Fluctuations in Uncertainty

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Abstract: This review article tries to answer four questions: (i) what are the stylized facts about uncertainty over time; (ii) why does uncertainty vary; (iii) do fluctuations in uncertainty matter; and (iv) did higher uncertainty worsen the Great Recession of 2007-2009? On the first question both macro and micro uncertainty appears to rise sharply in recessions. On the second question the types of exogenous shocks like wars, financial panics and oil price jumps that cause recessions appear to directly increase uncertainty, and uncertainty also appears to endogenously rise further during recessions. On the third question, the evidence suggests uncertainty is damaging for short-run investment and hiring, but there is some evidence it may stimulate longer-run innovation. Finally, in terms of the Great Recession, the large jump in uncertainty in 2008 potentially accounted for about one third of the drop in GDP.

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I) Introduction

There has been a vigorous debate on the impact of uncertainty on the Great Recession and recovery. While organizations like the IMF, the OECD, the EU and the Federal Reserve Board claim uncertainty has worsened the Great Recession and recovery, others like Paul Krugman have argued this is a smoke screen for bad policy and insufficient demand. There appears to be as much uncertainty about uncertainty itself as about the economy.

More generally at the micro level does uncertainty hold back investment and hiring as many firms and business lobbies claim? Or instead maybe it is essential for innovation as success stories built on risk-taking like Silicon Valley suggest?

This article tries to answer four questions:

i. What are the stylized facts about uncertainty over time?
ii. Why does uncertainty vary?
iii. Do fluctuations in uncertainty matter?
iv. Has higher uncertainty worsened the Great Recession and recovery?

In summary, on the first question both macro and micro uncertainty appears to vary strongly over time, rising sharply in recessions and falling in booms. It also varies heavily across countries – developing countries appear to have about a third more macro uncertainty than developed countries. On the second question two mechanisms appear to drive changes in uncertainty over time. First, the types of exogenous shocks that often cause recessions – like wars, oil price jumps and financial panics – appear to directly increase uncertainty. Uncertainty also appears to endogenously rise further during recessions, as economic slowdowns increase micro and macro volatility. On the third question the evidence suggests uncertainty is damaging for short-run growth, reducing firms' willingness to hire and invest, and consumers' willingness to spend. However, there is also some evidence that uncertainty can stimulate R&D – faced with a more uncertain future some firms appear more willing to innovate. Finally, in terms of the impact of uncertainty on the Great Recession, a 2008 jump in uncertainty was likely an important factor exacerbating the size of the contraction, accounting for maybe one third of the drop in GDP. From 2010 onwards uncertainty appears to have waned, although US policy uncertainty remains high due to the ongoing fiscal debates, potentially slowing the recovery.

II) What are the stylized facts about uncertainty over time?

First, what is uncertainty?

Frank Knight (1921) defined *uncertainty* as peoples' inability to forecast the likelihood of events happening. For example, the number of items in my wallet as I write this is article uncertain – it is hard for you to assign a sensible probability distribution to this. In contrast Knight defined *risk* as peoples known probability distribution over known events. For example, the outcome from flipping a coin is risky - you can assign a 50% chance to heads and a 50% chance to tails for a fair toss. In this article I'll refer to a single concept of uncertainty, although this will typically be a stand in for both risk and uncertainty.

How do we measure uncertainty?

Uncertainty is hard to measure since it is intrinsically unobservable concept. It reflects the uncertainty in the minds of consumers, managers and policymakers about possible futures. It is also a broad concept – reflecting uncertainty over macro phenomena like GDP growth, over micro phenomena like firm-growth, and over non-economic events like war and climate change. So not surprisingly there is no one perfect measure of uncertainty, but a range of proxies like stock-market and GDP volatility[2], forecaster disagreement, news mentions of "uncertainty" and firm TFP shock dispersion. Collectively these proxies suggest four stylized facts about uncertainty.[3]

Fact 1): Macro uncertainty rises in recessions

The volatility of stock-markets, bond-markets, exchange rates and GDP growth all rise steeply in recessions. In fact almost every macroeconomic indicator of uncertainty I know – from disagreement amongst professional forecasters to the frequency of the word "uncertain" in the New York Times (Alexopolous and Cohen, 2009) – appears to be countercyclical.

[2] Typically when a series – like the S&P500 stock-market index or GDP growth – is more volatile it is harder to forecast. So volatility is often used as an empirical proxy for uncertainty.
[3] All the data used in this paper is available here: www.stanford.edu/~nbloom/JEPdata.zip

For example, Figure 1 shows the VIX index of 30-day implied volatility on the S&P 500 stock-market index. This implied volatility index is the market's expectation of volatility over the next 30-days backed out from options prices. The VIX index is clearly counter-cyclical, rising by 58% on average in NBER recessions. One explanation for this is the effect of leverage - in recessions firms take on more debt and this increases their stock-returns volatility. However, as pointed out by Schwert (1989) the leverage effect can explain at most 10% of this rise in uncertainty during recessions. Another explanation is risk-aversion - increased risk aversion will increase the prices of options (which provide insurance), raising implied volatility. However, as Bekaert, Hoerova and Lo Duca (2013) note the fluctuations in the VIX appear to heavily reflect movements in uncertainty. Other financial prices, like exchange-rates and bond yields, are similarly more volatile in recessions. Non-financial measures of macro uncertainty include the volatility of quarterly GDP and industrial production growth, which based on GARCH models have about 35% more conditional volatility in recessions.

An alternative proxy of uncertainty is disagreement amongst professional forecasters. Periods when banks, industry and professional forecasters hold more diverse opinions are likely to reflect greater uncertainty. If everyone agreed on the path of future GDP it seems likely the future is predictable, while if professionals strongly disagree it seems likely it is harder to predict. Examining data from the Philadelphia Federal Reserve Boards' panel of about 50 forecasters shows that between 1968 and 2012 the standard-deviation across forecasts of industrial production growth was 64% higher in recessions, similar to results from other European countries (Bachmann, Elstner, and Sims, 2010).

A related proxy is how uncertain forecasters are about their own forecasts, which is called subjective forecast uncertainty. The Philadelphia Federal Reserve has since 1992 asked forecasters to provide probabilities for GDP growth (in percent) falling into ten different bins: "*<-2*", "*-2 to -1.1*", "*-1 to -0.1*" up to "*6+*". We plot the mean of forecasters' uncertainty calculated using this probabilities on Figure 2 (blue line, circles) alongside the mean of forecasters' mean (green line, crosses), plus for comparison the disagreement across forecasters' mean (red line, squares). We see that both uncertainty and disagreement more than doubled when growth fell sharply in 2008/2009, with a milder rise of about 50% during the recession of 2001.

Another proxy for uncertainty is the frequency of newspaper articles about economic uncertainty. Figure 3 shows the Baker, Bloom and Davis (2013) measure of economic policy uncertainty, which counts the frequency of articles containing the words "uncertain or uncertainty" and "economy or economics" and one of six policy words in ten leading US newspapers. Again, this is clearly countercyclical rising by 51% during recessions. A related proxy for uncertainty is the count of the word “uncertain” in the Federal Reserve’s Beige Book. The Beige Book is a 15,000 word overview of the US economy published after each FOMC meeting, which Baker et al (2013) report includes the word “uncertainty” 52% more often during recessions.

