Heterogeneous impact of monetary policy in the euro area?

The Eurosystem has a mandate to maintain price stability within the euro area. When making its decisions, the Governing Council of the ECB therefore looks at the inflation outlook for the euro area as a whole. To determine the monetary policy stance, the Governing Council must also evaluate the strength of monetary policy transmission. Disaggregated – i.e. also country-specific – data and analyses help to clarify and assess inflation developments and transmission mechanisms and are therefore an important factor in monetary policy decision-making.

Monetary policy transmission channels are also influenced by the structural characteristics of the euro area economies. Since these differ, in some cases significantly, the Eurosystem's single monetary policy can be assumed to have varying impacts across the Member States. There are indeed a number of empirical studies for the euro area that point to such differences. Studies also find evidence of regional differences in the impact of monetary policy for the United States.

This article presents the results of various empirical studies on possible differences in the impact of monetary policy on real gross domestic product (GDP) and consumer prices in the four major euro area countries (France, Germany, Italy and Spain). The effects of different monetary policy instruments are empirically examined. We find that the impact of changes in monetary policy rates on real GDP is stronger in Germany and weaker in Spain. This may be due to the more prominent role of interest rate-sensitive sectors in Germany, more flexible employment, greater export orientation and stronger competition in the banking system. By contrast, the price level response is strongest in Spain and weakest in Germany.

Alongside classic interest rate policy, the last few years have seen a number of unconventional monetary policy measures being taken, such as forward guidance – in other words, communication by monetary policymakers about the likely future path of their policy rates. The results for this instrument indicate that monetary policy has a stronger impact on both real GDP and consumer prices in Germany than in the other large euro area countries. The results of another study suggest that the impact of the government bond purchase programme also varied between the four major euro area countries. However, it is still too early to draw a conclusive, coherent picture of the relative strength of the effects of the different monetary policy instruments on the euro area countries under review from the available studies.

Introduction

Transmission analyses play an important role in current monetary policy tightening

The Eurosystem has responded to the high inflation of the past few years first and foremost by raising its policy rates sharply, with these hikes taking place at a scale and speed unprecedented in the history of the euro area. Through various channels, these measures influence expectations, financial variables, aggregate demand, production, and ultimately inflation. Empirical analyses of this transmission process typically look at the impact of monetary policy on the euro area as a whole.

Structural differences can lead to heterogeneous transmission of monetary policy

The aggregate, euro area-wide effects consist of the impact that monetary policy has on the individual Member States. Because there are – in some cases, significant – structural differences between the economies, monetary policy cannot be expected to have the same impact in all euro area countries.[1] These differences include, for example, the relative size of the various economic sectors and branches of activity, the degree of openness of the economy, the intensity of competition in various economic sectors, firms' funding structure, the labour market and its institutions, the structure of the financial sector, government activity, the tax and social system, and the wealth and wealth structure of households (e.g. the importance of residential property or shares). How large these differences are affects the strength, relative importance and temporal pattern of the transmission of the single monetary policy, which is geared toward the euro area as a whole, to the various euro area economies. As a result, the strength of the responses in the variables at the end of the causal chains, i.e. real gross domestic product and inflation, may differ in the individual euro area Member States.

Empirical studies find country-specific differences in monetary policy transmission

This raises the question as to whether such heterogeneous monetary policy effects do actually exist in the euro area or in other major currency areas. Empirical studies for the United States find evidence of regional differences in the impact of the Federal Reserve's monetary policy (Carlino and DeFina (1998, 1999); Owyang and Wall (2009); Pizzuto (2020)). There are already a number of empirical studies for the euro area, too, that point to the existence of country-specific differences. This article summarises the results of two new analyses on the subject of potential differences in the impact of the Eurosystem's monetary policy in the four major euro area countries of France, Germany, Italy and Spain, and examines the results in the context of the evidence already available from other studies. Both analyses use an approach that allows statistically rigorous statements to be made about the cross-country differences in monetary policy that are of interest here.[2] Ultimately, this also allows the importance of country-specific transmission analyses for the Eurosystem to be discussed.

Empirical analyses of potential heterogeneous impacts of Eurosystem monetary policy

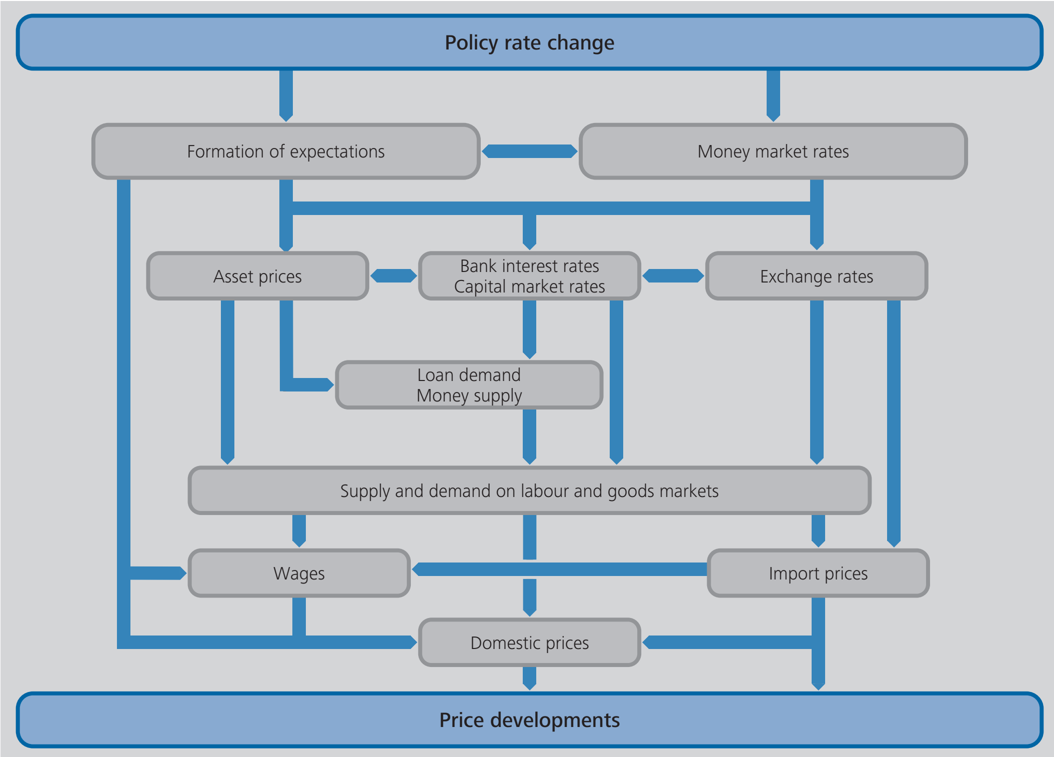
Possible factors influencing monetary policy transmission

A number of empirical studies have been carried out on the potential regional differences in the effects of monetary policy within or between countries in a monetary union, most of which focus on the effects of the central bank's interest rate policy.[3]

The chart on p. 39 shows a simple depiction of the transmission channels of a policy rate

1 For an overview of the structural differences between the euro area economies, see, for example, European Banking Federation (2022) and Sondermann et al. (2019).
2 For more information on this approach, see Mandler et al. (2022) and the remarks on pp. 44 ff.
3 Examples of this type of analysis for the United States include Carlino and DeFina (1998, 1999) and Owyang and Wall (2009) and, for Australia, Vespignani (2015). For an overview of the literature on country-specific effects of interest rate policy in the euro area, see Mandler et al. (2022), pp. 629 ff. For a broader overview of the empirical evidence on the regional effects of monetary policy, see Dominguez-Torres and Hierro (2019). This literature is also related to the body of work on the spillover effects of monetary policy in the United States or the euro area to other economies, e.g.: Benecká et al. (2020), Bluwstein and Canova (2016), Crespo Cuaresma et al. (2019) and Georgiadis (2016).

