot{p}^{*}\right) + cOG_{Euro,t} \tag{1}$$

where:

r* is the Eurozone neutral real interest rate of 2%;

$\dot{p}*$ is the Eurozone objective inflation rate of 2%; $\dot{p}_{Euro,t}$ is the Eurozone inflation in period t; and

$OG_{Euro,t}$, is the output gap, i.e., the relative deviation of real GDP from potential GDP.

Then, we apply the estimated rule with country-specific data to measure the optimum monetary policy stance for the countries that conform the initial Eurozone:

$$OTR_{i,t} = -1.604220 + r^* + \dot{p}^* + 0.238416(\dot{p}_{i,t} - \dot{p}^*) + 0.632445OG_{i,t} \quad (2)$$

where,

$\dot{p}_{i,t}$ is the country-specific inflation rate for period t; and

$OG_{i,t}$ is the country-specific output gap for period t.

Finally, we have computed the distance between de ECB nominal target rates and the optimum target rates for each country computed from the Taylor's Rule:

$$TRD_{i,t} = ECB\ Target\ Rate_t - OTR_{i,t} \quad (3)$$

In this way, we approximate the ECB monetary policy stance if these country-specific variables occurred in all country members at once. The results of this counterfactual analysis are shown in Figure 1.

3. Structural global monetary VAR

3.1 The nine-factor country-specific Structural VAR models

We use structural vector autoregressive (SVAR) models in our analysis of the relationship among the factors listed above. An SVAR model is a system of simultaneous equations that allow us to analyze interactions among the proxies of the factors involved in the model. In a SVAR model, the contemporary values of these proxy variables appear as explicative variables in different unrestricted equations, i.e., the same set of explicative proxy variables appears in each of the equations. Due to all variables are considered to be endogenous, each variable is explained by its own lagged values and by the current and past values for the rest of the variables in the system. The

VAR models are generally accepted as a way to analyze relationships within a set of variables and are used extensively in the literature on monetary policy. In that case, the shocks of monetary policy are represented by the residuals in the equation of the stance of monetary policy included in the model.

We collect the nine endogenous factors of the global structural VAR using vector X_t, where the different factors are measured using proxy variables described in the previous section. Without loss of generality, we can ignore the constants and consider the following structural VAR:

$$AX_t = \Phi X_{t-1} + \varepsilon_t \tag{4}$$

where:

A is a matrix (9x9) of the parameters of contemporary relationships between the endogenous variables of the model;

X_{t-1} is a matrix (9x1) of the endogenous variables lagged for one period;

Φ is a matrix (9x9) of the model parameters; and

ε_t represents structural shocks, that is, the elements of this vector correspond to the components of the endogenous variables that are not explained by the model.

When estimating the described SVAR model, we must formulate it as a reduced VAR, and so, we rewrite (4) in the following way:

$$X_t = BX_{t-1} + C\varepsilon_t \tag{5}$$

where: B is $A^{-1} \cdot \Phi$; and C is A^{-1}.

To correctly identify the structural relation, we must add 36 restrictions in the SVAR because, in general, for an SVAR such as the one proposed in equation (4),[4] of order k with N variables, one must identify $(k+1) \cdot N \cdot N$ parameters, and we can only estimate $k \cdot N \cdot N + N(N+1)/2$ parameters; thus, we need $N(N-1)/2$ additional restrictions to correctly identify the system. That is, for an SVAR with 9 variables, we need $9(9-1)/2 = 36$ additional restrictions.

Additionally, we must select the correct SVAR lag order for each empirical model. For this purpose, we use the Akaike (AIC), Hannan-Quinn (HQIC) and Schwarz Bayesian (SBIC) information criteria, the final prediction error (FPE) and the likelihood ratio (LR) statistic for the lag order selection in each SVAR model. We estimate all the empirical models without a constant. The results for every SVAR computed are shown in Table 2.

The empirical results are shown in form of (cumulative) impulse-response functions (IRF). All the IRF include confidence intervals up to 68% (from the 16th to the 84th percentile) as suggested by Sims and Zha (1999), [5] using parametric bootstrap calculations with 500 replications without resampling residuals. As usual in the

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4 In the terminology of SVAR models (Amisano and Giannini, 1997), it is an A-model in which structural shocks in different variables are uncorrelated with each other.

5 According to Sims and Zha (1999) it is a good idea to make one-standard-error intervals the norm, as they are likely to be closer to relevant range of uncertainty because the use of high-probability intervals camouflages the occurrence of large errors of over-overage. Moreover, sample characteristics described above in section 2 give us a firm foundation for using a "less certain" confidence level.

literature, shocks have been normalized to a standard deviation of the variable that provides the leverage. From each country-specific SVAR model we obtain the (cumulative) response of the country-specific stock market to the common ECB monetary policy.

