RATIO

Ratio Working Paper No. 287

The Cost Channel Effect of Monetary Transmission: How Effective is the ECB's Low Interest Rate Policy for Increasing Inflation?

Dorothea Schäfer*, Andreas Stephan, Khanh Trung Hoang

*Corresponding author: dschaefer@diw.de. German Institute for Economic Research DIW Berlin. We thank Caterina Forti Grazzini for valuable comments.

The Cost Channel Effect of Monetary Transmission: How Effective is the ECB's Low Interest Rate Policy for Increasing Inflation?

Dorothea Schäfer (DIW Berlin,[*] JIBS[†] and CERBE[‡])
Andreas Stephan (Linnæus University, Ratio Institute and JIBS[†])
Khanh Trung Hoang (DIW Berlin[*])

This version: March 23, 2017

Abstract

We examine whether monetary transmission during the financial and sovereign debt crisis was dominated by the cost channel or by the demand-side channel effect. We use two approaches to track down the potential pass-through of changes in the monetary policy rate to those in consumer prices. First, we utilize panel data from the German manufacturing industry. Second, we conduct time series analyses for Germany, Italy, and Spain. We find that when manufacturing firms' interest costs drop, the changes in their respective industry's price index are smaller one year later. This finding is consistent with the cost channel theory. Taken together, the results of both panel data and time series analyses imply that the ECB's low interest rate policy has worked better for boosting inflation in Italy and Spain than in Germany.

Keywords: Inflation, cost channel, monetary transmission
JEL: G01, G01, E31, E43, E43

[*]German Institute for Economic Research DIW Berlin, corresponding author. We thank Caterina Forti Grazzini for valuable comments.
[†]Jönköping International Business School
[‡]Center for Relationship Banking and Economics, LUMSA

1 Introduction

In June 2014, the European Central Bank (ECB) started implementing a "negative interest rate" policy. Since then, Eurozone banks must pay if they park money on their ECB account. Accompanying the continuing package of quantitative easing, the negative rate policy of ECB aims to encourage commercial banks to lend more to the public rather than accumulating liquidity, in which case they would have to pay either the negative rate or bear the cash storing expenses. According to ECB's arguments, a low interest rate creates incentives for people "to spend money or invest," thus stimulating demand in the economy. The ultimate goal or this policy is to boost demand and increase the inflation rate.

The purpose of this paper is examine whether the promise of the recent interest rate cuts to increase the inflation rate in the Eurozone is realistic. The motivation for our investigation lies in the theory of a cost channel of monetary policy developed by Barth & Ramey (2002). Normally, the conventional demand-side effect theory states that a drop in interest rates would generally relax borrowing constraints while making savings less attractive and, thus, would encourage both more investment and more consumption, ultimately leading to a surge in inflation (Rabanal 2007 and Tillmann 2008). However, in addition, the monetary decision made by central banks would also affect the supply side through the cost channel. Specifically, if the interest rate is reduced, the capital cost component in the marginal cost of production decreases. In a competitive environment, where firms are price-takers instead of having market power, firms would lower their prices. Consequently, the overall producer price level would decrease and, thusly via the cost channel effect, the monetary policy of cutting interest rates would, *ceteris paribus*, imply deflation.

A substantial number of both theoretical and empirical studies, using a variety of models and data sets, examine the cost channel effect. Notably, Ravenna & Walsh (2006) find evidence of a cost channel effect when studying data from the United States (US). In a similar manner, Chowdhury et al. (2006) conclude that in Canada, France, and Italy, United Kingdom (UK) and US the cost channel exists and it significantly alters the traditional interest rate channel's effect on inflation dynamics after a temporary monetary shock while the effect is not so clear for Germany and Japan. They argue that this discrepancy is attributed to the distinctive characteristics of financial markets in each country: a highly regulated and bank-based financial intermediary sector in Germany and Japan is less likely to experience the cost channel effect than a more liberal, stock-based, and competitive financial sector, as in Anglo-Saxon countries. This line of argument is extensively examined and supported by Hülsewig et al. (2009) for the Eurozone, with the authors pointing out that banks tend to smooth their lending rates when facing shocks in monetary base rates, thus shielding and mitigating the effect of these shocks on their customers. This phenomenon is known as the incomplete pass-through of policy interest rate to the actual lending rate.

Gaiotti & Secchi (2006) find supporting evidence for the existence of the cost channel effect. Instead of employing the traditional time series approach, they use panel data for over 2,000 companies in Italy. Similar results are found by Tillmann (2008) for the Eurozone, the US, and, at a lower significance level, the UK. The latter finding casts doubt about the role of distinctive financial markets in determining the strength of the cost channel effect.

In contrast, Rabanal (2007) confirms the traditional demand-side effect. He finds that in the US, after a monetary shock, inflation rates and interest rates move in opposite directions. Kaufmann & Scharler (2009), in their study of both the US and the Eurozone, conclude that there is limited evidence of the cost channel effect on inflation. More recently, Malikane (2012), examining emerging markets, finds no supporting evidence for the cost channel effect, except for Mexico. It is noteworthy that these results do not necessarily mean that the cost channel effect on inflation does not exist at all. In fact, as predicted by theoretical models, the effect is only observable under certain circumstances, when a particular number of macroeconomic conditions are simultaneously satisfied. Using a dynamic stochastic general equilibrium model, Henzel et al. (2009) study under which specific regimes, denoted by a set of parameters' values, the cost-channel would pose a detectable effect on inflation rate. The result shows that, without imposing restrictions on calibrated model parameters, no cost channel effect in response to an interest rate shock exists. However, the cost channel effect prevails if real wage rigidity is high enough, i.e. if either the rigidity in nominal wage is large enough or the price stickiness level is low enough.

Inspired by the post financial crisis monetary policy movements of the ECB, and the inconclusive evidence regarding the existence of a cost channel, we aim to examine the effect of expansionary monetary policy on German, Italian and Spanish inflation. In order to gain novel insights into the mechanisms that are behind a potential pass-through of lower interest rates to consumer price changes, we apply two approaches. First, we hypothesize that producer prices respond to movements in monetary policy prior to consumer prices and test this conjecture with industry panel data from the German manufacturing sector. This sector is of particular interest since it is usually considered to be the backbone of the German Economy.

Second, we use time series analysis to examine whether the cost channel effect in response to a hypothetical monetary shock would be strong enough to dominate the traditional demand-side channel effect. The results for Germany are then put into perspective by comparing it with those obtained for Italy and Spain, two countries specifically hit by the European economic and sovereign debt crisis.

To the best of our knowledge, no prior study uses panel data from the German manufacturing industry for tracking down a potential pass-through of changes in the monetary policy rate to prices. We are also the first to investigate the cost channel effect of ECB's post-crisis monetary policy for Germany, Italy, and Spain.

Other research on a similar topic, conducted by Cochrane (2016) and Smith (2016), focuses solely on the United States.

The rest of this paper is organized as follows. Section 2 illustrates recent trends in interest rates and interest costs. Section 3 lays out the empirical strategy and methodology, including the time series models that we use to identify the cost channel effect. Section 4 discusses our findings as well as their implications, while Section 5 describes the robustness checks with new inputs. Section 6 concludes.

2 Trends in Interest Rates and Interest Costs

Figure 1 illustrates the downward trend of the ECB's policy interest rates over the 2000-2015 period. The deposit facility rate is the rate that the ECB pays for the overnight deposits of commercial banks in its account, the marginal lending facility rate represents the overnight rate at which ECB is willing to lend money to the commercial banks, while the main refinancing operations rate demonstrates the longer term rate at which the ECB injects "the bulk of liquidity to the banking system". These three key interest rates move alongside each other and together constitute the toolkit for ECB's monetary policy. In 2014, the deposit facility rate became negative. The proportional "fee" on banks' reserves with ECB should, in theory, encourage banks to reduce reserves by making more commercial loans.

[Figures 1 and 2 here]

Figure 2 shows the movement and the trend of interest costs as share of gross output of the German manufacturing sector from 1995 to 2014. The interest cost share is the yearly average of 229 different manufacturing industries. In the years before the financial crisis, between 2005 and 2008, the interest cost share increased gradually. However, after 2008, the *interest cost per unit of output* share declined quickly, reaching a record low in 2014. The question arises of whether the ECB's rate cuts have lowered the cost burden for manufacturers and, thus, via the cost channel, reduced the incentives for companies to increase product prices.

