Articles

1 The impact of uncertainty on activity in the euro area

Fluctuations in uncertainty can play an important role in shaping the economic conjuncture and outlook. This article discusses the various methods proposed in the literature to measure uncertainty and shows how these measures have evolved in the euro area. It describes the transmission channels of fluctuations in uncertainty to the economy and provides some model-based evidence for the impact of uncertainty on euro area activity. The results suggest that uncertainty in the euro area rose substantially during the Great Recession and during the sovereign debt crisis, and that high uncertainty could significantly dampen activity in the euro area, and notably investment.

1 The relationship between uncertainty and activity

While difficult to measure, uncertainty – in its various forms – is widely cited as a factor that influences the economic conjuncture and outlook. A number of studies have argued that high uncertainty contributed to the downturn in the Great Recession and was an important factor behind both the weakness of the global recovery and, notably, the weakness of activity in the euro area after the Lehman episode.[1] Measuring macroeconomic uncertainty and understanding its impact on economic activity is thus crucial for assessing the current macroeconomic situation and forming a view on the outlook.

Uncertainty arises when economic agents are conscious of their limited knowledge about present facts or possible future outcomes. [2] It is a broad concept covering macroeconomic phenomena such as uncertainty of current and future real GDP growth; microeconomic issues such as uncertainty about the outlook for firm growth or the prospects for household income; or non-economic topics such as uncertainty related to terrorism, war and natural disasters. This article focuses on various types of macroeconomic uncertainty.

Uncertainty affecting an economy is hard to measure as it is an intrinsically unobservable concept. While there is no universal, single commonly accepted measure of uncertainty, a number of proxies have been proposed and applied in the

1 See, for instance, Federal Open Market Committee Minutes, April 29-30, 2008; Blanchard, O., "(Nearly) nothing to fear but fear itself", *The Economist*, 29 January 2009; Buti, M. and Padoan, P.C., "How to make Europe's incipient recovery durable: end policy uncertainty", Vox, 12 September 2013; the box entitled "Uncertainty and the economic prospects for the euro area", *Monthly Bulletin*, ECB, August 2009, pp. 58-61; and Kose, M.A. and Terrones, M., "How does uncertainty affect economic performance?", *IMF World Economic Outlook*, October 2012, pp. 49-53. For a discussion of the impact of uncertainty related to the UK referendum on EU membership see Carney, M., "Uncertainty, the economy and policy", Speech at the Bank of England, 30 June 2016.

2 See Black, J., Hashimzade, N. and Myles, G., *A Dictionary of Economics* (4 ed.), Oxford University Press, 2013.

economic literature. Proxies for uncertainty can be derived from financial market data; the frequency of articles in newspapers featuring certain key words; surveys among forecasters; surveys among private households and businesses; and from macroeconomic time series. While these proxies effectively measure different types of uncertainty – such as financial, political or forecast uncertainty – the empirical literature often applies these proxies to measure the impact of uncertainty on economic activity, typically industrial production, real GDP, investment or consumption. However, all of these proxies are subject to some caveats, and there is increasing agreement that the measurement of uncertainty should be based on an encompassing set of data. This article presents a composite measure of uncertainty for the euro area, based on a large number of proxies for uncertainty.

Increases in uncertainty adversely affect activity in the short term. As reversing investment or employment decisions is often impossible or costly on account of sunk costs or fixed adjustment costs, high uncertainty about the economic outlook or about future economic policies gives enterprises an incentive to postpone or cancel their decisions until uncertainty has declined and/or new information has become available. Managers might also become more risk averse in general during periods of heightened uncertainty, thus shying away from decisions about new investment projects or hirings. Uncertainty can similarly influence decisions of private households when it comes to purchases of durable consumer goods. In addition, high uncertainty about the economic outlook and in particular employment could induce households to reduce consumption and increase precautionary savings. Uncertainty could also adversely affect activity via the higher cost of financing attributable to increased risk premia.

This article surveys the literature on the measurement of uncertainty and its impact on activity, and provides some evidence for the euro area.[3] The remainder of this article is organised as follows. Section 2 starts with a definition of uncertainty and distinguishes uncertainty from risk. It then discusses the various data sources and methods proposed in the literature to measure uncertainty. Box 1 presents a composite measure of uncertainty for the euro area. The article then describes the channels by which fluctuations in uncertainty are transmitted to the economy, as discussed in the theoretical literature, and summarises the empirical literature on quantifying the impact of uncertainty on the real economy. While this literature typically focuses on the United States, Box 2 presents model estimates for the impact of uncertainty in the euro area. Section 5 concludes, also pointing out how the complex nature of fluctuations in uncertainty affects the assessment of the macroeconomic outlook for the euro area.

2 Measuring uncertainty

From an economic perspective, uncertainty can be broadly described as a state where economic agents lack the knowledge necessary to assess the

[3] The cut-off date for the statistics included in this article was 5 December 2016.

current situation with sufficient confidence and/or predict future outcomes. There are different types of uncertainty, and sometimes economic agents may face all of them at the same time.[4] For example, policymakers might be uncertain about the current state of the economy (so-called "measurement uncertainty"), as data are published with sometimes long delays, are prone to subsequent revisions, or are subject to uncertain methods of measurement. Policymakers might also be uncertain about the future ("temporal uncertainty") as any projection depends on a set of critical assumptions. The ECB accounts for uncertainty about the economic outlook by publishing ranges around its point forecasts and through risk assessments and scenario analyses.[5] Policymakers might also be uncertain about the true structure of the economy and the interactions between economic agents ("structural uncertainty"), indeed their policy measures might be intended to change them.

Uncertainty can take different forms.[6] It can be unresolvable ("aleatory uncertainty"): even if the probability distribution of the outcomes of tossing a coin is well known, it is impossible to predict the outcome of the next toss. "Epistemic uncertainty" represents a known and, in principle, resolvable lack of knowledge, which cannot be addressed owing to the lack of empirical data in the absence of previous occurrences. Finally, "ontological uncertainty" represents a state of complete ignorance: agents don't know what they don't know.

The economic literature distinguishes between risk and uncertainty.[7] Economic agents are facing risks in situations where they are able to form views about the probability distribution of possible future states, based on logic (like when assessing likely outcomes of throwing a dice) or on past experience (if similar shocks – to oil prices, exchange rates, etc. – have frequently happened in the past). Uncertainty, also known as Knightian uncertainty, arises when economic agents cannot reasonably assess the likelihood of all possible future states of nature or characterise the probability distribution of their possible impacts. Wars, terrorist attacks or other unprecedented events are examples where it might be impossible for economic agents to assess the likelihood of the event or its economic impact. In practice it is often impossible or inconvenient to maintain the distinction between risk and uncertainty. For example, while the probability of natural disasters can be calculated, agents are unable to assess when and where a natural disaster might occur. Accordingly, attempts to measure uncertainty typically also capture some elements of risk.

There is no objective or perfect measure of uncertainty. Many proxies or indicators of uncertainty developed in the empirical literature have the advantage of being directly observable. However, their adequacy as a measure of uncertainty depends on the extent to which their fluctuations can be attributed to changes in

4 See Rowe, W.D., "Understanding uncertainty", *Risk Analysis*, Vol. 14, No 5, 1994, pp. 743-750.

5 See *A guide to the Eurosystem/ECB staff macroeconomic projection exercises*, ECB, July 2016; see also *New procedure for constructing Eurosystem and ECB staff projection ranges*, ECB, 2009; both available on the ECB's website.

6 See, for example, Squair, M., Epistemic, ontological and aleatory risk; Der Kiureghian, A. and Ditlevsen, O., "Aleatory or epistemic? Does it matter?", *Special Workshop on Risk Acceptance and Risk Communication*, Stanford University, 26-27 March, 2007.

