Box I.1: The economic impact of uncertainty assessed with a BVAR model

This box underpins the assessment of the impact of uncertainty in section I.1 using model estimations. It first presents the concept of uncertainty as well as different indicators, including those derived from Commission datasets. The impact of uncertainty on economic activity in the euro area is then analysed using an econometric model.

If there are different types of uncertainty, their impact should be assessed separately. If there is only a single uncertainty, it is more useful to combine various uncertainty indicators into a single measure. Below, both approaches are followed, but the fundamental lack of knowledge about the nature of uncertainty is not solved.

Four main classes of uncertainty indicators have been proposed in the literature. Firstly, *financial market indicators*, such as the implied or historical volatility of stock market returns [(1)], sometimes including volatility in exchange rates and sovereign bond markets. While such measures are available in real time and at high frequency [(2)], changes in financial market volatility may be related to changes in overall market sentiment or investor risk aversion, rather than uncertainty itself [(3)]. Uncertainty as perceived by financial markets may also not be fully representative of other parts of the economy. Secondly, *news-based indicators*, or 'Economic policy uncertainty' rely on the frequency of key words in selected newspapers [(4)]. As in the previous case, it is questionable if a measure based on articles in selected newspapers is fully representative. Moreover, due to the fact that the concept of uncertainty has become popular in recent years, it might be that the frequency of the key words has increased and that the values of such indicators might not be entirely comparable across time. Finally, this measure does not distinguish between domestic or foreign sources of uncertainty.

Thirdly, *survey-based indicators* assess the dispersion of answers (regarding expectations for the future) in surveys such as the Commission's Business and Consumer Survey (BCS). This measure tracks responses of households and non-financial corporations, whose decision about consumption and investment are closely linked to overall economic developments [(5)]. However, the heterogeneity among firms and consumers, as well as differences in the information they possess can cause divergence in opinion across the business cycle irrespective of the subjectively perceived uncertainty [(6)].

And finally, *macroeconomic data sets and forecasts* are used to infer uncertainty following two approaches. The first rely on the dispersion of forecast (or alternatively on the dispersion of forecast errors) of individual macroeconomic variables by professional forecasters (e.g. consensus forecasts). Representativeness could be an issue here as well and (like in the survey-based measures) the dispersion can reflect different information available to the forecasters rather than true uncertainty [(7)]. The second approach attempts to identify moments when the economy becomes less predictable [(8)]. Uncertainty here is proxied by the unforecastable component of a large set of macroeconomic variables.

(1) Bloom, N. (2009). 'The impact of uncertainty shocks'. *Econometrica*, 77(3), pp. 623-85.

(2) The implied volatility, which unlike the historical volatility is a forward-looking measure, is based on some option pricing model. Options with the same maturity needed for its calculation are available only for large euro area countries.

(3) Baker, S.R. and N. Bloom (2013). 'Does uncertainty reduce growth? Using disasters as natural experiments'. NBER Working Paper 19475. address endogeneity between stock developments and business cycle using natural catastrophes and terrorist attacks as an exogenous instrument for the former.

(4) Baker, S.R., S.J. David and N. Bloom (2016). 'Measuring economic policy uncertainty'. *Quarterly Journal of Economics*, 131(4), pp. 1593-1636. The measure is currently available only for five largest euro area countries.

(5) Bachmann, R., S. Elstner and E. R. Sims (2013). 'Uncertainty and economic activity: evidence from business survey data.' *American Economic Journal: Macroeconomics*, 5(2), pp. 217-49.

(6) Girardi, A. and A. Reuter (2017). 'New uncertainty measures for the euro area using survey data'. *Oxford Economic Papers*, 69 (1), pp. 278-300.

(7) Rossi, B. and T. Sekhposyan (2015). 'Macroeconomic uncertainty indices based on nowcast and forecast error distributions.' *The American Economic Review*, 105(5), pp. 650-55.

(8) Dovern, J. (2015). 'A multivariate analysis of forecast disagreement: Confronting models of disagreement with survey data'. *European Economic Review*, 80, pp. 16-35. Jurado, K., S.C. Ludvigson and S. Ng (2015). 'Measuring uncertainty'. *The American Economic Review*, 105(3), pp. 1177-1216.

