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Uncertainty Fluctuations: Measures, Effects and Macroeconomic Policy Challenges

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Summary

"The outlook is subject to considerable uncertainty from multiple sources, and dealing with these uncertainties is an important feature of policymaking." Janet L. Yellen, Chair of the Board of Governors of the Federal Reserve System, speech "Inflation, Uncertainty, and Monetary Policy" given the 26 September 2017.

There has been a strong focus in recent policy debates, on the various types of uncertainty in the global economy from economic policy uncertainty to financial volatility. This Policy Brief presents the key challenges raised by this phenomena: How to measure uncertainty? Through which channels does uncertainty impact the economy? What are the implications of uncertainty for policy makers? We show evidence from the literature that uncertainty has adverse effects on the economic activity and draw three lessons for policy-makers facing increasing uncertainties. First, macroeconomic policies have a direct role to play in stabilizing policy-related uncertainty. Second, financial uncertainty should be modulated through financial regulation. Third, the effectiveness of economic stabilization policies depends on the state of uncertainty and should be adapted accordingly.

"The outlook is subject to considerable uncertainty from multiple sources, and dealing with these uncertainties is an important feature of policymaking." Janet L. Yellen, Chair of the Board of Governors of the Federal Reserve System, speech "Inflation, Uncertainty, and Monetary Policy" given the 26 September 2017.

"Today I want to discuss what uncertainty means for the UK's economic performance, and how the Bank of England can best respond to it." Mark Carney, Governor of the Bank of England, speech "Uncertainty, the economy and policy" given the 30 June 2016.

"And, finally, we need prudence. As the economy picks up we will need to be gradual when adjusting our policy parameters, so as to ensure that our stimulus accompanies the recovery amid the lingering uncertainties." Mario Draghi, President of the ECB, speech "Accompanying the economic recovery" given the 27 June 2017.

Introduction

There has been a strong focus in recent policy debates, on the various types of uncertainty in the global economy. Those discussions are motivated mainly by the fact that the global economic activity was extremely sluggish in the wake of the Global Financial Crisis (GFC), or at least much slower than most economists expected. Among the possible drivers of this sluggishness, business investment is frequently cited, and it appears that investment rates post-GFC have been much lower than those observed pre-2007. Also, uncertainty is a standard explanation in policy explanations for weak investment. Ten years after the GFC, uncertainty remains at the top of the policy makers agenda as can be seen from the comments made by central bankers, quoted above.

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By its nature, uncertainty is an unobservable variable and thus there are various approaches to its measurement. Compared to ten years ago, there is ongoing rich and active research efforts aiming at providing uncertainty measures. For example, the VIX has been extensively used as a measure of uncertainty reflecting the volatility in financial markets. The lack of consensus among forecasters surveyed is another widely used measure of uncertainty; it is assumed that there is a direct positive link between uncertainty about the future and the way opinion surveys diverge. More recently, text-based analyses have been used to assess perception of uncertainty by counting specific words in large databases of newspapers articles. Those new measures have been integrated by policy-makers into policy debates, and are shedding light on the concept of uncertainty leading in turn, to the development of new measures, within a virtuous circle. Following the GFC, economists have tried to achieve a better understanding of how fluctuations in these measures of uncertainty might influence the economy by offering numerous mechanisms through which uncertainty fluctuations are transmitted to the economy. Some channels are well known, for example the "wait-and-see" investment channel, especially for the most irreversible type of investment, and the precautionary savings channel. However, evidence on other channels is more recent, and we refer for example, to the role played by financial frictions. Uncertainties affect not just domestic activity. Indeed, the increasing integration of finance and trade has generated greater connectedness in the world economy with the result that an uncertainty shock is likely to propagate across borders.

Finally, it is clear that economic policy decisions are affected by the evolution of uncertainty. In a recent speech, Janet Yellen (2017) showed how uncertainties about the economic outlook are related to macroeconomic activities, to the assessment of the slack in the labor market and to measures for expected inflation and how these expectations weigh on monetary policy decisions, particularly in terms of unwinding unconventional monetary policy measures. Similarly, the great uncertainty about upcoming economic activity renders policy-making and policy decisions more complex in the context of the implementation of fiscal measures or structural reforms, whose effects, it is well known, are sensitive to the state of the economy (see, *e.g.* IMF, 2016). At the same time, economic policies have a role to play in reducing the various types of uncertainty by anchoring agents' expectations to a transparent and clear commitment. In this respect, forward guidance used by central banks for the future direction of short-term interest rates or multi-year credible fiscal consolidation plans are efficient ways to conduct economic policy while reducing uncertainty.

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In view of the buoyant literature on the topic, this Policy Brief is an attempt to review some recent results. We do not pretend to provide an exhaustive review of the papers dealing with the concept of uncertainty, rather we try to focus on the key challenges raised by the concept:

- How to measure uncertainty?
- Through which channels does uncertainty impact the economy?
- What are the implications of uncertainty for policy-makers?

To address these issues, in the first section we present various measures of uncertainty used by practitioners and their advantages and drawbacks. We then discuss the main macroeconomic effects of uncertainty fluctuations and the various channels through which they operate. In the final section, we discuss some policy implications and we draw three main lessons stemming from our reading of the literature:

- Lesson 1: Macroeconomic policies have a direct role to play in stabilizing policy-related uncertainty.
- Lesson 2: Financial uncertainty should be restrained by financial regulations.
- Lesson 3: The effectiveness of economic stabilization policies depends on the state of uncertainty and should be adapted accordingly.

1. Measuring uncertainty fluctuations

There has been a focus in recent policy debates on the uncertainties surrounding the global economy. The concept of uncertainty is not new; for instance, Knight (1921) in a seminal paper makes a conceptual difference between risk and uncertainty, while Bernanke (1983) considers the effect of uncertainty on investment. By its nature, uncertainty is an unobservable variable, and thus, to be estimated using various approaches. What has changed over the last ten years is that a rich and active literature has emerged proposinguncertainty measures. Those new measures have been integrated into policy debates by policy-makers to shed light on the concept of uncertainty which in turn has led to the development of new measures, within a virtuous circle. In this chapter, we do not pretend to provide an exhaustive review of the papers dealing with this concept but rather focus on the most popular measures of uncertainty and the provision of a sensible classification.