Transmission of policy rate changes



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change.[4] The strength and relative importance of the various transmission mechanisms are likely to depend on the structural features of the different economies, thus leading to differences in the impact of monetary policy across the euro area economies. For instance, if competition in the banking system becomes more intense, bank interest rates respond more strongly to changes in market interest rates influenced by monetary policy (see, for example, van Leuvensteijn et al. (2008)). The strength of monetary policy transmission via asset prices, such as those for shares or real estate, is influenced, amongst other things, by the distribution of share ownership and residential property. The strength of the exchange rate channel should increase with the degree of openness of the economy – in other words, the importance of exports and imports. How strongly changes in nominal demand for goods and services caused by monetary policy are reflected in changes in real output also depends on the structure of the labour market. If real wages become more rigid, output and employment should react more strongly to changes in nominal demand (see, for example, Abbritti and Weber (2010)). The extent to which output and inflation change in relation to one another as a result of monetary policy impulses depends largely on the slope of the Phillips curve, which also reflects structural characteristics of the economies.[5]

Widespread use of VAR models for monetary policy transmission analysis

Most analyses of potential country or region-specific differences in transmission use vector autoregressive (VAR) models for their estimations. These models look at dynamic relationships between multiple variables.[6] To estimate the impact of monetary policy, it is necessary to

4 For a schematic representation of the transmission mechanisms of the monetary policy purchase programmes, see, for example, Deutsche Bundesbank (2016), p. 35.
5 For information on estimates of the slope of the Phillips curve for the euro area countries, see, for example, Ciccarelli and Osbat (2017).
6 For an overview of VAR models, see, for example, Kilian and Lütkepohl (2017).

isolate the causal relationship between changes in monetary policy instruments, such as policy rates, and changes in the other variables. This is complicated by the fact that monetary policy, in turn, responds to changes in the other variables. Analyses using VAR models provide a number of approaches to solving this identification problem.[7] The analyses presented in the following sections use VAR models in which monetary policy impulses are identified by means of sign restrictions, i.e. by making assumptions about the direction in which a monetary policy impulse influences the other variables in the model (see the annex on pp. 54 ff.).

Using data prior to the introduction of the euro leads to problem of separating heterogeneous transmission from different monetary policy response functions

A number of studies for the euro area were conducted around the time it was created or in the first few years thereafter. These analyses were forced to rely, either to a large extent or entirely, on data from the period before the euro was launched. Only analyses carried out later on were able to rely exclusively on data from the period after the euro area was established.[8] The problem with using data from the period prior to monetary union is that any country-specific differences in the effects of monetary policy may also stem from differences in the behaviour of the individual national central banks.[9] The studies presented below only use data from 1999 onwards, meaning that any differences in the behaviour of the various central banks prior to the start of monetary union are irrelevant.

In addition to studies on country-specific effects of interest rate policy – i.e. conventional central bank monetary policy – there are also analyses of the different effects of unconventional monetary policy (see the sections on pp. 47 ff. and 51 ff.). For the euro area, these studies focus in part on the effects of unconventional monetary policy in general (e.g. Boeckx et al. (2017) or Burriel and Galesi (2018)), or on specific unconventional monetary policy measures such as the asset purchase programme (e.g. Wieladek and Pascual (2016)).

Heterogeneous impact of interest rate policy?

Multi-country BVAR model for analysing the impact of interest rate policy in France, Germany, Italy and Spain

In the current interest rate hike cycle, policy rates are once again the Eurosystem's primary instrument. This raises the question of whether policy rate changes have a different impact on the individual euro area economies. The study by Mandler et al. (2022) makes a contribution to this debate. It analyses the differences in the impact of the Eurosystem's interest rate policy between France, Germany, Italy and Spain using an empirical multi-country model. This is based on a Bayesian vector autoregressive (BVAR) model which captures the interactions between all the variables contained in the model for the various countries (see the annex on pp. 54 ff.). Including all the countries under review in a single model allows a statistically rigorous analysis of potential differences in the impact of monetary policy (see the box on pp. 44 ff.).

Cross-country differences estimated using statistical distribution of cross-country differences in the impact of monetary policy

The charts on pp. 42 ff. show the main results of this analysis. They present in graphic form the estimated statistical distributions of cross-country differences in the responses of real GDP and the Harmonised Index of Consumer Prices (HICP) to an interest rate increase of 25 basis points (bp). These distributions are calculated from the difference between the estimated impact of monetary policy on the variable in question in the first country minus the impact in the second.[10] As the model is symmetrical in terms of interest rate increases and

7 For an overview of identification approaches, see, for example, Kilian and Lütkepohl (2017), Chapters 8-15.
8 Examples include Cavallo and Ribba (2015), Ciccarelli et al. (2013) and Georgiadis (2015).
9 This problem is discussed in Guiso et al. (2000). Using data from before monetary union therefore means that monetary policy has to be modelled very carefully in order to control for the effects of possible differences in the monetary policy reaction function. Examples include Mojon and Peersman (2001) as well as Ciccarelli and Rebucci (2006).
10 Since real GDP and the HICP are fed into the estimation in log levels, the effects of monetary policy should be interpreted as percentage deviations of the variables from their long-term equilibrium. The charts therefore show the difference in these percentage deviations between the two countries.

reductions, the statements also hold for an interest rate reduction if the sign is reversed. The individual charts show these differences for different time horizons following the restrictive monetary policy stimulus for all six possible combinations of the four countries. The estimated probability distribution for a pair of countries compared with the zero line can be used to conclude whether and in what direction the effect of the interest rate change differs between the two countries. If the distribution is relatively symmetrical around zero, there is no clear indication of a difference in the effects of monetary policy. If the distribution of the difference is largely negative, an interest rate increase has a (mathematically) smaller effect on the variable in the first country than in the second. In this case, this means there is a stronger negative effect in the first country than in the second.[11] For ease of interpretation, each chart shows selected percentiles of the estimated probability distribution of the difference between the countries.[12] For more details, see the box on pp. 44 ff.

In a cross-country comparison, real GDP in Germany responds more strongly to changes in interest rates, …

The first three panels of the chart show that the cross-country differences with Germany as the first country are predominantly negative for time horizons of up to four quarters. Moreover, for a period of up to around six quarters, the probability of a negative difference is much higher than that of a positive one. All in all, these results therefore indicate that real GDP declines more sharply in Germany after an interest rate hike than in the other three countries.

The outcome of the comparison among the three other countries depends on the time horizon. The results for France and Italy relative to Spain in the last two charts point to a short-term negative difference, i.e. a stronger decline in real GDP in the first quarters in France and Italy than in Spain. After that, however, no further systematic differences can be identified.[13] Overall, the estimate suggests that monetary policy has a stronger short to medium-term impact on real GDP in Germany than in the other countries under review, whilst its impact on real GDP in Spain is the weakest in the short term.[14]

… but consumer prices respond more weakly

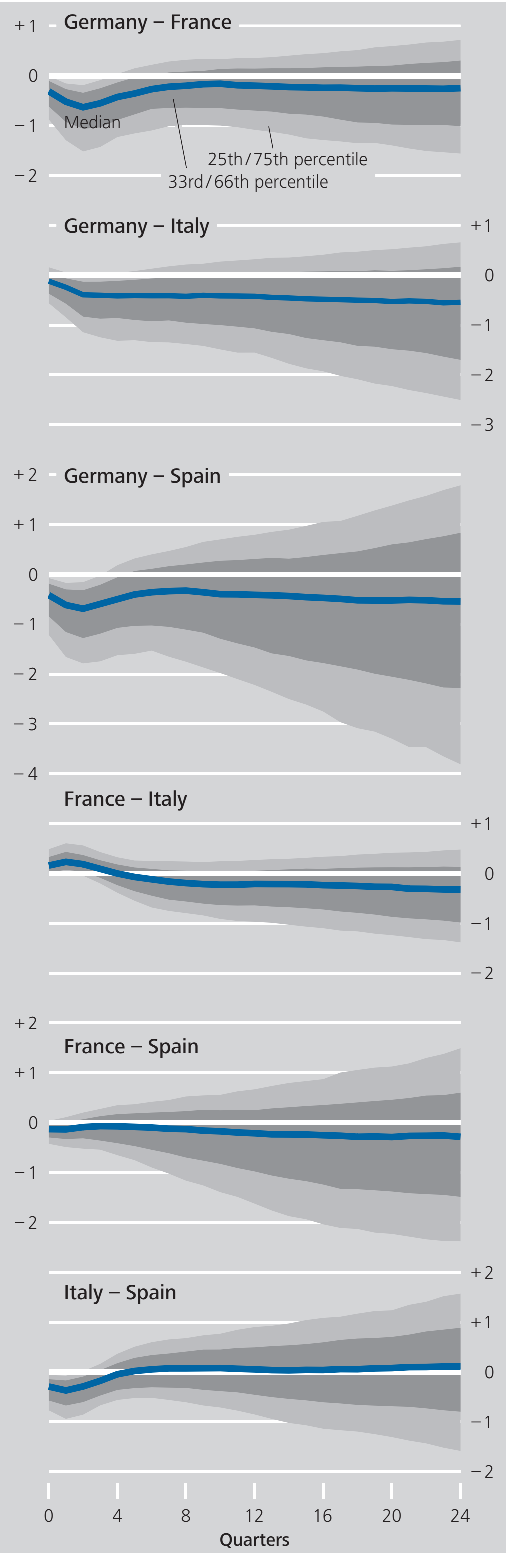
The first three sections of the charts for the HICP show a predominantly positive difference between Germany and the other countries. The positive difference is due to the fact that a stronger negative response in the other country is subtracted from the negative response of the HICP in Germany.[15] This means that the decline in the price level in Germany following an interest rate increase is not as pronounced as in the other countries. The last two charts showing the differences between France and Spain and between Italy and Spain point to a stronger decline in the HICP in Spain in the short term compared with Italy and France.[16] Overall, the results for consumer prices suggest that the strongest response to monetary policy takes place in Spain and the weakest response in Germany.[17]

