Uncertainty Shocks and Asymmetric Dynamics in Korea: A Nonlinear Approach

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This study investigates the impact of uncertainty shocks on macroeconomic activity in Korea. For this purpose, a Smooth Transition VAR model is employed to document the state-dependent dynamics of two distinct types of uncertainty shocks, namely, financial market based and news-based. When nonlinearity is allowed to play a role in our model, quantitatively very different asymmetric dynamics are observed. Following in inflation targeting, the responses tend to be smoother and less pronounced. Our empirical results support the view that the link between uncertainty and macroeconomic activity is clear over both recessions and expansions. Furthermore, the impact of uncertainty shocks is more pronounced when economic activity is depressed especially after shocks originate from the financial market, and not from news-based policy uncertainty in Korea.

Keywords: Uncertainty shocks, Smooth transition vector autoregression, Asymmetric dynamics, Recessions

JEL Classification: C32, E32, E52

I. Introduction

How do uncertainty shocks affect macroeconomic activity, and how does the process behave over the business cycle in Korea? Starting with the seminal work of Bloom (2009), there is a large body of literature which investigates the relationship between financial market uncertainty and the aggregate economy. Furthermore, Baker et al. (2016) construct an index of economic policy uncertainty (*EPU*) and find that an unexpected increase in the same is associated with a significant and persistent drop in real activity in the response of the U.S. and a number of other countries. Regardless of the type of uncertainty shock, the recent consensus from a growing body of literature shows that uncertainty rises dramatically in recession. While this empirical evidence supports the common understanding of the link between uncertainty and macroeconomic variables, especially in an advanced economy, the question of whether the different proxies for uncertainty shocks affect macroeconomic variables in heterogeneous ways remains unanswered.

Even though a large body of theoretical literature focuses on the channels through which uncertainty has macroeconomic impacts on the domestic economy,¹⁾ it is generally centered around the common effects of two different types of uncertainty shocks. The literature supports a general role for uncertainty in recessions, even though the uncertainty measures are strongly correlated with two different sources: financial and political uncertainty. While Bloom (2009), Arellano et al. (2012), Christiano et al. (2014), and Gilchrist et al. (2016) among others use financial market volatility as the proxy for the uncertainty shock, showing that uncertainty dampens the real economy through its influence on financial markets, a number of studies including Born and Pfeifer (2014),

1) See Bloom (2009), Bloom et al. (2012) for real option effects; Van Nieuwerburgh and Veldkamp (2006), Fajgelbaum et al. (2014) for feedback (uncertainty trap) channel; Fernandez-Villaverde et al. (2011) for precautionary savings channel; Carriere-Swallow and Céspedes (2013) for credit channel; Gertler et al. (2007) for financial friction for small open economy; Basu and Bundick (2012) and Leduc and Liu (2012) for search frictions channel.

Fernandez Villaverde et al. (2015), and Baker et al. (2016) find that policy risk or news-based shocks are also significant in understanding how uncertainty impacts the macroeconomic environment. Recently, Ng and Wright (2013) show that all post-1982 recessions have their roots in financial markets, and these recessions have considerably different features from recessions where financial markets play a passive role. Moreover, Ludvigson et al. (2015) argue that higher uncertainty in recessions is more likely to be an endogenous response to business cycle fluctuations, while the financial market uncertainty seems to be a source of these fluctuations. Based on this perspective, as well as the recent observation of the divergence between policy uncertainty and stock market volatility in Korea, if uncertainty shocks are still an important source of business cycle fluctuations, and financial markets play a key role in an economy, two popular measures of uncertainty shocks might affect the macroeconomic variables in different ways.²⁾

Linear Vector Autoregression (*VAR*) models are standard in many empirical macroeconomic studies including Bloom (2009), however, as shown by Koop and Potter (1999), van Dijk et al. (2002), and Morley et al. (2012), macroeconomic variables have been shown to have asymmetric dynamics over different phases of the business cycle. Moreover, the recent financial crisis highlights the fact that economic downturns can be far sharper than recoveries and uncertainty usually peaks in deep recessions. The stylized facts along with the recent observations easily lead us to consider a non-linear framework. Considering this, recessionary events seem to be informative periods for the identification of the asymmetric effects of uncertainty shocks in the aggregate economy.