3 Empirical Strategy

We use two approaches to track down a potential pass-through of changes in the monetary policy rate to consumer price changes during the financial and sovereign debt crisis. First, we utilize panel data of German manufacturing industries. Second, we conduct time series analyses for Germany, Italy, and Spain.

3.1 Panel Data Analysis

We start with a panel vector autoregression (PVAR) analysis covering 229 manufacturing industries. Instead of proposing a specific model, we estimate the coefficients by using a generalized method of moments (GMM) framework (for a similar approach see Galariotis et al. 2016). For the inputs of the PVAR model, we utilize the industry-specific cost structure and *PPI* data per industry provided by the Federal Statistical Office of Germany. The yearly data covers the period between 2008 and 2014. We break down the various components of these industries' cost structure into interest costs (*Icost*), consumption of fixed capital (*CFC*), wage and salary costs (*Wcost*), and other costs (*Ocost*). The explicit inclusion of the depreciation share *CFC* (consumption of fixed capital) in the model serves to take investment into account. *Ceteris paribus*, increasing investments leads to higher depreciation,[1] and at the same time to higher interest expenditures from financing these investments.

The raw data is given as percentage share of gross output, which then is multiplied by the turnover value index of the same year, obtained from the same

[1]We use consumption of fixed capital and depreciation interchangeably.

source.[2] For each industry, the base year of the respective *PPI* is 2010. We organize the 1,603 observations into the form of panel data for implementing the PVAR model. Table 2 in the Appendix provides descriptive statistics of the relevant variables for our test. The Harris-Tzavalis unit-root test for the panel data indicates that among the variables, only the series of *PPI* is non-stationary at a 1% level of significance (Table 3). Therefore, we take the first difference of this variable, ΔPPI, as input for the panel VAR (PVAR) model. The PVAR takes the general form:

$$X_{t,i} = \mu + \Theta \sum_{s=1}^{n} X_{t-s,i} + \epsilon_{t,i}, \tag{1}$$

where $X_{t,i} = [Icost_{t,i}, Wcost_{t,i}, Ocost_{t,i}, CFC_{t,i}, \Delta PPI_{t,i}]$ is the matrix of model variables of industry i at time t, μ denotes the matrix of constants, Θ the matrix of parameters, and $\epsilon_{t,i}$ is the matrix of error terms at time t for industry i. Note that errors are allowed to be correlated across equations.

We expect producer prices in the German manufacturing industry to have a mediating function in a potential pass-through of interest rate changes to changes in consumer prices. This conjecture is tested with a vector error correction model (VECM):

$$\Delta X_t = \alpha\beta' Y_t + \Psi \sum_{s=1}^{n} \Delta X_{t-s} + \epsilon_t, \tag{2}$$

where Ψ is the parameters matrix, ϵ_t is the error terms matrix at time t, while $\Delta X_t = [\Delta PPI_t, \Delta CPI_t]$ is the vector of first differences of the manufacturing sector's aggregated *PPI* and Germany's Consumer Price Index (*CPI*), $Y_t = [PPI_t, CPI_t]$ is the cointegration relationship, governed in the long run by the parameter vector β' and shock-adjusted in the short term by α. The mediating role of the manufacturing sector's producer price index is confirmed if the

[2] Let the cost component q at time t be $c_{q,t}$, then its shares of the gross output O_t at the same time is $\frac{c_{q,t}}{O_t}$. We observe this share in the raw data. Assume that companies can always sell all the goods they produce, i.e. gross output is equal to turnover, the turnover value index is $\frac{O_t}{O_r}$, where O_r is the output at a fixed time chosen as the origin. For comparison, we then use the proxy $\frac{c_{q,t}}{O_t} \cdot \frac{O_t}{O_r} = \frac{c_{q,t}}{O_r}$.

relation between the aggregated *PPI* and *CPI* is economically and statistically significant. The aggregated yearly *PPI* of the manufacturing sector for the 1995-2014 period in Germany is collected from the webpage of Federal Reserve Bank of St. Louis. Germany's yearly *CPI* data for the same period is taken from the Federal Statistical Office. Variables are described in Table 1.

3.2 Time Series Analysis

The time-series analysis covers 2000 to 2015 and coincides approximately with the time of Germany's participation in the Euro project. As mentioned above, previous research on the question of whether the cost channel effect of interest rate changes offsets the demand-side effect provides non-conclusive results. Accordingly, we test two hypotheses

1. ECB's monetary policy rate of cutting interest rates has induced a lower inflation rate,

or alternatively

2. ECB's monetary policy of cutting interest rates has induced a higher inflation rate.

A vector autoregression (VAR) model is employed to analyze the relationship between the time series of the ECB's policy interest rates, actual lending rates of commercial banks in Germany, and the level of inflation. It is notable that the inclusion of lending rates in the model serves the purpose of taking the mediating role of bank loans into account. In order to align our specification to the widely used Taylor rule and to avoid potential omitted variable bias, we also include the country's output level in the model. This approach is similar to that of Henzel et al. (2009).[3] The same models with appropriately different lag lengths

[3] We do not take wage inflation and commodity price inflation as separate factors into account due to data availability constraints.

are applied in estimating the models for Italy and Spain. The VAR model has the general form:

$$X_t = \mu + \Omega \sum_{s=1}^{n} X_{t-s} + \epsilon_t \tag{3}$$

where μ denotes the vector of constants and $X_t = [LGDP_t, R_t^P, R_t^L, INF_t]$ is the vector of model variables at time t. $LGDP$ is the log output level, R^P denotes the policy interest rate, R^L is the lending interest rate, and INF denotes the inflation rate. Ω is the matrix of parameters, and ϵ_t is the vector of error terms at time t.

For the VAR model inputs, we collect quarterly time series from Deutsche Bundesbank's website, OECD's website, as well as the Federal Reserve Bank of St. Louis. Inflation rate in Europe is defined as the change rate of ECB's Harmonized Index of Consumer Price all items (*HICP*) in percentage points over time. The ECB's deposit facility rate (*DRATE*), which is in negative territory since 2014, represents the rate of monetary policy. Commercial banks' lending rate is approximated by the interest rate on loans granted by monetary financial institutions in Germany (*LRATE*), specifically, the new business loan rate to non-financial corporations, as computed by the Bundesbank. Finally, the output level, indicated by the natural logarithm of German real gross domestic product adjusted for seasonality (*GDP*), is included. The respective time series start in the first quarter of 2000 and end in the fourth quarter of 2015, amounting to 64 observations in total. The data is summarized in Table 4 (Appendix).

After establishing the appropriate model, we use it for performing an impulse response analysis in order to see how the inflation rate reacts to an artificial shock in the policy interest rate. As a matter of focus, we neglect the magnitude of the cost channel effect, but seek to identify which effect of a tumble in the policy interest rate would have a greater effect on inflation: the pull-down force from the supply side or the push-up one from the demand side. For this purpose, we analyze the correlated movements of these two variables. From the obtained evidence, we can assess the effectiveness of ECB's recent monetary policy.

4 Results and Discussion

4.1 Cost Channel Effect in the German Manufacturing Industry

We estimate the coefficients of model (1) by using generalized method of moments (GMM) imposing restrictions on the number of lags of instrument variables. In order to test the validity of instruments, we use Hansen's J chi-squared statistic.[4]

We specify a first order lag model based on modified lag length criteria. The optimal lag length for instrument variables that satisfies the over-identification test is the inclusion of third, fourth, and fifth lags (see Appendix, Table 5 for the lag length test).

The coefficient estimates in Table 6 show that, on average, interest costs have a positive effect on changes in *PPI* at a 5% significance level. However, since a change in interest costs could be attributed to either a change of the interest rate or to a change of the debt level, further evidence is needed to determine whether an interest cost change imposes the same effect on the sector's *PPI* as an interest rate change. Fortunately, we can show that during the period of concern, the movements in interest cost of German manufacturing companies are mainly guided by the effect of interest rates, while debt variation plays only a limited role. As illustrated in Figure 3, the sector's average interest cost (*Icost*) closely follows the trend of the EONIA rate (*Lendrate*). In contrast, data from Bundesbank's enterprises' and households' time series database show that over the same period, the financial debt level of German companies involved in production activities followed a completely different pattern (Figure 4). Hence, we can safely assert that

[4]The statistical package in STATA we employ for the PVAR model is described in Abrigo & Love (2016). Moreover, the estimated system of equations must also be stable to be valid. This feature can be examined by the built-in `pvarstable` command of the package.

the variable interest cost in our model is dependent on the interest rate and, thus, impose the same effect on the sector's *PPI*.