3.2. Identification scheme

In order to identify the SVAR models, a frequently used alternative is to draw on the Cholesky decomposition of the estimated covariance matrix. This decomposition places restrictions on matrix A, which gathers contemporary relations. Thus, the order of variables becomes especially relevant, because depending on their position within vector X the variable are explained by the contemporary values of the other variables or not. We use this recursive identification scheme as a natural starting point.

The variables are ordered taking into account both the economic logic, confirmed by empirical evidence, and the aim of the analysis. The order that we have intentionally given to the variables allows that Eurozone monetary policy responds to global monetary policy shocks contemporarily, and that the specific-country factors respond instantaneously to the Eurozone and global monetary factor shocks. To achieve this, we have ordered the variables into three groups: First we have placed the block of variables relating to the global monetary policy factor, where the last is the global monetary policy factor; then we include the group corresponding to the common monetary policy area factor, where again the last is the Eurozone monetary policy factor; and finally we add the group of country-specific factors, where the last is the country-specific stock market factor.

Namely, we allow that the country-specific stock market factor responds contemporarily to global and Eurozone monetary policy shocks and also to the rest of the variables considered in the analysis. The model also allows that Eurozone monetary policy responds to country-specific factors but not simultaneously. Similarly, the ECB monetary policy responds instantaneously to the global macroeconomic and monetary policy factors and to the Eurozone macroeconomic factors but all of them respond to Eurozone monetary shocks in a lagged form.

3.3. Eurozone industry-specific analysis

We check whether the country-specific industry mix explains the different country-specific stock market responses to the common monetary policy shocks showed by the eleven country-specific nine-factor SVAR models. To do this, we initially perform a Eurozone industry-specific analysis in order to isolate the effect of the ECB monetary policy to each industry. We estimate eight-factor global structural VAR models similar to the nine-factor global structural VAR models described above but now without country-specific factors and adding the Eurozone industry factor. Now, the Eurozone industry factor is in the last position for allowing that responds contemporarily to Eurozone monetary policy, and also to the rest of the variables considered in the analysis.

We also use a Cholesky decomposition of the estimated covariance matrix. In this case, we have to impose twenty-eight restrictions on matrix A. In this way, we obtain the industry-specific (cumulative) response to a monetary policy shock. As usual in the literature, shocks have been normalized to a standard deviation of the variable that provides the leverage.

We use these industry-specific stock market responses to compute the country-specific stock market responses under the hypothesis that the entire response of a country-specific stock market are explained by its industry mix, i.e., a country-specific stock market response is the weighted average of the industry-specific stock market responses where the weights are the weights of each industry on the whole country-specific stock market capitalization. If the hypothesis that the entire response of a country-specific stock market is explained by its industry mix is true, no differences between the country-specific stock market responses to ECB monetary policy estimated by the nine-factor global SVAR models and the country-specific stock market responses to ECB monetary policy computed in this way may arise.

3.4. Taylor's rule analysis

Under the hypothesis that the response of a country-specific stock market to the ECB monetary policy is explained by its industry mix but not entirely as Rodriguez-Fuentes and Padrón-Marrero (2008) argued, we introduce an additional hypothesis to explain the remained heterogeneity among the country-specific responses to ECB monetary policy. We hypothesize that this heterogeneity depends on the adequacy of the ECB monetary policy to the macroeconomic country-specific conditions.

To check the plausibility of this hypothesis we relate the remaining difference between each country-specific stock market response and Eurozone stock market response after control for the country-specific industry mix, with the distance between the actual ECB stance and the obtained by applying a simple Taylor rule implied in the ECB policy to the country-specific macroeconomic data (*TRD*) computed in subsection 2.5. This analysis reports us country-specific time series that we must resume minimizing the loose of information that they content. So, to account for the importance of these deviations we compute their variance. On the other hand, to analyze the effect of the signs of these differences we compute the average of the positive differences and the average of negative differences for each country member analyzed. Concretely, we perform the following regression analysis:

$$X_i = c_1 + c_2 TRDA_i^+ + c_3 TRDA_i^- + c_4 \sigma_{TRD_i}^2 + \varepsilon_i \tag{6}$$

where:

$TRDA_i^+$ is the average of the positive monthly distances between the ECB stance and the obtained by applying a simple Taylor rule implied in the ECB policy to the country-specific macroeconomic data;

$TRDA_i^-$ is the average of the negative monthly distances between the ECB stance and the obtained by applying a Taylor rule implied in the ECB policy to the i-country macroeconomic data;

$\sigma_{TRD_i}^2$ is the variance of the monthly distances between the ECB stance and the obtained by applying a Taylor rule implied in the ECB policy to the i-country macroeconomic data; and

ε_i is the response of the i-country stock market to the ECB monetary policy that is not explained by its industry mix or the distance between the ECB stance and the obtained by applying a Taylor rule implied in the ECB policy to the i-country macroeconomic data.