This study examines the effects of two distinct types of uncertainty shocks on the aggregate economy of Korea.³⁾ The main research questions

2) The recent observation of the divergence between policy uncertainty and stock market volatility in Korea is likely to suggest that two popular measures of uncertainty shocks might affect the macroeconomic variables in different fashions. (i.e., The highest *EPU* index but the lowest *KVOX* index in 2016 due to the Presidential Scandal and the impeachment of President Park by the parliament in late 2016.)

3) Choi and Sim (2016) compared the impacts of financial uncertainty and policy uncertainty on business cycles in Korea with a linear VAR. Shin et al. (2018) construct Korean macroeconomic uncertainty measure and find that their measure explains aggregate fluctuations well in Korea.

are: How does uncertainty-and two different types of uncertainty-affect macroeconomic variables in Korea? Is this process asymmetric over the business cycle? The issue addressed in this study is the extent to which the responses of macroeconomic variables vary with two different uncertainty shocks in the pre- and post-Asian Financial Crisis (1997-1998), which coincided with the adoption of inflation targeting in 1998 in Korea. To answer these questions, a Smooth Transition *VAR* (*STVAR*) by Granger and Teräsvirta (1993) is employed to analyze the possible nonlinear effect of uncertainty on macroeconomic variables in Korea. Two distinct measures for uncertainty are considered: A measure of financial uncertainty from the *KOSPI* (Korean composite stock market index), and a measure of economic policy uncertainty index.

Comparisons are made, together with financial uncertainty and *EPU* index, and headline and core inflation, between recession and expansion as well as linear *VAR* and nonlinear *STVAR* models. Furthermore, since we observe the structural break in the data due to the Asian Financial Crisis of 1997-1998, which coincides with the switch to inflation targeting monetary policy regime in 1998, we also estimate the post inflation targeting periods from 1998. Our empirical findings are interesting, and they are as follows: First, we find evidence that there are significant asymmetric responses of inflation and unemployment in a recession, vs. an expansion similar to the findings in Caggiano et al. (2017), and Caggiano et al. (2014). The findings from non-linear *STVAR* which allows us to separate the impact of uncertainty shocks for recessions provide clear evidence for asymmetric dynamics for macroeconomic variables. The asymmetric empirical evidence implies that linear *VAR* models which are generally mixing up different phases of the business cycles might lessen the effects driven by uncertainty shocks, suggesting that the effects of uncertainty shocks from the non-linear *STVAR* analysis featuring two different phases may be larger than what a linear model would suggest.

Second, the type of uncertainty shocks matters, and the degree of asymmetry in the responses depends on where the shock originated.

Financial market volatility shocks have a greater impact on macroeconomic variables than *EPU* shocks. Similarly, forecast error variance decomposition shows that financial market volatility explains a great deal of the macroeconomic variances, implying that news-based uncertainty might not be a major source of business cycle fluctuations in Korea. While economic policy uncertainty mainly concerns uncertainty about domestic political and economic events and actions, financial market in Korea is directly linked to the global financial markets and international economic fluctuations driven by large open economies. This finding is in line with Ludvigson et al. (2015) in that financial market based uncertainty is a major source of business cycle fluctuations in Korea, where financial markets play a key role and which adapted an export oriented industrial strategy to spur its economic growth. Moreover, our observation in this study is also consistent with the findings in Caldara et al. (2016), Christiano et al. (2014), Gilchrist et al. (2014), and Arellano et al. (2010), indicating that a possible amplification mechanism and source of persistence for the uncertainty shock might be the financial friction channel in an emerging economy such as Korea. Furthermore, the empirical evidence from a nonlinear *VAR* is more obvious than the one predicted by a linear *VAR*, and is also robust to a variety of orderings of our baseline vector with different variables, sub-sample analysis, and different specifications.

These empirical findings viewed together are in support of the assessment that high uncertainty accompanies deep recessions. When nonlinearity is allowed to play a role in our model, quantitatively quite different asymmetric dynamics are observed. Moreover, although the asymmetric dynamics are apparent over both business cycle regimes, the impact of uncertainty is more pronounced when economic activity is depressed, especially after shocks originate from the financial markets and not from news-driven policy uncertainty in Korea.