Finally, an eclectic mix of other indicators of macro uncertainty also rise in recessions. One approach followed by Scotti (2013) is to measure the size of the surprise when economic data is released – that is compare the pre-release date expectations for things like non-farm payroll and quarterly GDP with their release values. Interestingly, she finds these surprises are almost 20% larger in recession. Another approach followed by Jurado, Ludvigson and Ng (2013) is to use data on hundreds of monthly economic series in a system of forecasting equations and look at the implied forecast errors. They found this rises dramatically in large recessions, most notably the OPEC I recession (1973-1974), the early 1980s rust-belt recession (1982-1982) and the Great Recession (2007-2009). A third approach by Nakamura, Sergeyev and Steinsson (2012) uses over 100 years of consumption data from 16 OECD countries to estimate short and long run fluctuations in volatility, again finding this rises strikingly in periods of lower growth.

Fact 2): Micro uncertainty rises in recessions

We can also examine micro uncertainty at different levels: industry, firm, plant or even individual product level. At every level uncertainty appears to rise during recessions. That is the story is fractal, at each level of disaggregation uncertainty rises in recession just like it does at the level above.

For example, Figure 4 shows the percentiles of industry output growth for a panel of almost 200 manufacturing industries followed by the Federal Reserve Board. During recessions these percentiles widen out, as some industries do well while others get hit hard. This increased

dispersion is a proxy for industry level uncertainty as it suggests that industries are getting larger industry-level shocks during recessions.

Drilling down to firm and plant level outcomes, we again find uncertainty proxied by dispersion surges in recessions. For example, Campbell et al. (2001) report how cross-firm stock-return variation is almost 50% higher in recession than booms. In the NBER industry uncertainty data we see that the dispersion of plant-level TFP shocks rises sharply in recessions, which Kehrig (2011) shows is particularly striking in durable producing industries. Figure 5 shows this graphically, plotting the spread of sales growth rates for a balanced panel of about 16,000 plants within the US manufacturing for 2008-2009 (the red solid-line) against their values for 2005-2006 (the black dashed-line). We can see that the variance of plant growth rates rose by 152% during the Great Recession compared to the years just before.

Amazingly, digging all the way down to individual product prices, we again find a similar story. Berger and Vavra (2012) analyzed price changes from the Bureau of Labor Statistics on 10,000s of products – such as a 1 liter bottle of Coke or a pack of 4 Duracell AAA batteries – and found these were about 50% more volatile during recessions.

This increase in both macro and micro uncertainty during recessions is true both for the US and on the global scale. For example, Figure 6 plots five different measures of uncertainty against the country GDP growth decile for 60 developed and developing countries. All five of these measures are higher when country growth is below their long-run average. This is true even when breaking down the sample into developed and developing countries, so counter-cyclical uncertainty seems to be a global stylized fact. Interestingly, the relationship is strongest for the bottom 5 deciles of growth, particularly the lowest decile where growth is negative on average. Hence, it appears that recessions (periods of negative growth) are particularly strongly associated with heightened uncertainty.

Fact 3): Wages and income volatility appear to be countercyclical

Increased uncertainty is not just an issue for firms and financial markets in the recession but also for households. In particular, wages and incomes also appear to be more volatility in recessions. Meghir and Pistaferri (2004) and Heathcote, Perri and Violante (2009) show how wage volatility appears to rise in recessions, while Storesletten, Telmer and Yaron (2004) report how cohorts of

individuals that have lived through more recessions have more dispersed incomes. Likewise, Guvenen, Ozkan and Song's (2013) analysis of the US Social Security Administration data from 1978 to 2010 reveals higher income volatility in recessions, driven mainly by an increasingly negative skewness as the bottom end of the income distribution collapses in recessions. So whatever factors appear to be increasing the volatility of macro, industry, firm and plant level outcomes in recessions these also translate to high volatility of wages for employees too.

Fact 4): Uncertainty is higher in developing countries

A long literature has highlighted how developing countries in regions like Africa and South America have more volatile GDP growth, stock-markets and exchange rates than developed countries in regions like Europe and North America. This was in fact the theme for the World Bank's 2013 Development Report "*Risk and Opportunity*", focusing on how households and firms in developing countries face a huge variety of macro and micro risks. In a panel of 60 countries with GDP and stock-market data I find that the developing countries (the 17 countries with less than $10,000 GDP per capita) had 50% higher volatility of GDP growth rates, 12% higher stock-market volatility and 35% more volatile bond than the developed countries (so around a third more volatility on average).

Finally, there have also been two lines of work investigating the presence of longer-runs trends in US volatility. One focused on the "Great Moderation" of macro volatility which began in the early 1980s (Stock and Watson, 2002), although this drop in macro volatility appears to have ended with the recession of 2007-2009. The other focused on the falling volatility of firm growth rates, which has occurred across all sectors from the late 1970s onwards, and appears to be (at least partly) explained by the gradual aging of firms and their employees (Davis et al. 2006).

III) Why does uncertainty vary?

While it appears clear that uncertainty rises in recessions (and is higher in developing countries), it is much less clear why this occurs. This is an important and active area of current research, and as such I will try to summarize the current state of play.

One simple explanation is that the types of bad events that cause recessions – like terrorist attacks, wars and oil-price shocks – also cause higher uncertainty at the same time. That is, recessions are caused by a combination of bad news (first moment shocks) and uncertainty (second moment shocks). For example, the 1973 OPEC oil embargo tipped the US recession by tripling oil-prices and increasing uncertainty over future oil prices. Interestingly, while bad events which cause recessions typically increase uncertainty the same appears to hold in reverse – almost all events which increase uncertainty appear to be bad news. For example, Bloom (2009) defined 17 uncertainty shocks from 1962 to 2008 on the basis of jumps in stock-market volatility, and found that all but one was bad-news in that they lowered expected growth. These uncertainty shocks included the Gulf wars, the assassination of JFK, the Cuban Missile Crisis, the 9/11 attack, the OPEC oil price shocks, and the Asian and Russian financial crises. In fact the only uncertainty shock in this series associated with good news was the October 1982 business cycle turning point, a relatively minor uncertainty shock.

So in summary, bad news shocks and uncertainty shocks appear to be closely tied together. One possible reason is that when good news events occur – like the fall of the Berlin Wall or the development of the internet – these are too gradual to cause jumps in uncertainty.

Another potential explanation for uncertainty rising in recessions is that recessions themselves increase uncertainty. That is, not only are recessions caused by a combination of bad news and uncertainty, but as growth slows uncertainty is endogenously increased further. For example, growth and good times may help economic agents to collect information to forecast the future. When business is good firms are trading actively, which helps to generate and spread information, as Van Nieuwerburgh and Veldkamp (2006) and particularly Fajgelbaum et al. (2012) emphasize. When business is bad this activity slows down, reducing the flow of new information thereby raising uncertainty.

A third potential explanation, which matches the recent experience of policy activism in the Great Recession, lays the blame at the feet of Governments and Central Banks. Lubos and Pastor (2012) argue that policy becomes more uncertain during recessions because policy makers want to experiment. When the economy is doing well politicians prefer to keep with their current policies which appear to be successful. This is simply the old adage of "*if it aint broke don't fix it*". But when the economy turns down politicians are tempted to experiment as they attempt to

revive growth. So policy-uncertainty is the side effect of the search for policies to revive growth. As a result policy uncertainty rises in recessions, as found empirically by Baker at al. (2013).

Another potential reason for higher uncertainty in recessions is that individuals are more confident in predicting the future when the economy is growing. "Business as usual" is an easier prediction to make when growth is normal. But when sudden events cause recessions forecasters have to predict something different from the usual pattern of positive growth, and they find it harder to make forecasts (Orlik and Veldkamp, 2012). This arises from the fact that recessions are rare events, so that people are unfamiliar with them.

Finally, another set of explanations focus on micro-uncertainty. Bachman and Moscarini (2011) and D'Erasmo and Moscoso Boedo (2011) argue that recessions are good times to experiment and spend on R&D. When business is slack it is cheap to try out new ideas and this leads to heightened micro-uncertainty, potentially feeding into higher macro uncertainty.