[Figures 3 and 4 here]

Wage and salary costs, as well as other costs, all have statistically significant effect on the changes in *PPI* at the level of 1%, while the effect of consumption of fixed capital is insignificant at conventional levels (see Table 6). Moreover, the Granger causality test results presented in Table 7 indicate that interest cost, wage and salary cost, as well as other costs all significantly Granger-cause the change in *PPI*, while consumption of fixed capital does not. However, in the other equations the remaining variables rarely have a Granger causality effect on each other.

In conclusion, we can assert that if manufacturing firms' interest cost drop, the changes in their respective industry's *PPI* are smaller one year later. This finding is in accordance with the prediction of the cost channel theory, as the interest rate, through interest costs in our model, positively affects the change of producer's price index.

The next thing we aim at is establishing a mediating role of producer prices in the transmission of interest rate changes to consumer price changes. That is, we would need to confirm a statistically significant relationship between *PPI* and Germany's consumer prices (*CPI*). By employing the Johansen cointegration test with two lags and linear deterministic trend in the series, we find that both variables are cointegrated of first order (Table 9). This prompts us to fit the time series with a vector error correction model VECM(2), whose result is shown in Table 10 in the Appendix. Our focus stays on the cointegration equation estimates, which indicates a significantly positive relation between Germany's *CPI* and the manufacturing sector's *PPI* in the long run. Moreover, in the short run, the coefficient estimates imply that changes in *PPI* positively and significantly affect changes in *CPI* one and two years later. In other words, inflation in producer prices leads to inflation in consumer prices.

Consequently, we establish a chained relationship between manufacturing firms' interest cost, the manufacturing sector's *PPI*, and Germany's *CPI*. As firms' interest costs go down, the changes in *PPI* of manufacturers would also fall in response, and the aggregate *CPI* would, in turn, move in the same direction. Therefore, *ceteris paribus*, cutting the interest rate leads to lower interest costs and, hence, to a lower inflation level. In line with the theory of cost channel effect of monetary transmission, the industry level result implies that the ECB's current low interest rate policy would likely fail to bring up the inflation level in Germany.

4.2 Time Series Results for Germany

We apply the proposed VAR model (2) to the quarterly time series inputs from 2000 to 2015. First, we use the Augmented Dickey-Fuller unit root test without trend and intercept to examine stationarity among the time series. The null hypothesis is that the time series contains a unit root, thus is non-stationary. The results[5] point out that inflation rate and policy rate are stationary at conventionally significant levels, while we cannot reject that a unit root exists for *GDP* and the lending rate *LRATE*. Therefore, we take the first difference of the two latter variable to make them suitable for being included in the VAR model, denoted as Δ*(LRATE)* and Δ*(GDP)*, respectively.

After comparing the results of lag length criteria tests, autocorrelation tests and heteroscedasticity tests, we arrive at the decision of using the VAR(2) model specification for the whole period, i.e. incorporating one-period and two-period lags of the variables into the right hand side of the model equation. According to the model's estimation result (see Table 14 in the Appendix), the deposit facility rate does not play a statistically significant role in affecting the *HICP* level. Even after taking the 2008 crisis peak into account by generating an interactive

[5]Not reported, but available from the authors upon request.

dummy variable with *DRATE* for the pre- and post-crisis periods (Table 15), we still cannot find a significant effect of monetary shocks on Germany's inflation level. We conclude that the time series analysis does not confirm the panel data results. There is no evidence for the existence of the cost channel effect from 2000 to 2015, however, there is also no evidence for the demand-side effect.

Our finding stands in stark contrast to the empirical work done by Tillmann (2008) and Henzel et al. (2009) for the Euro area and to the conclusion of Chowdhury et al. (2006) for Germany. Given the previous evidence for the manufacturing sector, we infer from our time series results that, in the best case, further cutting of the ECB's policy rate would not affect Germany's inflation rate.

4.3 Time Series Results for Italy and Spain

According to the ECB Inflation Dashboard (2016), as of June 2016, Germany experienced a relatively small, but positive, inflation rate of 0.2% (based on the overall HICP); in Italy and Spain it was -0.2% and -0.9%, respectively. As a result, ECB's policy may focus less on Germany and more on the peripheral countries experiencing deflation tendencies like Italy or Spain.

To explore this conjecture, we implement the similar econometric analysis of possible reactions of the inflation rate in Italy and Spain to a monetary shock. The aforementioned dashboard additionally points out that there are other European countries (e.g. Bulgaria and Romania) facing huge deflationary problems, but in terms of the scale of the economy measured by real GDP, Italy and Spain are more comparable to Germany and, thus, prove to be more relevant for the analysis. The data of these two countries are collected in the same manner as for Germany, except the lending rate. For Italy, it is represented by the financial intermediaries' rate for new business loans to non-financial corporations, other than bank overdrafts, from first quarter of 2000 through fourth quarter of 2015 and is downloaded from the website of Banca d'Italia. For Spain, it is approximated by the synthetic new business loan rate to non-financial corporations and is collected from Banco de España. The availability of data, however, only spans from the first quarter of 2003 to the fourth quarter of 2015.

The fitted VAR models for Italy and Spain are shown in the Appendix (Tables 16 and 17). The coefficient estimates for both countries imply a statistically significant and negative relation between the ECB's policy rate and inflation. These findings are in stark contrast to the evidence found for Germany. The graphs of the inflation rate's response to a hypothetical shock of a -1 percentage point change in monetary policy rate are illustrated in Figures 5 and 6.

[Figures 5 and 6 here]

The inflation rates in both Italy and Spain go up strongly when the deposit facility interest rate drops. The evidence contradicts Chowdhury et al. (2006)'s and Gaiotti & Secchi (2006)'s pre-crisis findings about the existence of a cost channel effect in Italy. The increase of Italy's inflation rate, while smaller in magnitude, lasts in general longer than that of Spain. Specifically, after spiking up for 2.5% points in the second quarter, the inflation rate in Spain quickly reverts back to its normal state and keeps fluctuating around that level onwards. In contrast, the increase of Italy's inflation rate clings to the positive level for a considerable period before starting to dive in the ninth quarter. Thus, solely in term of fighting deflation, aggressive rate cuts are likely to be more effective in Italy and in Spain than in Germany.

Unlike the German case, for Italy and Spain the cost channel effect of monetary transmission is likely to be dominated by the conventional demand-side channel. As argued by Chowdhury et al. (2006) and Hülsewig et al. (2009), the significance of the cost channel effect on inflation rate is greatly determined by the level of pass-through from the policy rate to the lending rate, i.e. the extent to which commercial banks are willing to adopt their rates for loans to changes in the monetary policy rate. In general, the easier the pass-through of rates, the more substantial is the cost channel effect on inflation (Hülsewig et al. 2009). Therefore, it is sensible to explore how the uniform ECB policy rate was transferred into average lending rates in the countries of concern. Figure 7 shows the movements of ECB's deposit facility rate (policy rate) and the lending rates in Germany, Italy, and Spain between 2003 and 2015.

[Figure 7 here]

In the period from 2003 to the beginning of 2009, before the crisis started to take its full toll, the three lending rates moved very closely to the pattern of the policy rate and to each other. However, after 2009, while the lending rate of Germany continued to track ECB's rate accurately and decreased gradually, there were dramatic increases in Italy's and Spain's lending rates. This divergence signals a much smaller level of pass-through of rates. In fact, retail rates moved in the opposite direction of the policy rate for a rather long period. As a result, the cost channel effect is more strongly suppressed in Italy and Spain than it is in Germany. The reason for the divergent lending rates in these three countries might have its roots in the European sovereign debt crisis (Neri 2013). While Germany's economy remained rather unaffected, Italy and Spain had to digest destructive blows as their level of sovereign debt became alarmingly high and their government bond rates spiked abnormally. This increasing sovereign risk, in combination with a widespread borrower risk and a worsened macroeconomic outlook, presumably explains why retail bank rates in Italy and Spain were stuck at such a high level, despite an overall downward trend in ECB's rate (Darracq Pariès et al. 2014).

5 Robustness Checks

We use the "core inflation" (*HICP*-all-items-less-food-and-energy), instead of the normal consumer price inflation, for our first robustness check. The "core inflation" represents the underlying inflation trend after removing from the basket of goods the components of food and energy. The latter prices are proven to be historically volatile and subject to random supply shocks. They may, thus, provide misleading information about the dynamics of true inflation (Wynne 1999). The "core inflation" might be considered, therefore, as the measure of inflation "over which monetary policy has the most influence" (Clark 2001). The data of the core *HICP* (*INF1*) for Germany, Italy, and Spain are collected from OECD Statistics, and those of marginal lending facility rate (*MRATE*) and main refinancing operations rate (*MRO*) from Bundesbank's website.

