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Level and volatility factors in macroeconomic data

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ABSTRACT

Macroeconomic models typically focus on innovations in the level of fundamentals as driver of business cycles because modeling of volatility can be demanding. This paper suggests a simple methodology that can separate the level from the volatility factors without directly estimating the volatility processes. This is made possible by exploiting features in the second order approximation of equilibrium models and using information in a large panel of data to estimate the factors. Augmenting the factors to a VAR shed light on the effects of the level and volatility shocks and their relative importance.

1. Introduction

It is a long tradition in macroeconomic modeling to attribute aggregate fluctuations to a handful of shocks. In a celebrated paper, King and Rebelo (1993) showed that a large fraction of macroeconomic variations at business cycle frequencies can be accounted for by a single shock to the level of technology. At lower frequencies, nearly all macroeconomic fluctuations are often attributed to technology shocks (e.g., King et al. (1991)). More elaborate macroeconomic models also incorporate shocks to policies, preferences, and other primitives. Although these newer models have richer features and theoretical foundations, it is fair to say that using a few "level" shocks to generate cyclical fluctuations and co-movements is at the heart of macroeconomic modeling.

More recently, there is a nascent theoretical literature suggesting that higher-order shocks, and more specifically, second-moment *volatility* shocks, can also be an important source of business cycles.[2] This alternative focus is motivated by the observation that realized volatility and expected future volatility (or uncertainty) tend to be high during recessions. This countercyclical feature of volatility is robust to whether the latent volatility variables are estimated or are replaced by proxy

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[2] See, for example, Schmitt-Grohe and Uribe (2004), Kim et al. (2008), Bloom (2009), Fernández-Villaverde et al. (2011), Fernandez-Villaverde et al. (2015), Jurado et al. (2015) and references there in.

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variables. Additional evidence that second-moment variations may have first-order effects is given in Fernandez-Villaderde and Rubio-Ramirez (2010), among others.

The need to model the dynamics of volatility has long been recognized. In a seminal paper, Engle (1982) presents evidence of autoregressive conditional volatility (also known as ARCH effects) in inflation data. Sims and Zha (2006) also conclude that time-varying volatility is an important feature that empirical macroeconomic models should incorporate. From estimation of structural models, Justiano and Primiceri (2008) find significant time-varying volatility in monetary policy and technology shocks, while Fernandez-Villaverde et al. (2015) find that a two-standard deviation shock to fiscal volatility can reduce output by up to 1.5 percentage points when the economy is at the zero lower bound. Work along this line tends to assume that volatility is exogenous and that its shocks are independent of the innovations to the level of the fundamentals.

Despite statistical and methodological progress made in modeling volatility, the source of volatility shocks as well as the interaction between the level and volatility dynamics remain open questions to a large extent. While exogenous time-varying volatility in productivity shocks is a natural starting point from a theoretical point of view, it may not necessarily be the most important source of volatility in the data. Furthermore, exogenous volatility precludes volatility-in-mean effects that allow for feedback between the first- and second-moment dynamics. But the stochastic volatility estimates are typically countercyclical, suggesting that volatility is likely related to and possibly predictable by observed cyclical variables[3], which is at odds with the assumed exogeneity of volatility.

While it may be tempting to criticize the limitations of the exogenous volatility assumption, relaxing the assumption is not easy for a number of reasons. To begin with, economic theory has focused on level shocks and does not provide much guidance about the source of volatility fluctuations and how the volatility process is supposed to evolve. It is quite common to adapt models designed for high-frequency financial data to macroeconomic data, even though the two data types have distinctive time series properties. Furthermore, with time-varying volatility, there can be many channels for generating equivalent first- and second-moment dynamics. Model identification and validation is difficult as the volatility is latent even ex-post.

Perhaps more important from a practical standpoint is that modeling non-linearity and volatility often requires computationally sophisticated methods. Non-linear VARs such as the one considered in Pesaran and Shin (1998) are already quite computationally demanding. Though conceptually simple, adding stochastic volatility to an otherwise standard VAR or dynamic stochastic general equilibrium (DSGE) model entails a significant change in the estimation methodology. It is relatively easy to assess the sensitivity of a homoskedastic model to alternative assumptions, but the flexibility disappears once the volatility process has to be explicitly modeled.

In this paper, we propose a simple and easy-to-implement framework for studying the interaction between the first- and second-moment dynamics. It preserves the traditional view that there are relatively few level shocks in macroeconomic data. However, it allows second-moment shocks to be a source of economic fluctuations and permits the second-moment factors to respond to the level shocks. Specifically, Benigno et al. (2013) shows that time-varying volatility has a second-order effect on the level of the endogenous variables. We demonstrate that if the data are generated according to a DSGE model and are observed without error, then under some additional assumptions, we can distinguish the "level" factors A from the "volatility" factors V. In practice, the V that we recover is likely a composite of second-moment factors whose interpretation we remain agnostic on. This limitation arises partly because there are likely shocks, some to second moments, that DSGE models fail to capture. Furthermore, the construction of V depends on the level factors estimated from a large panel of data, and these estimates are only consistent for the space spanned by the true factors. In other words, we only identify the true factors up to a rotation. The exercise is nonetheless of interest because it sheds light on the importance of the second-moment dynamics. After all, if the level shocks are the sole source of economic fluctuations, then the second-moment shocks should have no cyclical implications whatever their structural interpretation might be. We find that not only are the effects of the second-moment shocks significant, but their presence tends to reduce the importance of the level factors previously used in FAVARs.

Our objective is to separate the level and the volatility factors in the data, and to quantify their individual contributions as well as the non-linear interactions. Previous macroeconomic analysis typically incorporates volatility processes into fully specified structural models estimated from a small number of variables (see Fernandez-Villaderde and Rubio-Ramirez (2010)). Estimation is rather complicated and the results rely on correct specification of both the economic model and the volatility processes that theory offers little guidance on. Our methodology requires the presence of pervasive volatilities but is not tied to any particular economic model. Instead, it relies on information contained in a monthly panel of 134 macroeconomic time series to recover the space spanned by the volatility processes.[4]

Several patterns in the level and volatility factors are noteworthy. First, even though there are eight factors, we suggest that only three are level factors. Our dominant volatility factor V_1 is estimated to be countercyclical and persistent. It rises during the Great Recession considerably and remains at an elevated level for many years, but it is weakly and negatively correlated with the stochastic volatility directly estimated from our real-activity level factor. Second, our estimated V_1 is only weakly correlated with measures of volatility/uncertainty constructed in previous studies such as Baker et al. (2016) and

[3] See, for example, Justiano and Primiceri (2008) and Carriero et al. (2016) among others.

[4] Our emphasis is on the second-moment dynamics, hence distinct from the VAR proposed in Aruoba et al. (2017), whose focus is non-linearities. While Jurado et al. (2015) also exploits a data rich environment, their uncertainty measure concerns h step ahead volatility in the forecast errors. We evaluate the contemporaneous unconditional volatility; no forecasting model is involved in our approach.