As for higher uncertainty in developing countries Koren and Tenereyo (2007) and the World Bank Development Report (2013) argue this comes from three mechanisms. First, developing countries tend to have a more concentrated industrial structure so that shocks to individual industries hurt them more. For example, many industrial countries export only a few products so they are heavily exposed to fluctuations in their price. Second, the industries developing countries focus on tend to also be more volatile, often commodities products like rubber, sugar, oil and copper. Finally, developing countries appear to have more domestic political shocks like coups, revolutions and wars, are more susceptible to natural disasters like epidemics, typhoons and floods, and have less effective fiscal and monetary stabilization policies.

IV) Do fluctuations in uncertainty matter?

There is a large empirical literature on the short-run impact of uncertainty, which I discuss below. In summary, the literature finds that uncertainty is damaging for short-run (quarterly and annual) growth, reducing output, investment, hiring, consumption and trade. Intriguingly, some recent evidence hints, however, that uncertainty may stimulate R&D spending due to growth

options effects (the idea that uncertainty increases the potential upside from innovative new products), so that the impact of uncertainty on longer-run growth is less clear.

I then discuss the theoretical literature which emphasizes three negative channels of uncertainty: (i) *real-options* effects which act to make firms more cautious about hiring and investing, and consumers more cautious about buying durables, (ii) *risk-premium* effects which act to raise the cost of finance and (iii) *precautionary savings* effects which act to reduce consumption spending. But the theory also highlights two positive effect of uncertainty on growth: (i) *growth options* whereby higher uncertainty promotes investment by expanding the upside of future outcomes, and (ii) the *Oi-Hartman-Abel* effect, which highlights the fact that firms may expand when responding to positive shocks and contract when responding to negative shocks, so that a mean preserving spreads in outcomes can increase average output.

Empirical Literature:

The classic macro study is Ramey and Ramey (1995) who showed a strong negative association between volatility and growth in cross country regressions. They found a one standard deviation increase in volatility was associated with a 0.5% reduction in annual growth. This negative volatility effect on growth has been confirmed in a number of subsequent studies using more advanced estimations techniques (Engel and Rangel, 2008)), or using natural disasters and political shocks as instruments for uncertainty (Baker and Bloom, 2013). It has also been extended to other macro outcomes, revealing that uncertainty is associated with lower consumer spending (Romer 1990), investment and hiring (Bloom, 2009), and trade (Handley and Limao, 2012, and Novy and Taylor, 2012).

There is also a micro literature focusing on the impact of uncertainty on individual firms and households, again typically finding a negative impact. For example, Leahy and Whited (1996) examined a panel of US publicly listed firms finding a strong relationship between uncertainty proxied by stock-market volatility and investment, confirmed in UK data using lagged outcomes as instruments by Bloom, Bond and Van Reenen (2007). Guiso and Parigi (1999) used Italian data on firms' dispersion of subjective future demand expectations to measure uncertainty, again finding a large negative relationship between uncertainty and investment. More recently Stone and Stein (2012) used firms' exposure to exogenous variations in energy and currency volatility

as an instrument for uncertainty, again finding this depresses investment, hiring and advertising. Interestingly, Stone and Stein (2012) find, however, that uncertainty seems to increase R&D spending, something that growth options – the idea the more uncertainty yields a larger upside for long-run growth – can explain.

Theoretical Literature:

Real options: The largest body of theoretical literature focuses on real-options, which goes back at least to Bernanke (1983), Brennan and Schwartz (1985), McDonald and Siegel (1986), and Dixit and Pindyck (1994). The idea is that firms have a series of put-options on potential new investments. For example, a supermarket chain that owns an empty plot of land has the call-option to build a new store on the plot. If the supermarket is uncertain about the future – because for example, it is unsure if a local housing development will go ahead – the best action may be to wait. If the housing development proceeds the supermarket can develop the site, and if not it can continue to wait having avoided a costly mistake. In the language of real options, the option-value of delay for the supermarket chain is high when uncertainty is high. As a result uncertainty makes firms cautious about actions like investment and hiring, which adjustment costs often make expensive to reverse.

Investment adjustment costs are both physical (equipment may get damaged in installation and removal) and the used-good discount on resale. Ramey and Shapiro (2001) and Cooper and Haltiwanger (2006) estimate these investment adjustment costs are extremely large at roughly 50% of the value of capital.[4] Hiring adjustment costs include recruitment, training and severance pay, which Nickell (1986) and Bloom (2009) estimate are about 10% to 20% of annual wages. Schaal (2013) also emphasizes search frictions, showing how uncertainty can interact with search-costs to impede labor markets in recessions.

Real-options effects are not universal however. They rely first on the fact that decisions cannot be easily reversed, otherwise actions do not lead to the loss of an option. For example, hiring a part-time employee is typically easy for a firm to reverse – part-time employees generally have

[4] The literature distinguishes two families of adjustment costs. There are lumpy "non-convex" adjustments costs, which are fixed-costs (a one-off cost to buy/sell capital) and partial irreversibility (a cost per unit of capital sold). These "non-convex" adjustment costs generate real options effects. There are also smooth "convex" adjustment costs like quadratic adjustment costs (a cost that increases in the squared rate of investment), which do not generate real options.

very light hiring and firing costs. As a result firms may be happy to hire part-time employees even when uncertainty is extremely high, because if conditions deteriorate they can easily lay-off these employees. In fact, since part-time employees are so flexible firms may switch from hiring full-time to part-time employees during periods of high uncertainty. This often happens in recessions (Valetta and Bengali, 2013) which as we saw in section II are periods of high uncertainty.

Real-options effects also rely on firms having the ability to wait. But if firms are racing, for example to be the first to patent a new idea or launch a new product, this option disappears. Imagine the market for online books in the mid-1990s when the internet was beginning to emerge. Any entrepreneur considering launching an on-line book retailer – like Amazon's Jeff Bezos – would want to be early to market because of network economies. As a result delay would be extremely costly, so the option to delay would not have been valuable, breaking the negative real-options effect of uncertainty on investment.

Finally, real options require that actions that are taken now influence the returns to actions taken later, which in the most extreme case is a binary decision to invest now or invest later (but not both). For example, building a new supermarket on the plot of land can only be undertaken once. But in some situations - like firms producing with a constant returns to scale technology and selling into a perfectly competitive market – the choice of investment this period will have no impact on the profitability of investment next period, leading to no option value from waiting. So another requirement of the real-options literature is that firms are selling into imperfectly competitive markets and/or operating with a decreasing returns to scale technology.

Uncertainty not only reduces *levels* of investment and hiring, but also makes firms less *sensitive* to business conditions drivers like demand, prices and productivity.[5] So, for example, in low-uncertainty periods the elasticity of investment with respect to interest rates might be -1 (a drop of interest rates from 10% to 9% would stimulate 10% more investment) but when uncertainty is very high this could fall to -0.25 (the same drop would only stimulate 2.5% more investment). As a result high uncertainty can reduce the impact of stimulus policies like interest rate and tax

[5] Formally the *levels effect (*also called the *delay effect*) is $\partial I/\partial\sigma < 0$ whereby uncertainty (σ) reduces investment (I), and the *sensitivity effect* (also called the *caution effect*) is $\partial^2 I/\partial\sigma\partial A < 0$ whereby uncertainty makes firms less responsive to productivity or demand conditions (A).

cuts. This makes the increases in uncertainty that occur in recessions particularly challenging for policy makers. Just as the economy is heading into recession, higher uncertainty makes the usual monetary and fiscal stabilization tools less effective. The implications of this are twofold: (i) any given stimulus policy needs to be larger to overcomes firms' reduced sensitivity during periods of high uncertainty; and (ii) the ideal response to a second moment (uncertainty) shock may involve second moment policy, for example, a financial stabilization package to reduce systemic risk.