Taken together, the results suggest that the order of the countries is reversed when it comes to the strength of the impact of interest rate policy on consumer prices rather than real

11 The identification assumptions used in the model ensure that real GDP and the HICP only show a negative response in the impact period of the interest rate increase. The posterior distribution of the response of GDP to the interest rate increase also shows a mass above the zero line in the individual countries in later periods, meaning that a subsequent positive response of output to an interest rate increase cannot be ruled out. A negative difference in the chart therefore means, strictly speaking, that the response of output or the HICP in the first country is smaller, i.e. more strongly negative or more weakly positive, than in the second.
12 The percentile of order p of a probability distribution of a variable x is the characteristic value x_p that is not exceeded by the share p of all realisations, i.e. where $F(x)$ is the cumulative distribution function, $F(x_p) = p$.
13 The difference between France and Italy is positive at first, and then turns negative. This means that real output in France initially declines less after an interest rate increase, but then tends to decline more sharply than in Italy.
14 In the long term, the evidence for these differences disappears as real GDP returns to its long-term steady state, while, at the same time, uncertainty bands tend to widen as the horizon increases.
15 See also the comments in footnote 11.
16 Similarly to the GDP response, France and Italy switch places after just a few quarters compared with the previous period.
17 The rankings in terms of GDP and price effects are supported by a number of other tests in Mandler et al. (2022).

Cross-country comparison of the impact of monetary policy on real GDP*
Here: 25 bp increase in short-term interest rate

%



* Estimated probability distribution of the impact in the first country less the impact in the second country.

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GDP. This is not necessarily a contradiction in terms; instead, it can be interpreted as a cross-country difference in the slope of the aggregate supply function, which describes the relationship between real GDP and the aggregate price level. The results suggest that it is flatter in Germany than in the other countries considered here.18

Possible structural explanations for differences in the GDP response

This raises the question as to the reasons behind the differences identified. The literature on the regional and country-specific effects of monetary policy examines the importance of various structural factors as the cause of differences in the impact of monetary policy between economies. These factors include the importance of capital-intensive sectors or sectors with interest rate-sensitive demand, such as the manufacturing sector (see, for example Carlino and DeFina (1998, 1999) and Owyang and Wall (2009)), the production of durable goods or the construction sector (Georgiadis (2015)). Differences in the flexibility of the labour market are another potential reason. For example, the regression analysis by Georgiadis (2015) shows that the strength of the impact of monetary policy on real GDP depends significantly on labour market institutions and the industry mix. Other possible explanations include differences in the importance of the export sector, and thus the exchange rate channel, or in the intensity of competition in the banking system, which in turn may have an impact on interest rate pass-through.19

To assess the significance of the various possible causes, Mandler et al. (2022) combine indicators for the above-mentioned factors and review the consistency of the stronger GDP response in Germany with the relative position of

18 The results referred to above apply to the relationship between output, i.e. real GDP, and the price level. They are consistent with the evidence of a relatively flat Phillips curve in Germany; see, for example, Ciccarelli and Osbat (2017) and Reichold et al. (2022). The Phillips curve describes the relationship between actual inflation, expected inflation and the output gap, i.e. the deviation of output from potential.

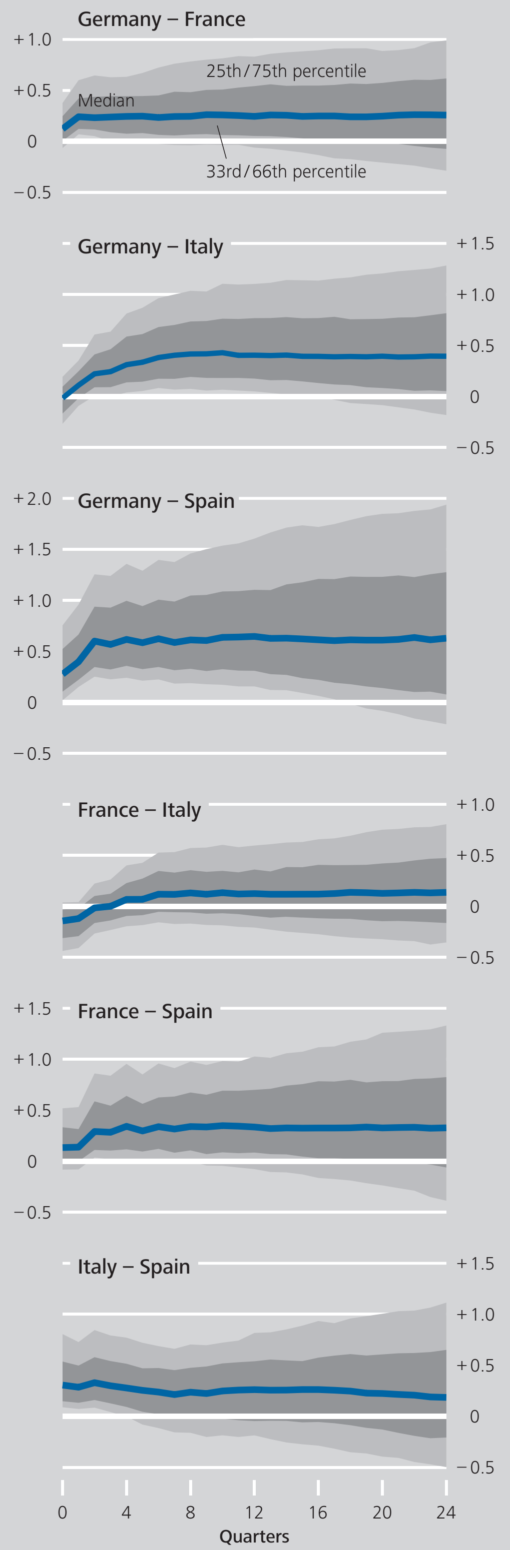
19 For a discussion of the various explanatory approaches, see Mandler et al. (2022) and the literature cited therein.

the country in relation to these indicators.[20] It turns out that the stronger GDP response in Germany to interest rate policy is consistent with the greater importance of the manufacturing sector and the production of durable goods, weaker employment protection, greater importance of exports and greater competition in the banking system than in the other countries under consideration.[21]

Differences difficult to explain for price developments

The search for what is behind the cross-country differences in the price response is a much more difficult endeavour. The analysis by Abritti and Weber (2010) of the impact of labour market institutions on the business cycle shows that a stronger response of employment – and thus also of output – to a monetary policy impulse is observed in conjunction with a weaker response of the inflation rate if the country in question exhibits a combination of relatively low real wage flexibility and high employment flexibility. While the above-mentioned indicators of employment protection legislation for Germany provide evidence of a greater degree of flexibility in the volume of employment compared with the other countries considered here, there are other indicators that do not

Cross-country comparison of the impact of monetary policy on HICP*
Here: 25 bp increase in short-term interest rate



* Estimated probability distribution of the impact in the first country less the impact in the second country.
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20 Other studies test possible explanatory approaches by regressing the trough response of GDP (Georgiadis (2015)) or the impulse response functions cumulated over eight quarters (Carlino and DeFina (1998, 1999)) on a constant and one or more explanatory variables. However, as the analysis presented here only provides results for four countries, it is not possible to perform a similar regression analysis. If a regression were to be carried out on a constant and one explanatory variable, only one degree of freedom would remain, as the residual variance also needs to be estimated. This problem does not apply to the other studies because they include more regions or countries. In these cases, however, the estimation of the model requires greater restrictions on the interaction between countries or the inclusion of fewer variables per region.
21 However, there are also indicators for structural features of the economy whose ranking is inconsistent with the results of the empirical analysis. This approach can therefore only provide rough indications of the potential underlying causes.