7 See Knight, F.H., *Risk, uncertainty and profit*, Houghton Mifflin, 1921.

uncertainty about economic fundamentals and separated from other unrelated developments. Moreover, these proxies often refer to only one specific group of economic agents (such as forecasters) or specific markets (such as financial markets) whose perception of uncertainty might not be representative for the overall economy. Against that background, it appears preferable to measure uncertainty using data from various sources and applying multiple methods.

Financial market data are most commonly used in the literature to derive proxies for uncertainty.[8] Equity prices, bond yields and exchange rates typically reflect financial market participants' expectations about future economic developments. Low volatility in equity, bond or foreign exchange markets should then indicate stable expectations about future outcomes broadly shared across market participants, while heightened volatility should reflect financial market uncertainty about these future outcomes. An advantage is that proxies for uncertainty based on financial market volatility can be calculated in various ways and at high frequency. However, financial market volatility can change over time even if there is no change in uncertainty about the economic outlook, i.e. when changes in risk aversion or sentiment are the main driving factors of market volatility.[9] In addition, perceptions of uncertainty derived from financial markets might follow a logic different from that of business and private households.

Financial market uncertainty tends to be high during periods of recession. A synthetic measure of financial market uncertainty in the euro area, calculated from bond markets, equity markets and the exchange rate is displayed in Chart 1. It can be seen that the volatility of financial markets rises steeply during the recession periods in 2008/09 and 2012/13. It also briefly spiked at other times, such as the 11 September 2001 terrorist attacks and in the context of the Greek debt crisis in May 2010, while it remained subdued during periods of resilient economic activity. The counter-cyclicality of financial market uncertainty with respect to real GDP growth in the euro area is confirmed by a negative correlation coefficient (of -0.6). Empirical tests also confirm that financial market volatility is useful in predicting real GDP growth and some of its expenditure components. More specifically, so-called Granger causality tests have been used to establish that an increase in uncertainty happens prior to its impact on real GDP growth, and that such an increase has significant information about the future value of real GDP.[10]

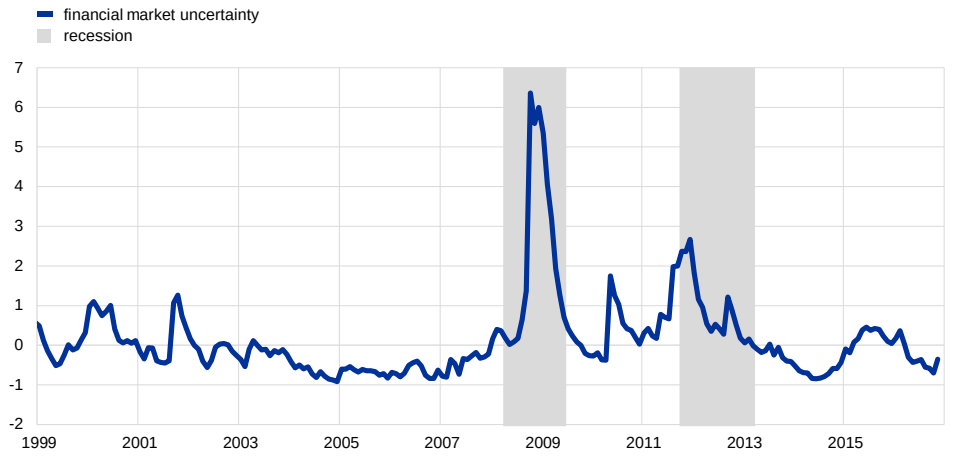
8 See, for instance Bloom, N., "The impact of uncertainty shocks", *Econometrica*, Vol. 77, No 3, 2009, pp. 623-685.

9 See, for example, Jurado, K., Ludvigson, S.C. and Ng, S., "Measuring uncertainty", *American Economic Review*, Vol. 105, No 3, 2015, pp. 1177-1216.

10 See Granger, C.W., "Investigating causal relations by econometric models and cross-spectral methods", *Econometrica*, Vol. 37, No 3, 1969, pp. 424-438.

Chart 1

Financial market uncertainty in the euro area



Sources: BIS, ECB and ECB calculations.
Notes: Areas in grey reflect euro area recessions as identified by the Centre for Economic Policy Research (CEPR).
Financial market uncertainty reflects the mean of conditional volatilities, measured as GARCH, of three financial market indicators: the DOW JONES EURO STOXX Broad Stock Exchange Index, the ten-year euro area benchmark government bond yields, and the USD/EUR exchange rate.

Disagreement among professional forecasters is another traditional proxy for uncertainty.[11] While the mean or median of point projections for real GDP growth across forecasters from banks, research firms and public institutions can be defined as a consensus, the variance of these forecasts has frequently been used as a proxy for the uncertainty surrounding this expectation. The underlying assumption is that increasingly diverse opinions about the economic outlook among forecasters are likely to indicate that it is becoming more difficult, and more uncertain, to project future economic developments. In other words, it is assumed that the interpersonal dispersion of projections is an acceptable proxy for the average subjective uncertainty faced by individual forecasters. The level and fluctuations in the dispersion of projections by professional forecasters may, however, also be traced to other factors, such as differences in forecast techniques, differences in information sets and, more generally, in diverse underlying views of forecasters about the economy. And the reverse, forecasters may keep their projections unchanged or revise them all in the same direction, while individual uncertainty about the point estimate may change a lot. Nevertheless, as can be seen from Chart 2, disagreement among forecasters on the economic outlook for the euro area increased substantially during recession periods, while it remained subdued during periods of resilient growth. It is counter-cyclical, with a correlation coefficient to real GDP growth of -0.4. And empirical tests confirm that changes in disagreement have predictive value for future changes in real GDP growth.

11 See, for example, Zarnowitz, V. and Lambros, L.A. , “Consensus and uncertainty in economic prediction”, *Journal of Political Economy*, Vol. 95, No 3, 1987, pp. 591-621; and Bomberger, W.A., “Disagreement as a measure of uncertainty”, *Journal of Money, Credit and Banking*, Vol. 28, No 3, 1996, pp. 381-392.

Chart 2

Forecast disagreement in the euro area

Sources: Consensus Economics, and ECB calculations.
Notes: Areas in grey reflect euro area recessions as identified by the Centre for Economic Policy Research (CEPR).
Forecast disagreement in the euro area is measured as the unweighted average of the standard deviations of point forecasts provided by Consensus panel members for real GDP, private consumption, fixed investment, consumer price inflation, industrial production and long-term interest rates.

Surveys among professional forecasters also allow a quantification of aggregate and individual forecast uncertainty.[12] Surveys of professional forecasters (SPF) as compiled by the ECB or the US Federal Reserve Bank of Philadelphia ask respondents to provide, in addition to the precise projection, a probability distribution around this point estimate which highlights the uncertainty faced by the individual forecaster in preparing the projection. A measure of aggregate individual forecast uncertainty can then be calculated as the average standard deviation of the individual probability distributions provided by the respondents (shown as the yellow line in Chart 3). One particular advantage of this measure is that it can be directly observed. As this measure tends to underestimate the degree of uncertainty surrounding the forecasts, it is also possible to calculate a broad measure of aggregate forecast uncertainty (shown as the blue line in Chart 3), which combines both forecast disagreement (measured as the standard deviation of individual point forecasts, shown as the red line in Chart 3) and individual uncertainty.[13] It can be seen that all these measures of forecast uncertainty increased strongly during the 2008/09 Great Recession. In contrast to other measures of uncertainty, though, individual and aggregate forecast uncertainty appears to have remained high throughout the post-recession period. This might represent a fundamental change in forecasters' risk perception: as almost all forecasters failed to predict the Great Recession, there might be an increased