This channel of uncertainty reducing firms' responsiveness also leads to endogenously procyclical productivity, an empirical regularity that is central to many modern studies of business cycles (King and Rebelo, 1999). The reason is as follows: when uncertainty is high, productive firms are less aggressive in expanding and unproductive firms are less aggressive in contracting. This produces a chilling effect on productivity-enhancing reallocation of resources across firms. Since this reallocation appears to drive the majority of aggregate productivity growth[6], higher uncertainty can stall productivity growth. This productivity impact of uncertainty shocks underlies the theories of uncertainty driven business cycles, which emphasize how uncertainty shocks reduce investment, hiring and productivity (Bloom et al. 2013). The difference with more traditional real business cycle models (e.g. Kydland and Prescott, 1982) is that the fall in productivity growth in an outcome of the uncertainty shock, rather than the shock itself.

Finally, turning from investment to consumption, there is an analogous channel for uncertainty to slow economic growth. When consumers are making decisions on buying durables like housing, cars, and furniture, they can usually delay purchases relatively easily. For example, they may be thinking about moving house but could either move this year or wait until next year. This option value of waiting will be much more valuable when income uncertainty is higher – if, for example, you are unsure about a major-promotion at the end of this year it makes sense to wait until this is decided before undertaking an expensive house move.[7] This channel is emphasized by Carol and Dunn (1997) who argue that one reason why unemployment reduces consumption

[6] See Foster, Haltiwanger and Krizan (2000) and (2006) on the importance of reallocation for driving 50%+ and 80%+ of productivity growth in manufacturing and retail respectively.
[7] Delaying purchases of non-durable like food and entertainment is harder, so the real-options effects of uncertainty on non-durable consumption will be lower.

is the increase in income uncertainty this generates. Like the investment literature, higher uncertainty should also make consumers' durable expenditure less sensitive to demand and prices signals, something both Foote, Hurst and Leahy (2000) and Bertola, Guiso and Pistaferri (2005) report in studies of US and Italian consumers.

Risk-premia: A second channel by which uncertainty can reduce growth is through increasing risk premia. As James Tobin pointed out investors want to be compensated for higher risk, and as uncertainty rises this should raise the cost of finance. To the extent that investors are diversified it will be the systemic (rather than idiosyncratic) component of uncertainty that will raise financing costs.

A related mechanism to risk-premia is that uncertainty increases the cost of debt finance by raising the probability of default, by expanding the size of the left-tail default outcomes. Since banks only care about being repaid a mean-preserving spread worsens their return on loans. As a result as the risk of default goes up banks will charge higher interest rates. This can reduce micro and macro growth, especially if there are dead-weight losses from bankruptcy, as emphasized in papers on the impact of uncertainty in the presence of financial constraints (Arellano, Bai and Kehoe, 2010; Christiano, Motto and Rostagno, 2009; and Gilchrist, Sims and Zakrasjek, 2010).

Another related mechanism is the *confidence* effect of uncertainty in models where consumers have worst-case beliefs (Ilut and Schneider, 2011). In these models agents are so uncertain about the future they cannot even form a probability distribution. Instead they have a range of possible outcomes and act as if the worst outcomes will occur, displaying a behavior known as ambiguity aversion. So as the range of possible outcomes (uncertainty) increases agents become more pessimistic, cutting back on investment and hiring. Of course if agents are excessively optimistic, as is sometimes suggested in the CEO literature (e.g. Malmendier and Tate, 2005) then this result can reverse, with uncertainty increasing growth.

Precautionary savings: The third major channel for uncertainty to impact growth is from consumers' desire for precautionary saving, which itself reduces consumption expenditure (e.g. Bansal and Yaron, 2004). While this potentially increases long-run growth by encouraging investment, in most open economies some of this increased saving will flow abroad, reducing domestic demand. One recent paper emphasizing this route is by Fernandez-Villaverde et al.

(2011) who argue that rising uncertainty can be crippling for growth, particularly in smaller highly open countries. They argue that countries like Argentina and Ecuador are damaged by higher uncertainty which leads domestic savers to move money abroad, reducing local investment.

Interestingly, however, the impact of this risk channel is less clear in the case of larger and more closed countries like the US. In a fully closed economy if rising uncertainty leads consumers to increase their level of savings this should push down interest rates, raising investment rates. So while higher uncertainty would reduce consumption it would simultaneously increase investment. Of course this feels intuitively wrong – uncertainty is seen as bad for growth rather than as a driver of investment fueled booms.

As Leduc and Liu (2012) and Basu and Bundick (2013) have pointed out, however, using New Keynesian models which allow prices to be sticky leads uncertainty shocks to cut both consumption and investment, by preventing prices falling enough to clear markets. In their models and a related paper by Fernandez-Villaverde et al. (2013) uncertainty is particularly damaging if other policy tools – like interest rates - are ineffective, because interest rates are constrained at zero.

Another precautionary effect of uncertainty will impact the CEOs of firms. Most CEOs are not well diversified – they typically hold financial assets (stocks and options) as well human-assets (future earnings) in their firm. Hence, when uncertainty is high they may become more cautious in making long-run investments. For example, the CEO of an oil exploration company may become increasingly nervous when the price of oil becomes volatile, leading them to take a more cautious position on explorations and growth. As Panousi and Pananikolaou (2012) have shown in a panel of US firms when uncertainty is higher investment drops, particularly in firms where the CEOs hold extensive equity in the firm and so are highly exposed to firm-level risk.

Growth Options:

Uncertainty can also potentially have a positive impact on growth. One way is through "Growth options", which highlight how in some circumstances uncertainty can even encourage investment if it increases the size of potential prize. Papers like Bar-Ilan and Strange (1996) note that if firms have long delays in completing projects, for example because of time-to-build, then

uncertainty have a positive effect on investment. For example, a pharmaceutical company developing a new drug may be encouraged by a mean-preserving increase demand uncertainty. Bad draws (i.e. the drug turns out to be unsafe) are capped from below since the firm can cancel the product losing only its sunk R&D costs. Good draws, however, are unconstrained and increasing in upside risk as this raises the expected profit when the product goes to market.[8]

Growth options were often invoked to explain the dot-com boom of the late 1990s. Firms were unsure about the internet, but that extreme uncertainty encouraged investment. The worst outcome for firms starting new websites was losing their development costs, while the best outcome was dependent on the success of the internet which increased with uncertainty. Since developing websites took time, building one was seen as investing in a "call-option" on the future success of internet. Likewise a literature on the value of oil drilling leases shows how these are call-options on possible future extraction so oil price uncertainty increases their value (Paddock, Siegel and Smith, 1988).

Oi-Hartman-Abel Effects:

There is a second channel which uncertainty can potentially increase growth, which was emphasized in the early work by Oi (1961), Hartman (1972) and Abel (1983). This "Oi-Hartman-Abel" effect highlights the fact that firms can expand to exploit good outcomes and contract to insure against bad outcomes, making them potentially risk loving. For example, if a factory can easily halve production volumes if the price of its products falls and double production volumes if the price rises, it should like a mean-preserving increase in uncertainty. The factory is partly-insured against bad-outcomes (by being able to contract) and has the option to expand on good outcomes (by being able to expand). Formally, if profits are convex in demand or costs then demand or cost uncertainty increases expected profits. However, for this mechanism to work firms need to be able to easily expand or contract in response to good or bad news, so while the Oi-Hartman-Able effects are typically not very strong in the short-run (because of adjustment costs) in the medium and long-run they can be more powerful.