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First, we need to revisit the conceptual difference between risk and uncertainty proposed in Knight (1921). Risk corresponds to a situation where the distribution of probabilities for a series of events is known. Within this framework, risk assessment corresponds to estimation of the quantiles of the distribution based on learning. On the other hand, uncertainty, sometimes referred to as deep or radical uncertainty, describes a situation in which agents have no way of predicting the probability that an event will occur. For example, Brexit corresponds more to the concept of uncertainty since it is the first time that a country has taken the decision to leave the European Union. However, from an empirical point of view, the recent literature tends not to make this distinction as can be seen from Bloom's (2014) recent review.[1] Therefore, in the rest of this section we consider volatility as one of various measures of uncertainty based on the understanding that it refers to both risk and uncertainty.

1.1. Uncertainty on financial markets

Traditionally, uncertainty is defined generally in terms of financial uncertainty, and has been described as stock market volatility in the empirical parts of some influential papers (see Bloom, 2009). The VIX index constructed by the Chicago Board of Option Exchange, sometimes called the fear index in financial markets, is the most widely used measure in the empirical literature and is aimed at assessing the effects of uncertainty shocks (see Figure 1). This index is a measure of 30-day volatility in the S&P500 index implied by option bid/ask quotes, and thus, reflects the expectations of agents in the equity market. Therefore, the VIX can be seen as a fairly broad measure of uncertainty since it captures uncertainty related directly to both equity markets and also the macroeconomic environment to the extent that it is related to financial developments. The VXO index which is based on S&P100 stock futures has also been used in empirical analyses, and starts earlier (January 1986 compared to January 1990 for the VIX). The monthly correlation between these two indicators is very high, close to 1. Bloom (2009) proposed to back-calculate the VXO to 1962 by taking the standard deviation of the daily S&P500 index normalized to the same mean and variance as the VXO when they overlap after 1986.

An alternative to the VIX / VXO is realized stock market volatility which has the great advantage that it is model-independent and simple to compute but it does not reflect expectations. For example, Chauvet and Zeynup (2014) use realized volatility to show empirically that it has a large negative impact on economic growth and employment in the US economy.

Lastly, financial volatility can be estimated using an econometric model that explicitly integrates conditional variance or stochastic volatility as in Ferrara *et al.* (2014) or Carriero, Clark and Marcellino (2016). For example, using a mixed-frequency model, Ferrara *et al.* (2014) find that using daily stock price volatility, estimated using a GARCH-type model, allows significant improvements in output forecasting accuracy for a set of advanced economies.

(1) "In this article, I'll refer to a single concept of uncertainty, but it will typically be a stand-in for a mixture of risk and uncertainty" (Bloom, 2014).

These measures of uncertainty are widely used in the empirical literature looking at the effects of uncertainty shocks but have been criticized, in particular because they integrate a time-varying risk premium which may not be directly related to uncertainty (*e.g.*, depressed demand leads to an increase in the risk of business failure, and therefore, a higher risk premium). In this respect, Bekaert, Hoerova and Lo Duca (2013) propose an approach to decompose the VIX into two components: an uncertainty measure, and a proxy for risk aversion.

1.2. Micro-level measures of uncertainty

Uncertainty can be assessed also using micro-level approaches. Following the introduction of financial volatility measures, some authors have proposed the estimation of uncertainty using high-frequency firm-level stock market returns. Typically, a standard deviation over a certain period of time is computed for a specific company. For example, Bloom, Bond and van Reenen (2007) use daily stock prices for a large panel of UK manufacturing firms to compute annual uncertainty measures. Bloom (2009) uses the within month cross-sectional standard deviation of US firm-level stock returns from the Center for Research in Securities Prices (CRSP). Gilchrist, Sim and Zakrajsek (2013) construct a proxy for idiosyncratic uncertainty using high-frequency firm-level stock market returns based on a panel of more than 11000 US non-financial corporations (see Figure 1). First, they estimate daily excess returns purged of their forecastable component using a standard factor model, then in a second step, they calculate a quarterly firm-specific standard deviation of daily returns that is supposed to reflect idiosyncratic uncertainty.

In his seminal paper, Bloom (2009) proposes two other cross-sectional measures of uncertainty based on US micro data. First, he uses the cross-sectional standard deviation of firms' pretax profit growth, from the quarterly national accounts of public companies. Those data are normalized by average sales for the period. Second, he computes the standard deviation of annual five-factor total factor productivity (TFP) growth taken from the NBER manufacturing industry database. He shows that those measures are strongly correlated to stock market return volatility (see Bloom, 2009, Table 1, p. 629).

Similarly, Bloom *et al.* (2012) construct measures of uncertainty at various aggregate levels (establishment, firm, industry) by computing standard deviations of TFP shocks estimated as residuals of a first order autoregressive panel regression.

1.3. Economic Policy Uncertainty

Economic policy uncertainty (EPU) has been at the heart of recent major uncertainty shocks that have affected the global economy, ranging from suspicions of currency manipulation in China to the Brexit situation, through unexpected political elections outcomes. All those events are generating uncertainties about the implementation of economic and social programs. Measuring the influence of such events is not easy, and the recent literature focuses mainly on textual analysis and news-based metrics to assess this type of

Figure 1 – Comparison of various measures of uncertainty for the US economy since 1990: VIX, EPU , JLN, Survey and IVOL

Source: Jurado, Ludvingson and Ng (2015) JLN, Ozturk and Sheng (2017) Survey and Gilchrist *et al.* (2015) IVOL (shaded areas corresponds to US recessions).