II. Data Description

To model responses of key macroeconomic variables to uncertainty shocks, we follow Caggiano et al. (2014) and consider a set of macroeconomic variables from four sources: DataStream, Korean Exchange, www.policyuncertainty.com and the St. Louis Fed FRED database. They are uncertainty, inflation, unemployment, and the policy rate measured by overnight loan rate which is the proxy for monetary policy. Inflation is based on the percentage change of the consumer price index (*CPI*). Headline inflation is used in our baseline model, but for a robustness check, we estimate the model with core inflation without volatile components such as food and energy. The data are monthly and cover the period of January 1991 to December 2016.⁴⁾ The summary statistics and sources of the variables are presented in Table 1. Interestingly, the correlation between *EPU* and financial market uncertainty index is only 0.05 and the mean values of the two different indexes in two distinct regimes are quit different, implying a possibly heterogeneous role of two distinct types of uncertainty shocks on the aggregate economy of Korea.

Two different proxies for uncertainty are employed; a measure of financial uncertainty from the *KOSPI* and the *EPU* index. For the measure of financial uncertainty from the *KOSPI*, we follow Bloom (2009), and use the implicit volatility of *KOSPI* (*VKOSPIX*), which is the best alternative for the *VIX* (Chicago Board Options Exchange Volatility Index) in Korea. This index measures stock market volatility one month ahead and captures forward-looking information. However, since *VKOSPIX* is only available from 2003, we compute the realized volatility from 1991 to 2002 based on the monthly standard deviation of the daily

4) The beginning of the sample of 1991 is due to data on several key variables being unavailable prior and the lack of suitable proxy for those variables. Monthly variables are employed for a couple of reasons. A lower frequency data usually smoothes out much of the variation and fluctuations of the variables concerned. Further, a higher frequency observation alleviates any issues related to zero contemporaneous restrictions employed for structural modeling.

return of the *KOSPI* matched to the same mean and standard deviation of the *VKOSPIX* from 2003 onward, and combine them to produce a consistent measure of financial uncertainty for Korea.⁵⁾

For economic policy uncertainty, we employ the *EPU* index for Korea by Baker et al. (2016).⁶⁾ They calculate the number of news articles that considers the following terms relative to the entire news articles in questions: Uncertain or uncertainty; economic, economy or commerce. They also use one or more of the following policy relevant terms: Government, Blue House, congress, authorities, legislation, tax, regulation, the Bank of Korea, central bank, deficit, WTO, law/bill, and ministry of finance. After they standardize each paper's *EPU* to unit standard deviation from 1995 to 2014, they average it across the papers by month, and then rescale the resulting series to a mean of one hundred from January 1990 to December 2014.

Figure 1 plots the volatility series and recessionary periods for Korea based on OECD recession indicators during the sample period. It is easily observed that recessions are associated with heightened uncertainty in the financial market, and with the *EPU* index. These include historical political and economic events such as the enactment of the Real Name Financial Transactions in August 1993, the death of Kim Il-Sung in July 1994, and Asian Financial Crisis in August 1997, which can be considered as uncertainty shocks in the 1990s. Other notable political and economic events in the heightened *EPU* index in the 2000s are the bankruptcy of Daewoo Motors in November 2000, Gulf War II in 2003, the Global Financial Crisis in 2008, and the Presidential Scandal and the impeachment of President Park by the parliament in late 2016. These can obviously be seen as considerable shocks which cast uncertainty in Korean aggregate economy.

5) The *VKOSPIX* from the datastream is available only after April, 2009. We employed both and no difference is found between them.

6) The *EPU* index is the only available standardized policy uncertainty index. To construct the *EPU* index for Korea, six news papers are used: Donga-Ilbo, Kyunghyang Shinmun, Maeil Business Newspaper, Hankyore Shinmun, Hankook Ilbo, and the Korea Economic Daily.