[8] This is sometimes called the "*good news principle*" that only good news matters in growth-options as bad news is capped by closing down the project. The origin of this phrase comes in fact from Bernanke (1983) who discussed the reverse "*bad news principle"* in terms of the classic real-options negative effects of uncertainty on investment. Segal, Shaliastovich and Yaron (2013) find interesting evidence for both these good news (growth option) and bad news (real option) effects of uncertainty in aggregate investment.

V) Has higher uncertainty worsened the Great Recession and recovery?

Finally, in terms of the impact of uncertainty on the depth of and recovery from the Great Recession the evidence is still speculative, and additional research would be valuable.

What we know so far is that every measure of economic uncertainty rose sharply in the 2008. These measures remained extremely high throughout 2008 and well into 2009, generating a massive and persistent uncertainty shock to the US economy. But from 2010 onwards many measures of uncertainty have fallen back, although policy-uncertainty appears to have remained stubbornly high through-out 2013 due to the ongoing battles in Congress.

This suggests that, firstly, there was a massive spike in uncertainty following the housing and financial crisis in 2008, with started to recede in 2010. Second this spike in uncertainty was an important factor driving the depths of the Great Recession. Based on simulations and empirical estimations, I estimate this spike in uncertainty reduced GDP by about 3% over this period, accounting for maybe one third of the 9% drop in GDP against trend that the US experienced during 2008-2009.[9] The reasons for this surge in uncertainty during 2008-2009 are two-fold, reflecting uncertainty's role as an impulse and propagation mechanism for recessions.

Firstly, the shocks precipitating the Great Recession – the financial crisis and the housing collapse – themselves directly increased uncertainty. That burst of uncertainty was part of the initial impulse that caused the recession. This uncertainty occurred because it was not clear initially how serious the financial and housing problems were, what their impact would be nationally and globally, or what the appropriate policy responses should be. Hence, these events directly increased uncertainty among firms and consumers. So in statistical terms the financial and housing crises were a nasty combination of large negative first moment and large positive second moment shocks. Together these led to the largest recession since the Great Depression of

[9] This 9% drop in GDP is taken from the difference between the prior trend 3.1% growth rate of real GDP from 1980 to 2007 and the -1.45% growth over 2008 and 2009. The estimated 3% contribution of uncertainty comes from simulation and empirical estimations. *Simulation*: From Bloom et al. (2013) take the -1.3% average drop in GDP in the year after an average recessionary uncertainty shock (Figure 6), and note that the increase in uncertainty around 2008-2009 was more than triple "normal" levels and about twice as persistent (Figure 3). *Estimation*: From Bloom (2009) take the vector-auto regression estimates (Figure 2) which show output falls by about 1% after an average uncertainty shock, and note that the 2008-2009 uncertainty shock was about three times the average size (Figure 1).

1929-1932. In fact, looking back to the Great Depression we see a similar situation – the financial meltdown and banking crisis starting in 1929 was both bad news (a negative first moment shock) and also induced massive uncertainty (a second moment shock).

Secondly, I think the Great Recession itself further increased uncertainty, leading the initial slowdown to be propagated and amplified over time. This was because of the necessarily aggressive monetary and fiscal policies aimed at mitigating the downturn (Baker, Bloom and Davis 2013) and the increasing business and individual uncertainty about future growth.

From 2010 onwards the picture is more complex since the measures of uncertainty have diverged. While many financial and output measure of uncertainty have dropped back, policy uncertainty appears to have remained high due to the ongoing uncertainty over the long-run size and reach of the Government. This has probably played some role in the slow recovery from the Great Recession, but this is hard to evaluate and is an area of ongoing research.

VI) Conclusions

In summary, there appears to be some two broad stylized facts on uncertainty. First, both micro and macro uncertainty are strongly countercyclical, rising in recessions and falling in booms. Second, uncertainty is substantially higher - maybe around a third - in developing countries.

Uncertainty rises in recessions partly because the types of shocks which cause recessions – like wars, oil price shocks and financial panics – also themselves increase uncertainty. So an increase in uncertainty is typically part of the initial impulse that leads to recessions. But uncertainty also appears to be a propagation and amplification mechanism, since economic slowdowns appear to induce yet more uncertainty.

In terms of the impact of uncertainty both the macro and micro literature suggests it has a strongly negative short-run impact on growth, reducing investment, hiring, and consumption. In the longer-run the impact of uncertainty is less clear, as uncertainty has some potentially positive effects on R&D.

Finally, the onset of the Great Recession was accompanied by a massive surge in uncertainty. The size of this uncertainty shock was so large it potentially accounted for around one third of the 9% drop in GDP versus trend during 2008-2009. In early 2010 uncertainty started to recede, but this fall has been moderated by rising policy uncertainty as Congress wrestles with sweeping fiscal reforms.