economic policy uncertainty – earlier work such as that by Julio and Yook (2012), use the election cycle to measure political uncertainty. Nick Bloom and co-authors have been at the forefront of this type of measurement. In a recent paper (Baker, Bloom and Davis, 2016), they proposed monthly economy policy uncertainty (EPU) indices for the US, the UK, Japan, Canada, Australia, some European countries, and Brazil, Chile, India, China, South-Korea and Russia, constructed from news coverage about policy-related economic uncertainty[2] (see Figure 1 for the US). The idea is based on counting the number of occurrences of specific words or a sequence of words, in certain newspapers in a given country. Typically, to be included in the count, the publication should simultaneously contain at least words referring to the economy (*e.g.* "economy" or "economics"), *and* to policy (*e.g.* "deficit" or "central bank" or "taxes"), *and* to uncertainty (*e.g.* "uncertain" or "uncertainty"). After some normalization steps an index is computed, allowing comparison over time. This set of EPU indexes constitutes the broadest worldwide database that can be used for international evaluations of uncertainty shocks. Davis (2016) used this database to create an index of global uncertainty by computing weighted averages of all those country-specific indexes to produce a single global measure. Note however, that for most of the countries (except the US and the UK), only two newspapers are considered to compute the indexes. Using the same methodology, on their website Baker, Bloom and Davis propose some specific EPU indicators. For example, they produce indexes for sub-sectors such as Brexit (for the UK), migration fears, health, trade, fiscal, monetary and regulatory policies. Another feature of interest is that they produce daily EPU indexes for both the US and the UK which allow investigation of the effects of high-frequency uncertainty shocks (for an application see Ferrara and Guérin, 2016). Similarly, Alexopoulos *et al.* (2014) construct general economic uncertainty measures for the US based on a detailed textual analysis of some *New York Times* articles, and suggest using a broader set of keywords.

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By applying a similar text-based approach, it is possible to develop indexes of monetary policy uncertainty (MPU). Husted, Rogers and Sun (2016) construct a daily news-based index of MPU to capture the uncertainty perceived by the public regarding the Federal Reserve's policy actions, based on counting words in ten large US newspapers. They search, in particular, for articles containing the combination (i) "uncertain" or "uncertainty", (ii) "monetary policy" or "interest rate" or "Federal Fund rates", and (iii) "Federal Reserve" or "Fed" or "Federal Open Market Committee" or "FOMC".

A global uncertainty measure was proposed by Caldara and Iacoviello (2016) who have constructed an index of global geopolitical risk resulting from a country's or region's political instability. This index is based on the frequency of words related to geopolitical tensions in leading international newspapers, and aims at capturing events which perhaps are more exogenous to macroeconomic conditions. For example, they were able to identify events such as the Gulf War, the 2003 invasion of Iraq, the 9/11 terrorist attacks and more recently, the spikes during the Ukraine/Russia crisis, and around the Paris terrorist attacks. Similarly, Manela and Moreira (2017) suggest a news-based measure of US uncertainty, starting at the end of the 19th century, using front-page articles from the *Wall Street Journal*.

1.4. Macroeconomic uncertainty based on forecasting

Beyond stock market volatility and economic policy, there is a growing literature aimed at measuring uncertainty based solely on macroeconomic information. The idea is to assume that uncertainty may be reflected in economic forecasting errors: the more uncertain the state of the economy the less accurate the forecasting.

In this context, Scotti (2016) develops a macroeconomic uncertainty index reflecting agents' uncertainty about the current state of the economy, defined as the weighted average of squared news surprises, for a set of macroeconomic variables and for a few advanced economies. Surprises are defined as differences between expected value from professional forecasters and realizations. The weights are estimated through a dynamic factor model applied to a set of macroeconomic variables. Those indexes are particularly interesting as they are available with daily frequency for the US, the UK, the euro area, Canada and Japan. Not surprisingly, the highest spikes in the indexes correspond to the latest financial crisis for both the US and euro area. Interestingly, the euro area uncertainty index reaches its highest values just before and just

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(2) Those indexes are downloadable at www.policyuncertainty.com

after the 2008-09 recession. While the uncertainty in the US appears subdued following this recession, it seems that the debt crisis kept uncertainty levels elevated in the case of the euro area. In the same vein, Jurado *et al.* (2015) calculate an uncertainty index based on the unpredictable component in a large set of US macroeconomic and financial variables. This component is estimated by taking the difference between conditional forecasts stemming from a large dynamic factor model, and realizations (see Figure 1). This index differs in its construction from Scotti's since it accounts for both macro and financial variables, and uses the conditional forecasts from an econometric model as the expected values. Since this index also integrates financial information, it is likely to have a stronger effect on economic activity when computing impulse response functions. This reflects the fact that uncertainty and financial shocks are often intertwined, and as Gilchrist *et al.* (2013) and Caldara *et al.* (2016) show, disentangling them is crucial in shock identification steps.

Rossi and Sekhposyan (2015) suggest measuring uncertainty as the distance between the realized value of a variable and its unconditional forecast error distribution, this latter being obtained either from a parametric model or from surveys. This differs from previous macro uncertainty measures in the sense that forecasts are unconditional, and are not conditioned by any information set.

Another approach to assess macroeconomic uncertainty at any date in time is to adopt a model-based approach that relies on estimating econometric models with stochastic volatility, and to identify the estimated volatility to an uncertainty measure. Mumtaz and Theodoridis (2016) adopt this model and propose a dynamic factor model with stochastic volatility allowing for simultaneous estimation of a common global factor and country-specific factors for a set of 11 OECD countries. They show that global uncertainty goes a long way to explaining the variance of real and nominal variables. In similar vein, Carriero, Clark and Marcellino (2016) propose of a large vector auto-regression (VAR) model estimated on both macro and financial variables with errors following a stochastic volatility model. Estimated volatilities then are supposed to track macro and financial volatilities.