The methodology for comparing monetary policy effects

The studies conducted by Mandler et al. (2022) and Mandler and Scharnagl (2023), summarised in the main body of this article, focus on a cross-country comparison of the estimated responses of various macroeconomic variables to monetary policy shocks. The dynamic effects of a monetary policy shock are typically shown as impulse response functions with uncertainty bands which provide information on the probability distribution of the estimation. Most of the studies, based on vector autoregressive (VAR) models, examine differences between countries or regions by means of a visual comparison of these impulse response functions. If the probability distributions of the impulse response functions for a variable show only very small overlap in two countries or regions, the conclusion drawn is that there is a difference in the effects of monetary policy.[1]

There are problems associated with this approach, however. The first is that it does not directly examine the variable of interest – the difference in the impulse response functions – but attempts to analyse it indirectly by looking at the distributions of the impulse response functions themselves.[2] The second problem is that it treats the two estimated impulse response functions to be compared as mutually independent. In fact, the estimation errors in the impulse response functions are likely to be correlated.[3] Third, comparing overlapping uncertainty intervals has less favourable statistical properties than directly testing for a difference.[4]

Mandler et al. (2022) propose an approach for comparing impulse response functions between regions which takes into account the correlation of the estimation errors and focuses directly on the probability distribution of the difference between the impulse responses. The approach therefore uses the information contained in the joint distribution rather than indirectly deriving conclusions from the comparison of the distributions of the two impulse responses. For their analysis, they use a multi-country model which simultaneously contains all countries examined. The correlation between the estimation errors of the countries' impulse response functions is thus captured by the model.[5] The Bayesian procedures used to estimate the model use stochastic simulations in order to generate the model parameters' probability distributions. This results in a large number of "draws", each containing a complete set of values for the model parameters. The sequence of these draws approximates the estimated joint distribution of the model

1 On the other hand, a simple comparison of the point estimators of the impulse response functions has only limited informational content as it ignores the uncertainty associated with the estimations. The greater the estimation uncertainty, the greater the distance between the point estimators has to be in order to indicate a difference between the countries.
2 The difference between the impulse response functions is a characteristic of the joint distribution of the countries' impulse response functions. However, the comparison of the impulse response functions only uses information from the marginal distribution or implicitly assumes that the impulse response functions are mutually independent. Under this assumption, the marginal distributions would contain the same information as the joint distribution.
3 Even if the impulse response functions have been calculated from separately estimated models for the individual countries, the estimation errors may nevertheless be correlated if, in some cases, the same data are inputted into the individual models or the data content of the models is correlated.
4 See Schenker and Gentleman (2001).
5 This is not the case if the impulse response functions are generated from individual, independently estimated models for the various regions. It is not absolutely necessary to use a model such as that described here to incorporate the correlation of the estimation errors. The approach to comparing impulse response functions can also be applied to other approaches for multi-country models, such as factor-augmented VAR (FAVAR) or panel VAR models.

parameters.[6] Impulse responses to a monetary policy shock can be calculated for all variables from each draw for the model parameters. All of these draws taken together thus approximate the joint distribution of the impulse response functions of all variables, and this joint distribution also reflects the correlation between the various countries' impulse responses.

The research question is aimed at possible differences between various countries' impulse response functions. Mandler et al. (2022) therefore suggest that, for one specific variable, such as gross domestic product or the Harmonised Index of Consumer Prices, the difference between the impulse response functions of two countries should be calculated from each draw in the estimation. The sequence of draws thus results in the probability distribution of the difference in the impact of monetary policy on this variable between the two countries examined, from which, as is shown in the main text, conclusions about potential heterogeneity in the transmission of monetary policy can be drawn.

The advantage of this test strategy can be illustrated by an example. Assume that two countries' impulse response functions differ by a constant but very small amount relative to the estimation uncertainty of the impulse response functions. Also, let the estimation error of the impulse response functions in the two countries be perfectly positively correlated. In this example, the calculation of the differences described above results in a constant and non-zero value, which clearly indicates a difference in the impact of monetary policy. In this example, however, the uncertainty bands of the impulse response functions overlap almost completely, which means that a visual comparison of the two does not provide any discernible evidence of differences.

The basic idea of this approach can be expanded from analysing country-specific differences between impulse response functions to cover differences in other variables (functions) derived from multi-country models, such as shock decompositions, forecasts or simulations. In that vein, Mandler and Scharnagl (2020) examine differences between the simulated effects of the Eurosystem's asset purchase programme (APP) on the large euro area countries. The applicability of the approach also goes beyond analyses of heterogeneous effects of common (monetary, fiscal policy or other) shocks in a monetary union or regions of a country. The approach is generally applicable to the question of heterogeneous effects of a common shock across entities such as countries, economic sectors, etc.[7]

The question of the different effects of various shocks on a given variable can be examined in a similar manner. The comparison of the impact of a conventional monetary policy shock with that of a shock to expected monetary policy interest rates in Mandler and Scharnagl (2023) is one example. For this purpose, however, the two shocks need to be suitably normalised in order to be made comparable.

For greater ease of interpretation, each diagram of the estimated probability distribution of the country differences on pp. 43 f. and pp. 50 f. in the main text shows five percentiles: the 25th, 33rd, 50th (median),

6 The sequence of draws approximates what is known as the posterior distribution of the model parameters. This is a combination of the prior distribution, i.e. ex ante assumptions about the distribution of the parameters, and the likelihood function that contains the data's information on the parameters. For an introduction to Bayesian estimation approaches, see, e.g., Koop (2003) and, for more information on Bayesian VAR models, e.g. Kilian and Lütkepohl (2017), chapter 5.
7 The studies of spillover effects mentioned in footnote 3 in the main text are one example.

66th and 75th percentile. As an example, let us explain the interpretation of the differences in the responses of real GDP between Germany and France and Germany and Italy on p. 42.

A comparison of the median and the zero line can provide an initial indication: if the median is below (above) zero, the probability of the actual difference between the two countries being negative (positive) is greater than the probability of a positive (negative) difference. In the quarter in which the shock occurs (quarter zero) and the subsequent three quarters, the 75th percentile is below the zero line for the difference in the GDP response between Germany and France. What that means is that the probability of a negative difference is at least three times as large as the probability of a positive difference (more than 75% to less than 25%). The 66th percentile then is near the zero line until around two years after the shock, which shows a probability ratio of around two to one for a negative versus a positive difference (around 66% to around 33%). Since the interest rate increase impacts negatively on real GDP in both countries, a negative difference means that, as a consequence of the interest rate increase, real GDP in Germany declines more sharply than in France.[8] Apart from the period in which the shock occurs, the 75th percentile of the difference is near zero until around four quarters after the shock for the comparison between Germany and Italy, which means that the probability ratio between a negative difference and a positive difference is around three to one. Beyond the subsequent horizon of up to around three years, the 66th percentile is close to the zero line, indicating a probability ratio of about two to one for a negative versus a positive difference. These results collectively indicate a negative difference and thus a stronger decline in real GDP in Germany. The other country differences shown can be interpreted accordingly by using the information contained in the percentiles.