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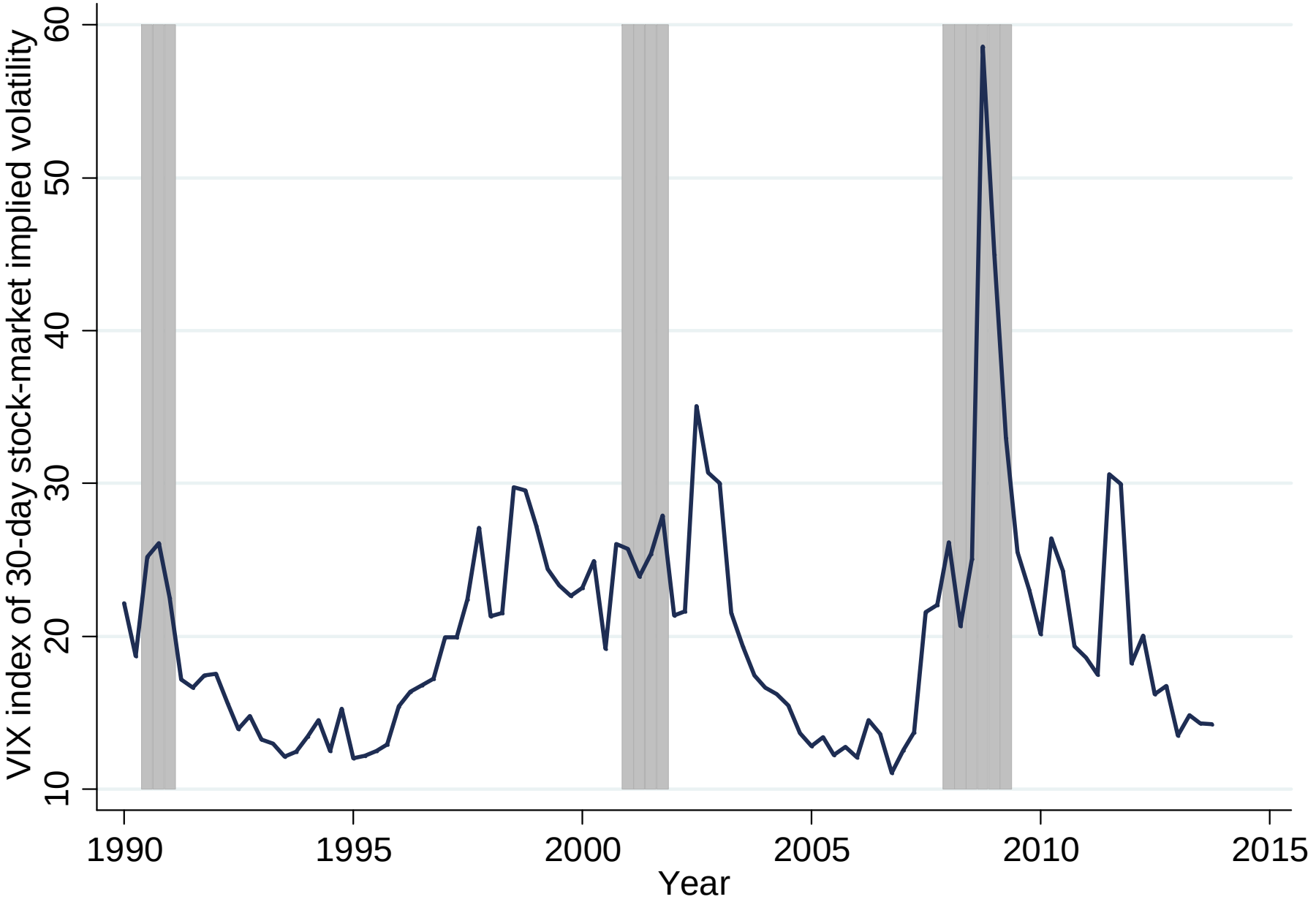
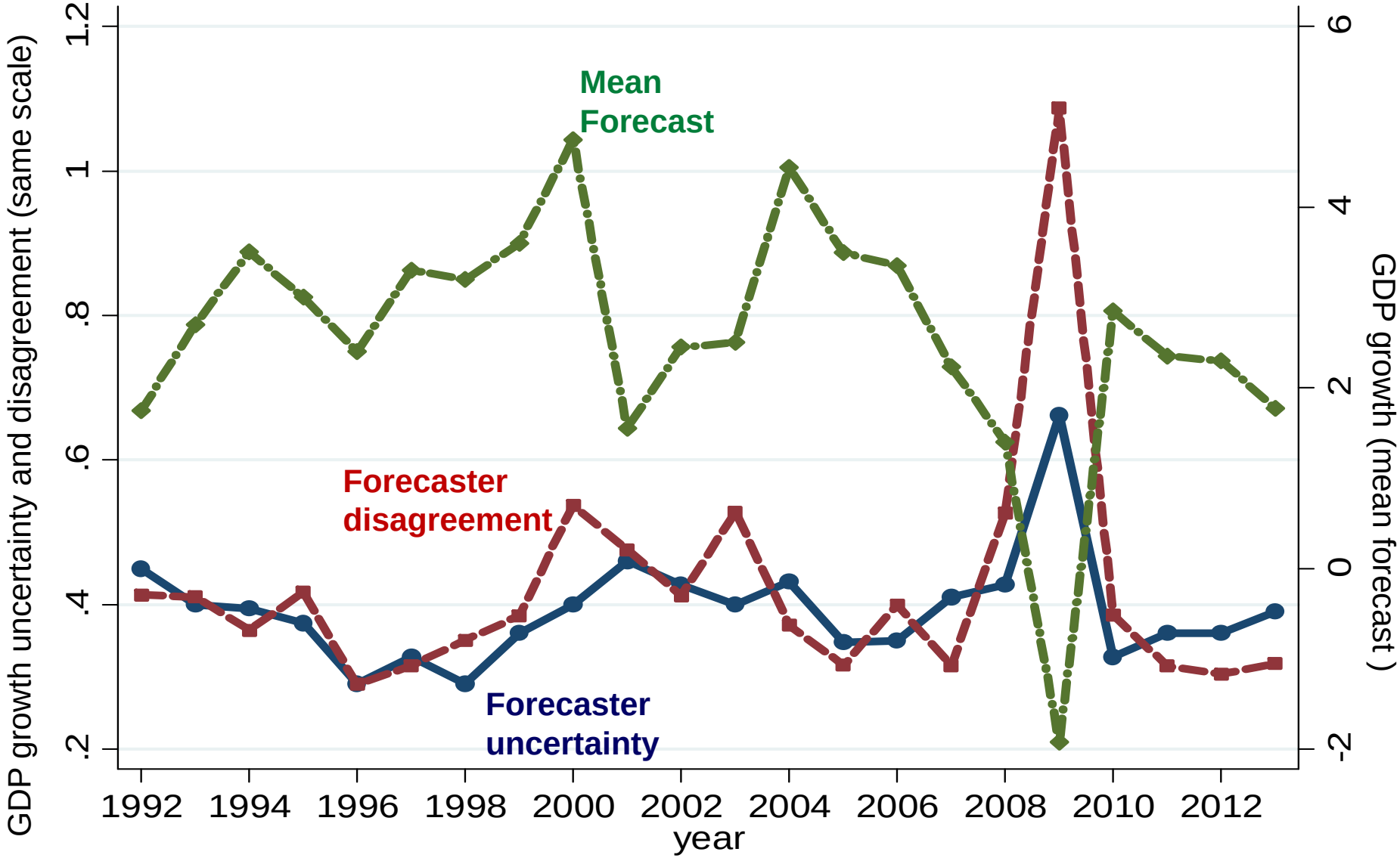
Figure 1: Stock-market implied volatility is 58% higher in recessions



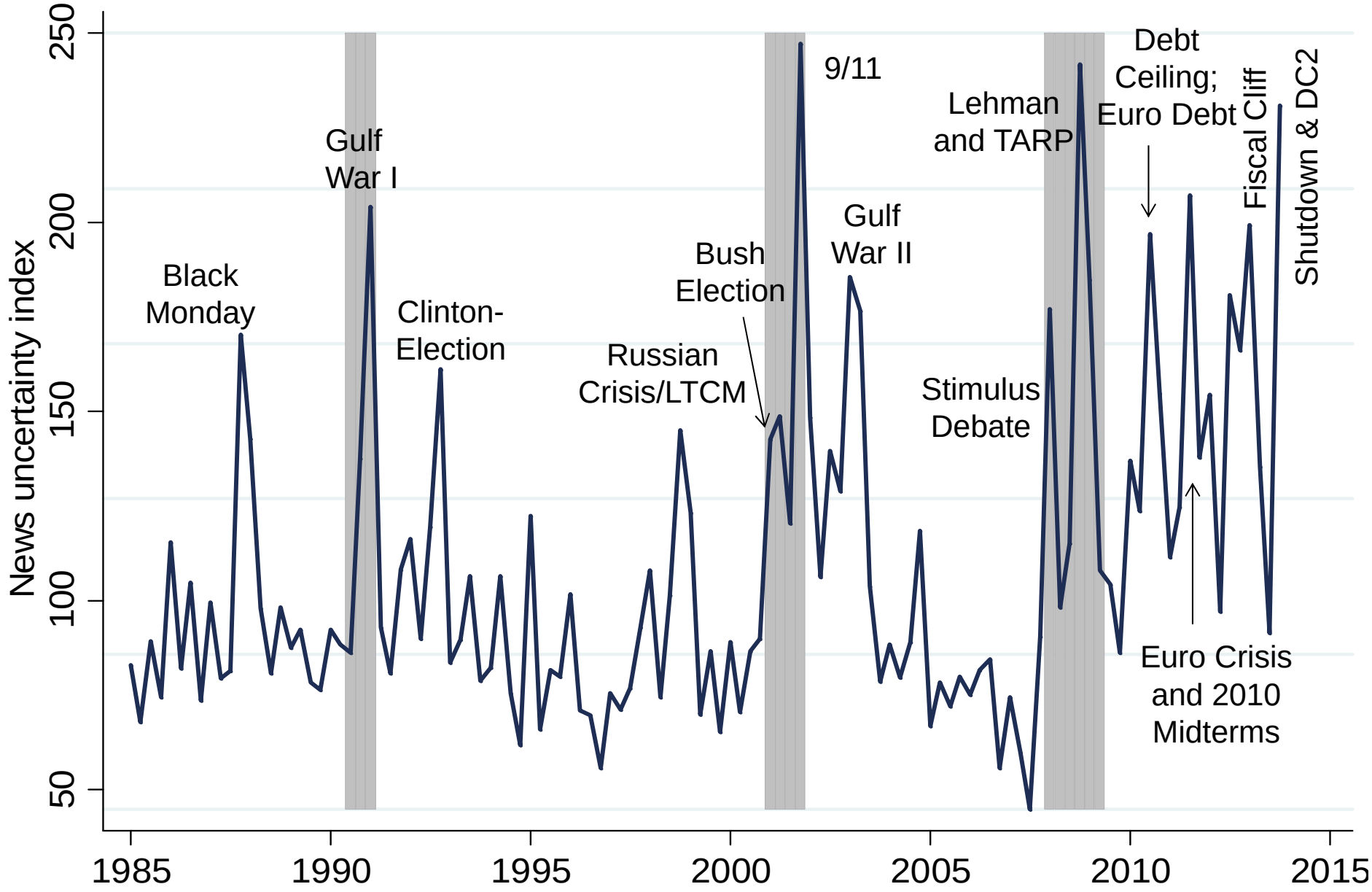
Source: VIX implied volatility on the S&P500, averaged to the quarterly level. Values are reported in standard-deviations on the S&P 500 at an annualized level. Grey bars are NBER recessions. Data spans 1990Q1-2013Q4.