1.5. Macroeconomic uncertainty based on surveys among forecasters

Macroeconomic uncertainty can be measured also by considering the disagreement among forecasters over selected macroeconomic variables in a specific opinion survey. The underlying idea is that the dispersion among forecasters should be high in periods of high uncertainty, and vice-versa. This approach consists of evaluating the cross-sectional dispersion of forecasts obtained from a panel of economists, without necessarily investigating how the forecasts are formed. For example, Bachmann *et al.* (2013) proposed a measure of US uncertainty based on forecasting disagreements from the Philadelphia Federal Reserve Business Outlook Survey, and a measure of uncertainty in Germany based on disagreements among the IFO Business Climate Survey participants. Similarly, Bloom (2009) computes the standard deviation of US nominal GDP forecasts from the Philadelphia Federal Reserve survey.[3]

Lahiri and Sheng (2010) show that disagreement in fact, is only a fraction of uncertainty, and that the volatility of aggregate shocks must also be accounted for to obtain a complete picture of uncertainty. The idea is that uncertainty stemming from market participants can be decomposed into two factors: a common component reflecting the perceived variability of future aggregate shocks, and an idiosyncratic component reflecting the disagreement among professional forecasters. This kind of decomposition relies on the literature on capital asset pricing models which decomposes the volatility of a typical stock into market and firm-level volatility. This approach is used also by Ozturk and Sheng (2017) to propose various uncertainty indexes across three layers, namely (i) variable-specific uncertainty for a set of macroeconomic variables, (ii) country-specific uncertainty for a large panel of advanced and emerging countries, and (iii) a global uncertainty measure obtained from a weighted average of country-specific uncertainty indexes. For example, US-specific uncertainty estimated using this approach is presented in Figure 1 (middle panel).

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Within the dimension of monetary policy uncertainty, Istrefi and Mouabbi (2017) propose what the call a subjective measure of interest rate uncertainty, for several developed countries. This measure reflects market perceptions of interest rates as expressed by professional forecasters in the Consensus Economics survey, and accounts for both disagreement among forecasters and the perceived variability of future aggregate shocks, in line with Lahiri and Sheng (2010). At the height of the global financial crisis, Istrefi and Mouabbi observed that while other macro and financial uncertainty measures used in the literature continued to rise, the uncertainty over interest rates fell. This reflects the reach of the zero lower bound (ZLB) on nominal interest rates and the forward guidance communication from several central banks to keep rates low for longer.

(3) Note that this approach can be implemented at a more micro-level by looking at managers' expectations about future demand growth (see Guiso and Parigi, 1999, for an application using Italian data).

Ismailov and Rossi (2017) use the methodology of Rossi and Sekhposyan (2015) to construct an exchange rate uncertainty index based on fixed-horizon forecast errors from surveys conducted by Consensus Economics. This measure allows the authors to establish a link between the deviations to the uncovered interest rate parity (UIRP) hypothesis and the level of uncertainty; ultimately it is shown that the UIRP condition holds when uncertainty is low.[4]

1.6. Discussion

Various measures of uncertainty have been proposed in the literature although they are not necessarily aimed at assessing the same concept. However, the various measures are quite well correlated. Typically, the VIX and realized volatility show a strong correlation (between 0.8 and 0.9). In his seminal paper, Bloom (2009) shows that measures of financial volatility are strongly correlated to the disagreement among forecasters, and the firm profits and industry productivity growth distributions, leading researchers to use financial volatility, either implied or observed, quite widely as a proxy for uncertainty, in applied works.

However, the degree of correlation is lower in the case of other measures. Table 1 presents correlation coefficients of the five measures[5] depicted in Figure 1. The start date is January 1990 but the ending date is dependent on the particular series (May 2017 for VIX and EPU, July 2014 for the survey measure in Ozrturk and Sheng, 2017, June 2016 for the macro measure proposed by Jurado *et al.*, 2015, and March 2015 for the micro measure in Gilchrist *et al.*, 2014).

Overall, the VIX seems to be quite well correlated to other uncertainty measures but the EPU is poorly related to other measures. Over our sample going from January 1990 to May 2017, the correlation between VIX and EPU is 0.45, meaning that VIX and EPU often move together but also show distinct variations. By nature, VIX tends to react more strongly to financial events while the EPU is related more closely to policy events such as wars, elections or political battles over debt ceilings and government fiscal policy. Also, by definition, the VIX tends to incorporate forward-looking information not embedded in the EPU.

Overall, the large number of uncertainty measures proposed in the burgeoning literature have a strong common component but do not capture exactly the same concept. In spite of a common behavior that can captured by estimating a factor model (see Haddow *et al.*, 2013), idiosyncratic components of the uncertainty measures clearly play a role, and a distinction needs to be made between the concepts of financial uncertainty, macroeconomic uncertainty and economic policy uncertainty. In addition, due to the inherent unobservable nature of uncertainty, estimation methods may generate some differences in uncertainty measures for the same concept of uncertainty. In this respect, robustness checks for various measures appear necessary in empirical studies dealing with uncertainty.

Table 1 – Linear correlation coefficients between various monthly measures of uncertainty for the US economy since 1990: VIX, EPU, JLN

Correlation	VIX	EPU	Survey	JLN	IVOL
VIX	1				
EPU	0.45	1			
Survey	0.58	0.19	1		
JLN	0.65	0.32	0.76	1	
IVOL	0.66	0.40	0.33	0.37	1

Source: JLN: Jurado, Ludvingson and Ng, 2015, Survey: Ozturk and Sheng, 2017 and IVOL: Gilchrist *et al.*, 2015.

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2. Understanding the effects of uncertainty fluctuations

Following the Great Recession, the profession has paid much attention to the role of fluctuations in economic uncertainty as a source of business cycle fluctuations. Both theorists and empiricists have sought to better understand how such fluctuations can influence the economy, by offering numerous mechanisms through which an uncertainty shock – defined as an unexpected change in an uncertainty variable (see previous section) – is transmitted to the economy.

Although no consensus has been reached, the efforts made by economists to propose improved theories, and to examine new data has resulted in a growing body of knowledge on the macroeconomics of uncertainty. The purpose of this section is to provide readers with a comprehensive overview of how fluctuations in uncertainty affect the economy through three main mechanisms. First, we describe how fluctuations in uncertainty affect aggregate activity within the framework of irreversible investment. Second, we discuss the role of

(4) See Husted *et al.* (2017) for an analysis of currency carry trade and uncertainty on foreign exchange markets.