8 For more, see footnote 11 on p. 41 of the main article.

support the notion of greater real wage rigidity.[22]

Existing body of studies for euro area countries with inconsistent findings

The finding in the analysis presented here – that real GDP shows a stronger response in Germany – can also be found in a number of other studies, such as that of Georgiadis (2015), which also only uses data since the euro was introduced. However, the findings for the relative ranking of the euro area countries are inconsistent across the existing body of empirical studies as a whole, both in terms of GDP and price effects.[23] The existing empirical analyses vary in terms of their estimation periods, model structures, the variables they contain and the methods they use to identify monetary policy impulses, which makes it difficult to compare the results. In addition, many of the studies – unlike the analyses presented here – do not use a rigorous statistical test strategy and are largely confined to a visual or tabular comparison of the estimated effects of monetary policy, which means it is unclear how these findings can be assessed from a statistical perspective.[24] Further research will be needed to reach a consensus on the differences and their determinants.

Heterogeneous impact of changes in interest rate expectations?

Forward guidance impacts through changes in interest rate expectations

Besides changes in key monetary policy interest rates, there are other instruments that central banks can use to exert an influence on consumer price developments. In the euro area, these instruments were deployed notably in the wake of the global financial crisis and the European sovereign debt crisis, when the ECB Governing Council reduced its policy rates to close to the effective lower bound, leaving only little room for further expansionary impulses by means of conventional monetary policy. These instruments include forward guidance, an explicit communication on the future path of monetary policy rates aimed at influencing interest rate expectations. According to the expectations hypothesis of the term structure of interest rates, changes in expectations about the future path of short-term interest rates affect medium to long-term capital market rates. In addition, communicating this information can reduce uncertainty about future policy rates and can also influence long-term interest rates via this channel.[25]

Basically, central banks can use forward guidance to influence interest rate expectations in one direction or another. Even before the financial crisis, central banks were using communications to influence interest rate expectations – but their statements were, at the time, less explicit about the future path of monetary policy rates.[26] During the negative interest rate policy period, the ECB Governing Council used forward guidance to provide additional expansionary monetary policy impulses, even though the short-term money market rate had reached the effective lower bound.[27]

Transmission of impulses to interest rate expectations may differ from that of changes in policy rates

Since conventional policy rate changes also have an effect to a large extent through changes in expectations (see the chart on p. 39), it would be fair to assume that the effects of forward guidance on euro area economies are

22 Such indicators include, for example, the degree of unionisation or coverage by collective wage agreements; see, for example, Babecky et al. (2010). These indicators do not suggest that real wage rigidity is stronger in Germany, however. Georgiadis (2015) regresses the trough response of the price level on possible explanatory variables, such as industry mix and labour market institutions, and finds that only the regression coefficient of the industry mix shows a value that is significantly different from zero at the 10% level.
23 See Mandler et al. (2022). A comprehensive overview of the empirical analyses on differences in the impact of monetary policy on economic activity can be found in Dominguez-Torres and Hierro (2019).
24 Excluded here is Ciccarelli and Rebucci (2006), in which the authors use the Kolmogorov-Smirnov test to examine the statistical significance of cross-country differences.
25 For an explanation of forward guidance, see Deutsche Bundesbank (2013). A number of analyses of the effects of forward guidance, carried out using various models, are summarised in Taskforce on Rate Forward Guidance and Reinvestment (2022).
26 Nelson (2021) describes the emergence of forward guidance as a policy tool using the Federal Reserve as an example.
27 For an overview of the Eurosystem's forward guidance and how it has changed over time, see Hartmann and Smets (2018) and Rostagno et al. (2019).

quite similar to those of policy rate changes. However, one major difference is that forward guidance has a stronger impact on the middle part of the yield curve, while changes in policy rates have a more pronounced effect at the short end.[28] It therefore makes sense to examine whether there are any country-specific differences in the impact of monetary policy as regards forward guidance, too. For example, Mandler and Scharnagl (2023) analyse whether changes in expectations about the future short-term money market rate have different effects on the four large euro area economies. This analysis can be interpreted as an approximation of the effects of forward guidance (see the annex on pp. 54 ff.).

BVAR model augmented by expectations variables

The model used for the study is based on the one from the previous section but differs in that it contains expectations variables in an effort to capture the effects of changes in interest rate expectations. The three-month interest rate is used as a policy indicator because expectations from the consensus forecasts are available for this rate. The model is outlined briefly on pp. 54 ff.

Real GDP in Germany shows stronger response to change in expected monetary policy interest rate

The charts on pp. 49 f. show the results of the cross-country comparison of the responses of real GDP and the HICP to an increase of 25 bp in the three-month interest rate expected in one year.[29] As regards the response of real GDP to the expected rise in interest rates, the estimated probability distributions of the differences between Germany and the three other countries for the first four to six quarters are predominantly in negative territory. This means that, following the restrictive interest rate expectations impulse, GDP falls more strongly in Germany than it does in the other three countries – that is, it shows a stronger response to the monetary policy impulse.[30] The chart also indicates that real GDP in Italy is least sensitive to the change in expectations, with France and Spain lying between the two extremes.[31] The differences between Germany, on the one hand, and France and Spain, on the other, subside over time, while the deviation of the effect in Italy shows a degree of persistence.

Differences in the response of consumer prices less clear-cut

The differences in HICP responses across countries are less clearly pronounced. The estimated probability distributions for the comparison of Germany with the other three countries point to a stronger negative effect of the expected interest rate hike on consumer prices in Germany. For the other countries, the differences are weaker and do not allow any clear conclusions to be drawn. As the model used here is symmetrical, the corresponding effects in the opposite direction on real GDP and consumer prices are to be expected in the event of a decline in expectations for the future monetary policy interest rate.

Just like a conventional interest rate shock, a change in interest rate expectations (given a constant actual interest rate) likewise leads to a stronger change in real GDP in Germany. However, the price level in Germany shows a stronger response to the expectations shock than it does in the other countries, while its response to the conventional interest rate im-

28 See Taskforce on Rate Forward Guidance and Reinvestment (2022), pp. 26 ff., and Altavilla et al. (2019). Mandler and Scharnagl (2023) compare the effects of policy rate changes with those of changes in interest rate expectations induced by monetary policy and find that the latter tend to impact more strongly on output and prices in some euro area countries. One reason for this is that expectations shocks induce a short-term interest rate response that is more persistent than conventional monetary policy impulses.
29 The findings in Mandler and Scharnagl (2023) relate to an expected -10 bp shock to the three-month interest rate. To make them comparable with those from the analysis presented above, the results were recalculated for an expected +25 bp shock to the three-month interest rate.
30 More precisely, a negative difference means that real GDP in the first country falls more sharply or rises less sharply than in the second. As the sign restriction in this model refers only to the average across countries, part of the probability mass of the impulse response functions of real GDP is also in the positive range.
31 The distribution of the difference between France and Spain does not point in any clear direction. By contrast, the difference between France and Italy is mostly negative from around four quarters onwards, and in the positive range between Italy and Spain.

pulse is smaller.[32] This need not necessarily be a contradiction in terms but could be because a monetary policy impulse in the form of forward guidance in Germany impacts more strongly on producers' price expectations than a change in the policy rate. This effect would, ceteris paribus, amplify the effect of forward guidance on consumer prices (relative to a change in the key interest rate). To the extent that this effect does not materialise in other countries or does so only in a weakened form, this may change the order of the countries.[33]