4. Results

We estimate the nine-variable global SVAR model for each of the eleven countries that conform the EMU since the beginning. We also estimate an eight-variable global SVAR for the whole Eurozone: In this case, adding the Eurozone stock market proxied by the STOXX index enlarges the number of factors related to the Eurozone but no country-specific factors are included. To unify criteria for all SVAR estimations we select a unique lag order to be used taking into account the individual optimal lag orders previously computed with the usual criteria as reported in Table 2. We select a lag length of two. The specified models are stable, and thus stationary, because all their eigenvalues are below one. The results in terms of cumulative IRFs are displayed in Figure 2.[6]

Responding to an expansionary monetary policy shock, as expected, all local exchange market selective indexes increase. However, as we can see Figure 2 the intensity of the responses varies across country-specific markets. As in Carlino and DeFina (1999), we select the cumulative response after 24 months, when all the functions have reached their maximum, to measure the average response in each country during the sample period. We summarize them in Table 5. The lowest impact, 0,3743, is the one produced on the MIB, the Italian selective stock market index. In contrast, the greatest impact of the ECB monetary policy occurs on the LUX, the selective index of the Luxemburg Stock Exchange, 0,6976. While the impact on the Eurozone stock market represented by the STOXX index is 0,4961. Six of the eleven countries analyzed (Austria, Belgium, France, Italy, Portugal and Spain) have an impact lower than the average for the

[6] In order to simplify the content of the paper, only the relations directly related to our main objectives are displayed and commented upon. The rest of the IRFs are available from the authors.

Eurozone, and the other five (Finland, Germany, Ireland, Luxemburg and Netherlands) have a greater impact.

To relate the heterogeneity of these responses to the different industry composition of the markets (indexes), we try to isolate the response of each of the ten ICB industries Eurozone portfolios to ECB monetary policy shocks. In the eight-variable global SVAR for the whole Eurozone, we replace the Euro STOXX index for each of the ten Euro STOXX industry-specific indexes and estimate the impact of ECB monetary policy shocks on the different Eurozone industries. To unify criteria for all SVAR estimations we select a unique lag order to be used taking into account the individual optimal lag orders previously computed with the usual criteria as reported in Table 3. Concretely, we select a lag length of two. The results of the Euro-zone analysis by industry in terms of cumulative IRFs are displayed in Figure 3.

The cumulative response at twenty-four months of each Eurozone industries is shown in Panel A of Table 4. It varies between 0,21, for the Euro STOXX Telecommunications, and 0,69, on the Euro STOXX Financials. Six of the ten Eurozone industry-specific indexes (Euro STOXX Oil and Gas; Euro STOXX Consumer Goods; Euro STOXX Health Care; Euro STOXX Consumer services; Euro STOXX Telecommunications; and Euro STOXX Utilities) react less than the whole, while four react more (Euro STOXX Basic Materials; Euro STOXX Industrials; Euro STOXX Financials; and Euro STOXX Technology). Now, the heterogeneity is greater than the one across country-specific stock markets. This fact, jointly with the pronounced heterogeneity displayed by the industry composition of the country-specific stock markets showed in Panel B of Table 4, would explain the heterogeneity found in the country-specific stock markets.

When we recompose the impact on the whole Eurozone stock market using these industry-specific impacts to the ECB monetary policy and the industry composition of the Euro STOXX index shown in Panel B of Table 4, we obtain a similar result than the one estimated using the eight-variable global SVAR for the whole Eurozone with the Euro STOXX index. Concretely, as we show in Table 5, only a difference of 0,0184 arises. The fact that the average industrial composition of the Euro STOXX index has been computed taking into account only the structure at the beginning and the end of the sample period could explain this difference.

As we previously do with the Euro STOXX index, we also recompose the impact on the each country-specific stock market using the industry-specific impacts to the ECB monetary policy and the industry composition of the country-specific indexes showed in Panel B of Table 4. In Table 5 these responses computed using the industry mix of each country stocks market are shown together with the differences between they and those estimated using the nine-factor global SVAR. The absolute values of these differences are in the range between 0,0133, for the Finnish stock market, and 0,1325, for the Austrian stock market. The differences are important and show a high level of heterogeneity: four country-specific stock markets respond less than they due by their industry mix while the other six do the contrary.