III. Empirical Model

Following Auerbach and Gorodnichenko (2012) and Caggiano et al. (2014), we make use of *STVAR* to analyze the possible non-linear effects of uncertainty on dynamics of macroeconomic variables. According to Granger and Teräsvirta (1993), the *STVAR* framework employs a regime switching *VAR* in which the transitions between recession and expansion are smooth.⁷⁾ This modeling strategy allows us to take advantage of the degree to which the economy is in expansion or recession and also allows for the segregation of different regimes. More specifically, it exploits variation in the degree (or probability) of being in a recession or an expansion. The *STVAR* takes the following form:

$$X_t = F(z_{t-1})\Pi_R(L)X_{t-1} + (1 - F(z_{t-1}))\Pi_{NR}(L)X_{t-1} + \mu_t, \mu_t \sim N(0, \Omega_t) \quad (1)$$

X_t is an $N \times 1$ set of macroeconomic variables entering the data set. $F(z_t)$ is a function bounded between zero and one. The state-dependent variance-covariance matrices Ω_R and Ω_{NR} act as the contemporaneous propagation of structural shocks and the lag polynomials $\Pi_R(L)$ and $\Pi_{NR}(L)$ act as the dynamic propagation of the structural shocks in recessions (R) and expansions (NR). The variance covariance matrices of the reduced form residual Ω_t is defined as follows:

$$\Omega_t = F(z_{t-1})\Omega_R + (1 - F(z_{t-1}))\Omega_{NR} \quad (2)$$

The variable z_t is a normalized index of the business cycle, where positive values indicate an expansion and negative indicate a recession. $F(z_{t-1})$ is a logistic transition function which captures the probability of being in a recessionary or expansionary phase. We define the transition

7) For more details, see Granger and Teräsvirta (1993).

function as follows:

$$F(z_t) = \frac{\exp(-\gamma z_t)}{(1 + \exp(-\gamma z_t))}, \gamma > 0, z_t \sim N(0, 1) \quad (3)$$

Setting the smoothness parameter to $\gamma > 0$ and letting the index z_t be the transition indicator, one can then interpret Ω_R and $\Pi_R(L)$ as describing the system when it is in a recession ($F(z_{t-1} \approx 1)$) and Ω_{NR} and $\Pi_{NR}(L)$ as describing the system when it is in an expansion ($1 - F(z_{t-1} \approx 1)$). We use the 12 month moving average of the growth rate of industrial production as our transition indicator variable, a common adoption in the literature. The model therefore can be described as a combination of two *VARs* in which transitions between ‘two states’(i.e. recession and expansion) are smooth and regulated by the transition indicator γ . Conditional on negative values of the transitions indicator z_t , the transition function indicates the probability of being in a recessionary stage. When the probability of being in a recession is sufficiently high, the model switches to capturing the effects of the shock in a recession.⁸⁾ This transition is regulated by the calibration of γ . High calibrations for γ imply abrupt regime switches, and the assumption that the economy is spending less time in the recessionary phase. Vice versa for lower calibrations. If $\gamma = 0$ the mode becomes linear and in the case of γ calibrated to infinity, the model would become discrete. In the case of Korea, more time was spent in recession following 1998. We calibrate $\gamma = 1.5$ for the period 1998M4-2016M12 ($F(z_t).75$) and $\gamma = 1.75$ ($F(z_t).8$) for period 1991M4-2016M12.⁹⁾ The transition function $F(z_t)$ shown in

8) We set the threshold for the probability as indicated by the transition function at .8 in this paper following Auerbach and Gordnichenko (2012) and Caggiano et al. (2014).

9) We calibrate it again for the sub-sample because for the full sample period, Korea experienced longer periods of recession. As robustness we estimated a range of γ calibrations from $\gamma = 1.25$ and $\gamma = 2$. The results were robust to these calibrations.

Figure 2 tend to follow the OECD recessionary periods for Korea.

Our baseline analysis is contingent on the vector $X_t = [Uncertainty_t, \pi_t, u_t, R_t]'$, where $Uncertainty_t$ stands for our proxy for uncertainty, either EPU_t or $VKOSPIX_t$, π_t stands for inflation, u_t is the unemployment rate, R_t is a policy rate.¹⁰⁾ Following Caggiano et al. (2014), the identification of exogenous variations of the uncertainty index will be achieved via the widely adopted Cholesky assumption, which implies that on-impact macroeconomic effects by the identified uncertainty shocks are allowed.¹¹⁾ Based on Auerbach and Gorod-nichenko (2012) and Caggiano et al. (2014) the models including both linear ($\gamma=0$) and nonlinear ($\gamma>0$) formulations are estimated via Monte-Carlo Markov-Chain simulation proposed by Chernozhukov and Hong (2003). Following Koop et al. (1996), effects of the uncertainty shock are computed by assuming that they start in a recession and remain in the state.¹²⁾ As discussed in Caggiano et al. (2014), this is desirable as the impulse response will not depend on initial conditions nor on the size of the shock and thus are not simply functions of history. Generalized impulse response functions (GIRFs) are computed as in Koop et al. (1996) and reported as the median response of the 95% confidence band.