When using the growth rate of *INF1* as the proxy for the inflation rate in model (3), the result are the same as in case of the normal *HICP*: The ECB's deposit facility rate causes no significant effect on inflation rate. For Italy, using the core inflation measure undermines the significance of policy rate's effect on inflation and, hence, makes the demand-side effect disappear. Noticeably, for Spain, the cost channel effect significantly emerges and dominates. When the deposit facility rate dropped by 1 percentage point, a quarter later inflation dropped by 0.23 percentage points.

Obviously, the response of food and energy goods' prices to the policy rate shock is a large part of the demand-side effect in Italy and an even greater part in the case of Spain. Excluding these items from the inflation indicator vastly reduces the significance of the effect in these countries.

In the second and third robustness checks, we substitute in the VAR model (3) the deposit facility rate with the marginal lending facility rate (*MRATE*) and the main refinancing operations rate (*MRO*), respectively. Together, these three rates constitute the key interest rate tools through which the ECB can maneuver the commercial banks' behaviors and the liquidity on the macro economy. Although they tend to move in parallel with one another, each affects different areas of the financial system and, thusly, might have different influences on the inflation rate.

For Germany, the respective effects of *MRATE* and *MRO* on inflation's dynamics are statistically insignificant at conventional levels. Similar findings also hold for both model versions of Italy. For Spain, however, the model with *MRATE* documents the existence of cost channel effect at the significance level of 10%. With a 1% point negative shock in ECB's marginal lending facility rate, Spain's inflation rate would experience a 1.02% drop one quarter later, which is then followed by a state of fluctuations as both cost channel effect and demand-side effect struggle and slowly die down. In contrast, for the model using *MRO* no significant results are obtained for the three countries.[6]

6 Conclusions

In this paper we aim to clarify on the effectiveness of the ECB's monetary policy for increasing the inflation rate to the target level of two percent. Against the backdrop of policy rate cuts during recent crisis years, we test whether the interest rate cost channel effect dominates the demand-side effect in Germany, Italy, and Spain. By using panel data of the German manufacturing sector we are able to establish a potential pass-through of interest rates to producer prices. We also find that producer prices have a mediating function in a potential pass-through of interest rate changes to changes in German consumer prices. However, the subsequent VAR-analysis for Germany yields an insignificant effect of ECB's policy rate changes on Germany's inflation rate.

In contrast, the VAR-analyses for the crisis countries Italy and Spain reveal a significant and negative effect, implying that a downward movement in the interest rate triggers an upward movements in the inflation rate in those countries. Therefore, in terms of fighting deflation, Italy and Spain may have benefited more from the ECB's low interest rate policy than Germany. The inflationary effect of

[6] The detailed estimation results of the robustness checks are available from the authors upon request.

a monetary shock in these two peripheral countries would be confined mostly to food products and energy.

Our results call for a better understanding of the mechanism of a potential pass-through of interest rate variations to changes in inflation rates. This request applies to both interest rate regimes, whether decreasing or increasing. Accordingly, more evidence at the individual firm level is necessary on how interest cost influence price behavior. Therefore, analyzing panel data covering costs and prices of individual firms in Europe is a particularly promising avenue for future research.

References

Abrigo, M. R. M. & Love, I. (2016), 'Estimation of panel vector autoregression in Stata', *Stata Journal* **16**(3), 778–804.
URL: *https://ideas.repec.org/a/tsj/stataj/v16y2016i3p778-804.html*

Barth, M. & Ramey, V. (2002), 'The cost channel of monetary transmission', *NBER Macroeconomics Annual 2001* **16**, 199–256.
URL: *http://www.nber.org/chapters/c11066*

Chowdhury, I., Hoffmann, M. & Schabert, A. (2006), 'Inflation dynamics and the cost channel of monetary transmission', *European Economic Review* **50**(4), 995 – 1016.
URL: *http://www.sciencedirect.com/science/article/pii/S0014292105000115*

Clark, T. E. (2001), 'Comparing measures of core inflation', *Economic Review* (Q II), 5–31.
URL: *https://ideas.repec.org/a/fip/fedker/y2001iqiip5-31nv.86no.2.html*

Cochrane, J. (2016), Do higher interest rates raise or lower inflation?, Technical report, Unpublished manuscript, University of Chicago Booth School of Busi-

ness.
URL: *http://faculty.chicagobooth.edu/john.cochrane/research/papers/fisher.pdf*

Darracq Pariès, M., Moccero, D., Krylova, E. & Marchini, C. (2014), The retail bank interest rate pass-through: The case of the euro area during the financial and sovereign debt crisis, Occasional Paper Series 155, European Central Bank.
URL: *https://ideas.repec.org/p/ecb/ecbops/2014155.html*

ECB Inflation Dashboard (2016). Link: https://www.ecb.europa.eu/stats/prices/hicp/html/inflation.en.html.

Gaiotti, E. & Secchi, A. (2006), 'Is there a cost channel of monetary policy transmission? an investigation into the pricing behavior of 2,000 firms', *Journal of Money, Credit and Banking* **38**(8), 2013–2037.
URL: *http://www.jstor.org/stable/4123042*

Galariotis, E. C., Makrichoriti, P. & Spyrou, S. (2016), 'Sovereign CDS spread determinants and spill-over effects during financial crisis: A panel VAR approach', *Journal of Financial Stability* **26**, 62 – 77.
URL: *http://www.sciencedirect.com/science/article/pii/S1572308916300900*

Henzel, S., Hülsewig, O., Mayer, E. & Wollmershäuser, T. (2009), 'The price puzzle revisited: Can the cost channel explain a rise in inflation after a monetary policy shock?', *Journal of Macroeconomics* **31**(2), 268 – 289.
URL: *http://www.sciencedirect.com/science/article/pii/S0164070408000669*

Hülsewig, O., Mayer, E. & Wollmershäuser, T. (2009), 'Bank behavior, incomplete interest rate pass-through, and the cost channel of monetary policy transmission', *Economic Modelling* **26**(6), 1310 – 1327.
URL: *http://www.sciencedirect.com/science/article/pii/S026499930900100X*

Kaufmann, S. & Scharler, J. (2009), 'Financial systems and the cost channel trans-

mission of monetary policy shocks', *Economic Modelling* **26**(1), 40 – 46.
URL: *http://www.sciencedirect.com/science/article/pii/S0264999308000631*

Malikane, C. (2012), Inflation dynamics and the cost channel in emerging markets, Mpra paper, University Library of Munich, Germany.
URL: *http://EconPapers.repec.org/RePEc:pra:mprapa:42688*

Neri, S. (2013), The impact of the sovereign debt crisis on bank lending rates in the euro area, Questioni di Economia e Finanza (Occasional Papers) 170, Bank of Italy, Economic Research and International Relations Area.
URL: *https://ideas.repec.org/p/bdi/opques/qef_170_13.html*

Rabanal, P. (2007), 'Does inflation increase after a monetary policy tightening? answers based on an estimated {DSGE} model', *Journal of Economic Dynamics and Control* **31**(3), 906 – 937.
URL: *http://www.sciencedirect.com/science/article/pii/S016518890600073X*

Ravenna, F. & Walsh, C. E. (2006), 'Optimal monetary policy with the cost channel', *Journal of Monetary Economics* **53**(2), 199 – 216.
URL: *http://www.sciencedirect.com/science/article/pii/S0304393205001583*

Smith, A. L. (2016), 'When does the cost channel pose a challenge to inflation targeting central banks?', *European Economic Review* **89**, 471 – 494.
URL: *http://www.sciencedirect.com/science/article/pii/S0014292116301416*