This evidence supports that not all the heterogeneity found in the responses of country-specific stock markets to ECB common monetary policy shocks are due to their industry mix. As we argue above, we hypothesize that almost part of this heterogeneity could be induced by the differences between country-specific and euro-specific monetary policy macroeconomic objective variables. These differences make ECB monetary policy more or less adequate for a particular country member and therefore different responses to that policy may occur. We compute these regional differences (TRD), their time-series variance and their time-series simple means conditioned by their sign, in order to perform a linear regression analysis using equation (6).

The regression analysis results are shown in Table 6. We can see how, despite the accumulated noise that must contain the dependent variable used in the regression analysis, an adjusted R-squared of 23% is reached. Moreover, all the parameters, except the constant, are significant at a 10% level, being the variance the most significant variable. The negative sign of c_3 indicates that the differences captured by the implicit Taylor's rule explain in the same direction the heterogeneity of the ECB monetary policy, but when these differences are positive they do it with greater intensity. The results suggest a nonlinear relationship between the heterogeneity effect of the ECB monetary policy on country-specific stocks markets and the differences between country-specific and euro-specific monetary policy macroeconomic objective variables.

5. Conclusions

The different response of the economies of member countries to the (common) actions of the European Central Bank (ECB) is one of the economic and political challenges that the European Monetary Union has faced. In this paper we estimate the transmission of common Eurozone monetary policy shocks across the Eurozone main regional stock markets. To do so, we develop nine-factor global SVAR models in which the common monetary policy is modeled as a function of Eurozone aggregate variables and the US variables that define the FED monetary policy shocks.

The results suggest, in line with economic theory, that the transmission of monetary policy across Eurozone stocks markets displays heterogeneities driven by differences in the listed firms' characteristics. Concretely, we find that the response of Eurozone industry-specific portfolios estimated by eight-factor global SVAR models can explain a large part of this heterogeneity. However, important and also heterogeneous differences arise between country-specific responses directly estimated by the nine-factor global SVAR models and responses computed indirectly from the Eurozone industry-specific portfolio responses to ECB monetary policy using the country-specific industry mix.

Finally, we search a relation between the impacts of ECB monetary policy on country-specific stock markets and the distance between the actual ECB stance and the obtained by applying a Taylor rule implied in the ECB policy to the country-specific macroeconomic data. Our regression analysis suggests a nonlinear relation between the responses of country-specific stock markets to the ECB monetary policy not explained by the country-specific industry mix and the differences between the actual ECB stance and those obtained by applying the Taylor rule implied in the ECB policy to the country-specific macroeconomic data. In this relation both the size and the sign of these differences are significant. Our results support the increasingly widespread hypothesis that the monetary policy per se would have a sufficiently strong effect to promote the bubbles generation (and pop them).

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Figure 1. Deviation Taylor's Rule Measure.