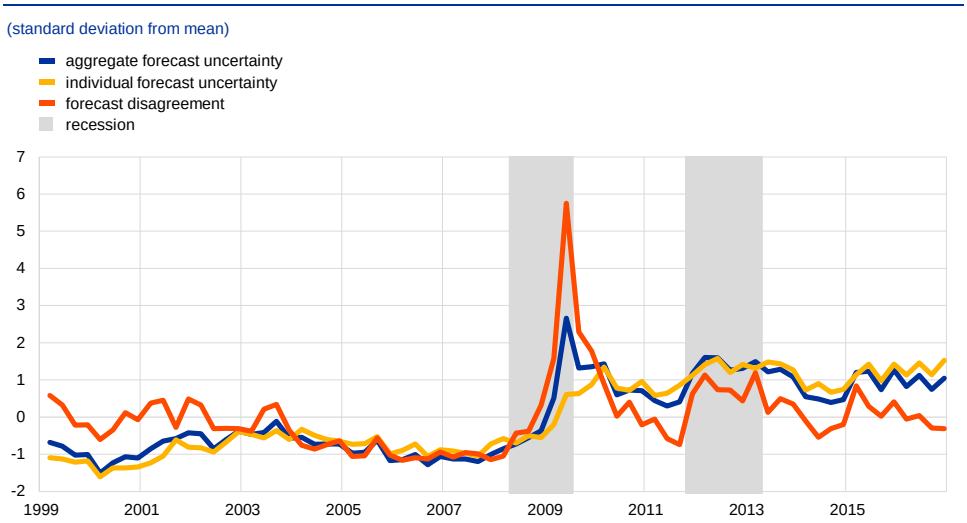
12 See the box entitled "Measuring perceptions of macroeconomic uncertainty", *Monthly Bulletin*, ECB, January 2010.

13 See, for example, Bowles, C., Friz, R., Genre, V., Kenny, G., Meyler, A. and Rautanen, T., "The ECB Survey of Professional Forecasters (SPF): A review after eight years' experience", *ECB Occasional Paper*, No 59, April 2007. As an alternative, aggregate forecast uncertainty can also be expressed as the sum of forecast disagreement and the perceived variability of future aggregate shocks. The latter component can be calculated on the basis of GARCH-type models. See, for instance, Lahiri, K. and Sheng, X., "Measuring forecast uncertainty by disagreement: the missing link", *Journal of Applied Econometrics*, Vol. 25, No 4, 2010, pp. 514-538.

awareness among forecasters of the risks surrounding their projections. Similar to financial market-based measures, proxies for uncertainty derived from surveys among professional economists are based on the views of a rather restricted set of people, whose perceptions of uncertainty might differ from that of other economic agents. In addition, while these proxies for uncertainty are negatively correlated with euro area activity, Granger causality tests suggest that fluctuations in euro area real GDP growth and its components have predictive power for forecast uncertainty in the euro area, but not the other way round.[14]

Chart 3

Forecast uncertainty in the euro area



Sources: ECB calculations.
Notes: Areas in grey reflect euro area recessions as identified by the Centre for Economic Policy Research (CEPR). Forecast disagreement, individual forecast uncertainty and aggregate forecast uncertainty in the euro area are each measured as unweighted averages of projections provided by SPF panel members for real GDP, HICP inflation and the unemployment rate over one, two and five year horizons.

A recently developed proxy for uncertainty is the frequency of newspaper articles referring to economic policy uncertainty.[15] A measure of economic policy uncertainty in the euro area, which counts the frequency of articles containing the words "uncertain or uncertainty" and "economy or economics" and one of a number of policy words (such as "deficit" or "regulation") in leading newspapers is shown in Chart 4. Economic policy uncertainty in the euro area tends to increase during recession periods, but also rises steeply on a number of other occasions, such as the 2003 Gulf war, the 11 September 2001 terrorist attacks, around the June 2016 referendum on EU membership in the United Kingdom, and again in November 2016. As a caveat, this proxy does not distinguish between uncertainty about domestic policies or external policies. In addition, the selection of newspapers (two per country) might not be representative of the media coverage in their countries as they do not include mass-market tabloids and other media coverage. Hence, this

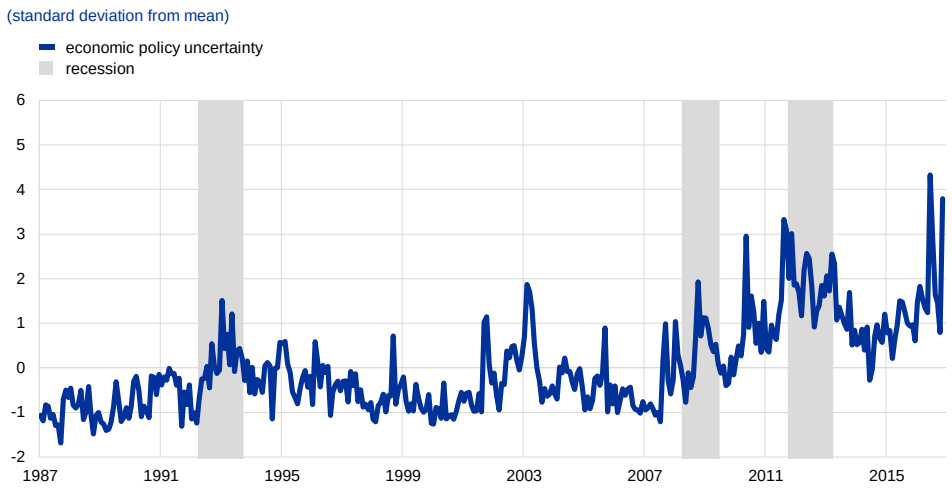
14 This observation is less clear cut for the United States, where all measures of forecast uncertainty are negatively correlated with real GDP growth, and some measures are also found to be Granger causal for real GDP growth.

15 See Baker, S., Bloom, N. and Davis, S., "Measuring economic policy uncertainty", *NBER Working Paper Series*, No 21633, October 2015.

measure of political uncertainty might rather reflect the perception of uncertainty of a group of selected journalists, and it is assumed that their perception of uncertainty represents that of the population at large. While this proxy for uncertainty is also counter-cyclical (with a correlation to real GDP growth of -0.5) and carries predictive power for euro area activity growth, it tends to be rather volatile and has also risen in periods of more stable economic growth.

Chart 4

Economic policy uncertainty in the euro area



Sources: Baker, Bloom and Davis, and ECB calculations.
Notes: Areas in grey reflect euro area recessions as identified by the Centre for Economic Policy Research (CEPR).
Economic policy uncertainty in the euro area has been calculated as the GDP-weighted average of country-specific data for economic policy uncertainty in Germany, Spain, France, Italy and the Netherlands.

Surveys among households and enterprises yield direct proxies for uncertainty. Business and consumer surveys published by the European Commission cover some 120,000 enterprises every month as well as 40,000 consumers across the EU and its applicant countries. They include both backward-looking and forward-looking questions, and are calculated as balance scores of positive and negative answers by respondents.[16] Several approaches have been proposed to exploit this dataset, whose principal advantage is that measures of uncertainty can be directly derived from perceptions of a large and representative number of economic agents. For example, the dispersion of positive and negative answers to forward-looking questions could be used as a proxy for uncertainty.[17] The rationale is that consumers (or enterprises) can be expected to have broadly similar expectations about future developments in times of low uncertainty and resilient growth, while an increasing dispersion of expectations indicates rising uncertainty and more difficult economic times. However, if the questions relate to the personal

16 For example, when asked: "how do you expect the financial position of your household to change over the next twelve months?", respondents can choose between the following answers: "get a lot better", "get a little better", "stay the same", "get a little worse", "get a lot worse", and "don't know". For details see The Joint Harmonised EU Programme of Business and Consumer Surveys (User Guide).