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Box (continued)

The economic impact of uncertainty using BVAR model

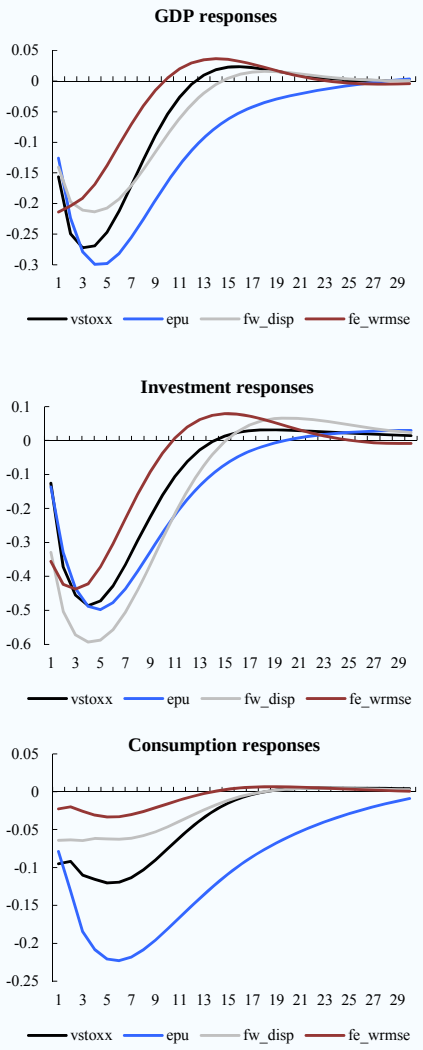
A Bayesian Vector Autoregression (BVAR) model is estimated on quarterly data for 1999-2016 [9]. It uses four alternative measures of uncertainty corresponding to the categories [10]: Financial-market volatility (VSTOXX), economic policy uncertainty (EPU), survey-based uncertainty (FW_DISP) and forecast errors (FE_WRMSE). The baseline model then includes 6 variables (alongside with constant term and linear trend to control for nonstationarity of some variables): stock prices, the economic survey indicator (ESI), the respective uncertainty measure, short-term interest rates (EONIA), log HICP and log GDP, consumption or inflation, respectively. The model is estimated with two lags (based on lag-length selection criteria). The results show generalised impulse-response functions (that are invariant to the ordering of variables in the BVAR) on one-off shock to uncertainty measures. Graph 1 documents the impact of uncertainty shocks on GDP, investment and consumption in the euro area using impulse-response functions from the estimated model. The bootstrapped confidence intervals are not reported because too many lines would make the graph unreadable.

The estimations suggest:

(i) An unexpected spike in uncertainty (of about one standard deviation of the relevant uncertainty indicator) has a negative impact on economic activity in the euro area with the impact increasing until around five quarters after the uncertainty shock.

(ii) While the persistence of responses differs slightly across uncertainty measures, the impact of an uncertainty shock takes around three years (12 quarters) to fully dissipate. There is little evidence of a subsequent overshooting of economic activity, thus confirming other results that suggest that uncertainly shocks imply a permanent output loss [11].

Graph 1: **Impact of uncertainty on the euro area GDP, consumption and investment**



(iii) The impact of uncertainty on overall output seems to be driven mainly by a decline of investment, most notably when the survey-based uncertainty measure (FW_DISP) is used.

[9] Shorter in some specification due to the data availability. The BVAR is employed to correct for a rather lower number of observations by imposing prior beliefs about the parameters of the model. More specifically, the common Minnesota/Litterman priors are applied.

[10] The concrete variables are described in Section I.1., footnote 6.

[11] The confidence intervals are not included not to clutter the graphs. However, they clearly suggest that while decline in economic activity following an uncertainty shocks is statistically significant for all the indicators, the subsequent overshooting is not.

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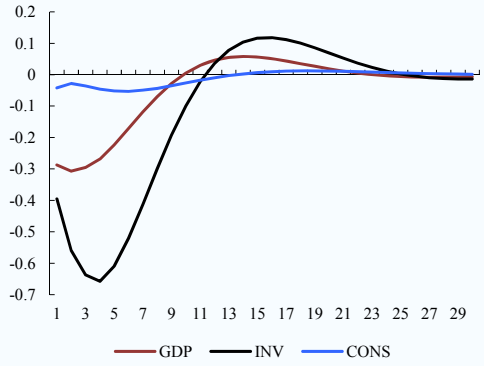
Box (continued)

Most indicators of uncertainty do not affect consumption in a significant manner. By contrast, the response of consumption is notable only when the economic policy uncertainty (EPU) indicator is used. This could suggest that EPU captures a dimension of uncertainty that is different from the uncertainty measured by the other indicators.