(5) Charles *et al.* (2017) propose a comparative analysis of the effects of various measure of uncertainty in terms of impulse responses and variance decomposition. They also provide a synthetic indicator based on a dynamic factor model.

households' precautionary saving as a way to propagate uncertainty shocks. Third, we discuss the role of financial market frictions through which volatility fluctuations can influence aggregate activity. Throughout the discussion, we will continuously confront the theory with data via large macroeconomic models so as to assess the empirical relevance of transmission mechanisms.

2.1. Irreversible investment

The first and best -known framework to study how fluctuations in uncertainty affect the economy is irreversible investment as discussed in the seminal contributions of Bernanke (1983) and Pindyck (1991). The basic idea is that, when investment projects are irreversible – that is, they cannot be "cancelled" or "modified" without very high costs – there exists a trade-off for investors between additional returns from the immediate launch of an investment project, and the benefits of waiting to gather more information in the future. The value of waiting is described in the literature as *real-option value*. At times, it can be preferable to postpone new investment projects, and at other times it might not. In such an environment, a rise in uncertainty clearly would tilt the balance in favor of *wait-and-see* behavior. Indeed, by pausing their investment and hiring, investors will obtain more information about the future which will increase the likelihood of making a good decision, and thus,vhaving a better understanding of long-run project returns. In the influential paper by Bloom (2009), the author highlights that "*increased uncertainty is depressing investment by fostering an increasingly widespread wait-and-see attitude about undertaking new investment expenditures*". Empirical results tend to show that the most irreversible investment categories, such as investment in infrastructure or equipment, react the most negatively to uncertainty shocks compared to for example, investment in intellectual property products (see Ferrara and Guérin, 2016).

To provide evidence of this mechanism, Bloom (2009) introduces a firm-level model with time-varying second moments (uncertainty shocks) and non-convex (labor and capital) adjustments costs. The introduction of such costs in the model creates a threshold of inaction below which firms delay their investment projects. When uncertainty increases, the threshold becomes higher and firms freeze their economic activity as well as their hiring and investment activities. The simulated model reveals that, after a temporary positive shock to uncertainty, employment, output and productivity growth drop sharply, and the model implies that both hiring and investment rates decrease and reach their minimum around four months after the shock. The *wait-and-see* behavior acts as a conduit to transmit fluctuations in uncertainty to the economy. Once the uncertainty is resolved, and the economic perspectives appear brighter, aggregate activity recovers quickly and then rebounds few months after the shock (see Figure 2). This pattern of overshooting – a short-lived period of above-normal growth – is explained by the massive come-back of the allocation of labor and capital to investment projects which previously was suspended. Recent empirical papers have highlighted the specific role of uncertainty during and after the Great Recession (see Figure 3). For example, Bussière *et al.* (2015) assess the importance of uncertainty to explain the weakness in business investment observed since 2010 among a panel of OECD

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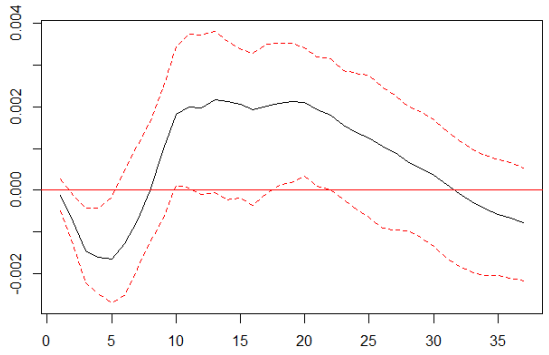
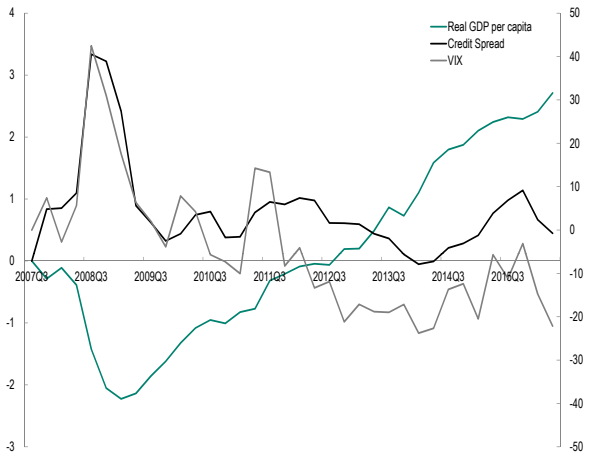
Figure 2 – Impulse response function of the US monthly industrial production to an uncertainty shock (95% Bootstrap Confidence Interval)



Source: R-package provided by Nicholas Bloom to replicate the Bloom (2009)'s paper https://people.stanford.edu/nbloom/sites/default/files/r.zip

Figure 3 – Real GDP per capita, Credit spread, and the VIX during and after the great recession in the US economy



Source: Data source: https://macro.nomics.world/article/2016-06/cmr14-data/. Real GDP and VIX are in log deviation and Credit spread in deviation with respect to the 2007Q3 value.

countries. While they conclude that the expected demand explains the main part of the investment slump, around 80%, they show also that uncertainty played a significant role, contributing around 17% (the rest being due to capital costs).

In spite of being a consensual channel of transmission, it should be noted that the role of wait-and-see behavior has been challenged by microeconomic data. For example, Bachmann and Bayer (2013) use a German firm-level data set to measure firms' profitability risk and cyclical fluctuations. In this context, they find that uncertainty shocks fed through the wait-and-see mechanism explain only a modest part of aggregate output variation. The authors rightly highlight that their findings "*open up room for other (propagation) mechanisms that are currently discussed in the literature*", as we will see below.

in a context of sticky prices, an increase in uncertainty that causes a decline in consumption demand implies a drop in output and demand for labor and capital because prices cannot adjust quickly to changing conditions

2.2. Precautionary saving

Precautionary saving is a well-known channel of influence of uncertainty on the economy, and is defined by Leland (1968) as "the extra saving caused by future income being random rather than determinate". Many economists have documented that heightened uncertainty during the Great Recession was accompanied by a surge in saving rates, suggesting that uncertainty can influence households' consumption decisions. For example, Mody, Ohnsorge, and Sandri (2012) use a panel of OECD countries and establish a close and positive relationship between saving rates and labor income uncertainty between 2007 and 2009. The reason for this relationship is straightforward: When faced with a higher risk of bad outcomes, households seek to protect themselves by saving more. This *precautionary saving* results in a further reduction in consumption and an excess of desired saving. The authors show that more than two-fifths of the rise in the household saving rate between 2007 and 2009 is a response to a precautionary savings motive.