IV. Empirical Results

Two sample periods are considered in our baseline approach, the full sample, covering 1991M1-2016M12, and the sub-sample for 1998M4-2016M12, due to the structural break in terms of both the Asian Financial Crisis of 1997-1998, and the switch to inflation targeting monetary policy regime in 1998.¹³⁾

10) Following Teräsvirta (1994) and Teräsvirta and Yang (2014), several tests are conducted to test for linearity as well as to confirm correct specification of transition function. See Appendix for details.

11) No recursive ordering is right because we are using monthly data. See footnote 4 for details.

12) For technical details, see Auerbach and Gorodnichenko (2012) and Chernozhukov and Hong (2003).

1. Full Sample Results for 1991–2016

Figure 3 plots estimated impulse responses to a one standard deviation shock of *VKOSPIX* and *EPU* respectively contingent on a recession and expansion. Starting with the recession contingent responses, on impact, headline inflation decreases by about .02% and the decrease stays significant for about 30 months. The *EPU* shock has a small negative impact on inflation in the sample period and the decreases are slight and hardly significant. The unemployment rate increases much more in a recession from a *VKOSPIX* shock than an *EPU* shock (roughly 10 times smaller than from the *VKOSPIX* shock). Unemployment increases by .02% and .002% respectively from a *VKOSPIX* and *EPU* shock. In terms of the policy rate, the estimates show a somewhat opposite path when the pre-inflation targeting era is included. On impact, the *VKOSPIX* shock raises the policy rate in a recession for about 10 months, before going back to zero.¹⁴⁾ The recession contingent shock to the *EPU* shows no discernible impact on policy rate.

An interesting and slightly different relationship is estimated via the expansion contingent *VAR*. Following a *VKOSPIX* or *EPU* shock in an expansion, headline inflation is shown to increase, contrary to the recession contingent estimates. The *VKOSPIX* impact is roughly 5 times as large as the *EPU* impact at .025% and .005% respectively. Unemployment follows a similar pattern to the previous estimates, but are less pronounced, which may be expected since a common theme in the literature is that macro variables tend to be less sensitive to shocks in an expansion than in a recession. In an expansion, the policy rate is much more responsive to the *EPU* news-based shock when the full sample period is considered in the model.

13) We also estimated the pre-crisis period (1991–1997). Unfortunately, however, the sample period is too short to reach a convergence for *STVAR*.

14) In a world with perfect capital mobility, when uncertainty rises, it is not surprising that the central banks raise the rate to avoid any capital outflows. See Rey (2016) for details.

While the responses on recessions are quantitatively quite different, a similar pattern emerges in responses when uncertainty shocks are estimated in a linear *VAR*. Though the responses to the news-based *EPU* shock show a very similar pattern to the *VKOSPIX* shock, they are quantitatively much smaller than those of the *VKOSPIX* shock. Inflation, however, decreases on impact, instead of with a lag. Simultaneously, unemployment rises, and the policy rate falls. The interesting point observed is that the shock is nearly ten times greater in some instances comparing the *VKOSPIX* shock to the *EPU* shock. Overall, the empirical finding is somewhat contrasting to Baker et al. (2016) and Caggiano et al. (2017), who find substantial impacts of policy uncertainty shocks on the U.S. economy. However, it supports Born and Pfeifer (2014), who provide evidence showing insignificant effects of policy uncertainty on the U.S. macroeconomic activity. Most importantly, although the empirical evidence from *STVAR* seems to show similar dynamics compared to a linear *VAR*, when nonlinearity is introduced in our model, quantitatively and statistically quite different dynamics are observed.