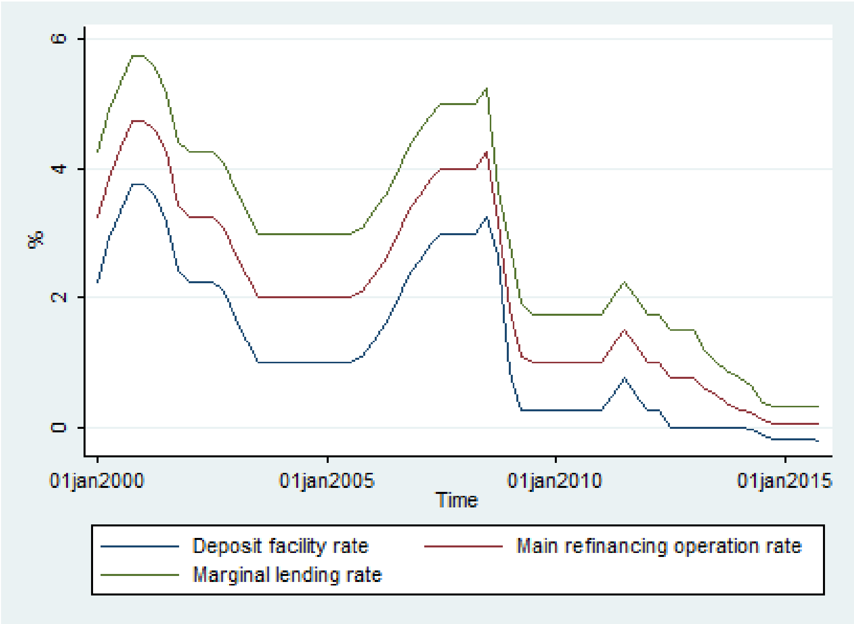
Tillmann, P. (2008), 'Do interest rates drive inflation dynamics? an analysis of the cost channel of monetary transmission', *Journal of Economic Dynamics and Control* **32**(9), 2723–2744.

Wynne, M. A. (1999), Core inflation: a review of some conceptual issues, Working Papers 9903, Federal Reserve Bank of Dallas.
URL: *https://ideas.repec.org/p/fip/feddwp/99-03.html*

Appendix

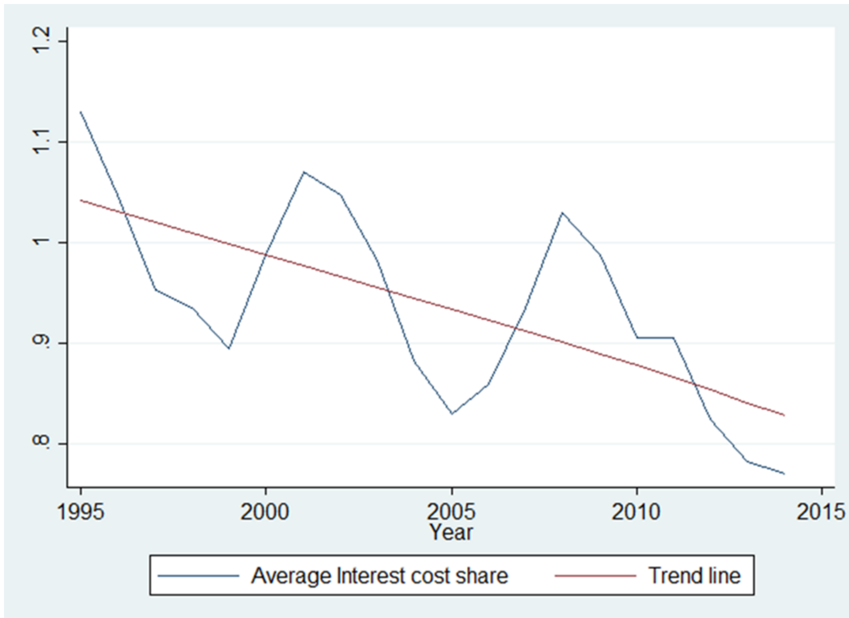
Figures

Figure 1: ECB's central bank rates from 2000 to 2015



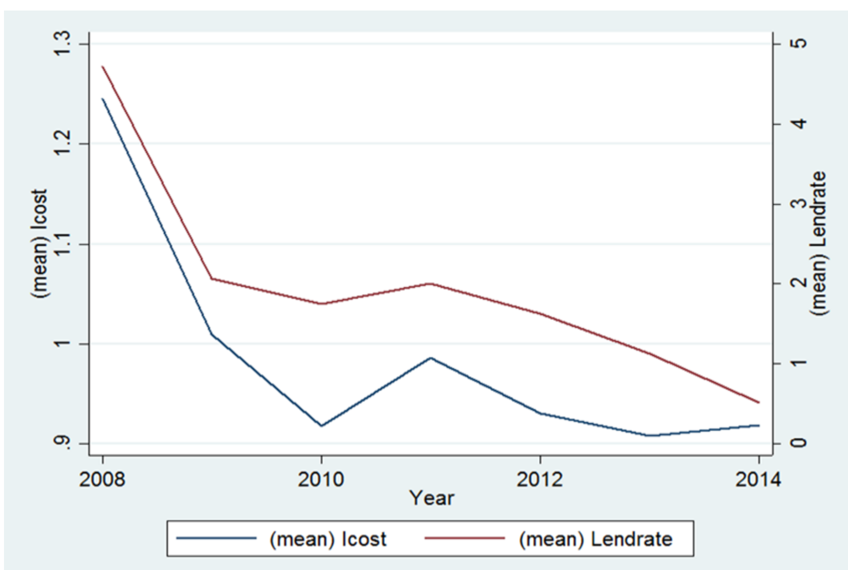
Sources: Deutsche Bundesbank, Own Calculations

Figure 2: Average interest cost share of gross output for the manufacturing sector with downward trend line from 1995 to 2014 (in percent)



Sources: Federal Statistical Office of Germany, Own Calculations

Figure 3: Movements of German manufacturing sector's average interest cost and the annual average EONIA rate from 2008 to 2014

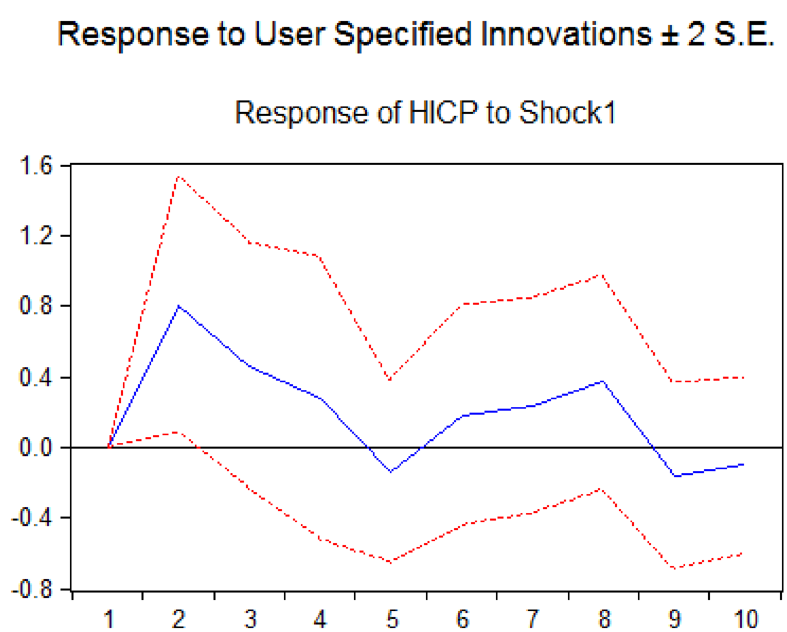


Sources: Federal Statistical Office of Germany, Deutsche Bundesbank,, Own Calculations

Figure 4: Movements of German production companies' average financial debt level in log from 2008 to 2014

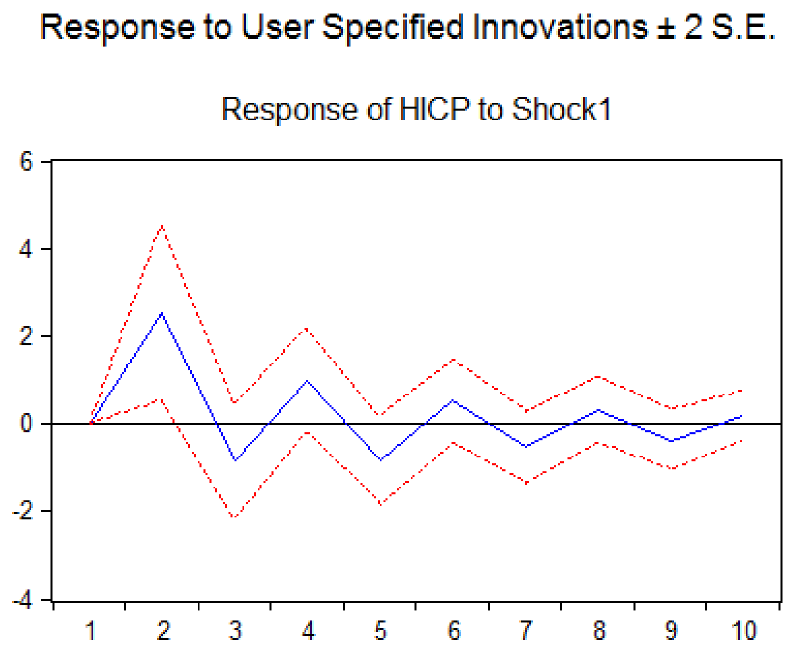
Sources: Bundesbank Time Series Database, Own Calculations