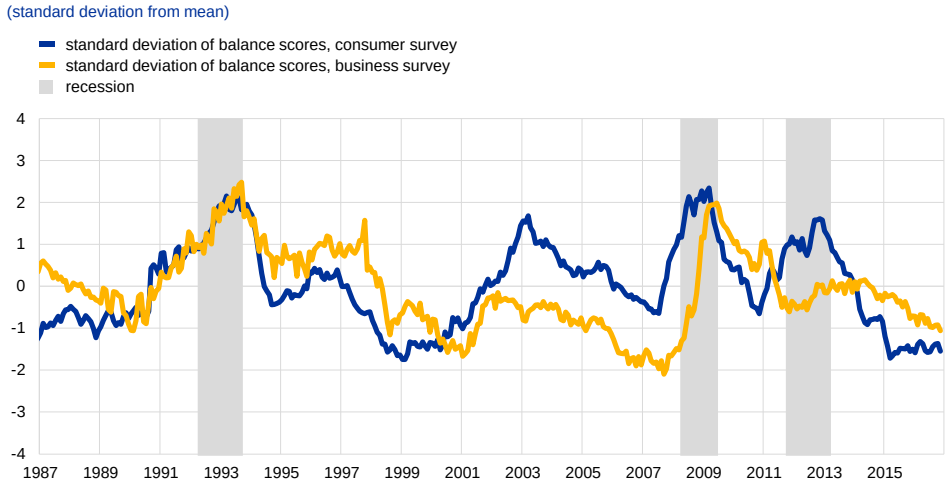
17 See Bachmann, R., Elstner, S. and Sims, E.R., "Uncertainty and economic activity: evidence from business survey data", *American Economic Journal*, Vol. 5, No 2, 2013, pp. 217-249. As several survey questions are asked twice – once with respect to the past, once with respect to the future – these authors also propose an alternative proxy for uncertainty based on the extent to which a given respondent's expectations have been met.

situation of the household or the enterprise, dispersion of expectations could also reflect idiosyncratic issues. One solution could be to calculate the average dispersion across all questions as a proxy for economic uncertainty.[18]

Another proxy for economic uncertainty derived from survey data looks at the dispersion of changes in balance scores in a given month compared to the previous month across all survey questions. The rationale for this proxy for uncertainty is that in times of certainty, i.e. when the economy is growing steadily, the assessment of most variables should be more or less commonly shared, that is, enterprises should have a favourable assessment of future output, orders, employment, etc. The opposite should be true in times of uncertainty. For example, when the economy is approaching a trough, the dispersion of balance scores is likely to increase as expectations on leading indicators turn positive (such as for expected orders), while expectations for other (lagging) indicators stay unchanged or continue to worsen (such as employment). The counter-cyclicality of such proxies for uncertainty, based on the dispersion of balance scores in the European Commission consumer survey (blue line) and the business survey (yellow line), is shown in Chart 5. Both proxies are clearly negatively correlated to activity growth, and both indicators have predictive power for future activity growth.

Chart 5

Survey-based proxies for economic uncertainty in the euro area



Sources: European Commission, and ECB calculations.
Notes: Areas in grey reflect euro area recessions as identified by the Centre for Economic Policy Research (CEPR). Economic uncertainty in the euro area has been calculated as the standard deviation of changes in balance scores in the consumer survey as well as the manufacturing and construction surveys.

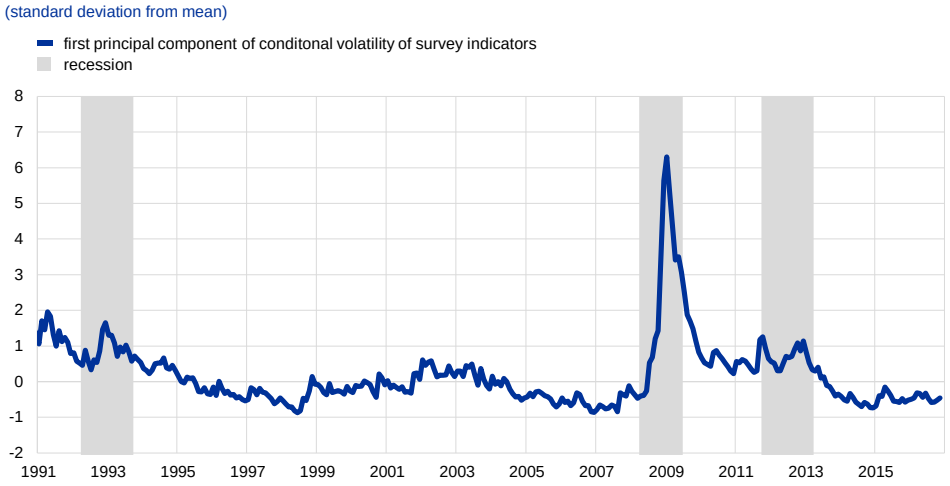
Forecast errors, representing the predictability of economic variables, can also be exploited as a proxy for uncertainty. One recently proposed approach is to apply factor models to predict a large number of variables such as industrial production, and then calculate the forecast errors. Rising and more volatile forecast errors would then suggest an increase in the unpredictable share of the evolution of

[18] See Girardi, A. and Reuter, A., "New uncertainty measures for the euro area using survey data", *Oxford Economic Papers*, Vol. 69, No 1, 2017, pp. 278-300.

a variable, which would then be interpreted as a sign of mounting uncertainty.[19] The rationale is that an assessment of the current situation and forecasting the economy becomes more difficult the larger and the more volatile the unexplained part in time-series models explaining the evolution of macroeconomic indicators. An advantage of this approach is that it can be simultaneously applied to a large set of variables covering all sectors of an economy. As an example, Chart 6 depicts the conditional volatility of European Commission business and consumer survey indicators.[20] This measure is significantly negatively related to real GDP growth, and is useful for predicting real GDP growth in the euro area.

Chart 6

Conditional volatility as a proxy for macroeconomic uncertainty in the euro area



Sources: European Commission, and ECB calculations.
Notes: Areas in grey reflect euro area recessions as identified by the Centre for Economic Policy Research (CEPR).
Macroeconomic uncertainty in the euro area has been calculated as the first principal component of the conditional volatility, measured as GARCH, of European Commission business and consumer survey indicators.

Box 1

A composite measure of macroeconomic uncertainty for the euro area

In the absence of a perfect proxy for uncertainty, it might be preferable to compile a composite measure of uncertainty which captures the information content of a large number of uncertainty proxies. This box presents a composite index of macroeconomic uncertainty for the

[19] See Jurado, K., Ludvigson, S.C. and Ng, S., op. cit. Another recent approach exploits the distribution of forecast errors from surveys of professional forecasters as a proxy for uncertainty; the less likely an observed forecast error compared to the historical distribution of forecast errors, the higher the related forecast uncertainty. See Rossi, B. and Sekhposyan, T., "Macroeconomic uncertainty indices based on nowcast and forecast error distributions", *American Economic Review*, Vol. 105, No 5, 2015, pp. 650-655.

[20] The conditional volatility of survey indicators has been estimated as follows: first, an ARMA model has been estimated for each survey indicator, with the optimal lag length determined by the Akaike information criterion. The conditional volatility of the forecast errors has then been estimated with a GARCH(1,1) model. As a final step, all results have been standardised to mean zero and unit standard deviation.

euro area, which is based on an encompassing dataset covering all types of methods of measuring uncertainty discussed above.[21]

Proxies for uncertainty should be negatively correlated with macroeconomic indicators, as one would expect an adverse contemporaneous or lagged impact of uncertainty on activity. In other words, proxies for uncertainty should be high in periods of recession and low during periods of resilient growth. One reason is that negative news shocks (such as terrorist attacks, wars and oil price shocks) that can cause recessions also cause higher uncertainty at the same time.[22] Another reason for heightened uncertainty during recessions is that recessions might themselves increase uncertainty. Active trading helps to generate and spread information; as trading activity slows down during recessions, the flow of new information also slows down, thereby potentially increasing uncertainty.[23] Another explanation is that policy becomes more uncertain during recessions because policymakers implement new measures to revive growth.[24] Finally, forecasters might find it more difficult to make forecasts during recessions, as the latter are more unusual events and deviate from the usual pattern of positive growth.[25]

The composite indicator of macroeconomic uncertainty in the euro area is based on proxies for uncertainty which are negatively correlated to activity, and which have proved to be Granger causal for activity growth. A number of activity variables have been used for these tests, including real GDP growth, private consumption growth, investment growth, employment growth (both in terms of persons and hours), and industrial production. For about 160 proxies for uncertainty, the correlation against each of these macroeconomic indicators has been calculated and Granger causality has been estimated. About 50 proxies have passed these two tests. All proxies have been standardised, i.e. they have been demeaned and divided by their standard deviations. The macroeconomic uncertainty indicator has been determined as the median of this group of uncertainty measures.[26] In order to capture the uncertainty around this indicator, Chart A shows both the median and the 25-75 percentiles of the group of uncertainty measures included along with Centre for Economic Policy Research (CEPR) recession dates for the euro area.