2. Sub-sample Results for 1998–2016

There exists the structural break in the data due to the Asian Financial Crisis of 1997-1998, which coincides with the switch to inflation targeting monetary policy regime in 1998. In order to avoid any issues related to biased estimation, we also estimate the post inflation targeting periods from 1998M4.¹⁵⁾ An interesting question, yet to be addressed specifically, for the sub-sample analysis, is whether inflation targeting lowers inflation uncertainty and unemployment uncertainty due to central bank transparency and commitment to policy directives after the Asian Financial Crisis. The

15) We considered three cases from 1998:1, 1998:4, and 1999:1, and then reported the case with 1998:4 simply because the BOK initiated inflation targeting at the second quarter of 1998. There is no difference in terms of empirical results between the three cases.

nonlinear *VAR* system will also allow us to explore the relationship and the hypothesis further, by investigating whether inflation targeting is an important factor in stabilizing the aggregate economy after uncertainty shocks and whether the relationship changes when accounting for the business cycle.

Figure 4 plots dynamic behavior over the sample period of 1998-2016 from the nonlinear *VAR* system contingent on a recession and an expansion. On impact, headline inflation decreases following the *VKOSPIX* and *EPU* shocks. Again, the result being nearly five times as strong for the *VKOSPIX* shock, compared to the *EPU* shock. Unemployment rises significantly following a *VKOSPIX* shock, with no discernible impact in the *EPU* shock. The policy rate decreases by about one basis point after a *VKOSPIX* shock only, following a pattern consistent with an inflation targeting strategy by the Bank of Korea.¹⁶⁾ This is in line with Basu and Bundick (2012) and Leduc and Liu (2013), implying that uncertainty shocks, especially the *VKOSPIX* shocks, act as aggregate demand shocks.

The estimates contingent on an expansion are less pronounced. Both the *VKOSPIX* and *EPU* shocks produce minor changes in headline inflation. Unemployment reacts slightly negatively due to a *VKOSPIX* shock and insignificantly due to an *EPU* shock. The policy rate is hardly changed due to a *VKOSPIX* shock, but does decrease in response to an *EPU* shock in an expansion. Overall the expansion contingent estimates indicate that uncertainty shocks are not a huge driver of the adjustment of the variables in the system in an expansion.

As can be seen from the full sample, a similar dynamic behavior is observed in a linear *VAR*, although the responses are quantitatively different in a nonlinear *VAR*. Headline inflation shows a similar pattern, yet is entirely unaffected by the *EPU* shock. Unemployment increases, yet

16) Inflation targeting is important as one of factors to stabilize the economy after uncertainty shocks, not the most important factor.

the increase is slightly less than in the longer sample period. The policy rate drops by around one basis point following *VKOSPIX* shock and by slightly less than one basis point in response to an *EPU* shock. In summary, the empirical finding from the sub-sample analysis shows that inflation targeting seems to play a significant role in lowering inflation and unemployment uncertainties. In particular, the evidence from a nonlinear *VAR* shows that financial uncertainty shocks are more dominant than the policy uncertainty shocks.

3. Forecast Error Variance Decomposition

To assess the contribution of two different types of uncertainty shocks for the dynamics of macroeconomic variables concerned, we perform a forecast error variance decomposition (*FEVD*). Table 2 documents the 24-month- ahead *FEVD* for the *VKOSPIX* and *EPU* shocks. Depending on recessions for both sample periods, *EPU* shocks explain only around 1%, and are negligible for inflation, unemployment rate, and policy rate. Conversely, dependent on recessions for both sample periods, a *VKOSPIX* shock explains significant amounts of the variances in the variables concerned. The same is true for the contributions of both of the uncertainty shocks dependent on expansions. This confirms our main finding that the *VKOSPIX* has a greater influence on macro variables than the news-based index.

V. Robustness

First, we use the core inflation rate to examine possible changes compared with headline inflation. Second, we include both the *EPU* and *VKOSPIX* in the same *VAR* system, to account for possible interdependence between the two. Third, several other omitted variables to be included in our *VAR* system are suggested by the literature, such

as industrial production, the log level of the stock market index, and the exchange rate.¹⁷⁾ Finally, we also conduct sensitivity tests with respect to the *VAR* system ordering, lag selection, and calibration of the smoothness parameter. Overall our results were confirmed by the robustness test.