many economists have documented that heightened uncertainty during the Great Recession was accompanied by a surge in saving rates, suggesting that uncertainty can influence households' consumption decisions

To support this intuition, Basu and Bundick (2017) use a simple VAR framework and show that a one-standard deviation unexpected change in uncertainty, measured by implied stock returns volatility, generates a large and persistent decline in output, consumption, investment and hours worked, with a trough for output of 0.2 percent. The ensuing co-movement among those macro variables is noteworthy since it means that the fall in consumption associated to precautionary saving is not necessarily compensated by a higher level of investment in the economy. In fact, most neoclassical models of precautionary saving fail to capture this and predict a negative co-movement between consumption and investment in response to uncertainty shocks. Heightened uncertainty induces precautionary saving, and thus, a decline in household consumption but an increased desire to supply labor (*i.e.*, to increase the hours worked) for any given level of the real wage. This phenomenon is known as *precautionary labor supply*[6]. On the demand side, demand for labor remains unchanged because technology and capital stock are invariant to changes in uncertainty. vAs a consequence, hours worked, investment and output increase while consumption decreases. This unpleasant property proceeds from the assumption of price flexibility and can be overcome by considering nominal rigidities.

Basu and Bundick (2017) develop a New-Keynesian model with sticky prices, in which output is driven exclusively by demand in a short-run horizon. Basically, in a context of sticky prices, an increase in uncertainty[7] that causes a decline in consumption demand implies a drop in output and demand for labor and capital because prices cannot adjust quickly to changing conditions. To sum up, the difference between neoclassical models and New-Keynesian models for explaining the co-movement of aggregates lies in the demand for labor. Leduc and Liu (2016) propose a more detailed analysis of the labor market[8]. They examine the aggregate demand channel via labor search frictions. Again, under sticky prices, the authors show that the decline in aggregate demand reduces firms' incentives to post new job vacancies – *i.e.*, a decrease in the value of a new match – causing a rise in unemployment. As fewer workers finds jobs, the incomes of households decrease further. The introduction of search frictions amplifies the effect of uncertainty shocks on aggregate activity via the aggregate

(6) See Domeij and Floden (2006), Pijoan-Mas (2006), and Floden (2006) shows that households tend to adopt a "precautionary labor supply" attitude when facing idiosyncratic income risk.

(7) See Fernandez-Villaverde, Guerron-Quintana, Kuester, and Rubio-Ramirez (2011) for the effects of fiscal uncertainty via the aggregate demand channel.

(8) Guglielminetti (2016) also shows the detrimental impact of uncertainty on the macroeconomy through frictional labor markets by using a DSGE model, and Caggiano, Catelnuovo and Groshenny (2014) point out the non-linear impact of uncertainty on US unemployment.

demand channel and also via the irreversibility channel discussed in the previous section. Indeed, when uncertainty increases, "*the option value of waiting increases and the match value declines*" and firms reduce their hiring activity. Since the long-term employment contract between employer and employee is irreversible, firms prefer to wait for more information which is in line with the irreversible investment literature. Overall, the interactions of both the option-value channel and the demand channel, allow uncertainty shocks to represent 60 percent of unemployment variation, which is equivalent to what we see in the data. However, the data show that uncertainty fluctuations also impact financial markets suggesting a specific channel associated to financial frictions.

2.3. Financial frictions

Financial intermediaries play an important role in the propagation of fluctuations in uncertainty. When risk rises, they tend to protect themselves against default risk by charging a premium to cover the costs of a default. Arellano, Bai and Kehoe (2012) and Christiano, Motto and Rostagno (2014) were the first to use a general equilibrium framework to model the interactions between financial markets and fluctuations in uncertainty. The establishment of such a relationship via explicit theoretical models was motivated, not surprisingly, by the Great Recession of 2008-09.

financial intermediaries play an important role in the propagation of fluctuations in uncertainty

To better understand why financial conditions are an important conduit for the transmission of uncertainty fluctuations to the economy, Christiano, Motto and Rostagno (2014) augment the *financial accelerator mechanism* business cycle model developed initially by Bernanke, Gertler and Gilchrist (1999) (hereafter BGG) to account for the presence of uncertainty shocks (described by the authors as "risk shocks").[9]

Entrepreneurs borrow externally to buy raw capital. Sometimes the allocation of this capital to the productive process is a success, sometimes it is not. In the model, the productivity level is decided independently by each entrepreneur. When the cross-sectional dispersion of productivities among entrepreneurs increases, the average productivity of entrepreneurs remains unchanged but more extreme high and low productivity values are observed. As a consequence, financial intermediaries charge a higher premium to protect themselves since more entrepreneurs choose low levels of productivity and then are unable to repay their debts. This positive risk shock increases both the risk of default and the cost of external funds which leads to a fall in the economic activity of entrepreneurs, and in turn is transmitted to the overall economy in general equilibrium.

When the model is estimated, Christiano, Motto and Rostagno (2014) conclude that fluctuations in risk constitute the most important shock driving the business cycle, much more than the real and nominal shocks usually considered in the literature. Brand and Tripier (2014) compare the predictions of this model for the US and the euro area, and conclude that risk shocks are a major source of business cycle fluctuations in both economies and explain a large part of their divergence in recent years.