The composite indicator of macroeconomic uncertainty in the euro area peaked during recessions and remained subdued during periods of resilient growth.[27] As can be seen in Chart A, the indicator suggests highest levels of uncertainty during the Exchange Rate Mechanism

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21 See also Haddow, A., Hare, C., Hooley, J. and Shakir, T., "Macroeconomic uncertainty: what is it, how can we measure it and why does it matter?", *Bank of England Quarterly Bulletin*, 2013 Q2, pp. 100-109, who follow a similar approach for measuring uncertainty in the United Kingdom.

22 See, for instance Bloom, N. (2009), op. cit.

23 See, Bloom, N., "Fluctuations in uncertainty", *Journal of Economic Perspectives*, Vol. 28, No 2, 2014, pp. 153-176.

24 See Pastor, L. and Veronesi, P., "Political uncertainty and risk premia", *Journal of Financial Economics*, Vol. 110, No 3, 2013, pp. 520-545; for empirical results see Baker, S., Bloom, N. and Davis, S., op. cit.

25 See Orlik, A. and Veldkamp, L., "Understanding uncertainty shocks and the role of black swans", *NBER Working Paper Series*, No 20445, August 2014.

26 For more details, see Gieseck, A. and Largent, Y., "The impact of macroeconomic uncertainty on activity in the euro area", *Review of Economics*, Vol. 67, No 1, 2016, pp. 25-52. Alternative ways of aggregation such as the mean or first principal of the group of indicators evolve very similar to the median.

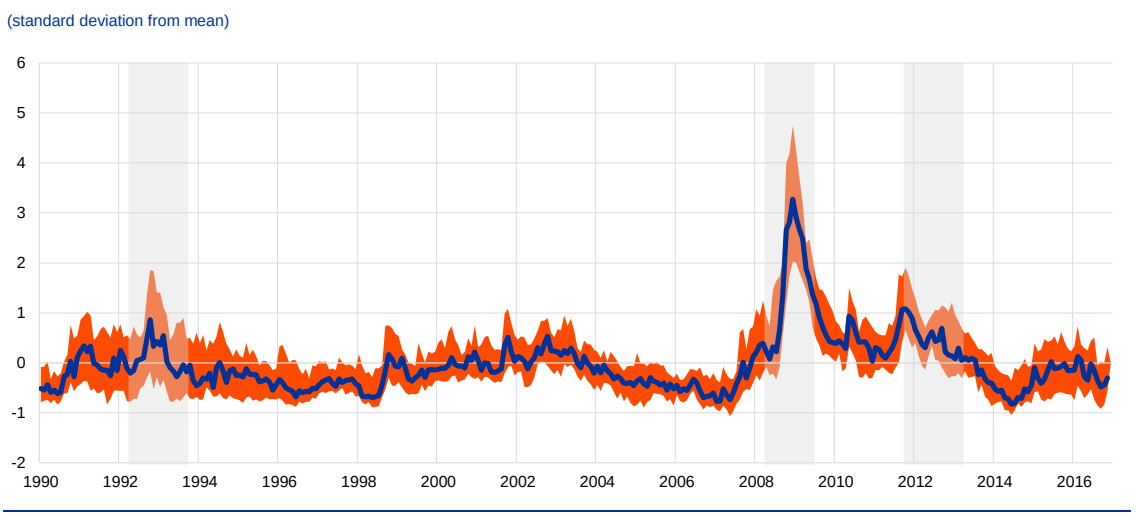
27 The peaks and troughs exhibited by the composite indicator of uncertainty are similar to those shown in alternative recent indicators. For example, Rossi, B. and Sekhposyan, T., "Macroeconomic uncertainty indices for the euro area and its individual member countries", September 2016, mimeo, develop an indicator based on exploiting forecast error distributions. Deutsche Bundesbank applies the methodology from Jurado et al. for the four largest euro area countries; see "Investment in the euro area", Deutsche Bundesbank, *Monthly Report*, January 2016, pp. 31-49.

(ERM) crisis in 1992/93, the Great Recession in 2008/09 and during the euro area sovereign debt crisis in 2011/13. It also shows peaks at some other times, notably the Long-Term Capital Management (LTCM) crisis in September 1998, the terrorist attacks in New York in September 2001 and the first Greek crisis in spring 2010. Uncertainty in the euro area, according to this indicator, decreased substantially as the current recovery started and recorded below average levels in 2014. However, it returned to its historical average level from early 2015 in the context of the debate on the debt crisis in Greece and, more recently, the referendum in the United Kingdom on EU membership.

Measured by the median, the composite indicator of uncertainty captures the joint development of all underlying proxies. In fact, the underlying individual proxies for uncertainty are in general significantly positively related to the median. However, its interpretation needs to take into account the development of individual indicators. For example, the increase of the composite indicator since early 2015 can be traced back to the economic policy uncertainty index for the euro area, which rose markedly during the course of 2015 and jumped to its highest level ever in July 2016 before receding in recent months (see Chart 4). Among its other components, aggregate and individual forecast uncertainties remain elevated at the current juncture, perhaps also reflecting an increased sensitivity of forecasters to the risks surrounding projections. All other proxies for uncertainty remain at or below their historical average levels.

Chart A

A composite index of macroeconomic uncertainty in the euro area



Sources: Baker, Bloom and Davis; Eurostat; European Commission; Consensus Economics; ECB; and ECB calculations.
Notes: The composite index of macroeconomic uncertainty in the euro area is standardised to mean zero and unit standard deviation over the full horizon. Areas in grey reflect euro area recessions as identified by the Centre for Economic Policy Research (CEPR).

The composite indicator of uncertainty in the euro area exhibits key characteristics similar to other recently published macroeconomic uncertainty indices. First, the indicator displays a wide range of observations; at its extremes, the indicator rose by up to three standard deviations from its mean in early 2009, and fell by up to one standard deviation below that level. Second, the indicator shows a positive skewness, which implies that the mass of the distribution of observed uncertainty levels is concentrated at below-average levels. In other words, the indicator suggests that there are more frequent and longer-lasting periods of low uncertainty than of high uncertainty. Third, the indicator also reveals a relatively high kurtosis. This implies that the distribution has tails that asymptotically approach zero more slowly than a Gaussian distribution. In other words, the

distribution of observed uncertainty levels includes more outliers (in this case on the right-hand side of the mean) than the normal distribution. Fourth, the half-life of a shock to the composite indicator of macroeconomic uncertainty (measured by the first lag in an autoregressive equation) is three quarters, implying a substantial persistence of the shock. This is substantially longer than the half-life of a shock to financial uncertainty, which lasts only around two quarters. Finally, the indicator is significantly negatively correlated to real GDP growth and other macroeconomic indicators. These key characteristics are comparable to the ones from recently published uncertainty indices for the United States.[28]