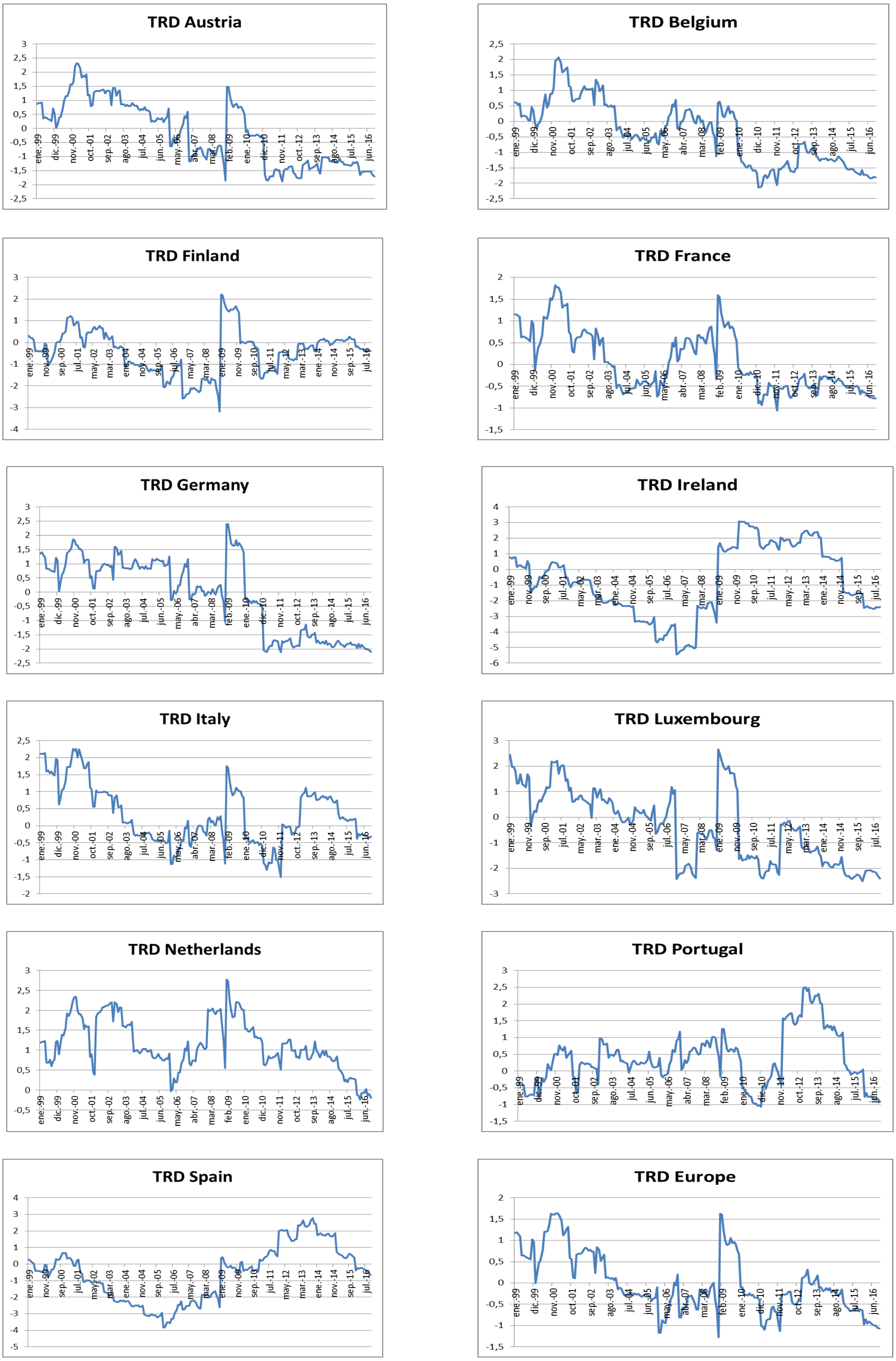

Figure 2. Accumulated Impulse – Response Functions for the nine-factor country-specific Structural VAR models.