This evidence based on the estimation of business cycles models is supported by empirical evidence from VAR models. In particular, Gilchrist, Sim and Zakrajsek (2014) analyze this transmission channel in the US from 1963.Q3 to 2012.Q3 and provide strong evidence that credit spreads are a key conduit for the propagation of uncertainty shocks to the economy. To show this, they propose to identify their uncertainty shocks according to two distinct identification schemes à la Cholesky. In the first specification, there is no allowance for contemporaneous reaction to credit spread, other macroeconomic variables, changes to innovations under uncertainty (here measured as idiosyncratic at the aggregate level). Conversely, the second identification does not allow such an immediate reaction of credit spread to innovations in uncertainty but does still affect the rest of the economy with a lag. Given these two identifying restrictions, the authors show that, under both specifications, an uncertainty shock leads to a decline in investment, prices and output, with the drop in prices being small and persistent while the drops in investment and output being substantial and immediate. Although the patterns remain qualitatively similar across the two specifications, there are differences at the quantitative level. Indeed, the response of the macroeconomic variables is amplified dramatically under the second specification which allows an immediate response of credit spreads after the shock. Following an unanticipated increase in uncertainty, and in contrast to the first identification, credit spreads rise immediately and then return very slowly towards trend, suggesting that financial conditions are essential for the transmission mechanism of uncertainty shocks to the aggregate activity.

A very recent literature stream is focusing on the joint effects of uncertainty and other types of shocks that can affect the economy at the same time. For example, Caldara *et al.* (2016) use a penalty function approach to jointly identify uncertainty and financial shocks, and to assess the impact of those two types of shocks on the economy. They find that uncertainty shocks have a significant macroeconomic impact in situations

(9) We focus our analysis on the BGG mechanism although there is a large class of business cycle models with financial frictions used in the literature to study the impact of uncertainty shocks but these financial frictions are not always modeled in the same way. For example, Arellano, Bai and Kehoe (2012) differ greatly from Christiano, Motto and Rostagno (2014) in the sense that uncertainty shocks imply large ranges of inaction by firms which decide to cut back investment projects to avoid default.

where they elicit a tightening of financial conditions. Interestingly, they obtain also that the rise in the impact on uncertainty in response to a financial shock, suggests that the evolution of uncertainty is influenced by changes in financial conditions. From a policy perspective, those results suggest close monitoring of both uncertainty and financial stress measures since a common upward movement in both variables could lead to damaging effects on the economy. We refer also to Shin and Zhong (2016) for further empirical evidence on the links between financial and uncertainty in the context of a structural VAR framework. Choi *et al.* (2017) show how sectoral-level data can be used to identify the effects of uncertainty on productivity through a financial friction-based channel. Alessandri and Mumtaz (2014) and Lhuissier and Tripier (2016) have advanced this work by allowing time-variation in the way that the macroeconomic variables respond to uncertainty shocks over time. The severity and the duration of their impact on the economy depend crucially on the degree of financial frictions.

uncertainty shocks have a significant macroeconomic impact in situations where they elicit a tightening of financial conditions.

2.4. Discussion

Economic theory has for long provided theoretical channels to explain the economic effects of uncertainty as due to the presence of irreversible investment, precautionary saving and financial frictions. Combined with the rich empirical literature on uncertainty measurement, recent quantitative macroeconomic researchers have been able to quantity the respective relevance and importance of these mechanisms. Below, we discuss three recent areas of further research on the complex relationships between uncertainty and the economy.

First, so far, we have considered the mechanisms through which exogenous fluctuations in uncertainty influence the economy. However, not all fluctuations in uncertainty are exogenous, and it is particularly important to understand in more depth the mechanisms through which uncertainty reacts endogenously to changes in the economic environment.

Ludvigson *et al.* (2017) argue that high uncertainty during recessions is more a response to other shocks that cause the recession, than the original cause of the recession. Working in environments where learning comes from market outcomes, several authors show that feedback mechanisms can occur when the economy is experiencing slowdown leading to heightened macroeconomic uncertainty. Nieuwerburgh and Veldkamp (2006) develop a business cycle model with incomplete information about the economy's fundamental (*i.e.*, the level of technology). They assume that the flow of information about the aggregate technology is time-varying and depends positively on the state of the economy. They show that recessions tend to generate less precise technological levels, leading in turn to more uncertainty and so further decline in investment projects and new hiring. Fajgelbaum, Schaal, and Taschereau-Dumouchel (2016) propose a similar learning framework in a model of irreversible investment with heterogeneous firms. The return from irreversible investment is a function of an imperfectly observed fundamental that follows an autoregressive process. Firms observe this return and update their beliefs appropriately. When the variance (*i.e.* uncertainty) of their beliefs about the fundamental is relatively lower, firms are more inclined to invest and produce. Furthermore, as the precision of these beliefs is procyclical and depends positively on the investment rate, a regime with low economic activity yields noisy estimates about fundamentals, leading in turn to a rise in uncertainty. During recessions, feedback mechanisms can result also from difficulties related to forecasting, as in the paper by Orlik and Veldkamp (2014). Indeed, recessions are rare event. As a consequence, it is more difficult to make accurate forecasts which induces large revisions in forecasting. Thus, poor accuracy in the probability of forthcoming extreme bad events – referred to by the authors to as the *black swan risk* – generates large fluctuations in uncertainty.

Second, so far, we have documented only how heightened fluctuations in uncertainty are able to generate macroeconomic contractionary effects. However, there is a channel through which uncertainty can stimulate investment, and which thus contrast with the channels described above and is referred to as "growth options" to use Bloom's (2014) terminology[10]. According to Bloom (2014), "*the growth options argument is based on the insight that uncertainty can encourage investment if it increases the size of the potential prize*". Typically, the growth options mechanism occurs when the decision process is very long. Bar-Ilan and Strange (1996) note that most investments take time, a phenomenon referred to as "investment lag". For example, Wheaton (1987) notes that "*the lag between issuing a construction permit and the completion of an office building is between 18 and 24 months*". Such lags tend to mitigate the negative effects of uncertainty on

economic theory has for long provided theoretical channels to explain the economic effects of uncertainty as due to the presence of irreversible investment, precautionary saving and financial frictions

(10) Bloom (2014) also discusses the "Oi-Hartman-Abel" case in which firms are risk loving because of specific irreversibly.

investment, and under some circumstances, even to stimulate investment. They act as negative real option phenomena since the investor can interrupt its decision and lose only the initial costs in the case of bad news, and keep its competitive advantage in the market in the case of good news. Krugman (2016) recalls this literature to explain why he was not convinced that the election of Donald Trump to US President would cause a recession because of the rising uncertainty. Future research should try to identify historical episodes (if they exist) when uncertainty stimulated economic activity.