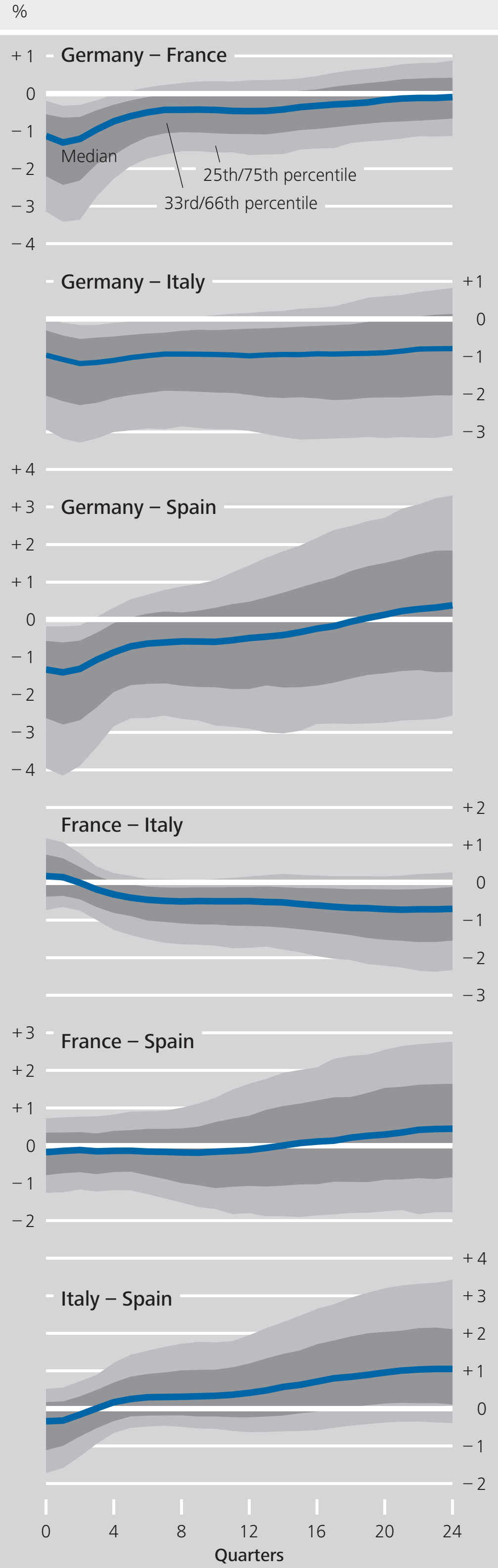
Model extensions suggest that effects on financing conditions in Germany are more persistent

Mandler and Scharnagl (2023) investigate possible reasons for the stronger GDP response in Germany to the change in expectations by incorporating additional variables into the model. This approach is useful at this juncture, unlike in the analysis presented in the previous section, as the benchmark version of the model contains fewer variables, which means additional variables can be more readily included. They repeat the estimation using model vari-

32 In addition to the interest rate expectations shock, Mandler and Scharnagl (2023) also identify a conventional monetary policy interest rate shock – albeit one in which the three-month interest rate is used as the policy indicator. The cross-country comparison of the effects of this interest rate shock shows that real GDP in Germany exhibits a stronger response to conventional interest rate policy than it does in other countries, as in Mandler et al. (2022). Again, the HICP response is strongest in Spain. This would suggest the findings are robust for conventional monetary policy. The order of each of the other countries changes, in some cases, from Mandler et al. (2022) and depends on the response horizon under analysis. The two models differ, amongst other things, in terms of the estimation period, the variables they contain and the assumptions they make when identifying monetary policy impulses. The model was tested for robustness in Mandler et al. (2022) by newly estimating the data subject to the restrictions described on p. 55 being imposed on the country averages of output and price responses, which thus brought it closer to the identification assumptions used in the later model. This exercise leads to a weakening of the country differences in the GDP response, though that response remains the strongest in Germany. By contrast, the price response continues to be strongest in Spain. This suggests that this identification approach is not driving the differences in the results.

33 In terms of model theory, this argument aims to ensure that the equilibrium in an economy, given a monetary policy impulse, not only moves along a given aggregate supply function, but that it also shifts vertically if price expectations change. Hence, price level responses of different strengths for the two different monetary policy impulses can be consistent with the same slope in the aggregate supply function, provided that price expectations react with different strengths to the two impulses.

Cross-country comparison of the impact of monetary policy on real GDP*
Here: expected 25 bp increase in 3-month interest rate

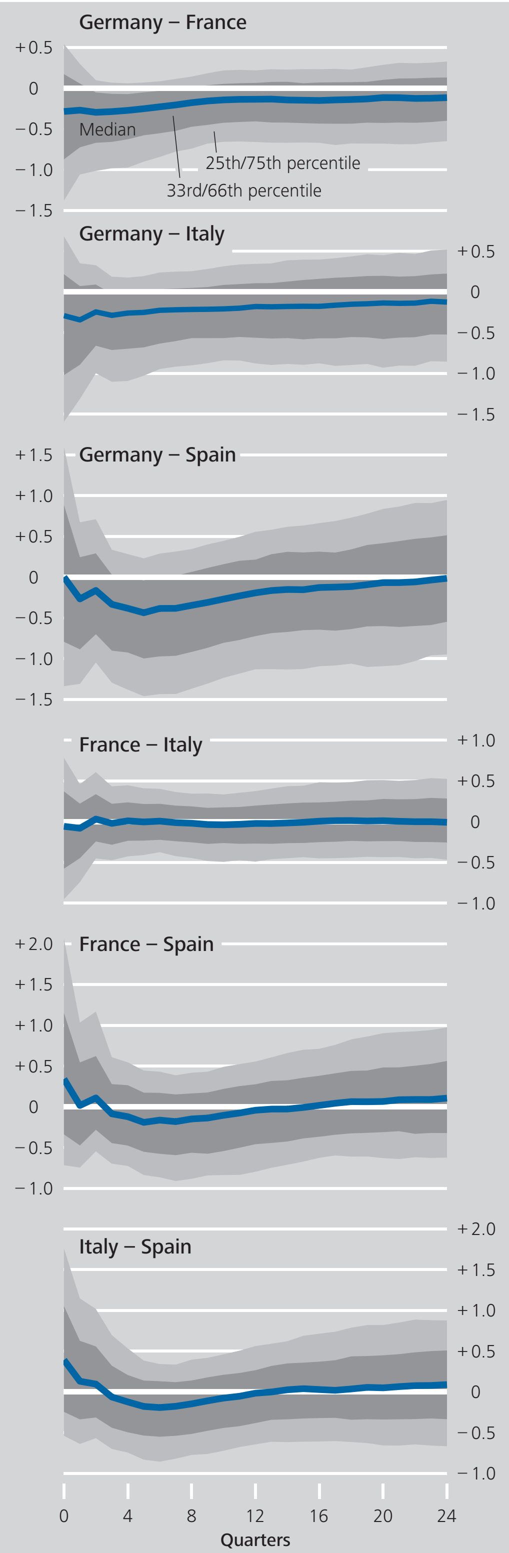


* Estimated probability distribution of the impact in the first country less the impact in the second country.

Deutsche Bundesbank

Cross-country comparison of the impact of monetary policy on HICP*
Here: expected 25 bp increase in 3-month interest rate

%



* Estimated probability distribution of the impact in the first country less the impact in the second country.
Deutsche Bundesbank

ants which, for each of the countries, contain either the two-year government bond yield, the spread between corporate and government bonds (the "excess bond premium" – see Gilchrist and Mojon (2018)), real investment or loans to non-financial corporations along with the corresponding lending rate. The results indicate that the change in the expected short-term interest rate in Germany leads to a more persistent change in financing costs than it does in other countries and has a stronger impact on loans and investment.

Another important non-standard monetary policy instrument used by the Eurosystem was the asset purchase programme (APP). Mandler and Scharnagl (2020) analyse possible differences in the effects of the APP on the four large euro area countries, again using a multi-country BVAR model (see the box on pp. 51 f.). Instead of investigating the effect of a one-off monetary policy impulse, they compare the simulated effects of the APP over the period from the beginning of 2015 to the end of 2018. Their findings suggest that the APP has had a weaker impact on GDP in France compared with other countries. The differences between Germany, Italy and Spain are not strong enough to allow any conclusions to be drawn. The estimated impact on the HICP is strongest in Spain and weakest in Italy, with Germany and France lying between the two with similar effects. However, different studies also come to different conclusions on the effects of the APP.[34]

34 The estimations by Boeckx et al. (2017) and by Burriel and Galesi (2018) likewise show that, out of the four countries, the strongest impact on prices can be found in Spain. Unlike Mandler and Scharnagl (2020), however, they estimate a stronger GDP effect in Germany than in other countries. Wieladek and Pascual (2016) estimate the strongest price effect in Germany and the strongest GDP effect in Spain. However, these studies compare the effect of a one-off unconventional monetary policy impulse, while the analysis on pp. 51 f. compares simulated aggregate effects of the APP over multiple years.

Has the asset purchase programme (APP) affected euro area countries differently?