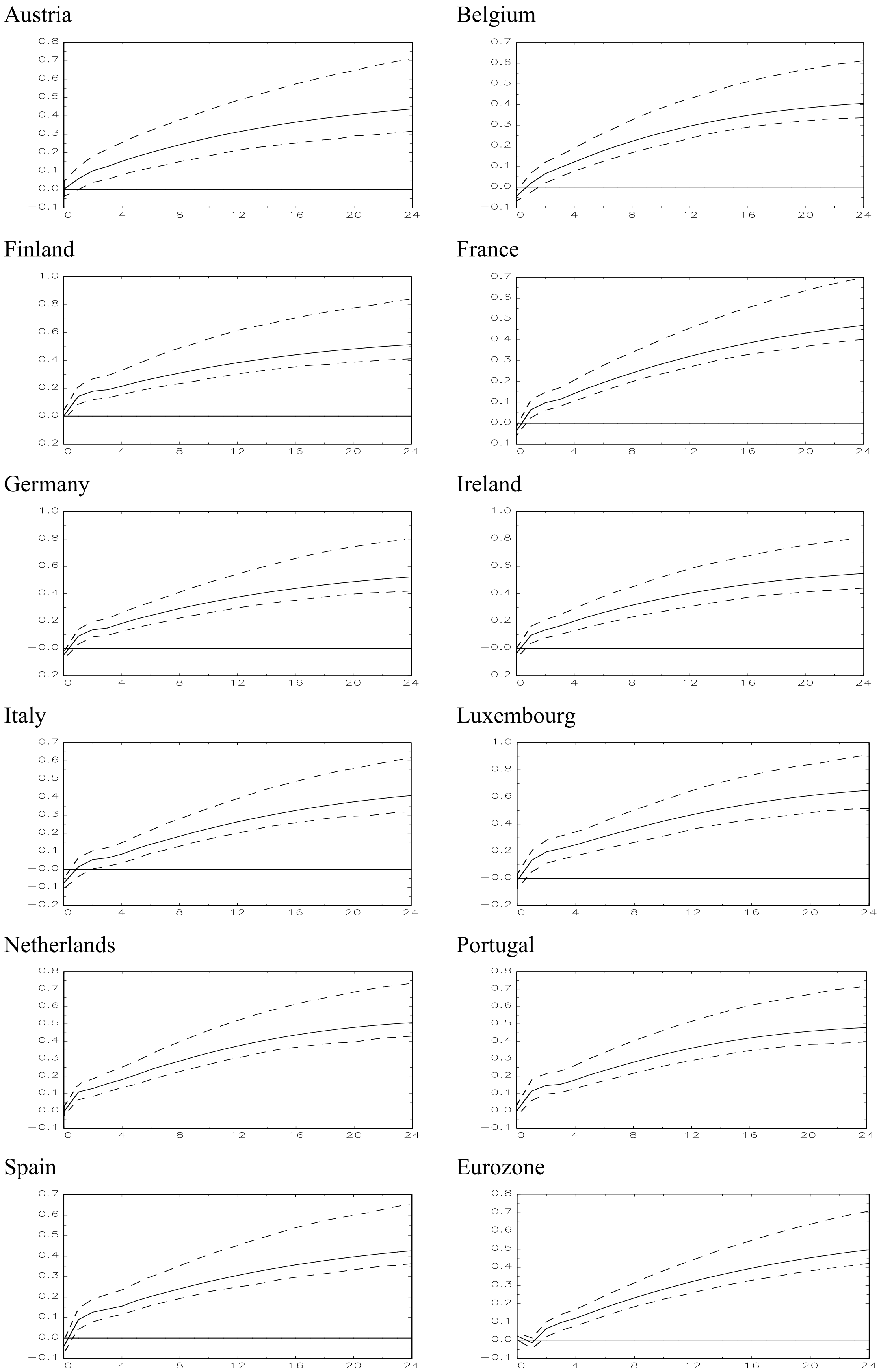

Figure 3. Accumulated Impulse – Response Functions for the eight-factor global structural VAR models by industries.