Figure 5: Italy's inflation rate responses to negative shock in deposit facility rate (2000- 2015)



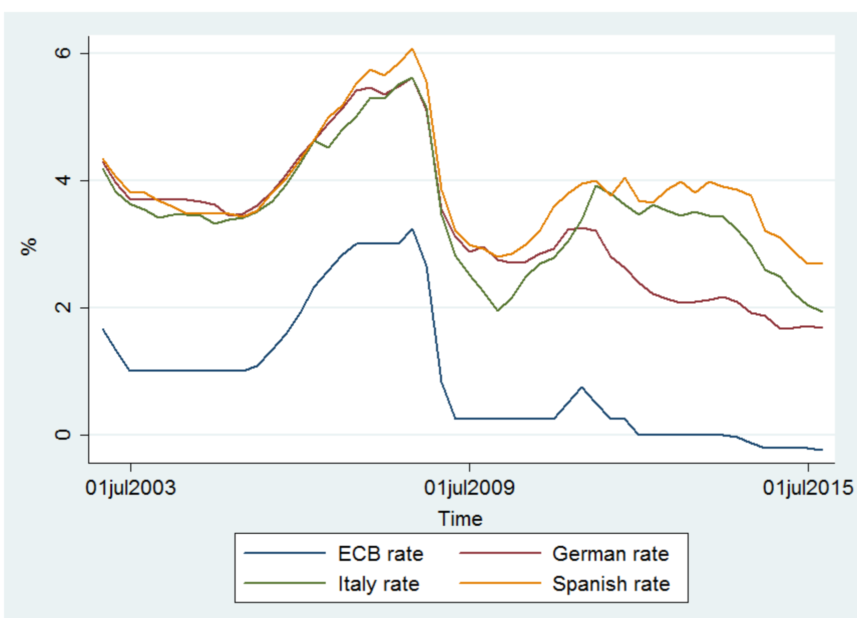
Sources: Own Calculations

Figure 6: Spain's inflation rate responses to negative shock in deposit facility rate (2003- 2015)



Sources: Own Calculations

Figure 7: Movements of ECB's deposit facility rate and lending rates in Germany, Italy, and Spain (2003-2015)



Sources: Own Calculations

Tables

Table 1: Description of Variables

Variables	Description	Data source
HICP	Inflation rate	OECD Statistics
DRATE	ECB's Deposit facility rate	Deutsche Bundesbank
LRATE	Lending rate	Deutsche Bundesbank, Banca d'Italia, Banco de España
GDP	Output level	Federal Reserve St. Louis
Icost	Interest cost as share of total cost	Federal Statistical Office of Germany
Wcost	Wage cost as share of total cost	Federal Statistical Office of Germany
Ocost	Other cost as share of total cost	Federal Statistical Office of Germany
CFC	Consumption of fixed capital	Federal Statistical Office of Germany
	as share of total cost	Federal Statistical Office of Germany
PPI	Producer Price Index per industry	Federal Statistical Office of Germany
CPI	Germany's Consumer Price Index	Federal Statistical Office of Germany

Table 2: Description of yearly data of cost components and producer price index across 229 manufacturing industries between 2008 and 2014

Variables	Mean	Standard Deviation	Minimum	Maximum
Icost	0.98	0.59	0.08	8.44
Wcost	17.55	6.86	0.99	45.06
Ocost	83.93	14.18	37.48	177.50
CFC	3.17	1.50	0.42	12.82
PPI	103.21	7.23	58.70	143.30

Sources: Federal Statistical Office of Germany, own calculations

Table 3: Harris-Tzavalis unit root test results for variables

H0: Panels contain unit roots vs.
Ha: Panels are stationary
Time trend: not included

Variable	*Icost*	*Wcost*	*Ocost*	*CFC*	*PPI*
Test Stats	-14.866***	-8.302***	-15.569***	-14.594***	-1.912**
p-value	0.000	0.000	0.000	0.000	0.028

Source: Own calculations

Table 4: Description of quarterly time series data between 2000 and 2015

Variables	Mean	Standard Deviation
HICP	0.377	0.414
DRATE	1.273	1.237
LRATE	3.781	1.392
GDP	13.362	0.055

Source: OECD, Bundesbank, Federal Reserve St. Louis, Own calculations

Table 5: PVAR lag length test

Selection Order Criteria
Sample: 2008-2014
No. of obs: 229
No. of panels: 229

Lag	CD	J	J-value	MBIC	MAIC	MQIC
1	1	92.723	.081	-314.806*	-57.277*	-161.171*
2	1	56.749	.238	-214.937	-43.251	-112.513
3	1	20.487	.721	-115.356	-29.513	-64.144

* indicates lag order selected by the criterion
CD: coefficient of determination
J: Hansen's J statistics
J-value: Hansen's J p-value
MBIC, MAIC, MQIC: Andrew and Lu's selection criterion

Table 6: Estimation PVAR model for German manufacturing sector 2008-2014

Variable	**Coefficient**	**Std. Err.**	**T-stats**
Equation 1 : $\Delta PPI_{t,s}$			
$Icost_{t-1,s}$	36.127**	(16.719)	2.16
$Wcost_{t-1,s}$	2.122***	(0.824)	2.58
$Ocost_{t-1,s}$	-0.847***	(0.197)	-4.29
$CFC_{t-1,s}$	-9.022	(9.250)	-0.98
$\Delta PPI_{t-1,s}$	0.128	(0.234)	0.55
Equation 2 : $Icost_{t,s}$			
$Icost_{t-1,s}$	0.203	(0.184)	1.10
$Wcost_{t-1,s}$	-0.009	(0.012)	-0.73
$Ocost_{t-1,s}$	-0.005*	(0.003)	-1.81
$CFC_{t-1,s}$	0.164	(0.134)	1.23
$\Delta PPI_{t-1,s}$	0.001	(0.003)	0.41
Equation 3 : $Wcost_{t,s}$			
$Icost_{t-1,s}$	-3.615	(3.453)	-1.05
$Wcost_{t-1,s}$	0.537***	(0.204)	2.63
$Ocost_{t-1,s}$	0.066	(0.045)	1.46
$CFC_{t-1,s}$	2.758	(2.546)	1.08
$\Delta PPI_{t-1,s}$	0.034	(0.056)	0.59
Equation 4 : $Ocost_{t,s}$			
$Icost_{t-1,s}$	-12.981	(10.330)	-1.26
$Wcost_{t-1,s}$	-0.044	(0.574)	-0.08
$Ocost_{t-1,s}$	0.094	(0.129)	0.73
$CFC_{t-1,s}$	9.175	(6.746)	1.36
$\Delta PPI_{t-1,s}$	0.351*	(0.184)	1.91
Equation 5 : $CFC_{t,s}$			
$Icost_{t-1,s}$	-1.196	(0.923)	-1.30
$Wcost_{t-1,s}$	-0.029	(0.049)	-0.59
$Ocost_{t-1,s}$	0.017	(0.011)	1.50
$CFC_{t-1,s}$	0.801	(0.619)	1.30
$\Delta PPI_{t-1,s}$	0.004	(0.014)	0.26

Significance levels: *: 10%, **: 5%, ***: 1%

Test of overidentifying restrictions:

Hansen's J chi2(45) = 49.359019 (p = 0.303)

Table 7: PVAR Granger-causality Wald test

H_0: Excluded variable does not Granger-cause
Equation variable for the respective dependent variable
H_1: Excluded variable Granger-causes Equation
variable for the respective dependent variable

Equation variable	**Excluded variable**	**Chi-squared**	**df**	**Prob**
ΔPPI				
	Icost	4.660	1	0.031**
	Wcost	6.636	1	0.010***
	Ocost	18.406	1	0.000***
	CFC	0.951	1	0.329
	ALL	21.099	4	0.000***
Icost				
	ΔPPI	0.166	1	0.684
	Wcost	0.533	1	0.465
	Ocost	3.293	1	0.070*
	CFC	1.508	1	0.219
	ALL	13.176	4	0.010***
Wcost				
	ΔPPI	0.353	1	0.552
	Icost	1.096	1	0.295
	Ocost	2.143	1	0.143
	CFC	1.173	1	0.279
	ALL	2.797	4	0.592
Ocost				
	ΔPPI	3.657	1	0.056*
	Icost	1.579	1	0.209
	Wcost	0.006	1	0.939
	CFC	1.850	1	0.174
	ALL	6.167	4	0.187
CFC				
	ΔPPI	0.066	1	0.797
	Icost	1.678	1	0.195
	Wcost	0.344	1	0.557
	Ocost	2.259	1	0.133
	ALL	3.226	4	0.521

Significance levels: *: 10%, **: 5%, ***: 1%

Table 8: PVAR stable test

Eigenvalue stability condition

Eigenvalue Real	Imaginary	Modulus
.808	0	.808
.363	-.389	.532
.363	.389	.532
.115	-.268	.291
.115	.268	.291

All the eigenvalues lie inside the unit circle.
PVAR satisfies stability condition.