3 Fluctuations in uncertainty and their transmission to the economy

Overall, the theoretical and empirical literature finds adverse effects of uncertainty on the short-term outlook for growth.[29] Some uncertainty always exists in an economy as no one can perfectly assess the current economic situation, or what will happen in the future. But as uncertainty about the economy changes over time, it can affect decisions by economic agents. Increases in uncertainty are typically related to bad news, such as oil price shocks or terrorist attacks; increases in uncertainty stemming from positive news appear to be rather rare, probably as good news – such as e-commerce opportunities – tends to emerge more gradually over time.[30] The theoretical literature emphasises diverse channels through which high uncertainty can adversely affect the economy in the short term. However, the impact of uncertainty is less clear in general equilibrium models and, under certain circumstances, high uncertainty can also have a positive medium to long-term impact on the economy.[31]

The real options channel suggests that the option value increases with uncertainty in the case of irreversible investment or consumption decisions. In many cases, an investment or employment decision is irreversible or costly to revert on account of sunk costs or fixed adjustment costs: once constructed, a factory building cannot be undone without costs; once hired, staff can often not be fired without compensation. If an investor, facing such a decision, is uncertain about the

28 See Jurado, K., Ludvigson, S.C. and Ng, S., op. cit.

29 An overview is provided by Bloom, N. (2014), op. cit.

30 See Bloom, N. (2014), op. cit.

31 Under certain circumstances, high uncertainty can have a positive medium to long-term impact on investment. The so-called growth options effect arises if an increase in mean-preserving risk means higher expected future profits. This effect can arise if the costs of bad news (e.g. the new product under development turns out to be ineffective) can be curbed (to some sunk costs), while the benefits of good news (e.g. the new product turns out to be more profitable than expected) are unconstrained; See Kraft, H., Schwartz, E.S. and Weiss, F., "Growth options and firm valuation", *NBER Working Paper Series*, No 18836, February 2013. A second channel, known as the Oi-Hartman effect, is based on the idea that firms may become increasingly in favour of taking risks if they can easily expand to exploit good conditions (rising demand, rising prices) and also smoothly contract to weather bad conditions. Increases in cost or demand uncertainty would then increase expected profits if the latter increase more than proportionally to rising demand and/or increase more than proportionally to falling costs; see, for example, Abel, A.B., "Optimal investment under uncertainty", *American Economic Review*, Vol. 73, No 1, 1983, pp. 228-233; and Hartman, R., "The effects of price and cost uncertainty on investment", *Journal of Economic Theory*, Vol. 5, No 2, 1972, pp. 258-266.

future, it might be preferable to wait (i.e. postpone the decision to invest) until further information has become available and uncertainty has diminished.[32] In other words, the option-value of delay is high when uncertainty is high as waiting for more information (and less uncertainty) is likely to make for a better decision. As an analogy, it might be preferable for private households to postpone purchases of major durables like housing and cars in times of heightened uncertainty.[33] While the empirical literature has shown that adjustment costs can be rather substantial, the real options channel nevertheless rests on a number of critical assumptions. In particular, investors must be able to wait, and the costs of delay must be limited. These conditions might not be met, for example, in sectors with fierce competition and rapidly evolving innovation, such as in e-commerce.

Uncertainty can adversely affect the economy through increasing risk premia. Investors want to be compensated for higher risk, and rising uncertainty leads them to demand higher risk premia. Uncertainty could also lead to rising costs of debt financing; banks are likely to charge higher interest rates as uncertainty raises the probability of default. In both cases, the resulting higher cost of finance would adversely affect the economy via its impact on investment and consumption. In general equilibrium models, it can be shown that this effect is of particular importance in the presence of financial constraints.[34]

High uncertainty could lead private households to increase precautionary savings, which would reduce current private consumption. This effect is likely to weigh adversely on the economy in the short term, while its medium-term impact is less clear. To the extent that savers decide to keep these savings in their domestic economy, higher savings should lower the costs of finance and thereby facilitate investment and benefit longer-term growth prospects. However, to the extent that savings increase in excess of domestic financing needs, they are likely to be invested abroad, implying that heightened uncertainty reduces domestic demand.[35] In addition, the impact of precautionary savings on activity might turn negative if prices and interest rates do not fall enough to stimulate an increase in investment; this effect can be particularly damaging if interest rates are constrained by the zero lower bound.[36]

Uncertainty may not only reduce the level of investment, consumption or employment, but could also make the economy less sensitive to changes in business conditions. For example, if firms decide to postpone investment projects

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32 See, for instance, Bernanke, B.S., "Irreversibility, uncertainty and cyclical investment", *The Quarterly Journal of Economics*, Vol. 98, No 1, 1983, pp. 85-106.

33 See Eberly, J., "Adjustment of consumers' durables stocks: evidence from automobile purchases", *Journal of Political Economy*, Vol. 102, No 3, 1994, pp. 403-436.

34 See Gilchrist, S., Sim, J.W. and Zakrajšek, E., "Uncertainty, financial frictions, and investment dynamics", *NBER Working Paper Series*, No 20038, April 2014; Christiano, L.J., Motto, R. and Rostagno, M., "Financial factors in economic fluctuations", *ECB Working Paper Series*, No 1192, 2010; and Bonciani, D. and van Roye, B., "Uncertainty shocks, banking frictions, and economic activity", *Journal of Economic Dynamics and Control*, Vol. 73, 2016, pp. 200-219.

35 See Fernández-Villaverde, J., Guerrón-Quintana, P., Rubio-Ramírez, J. and Uribe, M., "Risk matters: the real effects of volatility shocks", *American Economic Review*, Vol. 101, No 6, 2011, pp. 2530-2561.

36 See Leduc, S. and Liu, Z., "Uncertainty shocks are aggregate demand shocks", *Journal of Monetary Economics*, Vol. 82, 2016, pp. 20-35; and Basu, S. and Bundick, B., "Uncertainty shocks in a model of effective demand", *NBER Working Paper Series*, No 18420, September 2012.

because of heightened uncertainty, the elasticity of investment with regard to changes in its driving factors would be lower than in periods with normal uncertainty. The reduced responsiveness of firms to react to changes in business conditions in periods of high uncertainty could also lead to pro-cyclical productivity growth: if productive firms are less aggressive in expanding and unproductive firms are less aggressive in contracting, the productivity-enhancing reallocation across firms would slow, thereby temporarily dampening aggregate productivity growth.[37]

Uncertainty might also have an impact on the effectiveness of economic policies, and could imply changes in composition of the optimal policy mix. For example, the reduced elasticity of investment to changes in business conditions, such as the level of interest rates, at times of heightened uncertainty would require a more substantial cut in interest rates to achieve the same impact on investment as in normal times.[38] Periods of heightened uncertainty could also require a different policy mix, as the latter might also need to include measures aimed at reducing the level of uncertainty, which would in turn make other policy measures more effective.

4 Empirical evidence on the impact of uncertainty

The empirical literature finds evidence for an adverse impact of uncertainty on activity. However, given the difficulties in measuring uncertainty mentioned above and the diversity of data sources and channels covered, it is understandable that the macroeconomic impact of various uncertainty measures can differ.[39] For the euro area as a whole, there is very limited evidence about the impact of uncertainty on activity as the empirical literature typically focuses on the United States or on individual euro area countries.[40]

A key challenge in the empirical literature is to distinguish the causal impact of uncertainty from the impact of other factors driving activity. Uncertainty tends to move with the business cycle, and shocks to uncertainty are unlikely to occur independently from other shocks. For example, an adverse shock to global demand dampens the outlook for companies' exports, thus causing a decline in expected output growth. Such a confidence (or first-moment) shock would lower the mean of the probability distribution of expected output growth, i.e. shift the probability density function of expected output growth to the left. However, companies might also envisage greater diversity in possible outcomes of the shock to global demand, thus

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37 See Bloom, N., Floetotto, M., Jaimovich, N., Saporta-Eksten, I. and Terry, S., "Really uncertain business cycles", *US Census Bureau Center for Economic Studies Paper*, No CES-WP-14-18, 2014.