Figure 2: GDP growth forecaster uncertainty and disagreement both rose significantly during the Great Recession



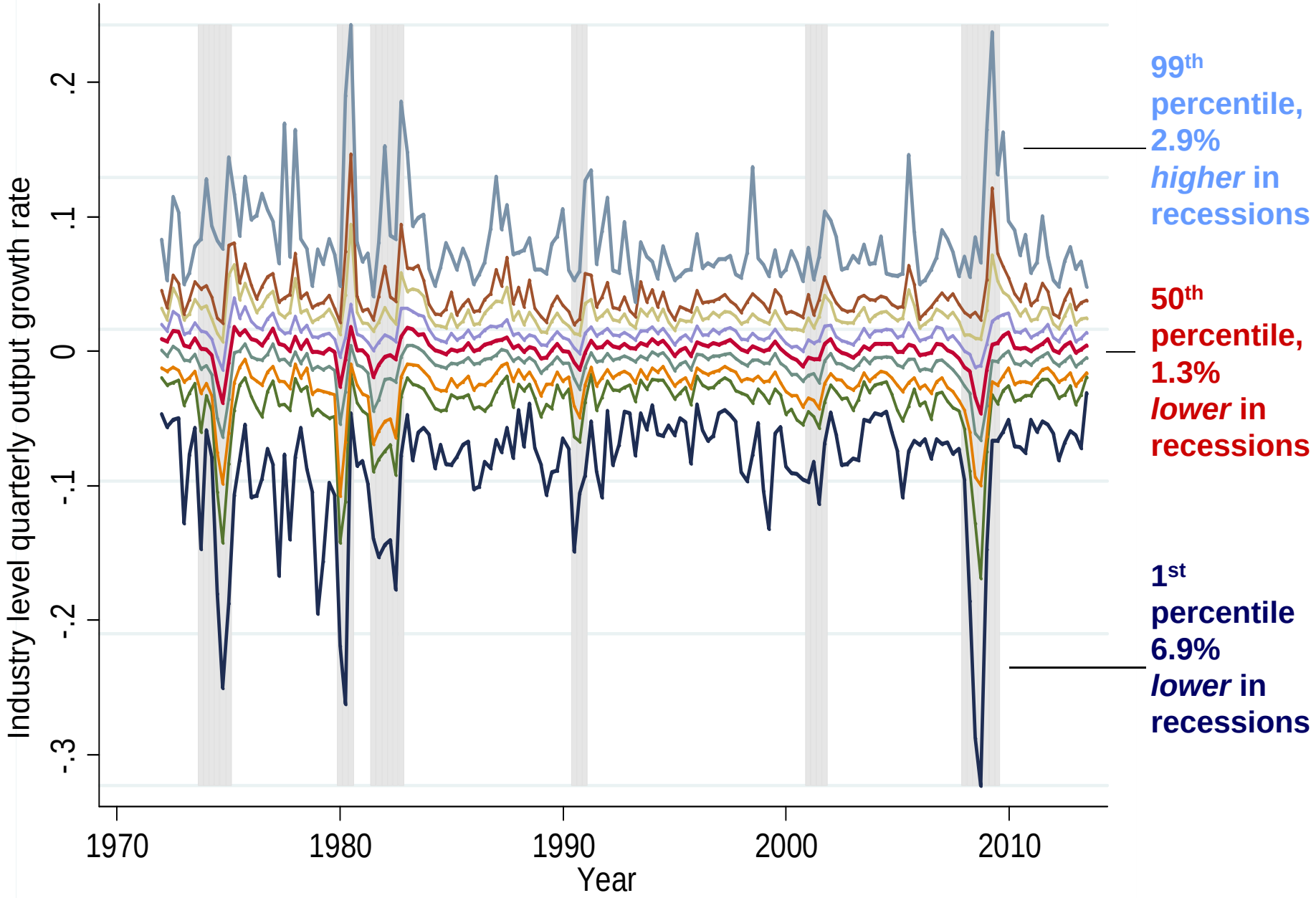
Notes: Data from the probability changes of GDP annual growth rates from the Philadelphia Survey of Professional Forecasters. **Mean forecast** is the average forecasters expected GDP growth rate, **forecaster disagreement** is the cross-sectional standard-deviation of forecasts, and **forecaster uncertainty** is the median within forecaster subjective variance. Data only available on a consistent basis since 1992 Q1, with an average of 48 forecasters per quarter. Data spans 1992-20013.