Table 9: Johansen cointegration test for German manufacturing sector's PPI and Germany's CPI 1995-2014

Date: 09/28/16 Time: 11:11
Sample (adjusted): 1998-2014
Included observations: 17 after adjustments
Trend assumption: Linear deterministic trend
Series: CPI PPI
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.688	21.131	15.495	0.006
At most 1	0.076	1.343	3.841	0.247

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.688	19.788	14.265	0.006
At most 1	0.076	1.343	3.841	0.247

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegrating Coefficients (normalized by b′*S11*b=I):

CPI_t	CPI_t
-1.533	1.838
1.423	-2.025

Unrestricted Adjustment Coefficients (alpha):

ΔCPI_{t-1}	-0.281	-0.089
ΔPPI_{t-1}	-0.873	-0.081

1 Cointegrating Equation(s): Log likelihood -14.168

Normalized cointegrating coefficients (standard error in parentheses)

CPI_t	CPI_t
1.000	-1.199
	(0.031)

Adjustment coefficients (standard error in parentheses)

ΔCPI_{t-1}	0.431
	(0.173)
ΔPPI_{t-1}	1.339
	(0.304)

Table 10: Estimated VECM for German manufacturing sector's PPI and Germany's CPI 1995-2014

Vector Error Correction Estimates		
Date: 09/28/16 Time: 11:10		
Sample (adjusted): 1998-2014		
Included observations: 17 after adjustments		
Standard errors in ( )		
Cointegrating Eq:	CointEq1	
CPI_{t-1}	1.000	
PPI_{t-1}	-1.199^{***}	
	(0.031)	
Const.	20.890†	
Error Correction:	ΔCPI_t	ΔPPI_t
CointEq1	0.431^{**}	1.339^{***}
	(0.173)	(0.304)
ΔCPI_{t-1}	-0.119	-0.834
	(0.424)	(0.743)
ΔCPI_{t-2}	-0.855^{**}	-2.577^{***}
	(0.420)	(0.737)
ΔPPI_{t-1}	0.322^{*}	0.445
	(0.187)	(0.328)
ΔPPI_{t-2}	0.337^{**}	0.736^{***}
	(0.142)	(0.250)
Const.	2.028^{***}	4.492^{***}
	(0.491)	(0.861)
R-squared	0.587	0.802
Adj. R-squared	0.400	0.711
Sum sq. resids	2.389	7.346
S.E. equation	0.466	0.817
F-statistic	3.132	8.891
Log likelihood	-7.443	-16.990
Akaike AIC	1.582	2.705
Schwarz SC	1.876	2.999
Mean dependent	1.376	0.995
S.D. dependent	0.602	1.521
Determinant resid covariance (dof adj.)		0.0434
Determinant resid covariance		0.018
Log likelihood		-14.168
Akaike information criterion		3.314
Schwarz criterion		4.000

. . . continued

Significance levels: *: 10%, **: 5%, ***: 1%
† The standard error of the constant is not reported
because we impose no restriction on the cointegrating equation.

Table 11: Estimated VECM for German manufacturing sector's PPI and Germany's CPI 1995-2014 - Autocorrelation LM test

VEC Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 09/28/16 Time: 11:12
Sample: 1995-2014
Included observations: 17

Lags	LM-Stat	Prob
1	4.562	0.335
2	4.941	0.293
3	4.867	0.301
4	3.764	0.439
5	6.371	0.173

Probs from chi-square with 4 df.

Table 12: Estimated VECM for German manufacturing sector's PPI and Germany's CPI 1995-2014 - White Heteroskedasticity test

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 09/28/16 Time: 11:13
Sample: 1995-2014
Included observations: 17

Joint test:

Chi-sq	df	Prob.
31.825	30	0.376

Individual components:

Dependent	R-squared	F(10,6)	Prob.	Chi-sq(10)	Prob.
res1*res1	0.584	0.842	0.615	9.927	0.447
res2*res2	0.640	1.069	0.490	10.887	0.366
res2*res1	0.550	0.732	0.684	9.343	0.500

Table 13: Augmented Dickey-Fuller unit root test results for time series

Unit root test (no trend and intercept)	*HICP*	*DRATE*	*LRATE*	*GDP*	$\Delta LRATE$	ΔGDP
Test statistics	-1.675	-2.205	1.390	-1.543	-4.456	-4.804
p-value	0.089*	0.028**	0.958	0.115	0.000***	0.000***

Significance levels: *: 10%, **: 5%, ***: 1%

Source: Own calculations

Table 14: Estimated VAR model for Germany from 2000 to 2015

Vector Autoregression Estimates
Date: 09/20/16 Time: 11:46
Sample (adjusted): 2000Q4 2015Q4
Included observations: 61 after adjustments
Standard errors in ( )

	$DRATE_t$	$\Delta LRATE_t$	$HICP_t$	ΔGDP_t
$DRATE_{t-1}$	1.236^{***}	-0.262	-0.057	0.001
	(0.202)	(0.196)	(0.337)	(0.007)
$DRATE_{t-2}$	-0.297	0.232	0.133	-0.003
	(0.201)	(0.195)	(0.336)	(0.007)
$\Delta LRATE_{t-1}$	0.098	0.226	-0.185	-0.002
	(0.207)	(0.201)	(0.346)	(0.007)
$\Delta LRATE_{t-2}$	-0.146	-0.034	-0.080	-0.002
	(0.158)	(0.153)	(0.263)	(0.005)
$HICP_{t-1}$	0.185^{**}	0.125	-0.087	0.004
	(0.082)	(0.080)	(0.137)	(0.003)
$HICP_{t-2}$	0.009	0.029	-0.021	0.001
	(0.086)	(0.083)	(0.143)	(0.003)
ΔGDP_{t-1}	9.047^{*}	17.044^{***}	11.414	0.345^{*}
	(5.410)	(5.235)	(9.032)	(0.179)
ΔGDP_{t-2}	1.561	4.509	17.016^{*}	0.009
	(5.360)	(5.188)	(8.949)	(0.177)
Const.	-0.073	-0.151^{**}	0.218^{*}	0.002
	(0.075)	(0.072)	(0.125)	(0.002)
R-squared	0.963	0.411	0.147	0.261
Adj. R-squared	0.957	0.321	0.016	0.147
Sum sq. resids	3.298	3.089	9.193	0.004
S.E. equation	0.252	0.244	0.420	0.008
F-statistic	167.329	4.540	1.123	2.292
Log likelihood	2.429	4.426	-28.837	210.396
Akaike AIC	0.215	0.150	1.241	-6.603
Schwarz SC	0.527	0.461	1.552	-6.292
Mean dependent	1.196	-0.072	0.376	0.003

...continued

S.D. dependent	1.212	0.296	0.424	0.009
Determinant resid covariance (dof adj.)	$9.44E-09$			
Determinant resid covariance	$4.99E-09$			
Log likelihood	236.828			
Akaike information criterion	-6.585			
Schwarz criterion	-5.339			

Significance levels: *: 10%, **: 5%, ***: 1%

Table 15: Estimated VAR model for Germany from 2000 to 2015 with dummy variable DUM

Vector Autoregression Estimates
Date: 09/28/16 Time: 11:05
Sample (adjusted): 2000Q4 2015Q4
Included observations: 61 after adjustments
Standard errors in ( )