(iv) The decline of economic activity reaches around 0.25% in the case of GDP and 0.5% in the case of investment compared to the baseline following a standard uncertainty shock (one deviation). As it will be shown below (see Graphs 2 and 3), the impact can be even reinforced in case of generalised uncertainty or in the case of a very persistent uncertainty shock.

(v) Based on variance decomposition analysis, the uncertainty shocks could explain 30% of the variability of GDP and investment, and around 15% of the variability of consumption (after 12 quarters). That means that almost one third of the dynamics of GDP and investment may be driven by uncertainty shocks.

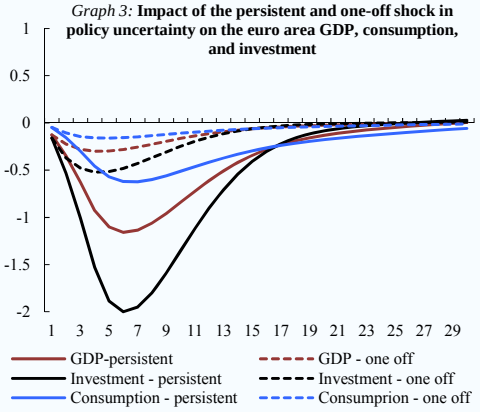
Graph 2: **Responses to uncertainty factor**



The previous analysis implicitly assumed that different measures of uncertainty represent different types of uncertainty. In terms of policy usefulness, it is indeed important to understand what type of uncertainty (or what type of uncertainty proxy) matters most for real economic developments. However, one can also reasonably assume that different measures of uncertainty represent noisy proxies of the same concept of uncertainty. [12]

Consequently, factor analysis was applied to these four alternative measures of uncertainty to identify potential commonalities. The analysis revealed that a single common factor, representing an overall level of uncertainty in the economy (irrespective of its source), is able to explain a large share of the variability present in the series [13].

Graph 3: **Impact of the persistent and one-off shock in policy uncertainty on the euro area GDP, consumption, and investment**



The results tracking the impact of uncertainty using this common factor are presented in Graph 2. The decline of investment is deeper in this case but there is some indication of subsequent overshooting. The stronger response of investment seems to be related to the fact that the common factor represents rather extreme cases of uncertainty, when spikes coincided for most of the indicators. By contrast, it is interesting to note that the response of consumption is very muted. This could be explained by consumption smoothing, for example when even large uncertainty shocks affect purchases of some durable goods but not the overall consumption basket. This reflects that in general consumption is much less volatile than investment, and, therefore, is likely to be less affected by diverse shocks.

[12] Haddow, A., Ch. Hare, J. Hooley and T. Shakir (2013). "Macroeconomic uncertainty: what is it, how can we measure it and why does it matter?" *Bank of England Quarterly Bulletin* 2013 Q2. ECB (2016), op. cit.

[13] Principal factor method is used with number of factors determined by minimum average partial. Most measures are highly correlated with the estimated common factor (i.e. have relatively high factor loading) with the exception of the EPU reflecting its low correlation with the other measures.

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Box (continued)

A potential limitation of this empirical approach is its focus on one-off uncertainty shocks. However, as recent experience suggests, numerous (mainly policy) uncertainty-generating events can occur sequentially resulting in a prolonged period of uncertainty.

To study the impact of such a prolonged period of uncertainty, a persistent shock to uncertainty was assumed. More specifically, a new uncertainty shock is assumed to occur every quarter for a year keeping uncertainty at a high level. This is inspired by developments in recent quarters, such as the UK's vote to leave the EU, which was followed by the US election campaign and the policy uncertainty in its aftermath, constitutional changes in Italy that were rejected by referendum, and elections lined up in several large EU economies.

Graph 3 summarizes the impact of a persistent versus a one-off shock in uncertainty, measured by policy uncertainty, on investment, consumption and GDP. Such a persistent shock unsurprisingly depresses all the three macroeconomic variables substantially more than in the case of an isolated shock. Investment is still the most affected and could decline up to 2%. Persistent uncertainty shocks also represent a danger of a long-term impact on the productive capacity of the economy as a sustained decline in investments affects the capital stock, slows down total factor productivity growth and increases the risks of hysteresis on the labour market with a more significant decay of existing (human, knowledge and physical) capital.