38 See, for example, Aastveit, K.A., Natvik, G.J. and Sola, S., "Economic uncertainty and the effectiveness of monetary policy", Norges Bank, *Working Paper*, No 2013/17, 2013, who find that the impact of US monetary policy on investment in the United States is half as large if uncertainty is in its top decile rather than in its bottom decile.

39 See Rossi, B. and Sekhposyan, T. (2015), op. cit.

40 See, for example, Popescu, A. and Smets, F.R., "Uncertainty, risk-taking, and the business cycle in Germany", *CESifo Economic Studies*, Vol. 56, No 4, 2010, pp.596-626; Basselier, R. and Langenus, G., "Recent changes in saving behaviour by Belgian households: the impact of uncertainty", *NBB Economic Review*, December 2014, pp. 53-62; and Busetti, F., Giordano, C. and Zevi, G., "Main drivers of the recent decline in Italy's non-construction investment", *Questioni di Economia e Finanza*, No 276, June 2015.

becoming more uncertain about the outlook. In this case, it is likely that the mean expectation for output growth would decline, and the likelihood of much lower and much higher future outcomes would increase (second-moment shock).[41] A key problem is to distinguish the impact of first-moment shocks (on the mean of a probability distribution) from uncertainty shocks (on the width of the probability distribution).

The literature presents three approaches to identify the causal effects of uncertainty on activity. A standard approach has been to rely on timing: estimating the movements in output, investment and employment that follow jumps in uncertainty.[42] This approach is problematic if changes in uncertainty are correlated with other factors driving the economic cycle, but which are not included in the empirical model. In this case, the economic impact attributed to changes in uncertainty could at least partly reflect the impact of omitted variables. A second approach has been to use structural general equilibrium models to quantify the impact of uncertainty shocks.[43] A key problem in this approach is the need to rely on a – sometimes large – set of assumptions, and to take into account the uncertainty around their validity. A final approach relies on events such as natural disasters, political coups, terrorist attacks, etc. to identify uncertainty shocks.[44] An issue with this approach is that such shocks might influence the behaviour of investors and consumers beyond changes in uncertainty. For example, agents might decide or be forced to relocate production facilities to safer places in the aftermath of such events.

Time-series models have been the standard approach to estimate the impact of uncertainty shocks on activity. Vector autoregressive (VAR) models have been widely used to capture the existing dynamic relationship between various macroeconomic variables. A VAR model is a system of equations where every variable is dependent on its own past values and the past values of all other variables in the system. Uncertainty and economic activity therefore depend on each other. It is then possible to introduce an exogenous shock to the uncertainty equation and observe its impact on all variables within the system. The empirical results in VAR models are typically derived from so-called impulse response functions which display the impact of a typical change in one variable on all variables captured within the system. These shocks typically amount to one standard deviation of the historical volatility of the variable and are typically temporary, with the unwinding of the shock itself endogenously being determined within the model. Structural VAR models have proved especially useful in this context as they allow for an improved identification and estimation of the true uncertainty shocks.[45] Such analysis has been carried out

41 In addition, companies might also become increasingly concerned about extreme events, such as the possibility of a global recession (third-moment shock).

42 See, for instance, Bloom, N. (2009) op. cit.; and Bloom, N., Bond, S., and Van Reenen, J., "Uncertainty and investment dynamics", *Review of Economic Studies*, Vol. 74, No 2, 2007, pp. 391-415.

43 See, for instance, Bloom, N., Floetotto, M., Jaimovich, J., Saporta-Eksten, I. and Terry, S. J., op. cit.; and Bonciani, D. and van Roye, B., op. cit.

44 See, for instance, Baker, S.R. and Bloom, N., "Does uncertainty reduce growth? Using disasters as natural experiments", *NBER Working Paper Series*, No 19475, September 2013.

45 The Cholesky decomposition of the variance-covariance matrix of the VAR residuals is the most commonly applied identification methodology used to estimate uncertainty shocks elasticities to the endogenous variables.

to quantify the impact of uncertainty shocks on economic activity for the United States and a few individual countries[46] by using different proxies to measure the level of uncertainty (implied equity market volatility, economic policy uncertainty, financial uncertainty or macroeconomic uncertainty).

VAR models typically show an initial adverse impact of uncertainty shocks, but differ on duration and persistence of the impact. Most empirical studies focus on the United States and on industrial production as an economic activity indicator. For example, a temporary one standard deviation increase in implied stock-market volatility as a proxy for uncertainty is found to be associated with a rapid drop in industrial production followed by a sharp rebound, suggesting that uncertainty shocks amplify the magnitude of business cycles. In comparison, a temporary first-moment shock to the federal funds rate displays a much more persistent drop and subsequent recovery.[47] Other studies, although using different indicators of uncertainty, exhibit far more protracted responses of industrial production and employment than those using an implied stock market volatility indicator; in addition, shocks to these uncertainty indicators do not generate any significant overshooting.[48] Other studies find evidence of an asymmetric impact of uncertainty shocks during the cycle, showing that activity reacts more strongly to increases in uncertainty during recessions than during periods of expansion.[49] For the euro area, it has been shown that uncertainty indicators based on European Commission surveys and on economic policy uncertainty can be successfully added to standard regression equations for private consumption and investment, showing significantly negative effects of increases in uncertainty; in addition, the impact of uncertainty appears to have increased since the Great Recession.[50]

Box 2
Quantifying the effects of uncertainty shocks on economic activity in the euro area

This box summarises some results from an analysis of the impact of uncertainty shocks on euro area activity using a Bayesian vector autoregressive (BVAR) model. One problem with structural VAR models is that only a limited number of endogenous variables can be included; this raises the possibility that the estimated impact of an uncertainty shock might, at least partly, reflect

46 See, for instance, Bijsterbosch, M. and Guérin, P., "Characterizing very high uncertainty episodes", *Economics Letters*, Vol. 121, No 2, 2013, pp. 239-243; Carriero, A., Mumtaz, H., Theodoridis, K. and Theophilopoulou, A., "The impact of uncertainty shocks under measurement error: a proxy SVAR approach", *Journey of Money, Credit and Banking*, Vol. 47, No 6, 2015, pp. 1223-1238; and Popescu, A. and Smets, F.R., op. cit. For the euro area, see Gieseck, A. and Largent, Y., op. cit.

47 See Bloom, N. (2009), op. cit.

48 See Jurado, K., Ludvigson, S.C. and Ng, S., op. cit., who use a measure of uncertainty derived from a stochastic volatility model; Jo, S. and Sekkel, R., "Macroeconomic uncertainty through the lens of professional forecasters", Bank of Canada, *Staff Working Paper*, No 2016-5, 2016, who exploit forecast errors as measure of uncertainty; Bachmann, R., Elstner, S. and Sims, E.R., op. cit., who use survey data; and Baker, S.R., Bloom, N. and Davis, S.J., op. cit., who use newspaper articles as a measure of uncertainty.

49 See, for example, Ferrara, L. and Guérin, P., "What are the macroeconomic effects of high-frequency uncertainty shocks?", Université de Paris Ouest, *Working Paper 2015-12*, 2015; and Caggiano, G., Castelnuovo, E. and Groshenny, N., "Uncertainty shocks and unemployment dynamics in U.S. recessions", *Journal of Monetary Economics*, Vol. 67, 2014, pp. 78-92.

50 See Balta, N., Valdes Fernandez, I. and Ruscher, E., "Assessing the impact of uncertainty on consumption and investment", European Commission, *Quarterly Report on the Euro Area*, Vol. 12, No 2, 2013, pp. 7-16.

the impact of shocks to other variables not included in the model. However, using Bayesian estimation methods, it is possible to specify VAR models which include a much larger number of endogenous variables and which thus may help to better distinguish the impact of uncertainty shocks from that of other variables. The model discussed in this box includes twenty-one macroeconomic variables, including real GDP and its expenditure components, some nominal variables and a number of important cyclical driving factors.[51] The composite indicator of macroeconomic uncertainty shown in Box 1 is used as a proxy for macroeconomic uncertainty in the euro area. The model is estimated over the period from the first quarter of 1987 to the second quarter of 2016 using quarterly data, with four lags.[52] The model is then used to simulate the dynamic effects of an adverse macroeconomic uncertainty shock[53] on the euro area economy.