	$DRATE_t$	$\Delta LRATE_t$	$HICP_t$	ΔGDP_t
$DRATE_{t-1}$	1.233^{***}	-0.265	-0.060	0.001
	(0.203)	(0.197)	(0.341)	(0.007)
$DRATE_{t-2}$	-0.289	0.241	0.140	-0.002
	(0.203)	(0.196)	(0.340)	(0.006)
$\Delta LRATE_{t-1}$	0.103	0.232	-0.181	-0.001
	(0.209)	(0.202)	(0.349)	(0.007)
$\Delta LRATE_{t-2}$	-0.143	-0.032	-0.078	-0.002
	(0.159)	(0.153)	(0.266)	(0.005)
$HICP_{t-1}$	0.198^{**}	0.140^{*}	-0.075	0.005^{*}
	(0.085)	(0.082)	(0.143)	(0.003)
$HICP_{t-2}$	0.027	0.048	-0.006	0.002
	(0.090)	(0.087)	(0.151)	(0.003)
ΔGDP_{t-1}	8.745	16.719^{***}	11.164	0.316^{*}
	(5.461)	(5.280)	(9.145)	(0.175)
ΔGDP_{t-2}	1.523	4.468	16.985^{*}	0.005
	(5.391)	(5.212)	(9.028)	(0.173)
Const.	-0.082	-0.160^{**}	0.211	0.002
	(0.077)	(0.074)	(0.128)	(0.002)
DUM	-0.032	-0.035	-0.027	-0.003^{*}
	(0.05)	(0.049)	(0.084)	(0.002)
R-squared	0.963	0.417	0.149	0.312
Adj. R-squared	0.956	0.314	-0.001	0.190

...continued

Sum sq. resids	3.272	3.058	9.175	0.003
S.E. equation	0.253	0.245	0.424	0.008
F-statistic	147.106	4.055	0.992	2.567
Log likelihood	2.675	4.731	-28.777	212.576
Akaike AIC	0.240	0.173	1.271	-6.642
Schwarz SC	0.586	0.519	1.617	-6.296
Mean dependent	1.196	-0.072	0.376	0.003
S.D. dependent	1.212	0.296	0.424	0.009
Determinant resid covariance (dof adj.)	$9.38E-09$			
Determinant resid covariance	$4.58E-09$			
Log likelihood	239.394			
Akaike information criterion	-6.537			
Schwarz criterion	-5.153			

Significance levels: *: 10%, **: 5%, ***: 1%

Table 16: Estimated VAR model for Italy from 2000 to 2015

Vector Autoregression Estimates
Date: 09/20/16 Time: 11:36
Sample (adjusted): 2001Q2 2015Q4
Included observations: 59 after adjustments
Standard errors in ( )

	$DRATE_t$	$\Delta LRATE_t$	$HICP_t$	ΔGDP_t
$DRATE_{t-1}$	1.010***	-0.045	-0.804**	-0.005
	(0.211)	(0.226)	(0.361)	(0.005)
$DRATE_{t-2}$	-0.390	-0.016	0.556	0.001
	(0.320)	(0.344)	(0.549)	(0.008)
$DRATE_{t-3}$	0.562*	0.316	0.130	0.006
	(0.319)	(0.342)	(0.546)	(0.007)
$DRATE_{t-4}$	-0.238	-0.341	0.180	-0.003
	(0.223)	(0.239)	(0.381)	(0.005)
$\Delta LRATE_{t-1}$	0.193	0.187	0.384	-0.001
	(0.199)	(0.213)	(0.340)	(0.005)
$\Delta LRATE_{t-2}$	0.186	0.016	0.771**	0.001
	(0.190)	(0.204)	(0.325)	(0.004)
$\Delta LRATE_{t-3}$	-0.012	-0.341	0.212	-0.001
	(0.204)	(0.219)	(0.349)	(0.005)
$\Delta LRATE_{t-4}$	0.277**	0.309**	-0.317	-0.003
	(0.139)	(0.149)	(0.237)	(0.003)
$HICP_{t-1}$	0.140*	0.286***	0.040	0.001
	(0.082)	(0.088)	(0.141)	(0.002)

...continued

$HICP_{t-2}$	-0.036	0.090	0.116	-0.002
	(0.087)	(0.093)	(0.149)	(0.002)
$HICP_{t-3}$	-0.161^{**}	-0.109	-0.293^{**}	-0.003
	(0.080)	(0.086)	(0.137)	(0.002)
$HICP_{t-4}$	0.011	0.112	0.544^{***}	0.000
	(0.082)	(0.088)	(0.140)	(0.002)
ΔGDP_{t-1}	20.127^{***}	16.514^{**}	30.496^{**}	0.812^{***}
	(7.659)	(8.215)	(13.109)	(0.180)
ΔGDP_{t-2}	12.874	7.704	12.224	-0.099
	(8.368)	(8.976)	(14.324)	(0.196)
ΔGDP_{t-3}	-0.746	2.213	-22.577	0.117
	(8.455)	(9.069)	(14.471)	(0.198)
ΔGDP_{t-4}	-20.439^{***}	-11.008	14.238	-0.000
	(6.970)	(7.477)	(11.931)	(0.164)
Const.	0.061	-0.118	0.190	0.002
	(0.084)	(0.090)	(0.144)	(0.002)
R-squared	0.978	0.687	0.721	0.679
Adj. R-squared	0.969	0.568	0.614	0.557
Sum sq. resids	1.652	1.901	4.840	0.001
S.E. equation	0.198	0.213	0.340	0.005
F-statistic	116.097	5.759	6.771	5.560
Log likelihood	21.762	17.625	-9.949	243.151
Akaike AIC	-0.161	-0.021	0.914	-7.666
Schwarz SC	0.437	0.577	1.512	-7.068
Mean dependent	1.110	-0.064	0.494	-0.000
S.D. dependent	1.135	0.324	0.547	0.007
Determinant resid covariance (dof adj.)		$1.19E-09$		
Determinant resid covariance		$3.06E-10$		
Log likelihood		311.358		
Akaike information criterion		-8.249		
Schwarz criterion		-5.855		

Significance levels: *: 10%, **: 5%, ***: 1%

Table 17: Estimated VAR model for Spain from 2003 to 2015

Vector Autoregression Estimates
Date: 09/20/16 Time: 11:42
Sample (adjusted): 2003Q4 2015Q4
Included observations: 49 after adjustments
Standard errors in ( )

	$DRATE_t$	$\Delta LRATE_t$	$HICP_t$	ΔGDP_t
$DRATE_{t-1}$	0.963^{***}	0.067	-2.520^{**}	0.001
	(0.285)	(0.329)	(0.993)	(0.003)
$DRATE_{t-2}$	-0.076	-0.161	2.583^{***}	-0.001
	(0.278)	(0.320)	(0.968)	(0.003)
$\Delta LRATE_{t-1}$	0.170	0.141	1.680^{*}	-0.001
	(0.253)	(0.292)	(0.882)	(0.003)
$\Delta LRATE_{t-2}$	-0.166	-0.035	0.016	-0.004^{***}
	(0.131)	(0.151)	(0.457)	(0.001)
$HICP_{t-1}$	0.136^{***}	0.137^{***}	-0.206	-0.001
	(0.044)	(0.051)	(0.154)	(0.000)
$HICP_{t-2}$	0.125^{***}	0.147^{***}	0.519^{***}	-0.000
	(0.048)	(0.056)	(0.168)	(0.001)
ΔGDP_{t-1}	13.604	5.025	103.523^{**}	0.862^{***}
	(14.507)	(16.729)	(50.524)	(0.161)
ΔGDP_{t-2}	4.648	5.249	-63.285	0.133
	(14.543)	(16.770)	(50.649)	(0.162)
Const.	-0.103^{*}	-0.105	0.133	0.001^{*}
	(0.060)	(0.070)	(0.209)	(0.001)
R-squared	0.961	0.477	0.364	0.893
Adj. R-squared	0.953	0.372	0.237	0.872
Sum sq. resids	2.156	2.867	26.156	0.000
S.E. equation	0.232	0.268	0.809	0.003
F-statistic	122.548	4.558	2.860	41.797
Log likelihood	6.995	0.0123	-54.148	227.399
Akaike AIC	0.082	0.367	2.577	-8.914
Schwarz SC	0.429	0.714	2.925	-8.567
Mean dependent	0.887	-0.023	0.508	0.002
S.D. dependent	1.071	0.338	0.926	0.007

Determinant resid covariance (dof adj.)	$3.32E-09$
Determinant resid covariance	$1.47E-09$
Log likelihood	220.115
Akaike information criterion	-7.515
Schwarz criterion	-6.125

Significance levels: *: 10%, **: 5%, ***: 1%