Figure 3: Newspaper policy uncertainty index is 51% higher in recessions



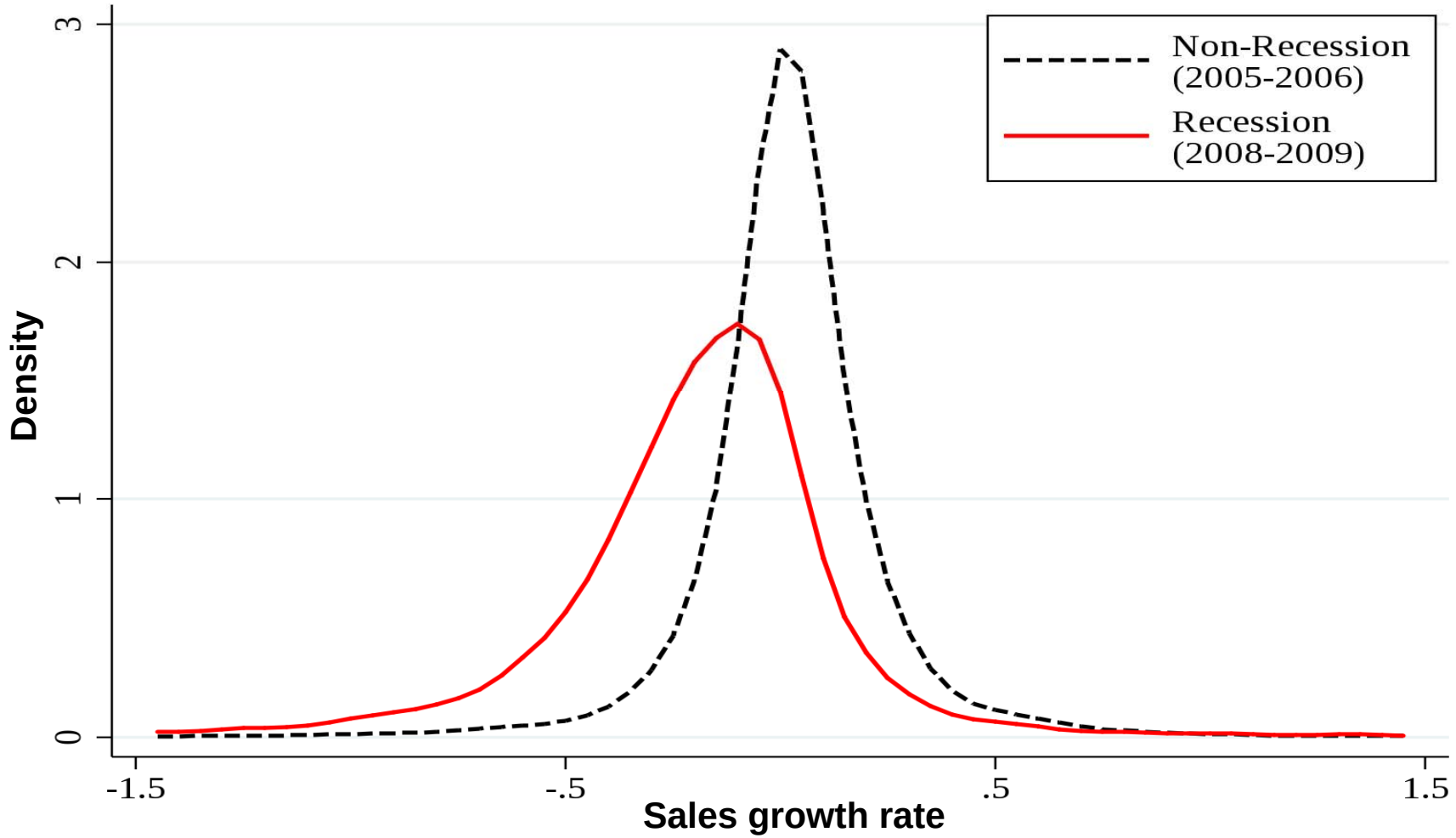
Notes: Source Baker, Bloom and Davis (2013) policy uncertainty news index. Frequency of newspaper articles in 10 US papers about economic policy uncertainty. Data from January 1985 to October 2013, normalized to 100 prior to 2010. Grey bars are NBER recessions. Data spans 1985Q1-2013Q4.

Figure 4: Industry growth rate spreads increase in recessions



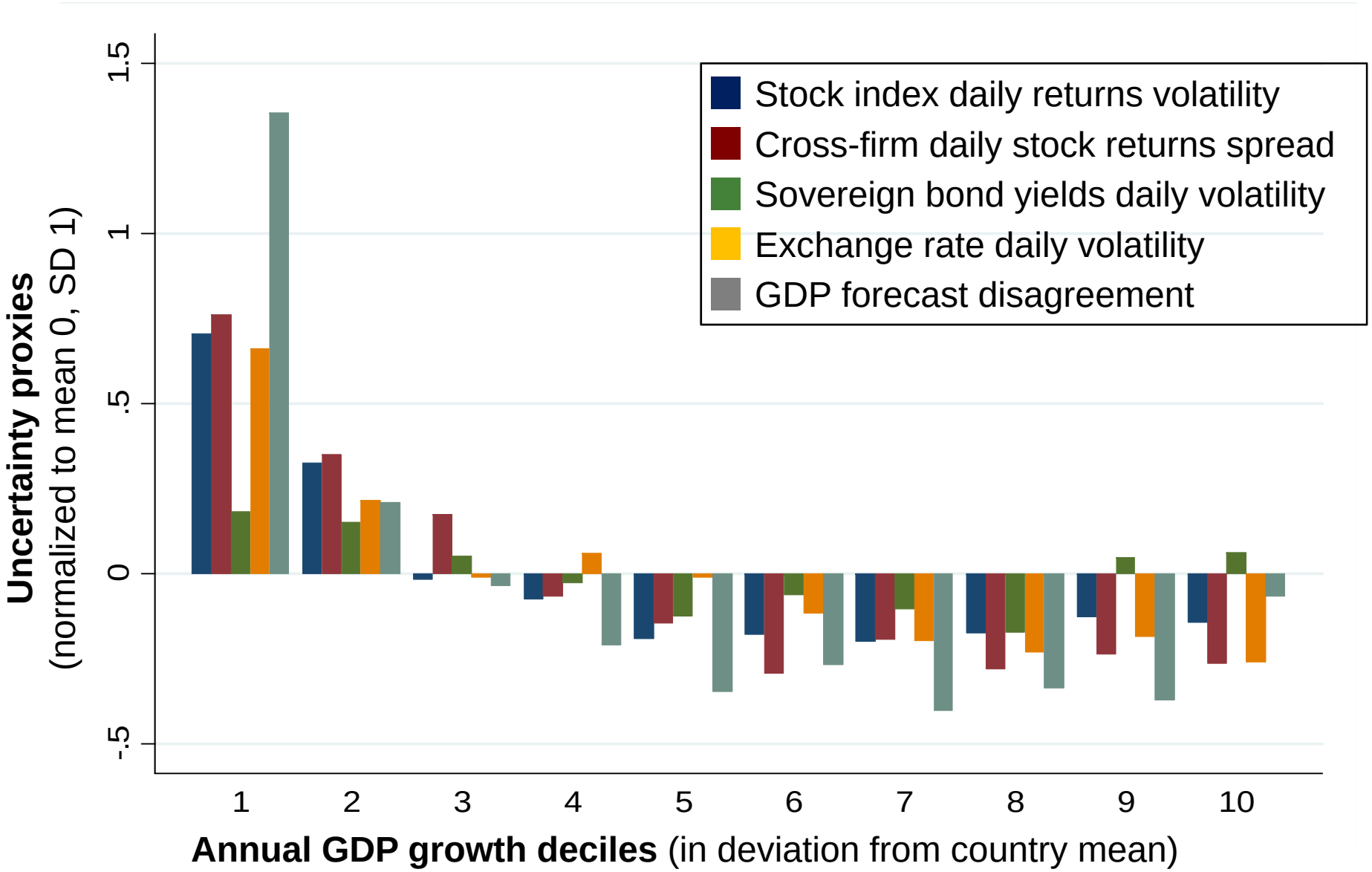
Notes: 1st, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 99th percentiles of 3-month growth rates of industrial production. All 196 manufacturing NAICS sectors in the Federal Reserve Boards' industry database. Data spans 1972Q1-2013Q3.

Figure 5: Plant uncertainty – sales growth dispersion



Notes: Source Bloom, Floetotto, Jaimovich, Saporta and Terry (2013)**.** Constructed from the Census of Manufactures and the Annual Survey of Manufactures using a balanced panel of 15,752 establishments active in 2005-06 and 2008-09. Moments of the distribution for non-recession (recession) years are: mean 0.026 (-0.191), variance 0.052 (0.131), coefficient of skewness 0.164 (-0.330) and kurtosis 13.07 (7.66). The year 2007 is omitted because according to the NBER the recession began in December 2007, so 2007 is not a clean “before” or “during” recession year.

Figure 6: Uncertainty measures are countercyclical across countries



Notes: Source Baker and Bloom (2013). Volatility indicators constructed from the unbalanced panel of daily data from 1970 to 2012 from 60 countries. Volatility values are calculated across all trading days (forecasts) within each year, and then normalized for presentational purposes so each of the four indicators has a mean of 0 and a standard-deviation of 1 by country. The GDP growth deciles are calculated within each country.