Mandler and Scharnagl (2020) use a BVAR model to examine whether the Eurosystem's APP has had differing impacts on the four major euro area economies. The purchase programme was intended to provide expansionary monetary policy stimuli at a time when conventional monetary policy had little remaining scope for further interest rate cuts.[1] The empirical analysis estimates and compares the effects of the purchase programme from the beginning of 2015, when it was adopted, up to the end of 2018, when net purchases were ended for the first time. Unlike the two papers in the main text, however, it does not compare impulse responses to a monetary policy shock; instead, simulated effects of the APP on the four countries are compared.

The model consists of a block of euro area variables and blocks of country-specific variables.[2] The country-specific blocks – for France, Germany, Italy and Spain – contain real gross domestic product (GDP), the Harmonised Index of Consumer Prices (HICP), bank loans to non-financial corporations, the lending rate and the yield on government bonds with a maturity of five years. The euro area block comprises financial variables for the euro area as a whole: the euro overnight index average (EONIA), a stock price index, the nominal effective exchange rate, the composite indicator of systemic stress (CISS),[3] the yield spread of corporate over government bonds (excess bond premium), the average yield on government bonds with a maturity of five and ten years, and the spread between government bond yields in Germany and the euro area average with a maturity of five years.

The simulation of APP effects is calculated as the result of a sequence of monetary policy shocks. To this end, two monetary policy shocks are identified using sign restrictions: a conventional monetary policy shock, i.e. an interest rate policy shock, and an unconventional monetary policy shock. For the conventional monetary policy shock, it is assumed that a decline in the EONIA lowers government bond yields in the euro area and in the individual countries and that real GDP and the HICP increase on average across the four countries.[4] Identification of the unconventional monetary policy shock is based on the documented financial market effects of monetary policy purchase programmes (e.g. Altavilla et al. (2021)). The shock leads to an increase in the stock price index, a depreciation of the euro and a decline in government bond yields. In addition, it is assumed that the CISS and the excess bond premium decrease, i.e. that asset purchases reduce risk premia, and the yield spread between German government bonds and the euro area average declines, i.e. the German government bond yield falls less sharply than the euro area average. Furthermore, the unconventional monetary policy shock leads to an increase in GDP and the HICP on average across the countries. The difference between the uncon-

1 For more information on the transmission mechanisms of monetary policy purchase programmes, see, for example, Deutsche Bundesbank (2016).
2 For details about the model, see Mandler and Scharnagl (2020).
3 The CISS is an indicator of stress in the financial system. It consolidates the importance of frictions and tensions in the financial system in one indicator; see Holló et al. (2012).
4 When calculating the averages, the country-specific variables are weighted by the relevant GDP. This sign restriction is less restrictive than the assumption that the monetary policy shock will lead to an increase in GDP and the HICP in each country.

ventional and conventional monetary policy shocks is that the former has no effect on the EONIA.[5] All of these restrictions apply in the period in which the shocks occur.

The simulation of the effects of the APP is based on a series of expansionary unconventional monetary policy impulses. These impulses are calibrated such that their effects on the ten-year government bond yield correspond to the revisions to the assumptions about this yield in the Eurosystem's macroeconomic projections over the analysis period. These assumptions reflect market expectations at the time of the relevant projection. The simulation thus assumes that these revisions to expectations were driven primarily by unconventional monetary policy and, above all, by the APP.[6] Taken in isolation, the expansionary effects of the unconventional monetary policy shocks would lead to an increase in the EONIA in line with the monetary policy response function estimated in the model. In order to avoid this effect, which counteracts unconventional monetary policy measures, unconventional monetary policy shocks are combined with conventional ones to keep the EONIA at its baseline.[7]

The comparative approach described on pp. 44 ff. is applied to the simulated effects of the APP. Overall, the results indicate that the APP had a weaker impact on real GDP in France than in the other countries. The differences between Germany, Italy and Spain are not pronounced enough to discern a clear ranking. According to the estimates, the impact on consumer prices was strongest in Spain and weakest in Italy, with Germany and France between the two extremes. Overall, the analysis shows that Germany, too, benefited from the APP and that the programme's effects in Germany were by no means the weakest among the countries under analysis.

5 The identification of an unconventional monetary policy shock via the term structure with the central assumption that an unconventional monetary policy shock affects the long-term interest rate but not the short-term money market rate follows Baumeister and Benati (2013).
6 Unconventional monetary policy shocks encompass all monetary policy measures that affect the term structure of interest rates according to the assumptions made during their identification. This also includes forward guidance, for example. Strictly speaking, the simulations therefore estimate the combined effects of various unconventional monetary policy measures. When interpreting the results, it is assumed that the greatest share of these is attributable to the APP.
7 For details about the simulation, see Mandler and Scharnagl (2020). This approach is based on the fact that the Eurosystem's scope for further interest rate cuts was limited by the effective lower bound and the APP was intended to provide expansionary monetary policy stimulus. Conventional monetary policy, which would counteract these expansionary monetary policy impulses, was therefore unlikely.

Importance of regional differences in monetary policy transmission for monetary policy

Literature provides evidence for heterogeneous effects of Eurosystem monetary policy

The current studies on country-specific differences in the effects of monetary policy in the euro area, together with the analyses presented here, suggest that the Eurosystem's single monetary policy has varying impacts across the euro area economies. This is true not only of the Eurosystem's conventional interest rate policy but also of non-standard monetary policy measures such as forward guidance. Some of the analyses point to the structural differences between the economies that might play a role in this. However, the available studies typically only take into account a limited number of structural factors, and it remains unclear how important they are, including relative to one other, when it comes to explaining the differences.

Ranking of countries is not robust across the existing studies

The results of the studies which document indications of varying impacts of monetary policy on the euro area countries differ, however, in terms of the relative ranking of the countries examined.[35] Looking at the literature as a whole, it seems the results possess a certain degree of sensitivity as regards the estimation period, the model structure and the identification assumptions, amongst other factors. The importance of the specific ranking of countries therefore should not be overstated until a consensus has been reached on this. What is more, it is possible this ranking could also change over time, for example owing to structural reforms. The following section therefore does not deal with the results for individual countries, but with the more fundamental implications of regional differences in monetary policy transmission for the Eurosystem's monetary policy.

Disaggregated analyses provide important information for monetary policy decision-making

The Eurosystem's mandate is to maintain price stability within the euro area. Consequently, the Governing Council of the ECB has defined the price stability objective for the euro area as a whole on the basis of the HICP. This means that country-specific developments cannot play a role at the target level of monetary policy. However, this need not necessarily apply to the level below that at which the use of monetary policy instruments is calibrated (see Angelini et al. (2008)). This is not to be confused with a monetary policy geared primarily to national circumstances, though. The mandate of the Eurosystem's monetary policy relates to price stability in the euro area as a whole, and in this context country-specific factors only matter to the extent that they are relevant to inflation developments in the euro area. Thus, although the Governing Council of the ECB makes its decisions based on economic developments in the euro area as a whole, disaggregated data, which include country-specific data, provide important information for monetary policy decision-making. These data help to improve the understanding and assessment of aggregate inflation developments and the transmission mechanisms of monetary policy in the euro area (see Issing (2004)). Since the start of monetary union, both country-specific data and microdata, for example about banks, have become more important for the analysis of monetary policy transmission.[36]

ECB Governing Council uses all relevant information

When preparing monetary policy decisions, the Eurosystem uses not only models at the aggregate euro area level but also various multi-country models that capture differences in the interrelationships.[37] This category also includes the models presented in this article. The key

35 See the discussion on p. 47. For example, in the analysis by Georgiadis (2015), the output response to an interest rate shock is weakest in France out of the four countries considered here, whereas the analysis in the section entitled "Heterogeneous impact of interest rate policy?" indicates a stronger reaction in France than in Italy and Spain. While the output response is strongest in Germany in the analysis contained in the same section, Ciccarelli et al. (2013), for example, estimate that monetary policy has greater effects on the real GDP of euro area countries more affected by the financial and sovereign debt crisis.
36 See the overview of developments in monetary and financial analysis in Deutsche Bundesbank (2023). For an overview of the information about the inflation process and transmission at the euro area level contained in microdata on price-setting behaviour, see Dedola et al. (2023).
37 One example is the ECB staff's BASE model; see Angelini et al. (2019).

macroeconomic projections are based on forecasts for the individual euro area countries, which are aggregated at the euro area level.[38]

Structural and institutional determinants of heterogeneous transmission are the responsibility of other policy areas

Finally, it should be stressed that it is not the task of monetary policy to smooth out differences in the transmission of monetary policy across countries. Empirical evidence suggests that these differences are driven by structural and institutional factors that fall within the responsibility of other policy areas, particularly national ones. Moreover, differences in the regional effects of monetary policy are not a problem specific to a monetary union such as the euro area. Empirical analyses for the United States, for instance, also indicate that the Federal Reserve's monetary policy does not have a homogeneous effect throughout the entire country (e.g. Carlino and DeFina (1998, 1999) and Pizzuto (2020)).