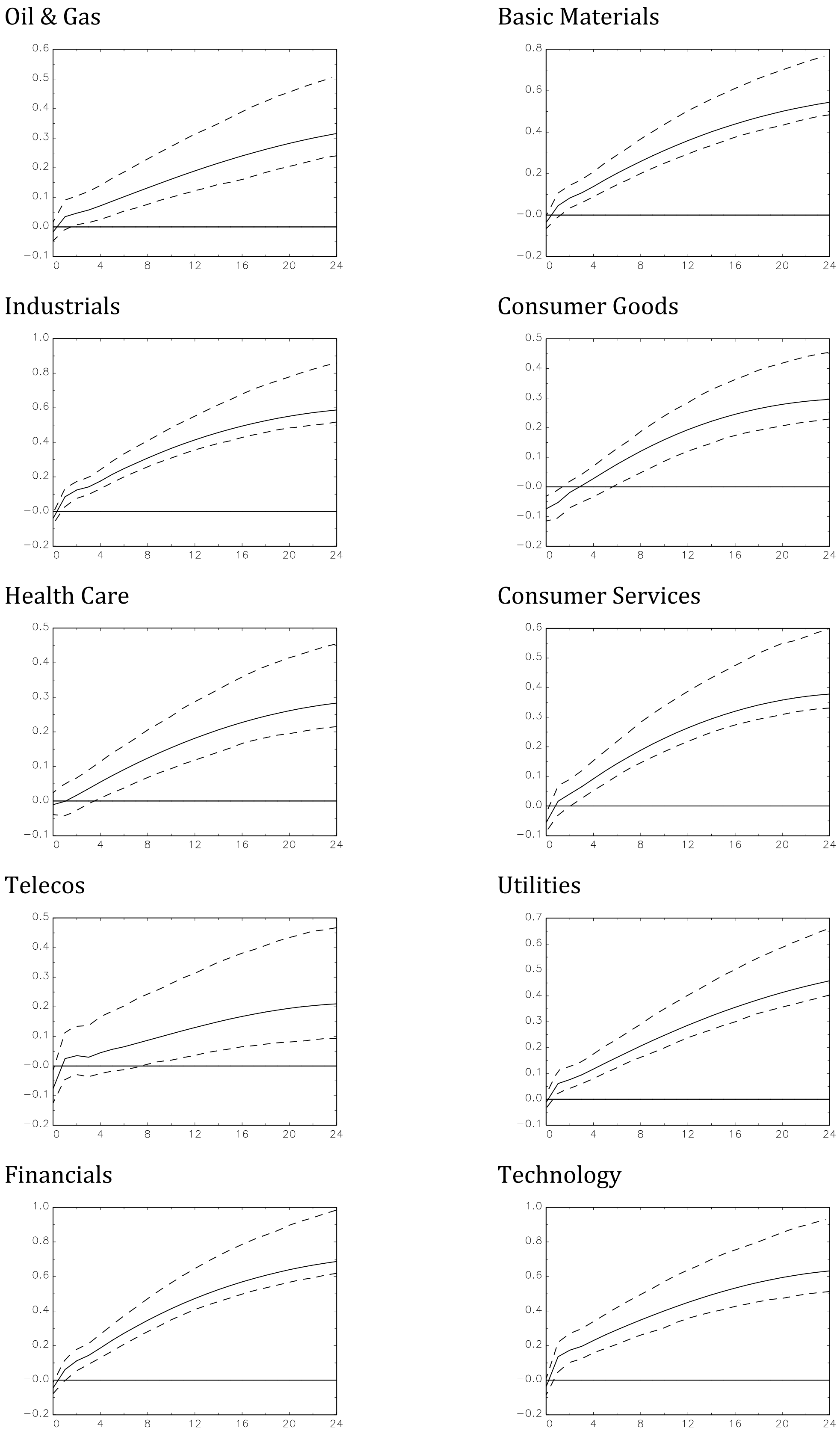

Table 1. Data. Basic variables and sources.

VARIABLE	SOURCE
ECB Nominal Interest Rate	European Central Bank (http://sdw.ecb.int/)
Eurozone harmonized cons. price index	European Central Bank (http://sdw.ecb.int/)
Eurozone Industrial Production Index	European Central Bank (http://sdw.ecb.int/)
Harm. Cons. Price index (all the countries)	European Central Bank (http://sdw.ecb.int/)
Industrial Prod. Index (all the countries)	European Central Bank (http://sdw.ecb.int/)
FED Nominal Rate	Federal Reserve US (http://www.federalreserve.gov)
US Consumer Price Index	Bureau of Labor Statistics US (http://www.bls.gov)
US Industrial Production Index	Bureau of Labor Statistics US (http://www.bls.gov)
S&P 500	CBOE (http://www.cboe.com/)
DAX30	Börse Frankfurt (http://en.boerse-frankfurt.de)
ATX	Wiener Borse (http://wienerborse.at)
BEL20	Bourse de Bruxelles (http://beurs.be)
IBEX35	Bolsa de Madrid (www.bolsamadrid.es)
OMXH25	Helsingin Pörssi (www.naskaqomxnordic.com)
CAC40	Bourse de Paris (www.boursedeparis.fr)
AEX25	Amsterdam Stock Exchange (www.aex.nl)
ISEQ20	Irish Stock Exchange (www.ise.ie)
FTSE MIB	Borsa Italiana (www.borsaitaliana.it)
FTSE LUX	Luxembourg Stock Exchange (www.bourse.lu)
PSI20	Bolsa de Lisboa (www.bolsadelisboa.com.pt)
Euro STOXX Oil and Gas	Thomson Reuters Eikon
Euro STOXX Basic Materials	Thomson Reuters Eikon
Euro STOXX Industrials	Thomson Reuters Eikon
Euro STOXX Consumer Goods	Thomson Reuters Eikon
Euro STOXX Health Care	Thomson Reuters Eikon
Euro STOXX Consumer Services	Thomson Reuters Eikon
Euro STOXX Telecos	Thomson Reuters Eikon
Euro STOXX Uilities	Thomson Reuters Eikon
Euro STOXX Financials	Thomson Reuters Eikon
Euro STOXX Technology	Thomson Reuters Eikon
Euro STOXX	Thomson Reuters Eikon

Table 2. Selection of the optimal lag for the nine-factor country-specific Structural VAR models.

SVAR Country	AIC	FPE	HQC	SC
Austria	2	2	2	1
Belgium	2	2	2	1
Finland	2	2	2	1
France	2	2	2	1
Germany	2	2	2	1
Ireland	12	2	2	1
Italy	12	2	2	1
Luxembourg	12	3	2	1
Netherlands	2	2	2	1
Portugal	12	2	2	1
Spain	12	2	2	1
STOXX	6	2	2	1

AIC: Akaike Info Criterion. FPE: Final Prediction Error. HQC: Hannan-Quinn Criterion. SC: Schwarz Criterion

Table 3. Selection of the optimal lag for the Eurozone industry-specific analysis.

SVAR Industry	AIC	FPE	HQC	SC
STOXX	6	2	2	1
STOXX Oil and Gas	3	3	2	1
STOXX Basic Materials	6	3	2	1
STOXX Industrials	6	6	2	1
STOXX Consumer Goods	3	3	2	1
STOXX Health Care	6	2	2	1
STOXX Consumer services	6	2	2	1
STOXX Telecos	3	3	2	1
STOXX Utilities	6	4	2	1
STOXX Financials	6	6	2	1
STOXX Technology	2	2	2	1

AIC: Akaike Info Criterion. FPE: Final Prediction Error. HQC: Hannan-Quinn Criterion.
SC: Schwarz Criterion

Table 4. Accumulated response for the European stock market industries from the eight-factor global structural VAR models.