The generalised impulse response functions show that temporary uncertainty shocks have strong adverse impacts on economic activity in the euro area (see Chart A). Following an increase in uncertainty by one standard deviation, real GDP growth is dampened for up to three quarters. The biggest impact is observed in the second quarter after the shock, and the total impact on real GDP is estimated to amount to around 0.3 percentage point. Among the components of expenditure, and in line with theory, real investment growth is found to be significantly more affected than real private consumption growth.[54] The adverse impact on employment growth appears to be somewhat weaker in total, albeit more persistent. It is interesting to note that this model shows some (albeit hardly significant) overshooting of real GDP growth after the initial adverse shock, consistent with the real option value strand of the economic literature.[55]

51 These macroeconomic variables are: macroeconomic uncertainty, real GDP, real private consumption, total employment, real imports, real exports, real investment, real government consumption, world demand, oil prices, commodity prices (excluding energy), the USD/EUR exchange rate, EURO STOXX 50 index, the long-term interest rate, the savings rate, compensation per employee, HICP (excluding energy), consumer confidence, manufacturing confidence, construction confidence, and the short-term interest rate.

52 The large BVAR methodology and the priors used in this analysis are described in Bańbura, M., Giannone, D., and Reichlin, L., "Large Bayesian vector auto regressions", *Journal of Applied Econometrics*, Vol. 25, No 1, 2010, pp. 71-92. A Cholesky decomposition is applied on the variance-covariance matrix of the residuals in order to estimate the shock elasticities.

53 The shock corresponds to a positive one standard deviation shock to macroeconomic uncertainty. The responses of the macroeconomic variables are estimated using a variant of the generalised impulse response function (GIRF) methodology described in Koop, G., Pesaran, M.H. and Potter, S.M., "Impulse response analysis in nonlinear multivariate models", *Journal of Econometrics*, Vol. 74, No 1, 1996, pp. 119-147.

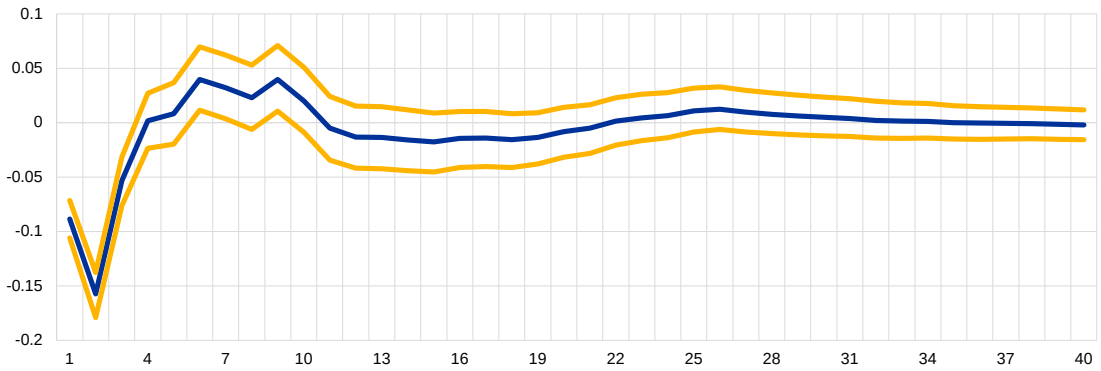
54 These results are comparable to those found by Bonciani, D. and van Roye, B., op. cit. based on a small Bayesian VAR model and using implied stock market volatility as a proxy for uncertainty.

55 For a similar finding in the case of an adverse, temporary shock on investment in Germany and France, see Bundesbank, op. cit.

Chart A

Responses of real GDP growth following a temporary shock on macroeconomic uncertainty

(percentage point)

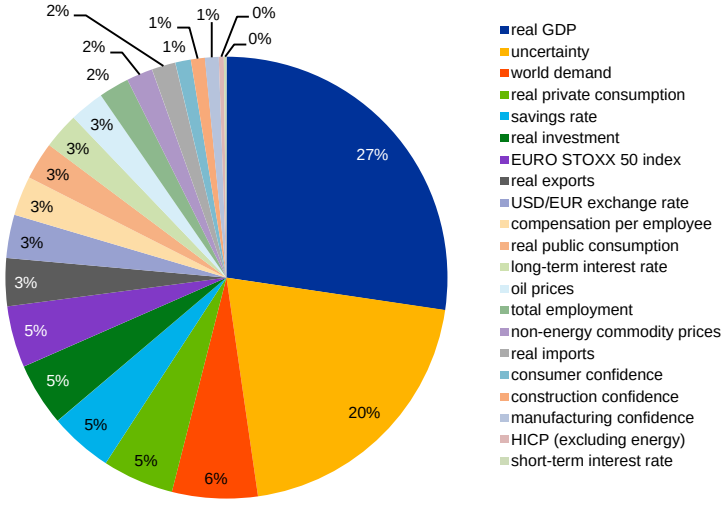


Source: ECB calculations.
Note: The blue line denotes the median response of real GDP growth and the yellow lines denote the 95% one standard deviation confidence bands.

Uncertainty shocks appear to contribute significantly to real GDP growth fluctuations in the euro area. To assess the quantitative importance of uncertainty shocks for macroeconomic fluctuations, Chart B reports the forecast error variance decomposition for real GDP growth.[56] On average over the whole forecast horizon (forty quarters), macroeconomic uncertainty is estimated to have contributed significantly to real GDP growth fluctuations in the euro area, second only to the lagged contribution of past real GDP growth.[57]

Chart B

Average shock contribution to euro area real GDP fluctuations



Source: ECB calculations.
Notes: The chart depicts the average shock contribution to real GDP fluctuations (in percentages), computed from a forecast error variance decomposition performed over a horizon of forty quarters. The composite indicator of macroeconomic uncertainty presented in Box 1 has been used as a proxy for uncertainty. The legend (on the right) displays the nature of the shocks according to their level of contribution.

56 The forecast error variance decomposition denotes the proportion of the h-step ahead forecast error variance of an endogenous variable which is accounted for by each estimated structural shock.

57 Jurado, K., Ludvigson, S.C., and Ng, S., op. cit., show similar contributions of macroeconomic uncertainty for real GDP growth dynamics in the United States.

Further analysis of the transmission of uncertainty shocks to activity is warranted. The results presented above are robust to various tests, including different ordering of variables within the system and using other priors that have been applied in large BVAR models. One particular problem with large BVAR models is that they make it increasingly difficult to apply identification schemes – other than the standard Cholesky decomposition – which allow theory-based restrictions to be imposed. In addition, the inclusion of further variables into the system could further help to disentangle the impact of uncertainty shocks. These variables could include indicators on financial frictions and liquidity constraints.

5 Conclusion

While difficult to observe and quantify, there is some evidence that increases in uncertainty can adversely impact the economy. The economic literature offers many different ways to measure uncertainty, and in combining these approaches and the various data sources it might be possible to achieve a useful composite indicator of uncertainty for the euro area.

Given its potential role as a driver of business cycles in the euro area, it is important to construct and monitor indicators of uncertainty, for forecasters and policymakers alike. An assessment of the current level of uncertainty and an assumption about expected uncertainty during the projection horizon is imperative for any projection, and scenario analysis capturing the estimated impact of possible uncertainty shocks can serve as an indication of the risks surrounding projections. For policymakers, in times of heightened uncertainty, optimal policies might include measures aimed at reducing this uncertainty and mitigating its impact.