when implementing policies, public authorities should take into account their effects on the degree of uncertainty

Third, assessing and disentangling the joint effects of, and the interplay among, uncertainty shocks and various types of other shocks is a topic for future research (see Caldara *et al*., 2016, regarding the link between financial and uncertainty shocks). For example, Cascaldi-Garcia and Galvao (2016) try to evaluate the joint effect of technology news shocks à la Beaudry and Portier (2006), and uncertainty shocks, starting from empirical evidence that both are correlated. Indeed, when a news shock hits the economy, it is accompanied by increasing uncertainty about the interpretation of this news, though the effects are likely to differ overtime (news shocks are known to increase total factor productivity mainly over the medium-term). The authors find that the negative effects of uncertainty in the medium-term are attenuated by positive news shocks, in both amplitude and duration. Similarly, this attenuation bias means that news shocks have lower positive effects in the short-run than if news shocks were assumed to be orthogonal to uncertainty shocks.

3. Policy implications: Three lessons from the literature

A better understanding of whether and how fluctuations in uncertainty affect the real economy is essential not only for academic economists but also policy-makers. Indeed, as explained in the previous sections, the recent literature tends to suggest that a disturbance originating from uncertainty is an important driver of economic fluctuations. In this respect, policy measures aimed at eliminating or mitigating periods of long-lasting uncertainty fluctuations and setting up defenses against the threat of future uncertainty fluctuations are thus appropriate. The traditional conception of stabilization policies needs to be extended to account for fluctuations in uncertainty. The corollary to this is that uncertainty needs to be monitored in real-time using the various available measures. Based on our own reading of the literature and our experience in this topic, to conclude the paper we suggest three policy implications.

#1 lesson: Macroeconomic policies have a direct role to play in stabilizing policy-related uncertainty

Stabilization policies traditionally are defined as monetary and fiscal policies implemented in response to supply or demand shocks to reduce the gap between the current level of economic activity, or inflation, and its long-term (or natural) level. Alongside the traditional supply and demand shocks, uncertainty fluctuations need also to be considered by the public authorities which may be directly responsible for them. Indeed, large fluctuations in the policy-based uncertainty measures can be interpreted as inefficient public management. Public authorities can be at the origins of policy uncertainty, *e.g.* through too frequent changes to fiscal policy as suggested by Fernández-Villaverde *et al.* (2015), or by amplifying uncertainty through lack of efficient coordination of political institutions in highly uncertain periods, *e.g.* the coincidence in 2012 of the discussions about the US fiscal cliff issue and the European crisis. Thus, when implementing policies, public authorities should take into account their effects on the degree of uncertainty. This issue has been discussed intensively in the context of monetary policy; we can refer to the recent debates on the stance of monetary policy in all the advanced economies. However, it also concerns fiscal policy as suggested by Auerbach (2014) who focuses on long-term projections of the US federal budget, and by Alesina *et al.* (2015) who show that the output costs of fiscal consolidation plans are magnified when they consist of stop-and-go changes to taxes and spending.

a better understanding of whether and how fluctuations in uncertainty affect the real economy is essential not only for academic economists but also policy-makers

#2 lesson: Financial uncertainty should be restrained trough financial regulations

However, policy-related uncertainty is only one among several sources of uncertainty fluctuations. The bulk of the evidence provided in the previous sections highlights the key role of financial markets as both the source of uncertainty and as mechanism amplifying uncertainty[11]. This suggests a new role for financial regulation: reducing the instability of financial markets which feed uncertainty in the economy as a whole. New institutions were implemented after the Great

(11) Candelon, Ferrara and Joëts (2017) show that equity market spillovers are much stronger during periods of high uncertainty.

Recession to avoid a repetition of that financial turbulence. For example, in Europe, the European Systemic Risk Board's mission is precisely to monitor and assess financial risks while the Banking Union is responsible for reducing the risk (and the consequences) of bank fragility in the future. The potential interest of regulation deals also with international financial markets through which uncertainty can be transmitted and amplified among economies. The institutional view expressed by the IMF (2012) supports the role of capital controls to protect economies from the macroeconomic and financial stability risks associated to disruptive surges in inflows or outflows[12].

#3 lesson: The effectiveness of economic stabilization policies depends on the state of uncertainty and should then be adapted accordingly

Beside the role of public authorities in stabilizing political, economic and financial uncertainty, the channel of transmission of macroeconomic policies is likely to be impaired by uncertainty. Under conditions of high uncertainty, the effectiveness of fiscal and monetary policies is damaged, and thus economic actors (households, firms, and investors) become less inclined to respond to policy impulses. Aastveit, Natvik and Sola (2013) provide strong empirical evidence to support this intuition. Estimating VAR models for the US, Canada, the UK and Norway, the authors show that, in periods of low uncertainty, an expansionary monetary policy that causes an unexpected decline in nominal interest rates would raise investment, consumption and GDP by more than twice as much as in a period of high uncertainty. Caggiano, Castelnuovo and Pellegrino (2017) show that the contractionary effects of uncertainty shocks are significantly larger when the Zero Lower Bound is binding, thereby justifying use of unconventional monetary policy tools such as forward guidance, or large scale asset purchase programs since the onset of the Great Recession. Bloom *et al.* (2016) investigate the efficiency of policies in a "really uncertain business cycle" model with heterogeneous firms and factor adjustment costs. They show that the stimulating effect of a wage subsidy policy on output declines by over two-thirds when the level of uncertainty in the economy is high. As a result, policymakers should take into account the degree of uncertainty surrounding the economy. The higher the uncertainty, the more aggressive should be the policy response.

under conditions of high uncertainty, the effectiveness of fiscal and monetary policies is damaged

(12) The importance of these risks for emerging economies was proposed by Rey (2013) in her Jackson Hole Conference and confirmed by much evidence in the literature, see among others Bruno and Shin (2015), Chinn et al. (2017) and Converse (2017).

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