Panel A. Cumulative response in STOXX and in STOXX industry-specific indexes from ECB monetary policy shocks.

	STOXX	S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
Cum. Resp. *	0,50	0,32	0,54	0,59	0,30	0,28	0,38	0,21	0,46	0,69	0,63

*Cumulative Response in period 24 for a monetary policy shock computed with 2 lags.

Panel B. Industry weights for each country-specific stock market index and for the Eurozone stock market.

	S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
Eurozone	0,07	0,09	0,14	0,19	0,08	0,03	0,05	0,04	0,23	0,07
Austria	0,14	0,24	0,16	0,01	0,00	0,01	0,02	0,03	0,40	0,00
Belgium	0,00	0,10	0,03	0,12	0,08	0,12	0,03	0,11	0,40	0,00
Finland	0,04	0,19	0,28	0,07	0,04	0,03	0,05	0,06	0,14	0,12
France	0,16	0,08	0,19	0,15	0,13	0,13	0,04	0,01	0,11	0,01
Germany	0,03	0,09	0,33	0,05	0,16	0,01	0,06	0,03	0,19	0,07
Ireland	0,00	0,07	0,26	0,25	0,00	0,31	0,00	0,00	0,11	0,00
Italy	0,19	0,00	0,11	0,08	0,07	0,03	0,04	0,17	0,30	0,02
Luxembourg	0,00	0,48	0,00	0,00	0,00	0,00	0,19	0,00	0,33	0,00
Netherland	0,17	0,09	0,03	0,17	0,07	0,12	0,04	0,00	0,23	0,10
Portugal	0,17	0,08	0,10	0,02	0,00	0,28	0,01	0,27	0,09	0,00
Spain	0,08	0,02	0,13	0,14	0,02	0,08	0,10	0,14	0,28	0,00

The ten STOXX industry-specific indexes are labelled as follows. S0: EURO STOXX Oil and Gas; S1: EURO STOXX Basic Materials; S2: EURO STOXX Industrials; S3: EURO STOXX Consumer Goods; S4: EURO STOXX Health Care; S5: EURO STOXX Consumer services; S6: EURO STOXX Telecommunications; S7: EURO STOXX Utilities; S8: EURO STOXX Financials; and S9: EURO STOXX Technology.

Table 5. The explanatory power of the industry structure with regard to the response to ECB monetary policy shocks.

Country	Cumulative Response	Compounded Response	Difference	% of difference
Eurozone	0,4961	0,47773149	0,01836851	3,70%
Austria	0,4294	0,56187185	-0,13247185	-30,85%
Belgium	0,4203	0,51043034	-0,09013034	-21,44%
Finland	0,5378	0,52446417	0,01333583	2,48%
France	0,4838	0,42597428	0,05782572	11,95%
Germany	0,5376	0,50474404	0,03285596	6,11%
Ireland	0,6178	0,45760793	0,16019207	25,93%
Italy	0,3743	0,4808481	-0,1065481	-28,47%
Luxembourg	0,6976	0,52692473	0,17067527	24,47%
Netherland	0,5624	0,45765334	0,10474666	18,62%
Portugal	0,491	0,44589402	0,04510598	9,19%
Spain	0,4321	0,47152715	-0,03942715	-9,12%

Cumulative response in period 24 for a Monetary Policy shock computed with 2 lags. Compounded response by country, taking into account the sectorial composition of each country-specific stock market index (Table 4 Panel B) and the accumulated response for the European stock market industries (Table 4 Panel A).

Table 6. Taylor's Rule Distance (TRD) analysis. Regression of the difference between country-specific cumulative response to ECB monetary policy shocks and the compounded response (Table 6) on the country-specific variance of TRD, the average of the positive values of TRD and the average of the negative values of TRD.

$$X_i = c_1 + c_2 TRDA_i^+ + c_3 TRDA_i^- + c_4 \sigma_{TRD_i}^2 + \varepsilon_i$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.113544	0.071498	1.588076	0.1509
C(2)	0.194278	0.102770	1.890402	0.0954
C(3)	-0.044747	0.023111	-1.936223	0.0889
C(4)	0.112645	0.049832	2.260485	0.0537

R-squared	0.440216	Mean dependent var	0.019544
Adjusted R-squared	0.230297	S.D. dependent var	0.098503
S.E. of regression	0.086420	Akaike info criterion	-1.798000
Sum squared resid	0.059747	Schwarz criterion	-1.636365
Log likelihood	14.78800	Hannan-Quinn criter.	-1.857844
F-statistic	2.097078	Durbin-Watson stat	1.889652
Prob(F-statistic)	0.178987		