38 For an overview of the projections, see European Central Bank (2016). This approach draws on the expertise available at the national level and allows for the inclusion of different national data sources and institutions.

Annex: Brief outline of the models used

The analysis of differences in the impact of interest rate policy across the four major euro area countries in Mandler et al. (2022) uses a Bayesian vector autoregressive (BVAR) multi-country model.[39] This flexible approach captures possible interactions between all variables contained in the model for the different countries. Including all the countries in the empirical model is also a condition for the statistical analysis of differences in the impact of monetary policy (see the box on pp. 44 ff.).

The model is estimated based on quarterly data from the first quarter of 1999 to the third quarter of 2014. This excludes the subsequent period in which the Eurosystem steered the monetary policy stance mainly using the asset purchase programmes. For each of the four countries, the model contains real GDP, the HICP, the broad monetary aggregate M3, loans to the non-financial private sector and the yield on government bonds with a maturity of five years. The yield on US government bonds with a maturity of five years and a US shadow interest rate are included as additional variables to capture possible effects of the Federal Reserve's monetary policy or the international capital markets.[40]

The shadow interest rate of Wu and Xia (2016) serves as an indicator of monetary policy for the euro area. The results are qualitatively very similar when using the money market interest rate for overnight loans (EONIA). Eurosystem monetary policy responds to economic developments in the euro area as a whole. While the model does not cover all euro area economies, the four countries it contains account for more than three-quarters of euro area real GDP over the estimation period. This should enable sufficiently sound empirical modelling of the Eurosystem's monetary policy response to economic developments in the euro area.

Estimating the effects of interest rate policy requires separating the causal effects of monetary policy on the other variables from the endogenous response of monetary policy to changes in the macroeconomic environment. To this end, "monetary policy shocks" are identified using sign restrictions: the analysis assumes that an increase in the monetary policy interest rate leads to a decline in real GDP and the HICP in all countries within the same quarter.[41] Under this assumption, the estimated model can be used to calculate the responses of all variables to an interest rate rise in the Eurosystem, known as impulse response functions.

39 For a precise description of the model and the estimation approach, see Mandler et al. (2022). Mandler et al. (2016, 2017) represent earlier versions of this analysis, which was further developed into the version summarised here during the publication process.

40 A shadow interest rate is a hypothetical overnight money market rate that would have arisen in the absence of a binding effective lower bound. It is estimated using interest rates of different maturities from a term structure model. The shadow interest rate responds to changes in short-term interest rates, i.e. to the central bank's conventional monetary policy, as well as to non-standard monetary policy measures that affect medium and longer-term interest rates. For an overview of the construction and interpretation of the shadow interest rate, see Deutsche Bundesbank (2017).

41 Another assumption is that an increase in real GDP or in the price level in a given country, taken in isolation, leads to an increase in the monetary policy interest rate in the same quarter, i.e. the coefficients of current output and price levels are assumed to be positive in the monetary policy response function; see Arias et al. (2019).

The analysis of the effects of changes in interest rate expectations is taken from the study by Mandler and Scharnagl (2023). The model used in that study is similar to the one used to analyse actual interest rate changes. Compared with the model described above, however, it contains fewer country-specific variables and has instead been expanded to include expectations variables, based on D'Amico and King (2023), which allow the effects of expectations shocks to be captured.

The model contains real GDP and the HICP for each country. For the euro area as a whole, it contains real GDP, the HICP, the average yield on government bonds with a maturity of five years, a stock price index and the three-month money market interest rate as a monetary policy indicator. Additional variables are the oil price and the yield on US government bonds with a maturity of five years. These variables are supplemented by consensus expectations for the euro area as a whole on future real GDP, the future HICP and the future three-month interest rate.[42] The three-month interest rate is used as a monetary policy indicator because consensus expectations are available for the three-month interest rate, but not for the overnight interest rate or a shadow interest rate in the euro area. Mandler and Scharnagl (2023) estimate three model variants which differ in terms of the time horizon of the expectations variables – two, four or six quarters ahead. The results summarised in the main text relate to the model which includes expectations variables with a four-quarter horizon. The analyses for the other expectations horizons result in the same ranking of countries in terms of the effects of monetary policy.[43]

This analysis focuses on the causal effects of a change in interest rate expectations. The required identification of an interest rate expectations shock is accomplished using sign and zero restrictions:[44] under these assumptions, an increase in the expected three-month interest rate leads to a decline in both current and expected real GDP and the HICP in the euro area. In addition, the stock price index falls and the government bond yield rises. The interest rate expectations shock is assumed to have no effect on the current three-month interest rate (zero restriction). This requirement separates the effects of a change in the expected three-month interest rate from those of a change in the current three-month interest rate. All of these restrictions apply to the quarter in which the shock occurs. As in D'Amico and King (2017), consistency between changes in the expected three-month interest rate and the subsequent actual change in the rate is also required (forecast consistency). If the three-month interest rate expected in a given year decreases by a certain number of basis points, the actual three-month interest rate four quarters after the stimulus must also have fallen by this number of basis points. Similar consistency assumptions are made for the actual and expected changes in real GDP and the HICP. For country-specific real GDP and consumer prices, Mandler and Scharnagl (2023) assume that an increase in the expected three-month interest rate leads, in the same quarter, to a decline in the averages of GDP and the HICP weighted by the real GDP of the respective countries. These assumptions are less restrictive than requiring a negative response of real GDP and the HICP in each individual country.

In this analysis, too, the estimation period starts in the first quarter of 1999, but ends in the fourth quarter of 2018. The Governing Council of the ECB used forward guidance mainly in the negative interest rate period that began in 2014, to provide additional expansionary monetary policy stimuli. Nevertheless, interest rate expectations were already influenced before that by the Eurosystem's communication, even in cases where the actual policy rates did not change. Assuming that the effects of these changes in expectations are similar to those of more explicit forward guidance on interest rates, the pre-2013 data are therefore also informative in this respect.

The effects of forward guidance are also analysed in structural macroeconomic models.[45] In the BVAR model used here, the short-term interest rate expected for a given future date changes, and the actual value of this interest rate at that later date must

42 The growth and inflation expectations from the consensus survey are converted into expectations about output and the price level for the analysis. Real GDP and the HICP for the euro area are included in the model in order to establish a link between the realised and expected variables.
43 For the other results, see Mandler and Scharnagl (2023) and the online appendix.
44 The published study refers to an expansionary expectations shock, i.e. an expected decline in the three-month interest rate. In order to make the results more comparable with those of the other study, the main text and these explanatory notes describe an expected interest rate rise. As the model is symmetrical, these results are obtained simply by reversing the signs accordingly.
45 For an overview, see Taskforce on Rate Forward Guidance and Reinvestment (2022), Section 3.

be consistent with this change in expectations, i.e. must differ by the same amount from the original baseline. Before and after that, however, the path of the short-term interest rate is unrestricted, aside from the fact that it may not respond immediately to the change in expectations. This is comparable to the modelling of forward guidance in the structural model of Giannoni et al. (2015). They also allow the short-term interest rate to react endogenously to the impact of the announced and expected future change in the monetary policy rate.[46] However, the modelling approach presented here is less comparable to a number of other structural models, which model forward guidance in such a way that, after the announcement of future interest rate policy, the monetary policy interest rate remains on its starting path and does not deviate from the original interest rate path, i.e. the one expected prior to the announcement, until the time to which the announcement referred (e.g. Levin et al. (2010) and McKay et al. (2016)).

46 However, unlike the analysis presented here, their model allows them to ensure that the actual path of the monetary policy interest rate is fully anticipated by agents after the central bank announces a future change.

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