1. Core Inflation

To test whether headline inflation is an appropriate target, and how our results may change under inflation targeting, core inflation is also considered in our model. This is partly due to the fact that monetary policy should not be held responsible for non-monetary factors that influence prices.¹⁸⁾ Based on the impulse responses in Figures 5 and 6, we did not find a significant difference, but did find similar behaviors between the variables. A shock to either uncertainty index causes address a decrease in inflation, an increase in unemployment, and a decrease in the policy rate. The effects are once more significantly larger when the shock is due to the *VKOSPIX*. The effects are around 5 times larger for the three variables of inflation, unemployment, and the policy rate. This confirms the overall conclusion that financial market volatility plays a significantly greater role in influencing macro variables under inflation targeting than news-based shocks.

2. The EPU and VKOSPIX Index

As done by Bacchetta and Van Wincoop (2013), to test whether uncertainty regarding global financial markets is more dominant than political uncertainty, and to document the differences and similarities of the type of shock affecting the aggregate economy, we include both the *EPU* and *VKOSPIX* in the same *VAR* system. Even though the two

17) For details, see Caggiano et al. (2014).

18) See Hoffmaister (2001) and Bodenstein et al. (2008) for details.

indices are based on separate underlying indicators, there might be some level of interdependence and an interrelationship between the two different types of uncertainty. The findings from the impulse response functions in Figure 7 indicate that one standard deviation shock to the *VKOSPIX* index raises the *EPU* index for the recession by sizable amounts, while an *EPU* shock has a negligible impact on the *VKOSPIX*. Although two different uncertainty shocks are important in the U.S., it is likely that uncertainty regarding financial market, rather than domestic economic policy uncertainty, plays a more dominant role in explaining business cycle fluctuations in an emerging economy such as Korea.

3. Omitted Variables and Specification

To avoid any issues related to model misspecification, we consider three omitted variables in our *VAR* system: *KOSPI* stock market index, industrial production, nominal effective exchange rate (*NEER*).

3.1 The KOSPI Index

Following Caggiano et. al (2014), we add the *KOSPI* stock market index to the *VAR* system so that our vectors of variables becomes $X_t = [VKOSPIX_t, \pi_t, \mu_t, KOSPI_t, r_t]'$ and $X_t = [VKOSPIX_t, EPU_t, \pi_t, \mu_t, KOSPI_t, r_t]'$. Though *VKOSPIX* captures the volatility of the *KOSPI*, variations in the log level of the *KOSPI* itself may be an important determinant of fluctuation in our time series. Figure 8 captures the impulse responses of *VKOSPIX* and *EPU* shocks to inflation, unemployment and the policy rate when the *KOSPI* is placed in the *VAR* system. These robustness checks were carried out on the sample period following inflation targeting. A negligible impact is observed, and the baseline model results are robust to the inclusion of the variables.

3.2 Industrial Production

To the extent that monetary policy is based solely on the relationships between unemployment and inflation is a strong assumption. To see any sensitivity issues related to the absence of changes in aggregate demand in terms of nonlinear dynamics, we place the log level of industrial production in our *VAR* system. Based on Figure 8, the addition of industrial production does not substantially change our results from the baseline estimates.

3.3 NEER

To account for a small open economy issue, and to test the extent to which the addition of the exchange rate may influence our model, we include the nominal effective exchange rate (*NEER*). Figure 8 plots impulse responses and the same dynamics captured in our baseline specification are in fact robust to the inclusion of the exchange rate.

3.4 Alternative Model Specifications

Alternative model specifications are considered with reverse orderings of the variables in the system, different lag lengths, and different calibration of γ . First we run variations on the orderings. As discussed by Caggiano et al. (2014) this allows us to purge uncertainty variables, which allows for both contemporaneous and lagged shocks in the system to affect the uncertainty variables. Second, we adjust lag lengths of the main regression in the model as well.¹⁹⁾ Finally, following Auerbach and Gorodnichenko (2012) and Caggiano et al. (2014), different calibration of γ is considered to see how the dynamic responses may differ and to match the OECD recession dates for Korea. The results in Figures 9 and 10

19) We use five for the full sample and four for subsample based on AIC and BIC. The models were also run with higher and lower lag lengths.

confirm the negligible impact of uncertainty shocks on aggregate economic activity in Korea. Further, the nonlinearity in the system and asymmetric dynamics in recession and expansion are still present after changing the specifications in our model.

VI. Conclusion

How do two different types of uncertainty affect macroeconomic variables, and how does the process perform over the business cycle in Korea? The issue addressed in this study is the extent to which the responses of macroeconomic variables vary with two different uncertainty shocks in pre- and post-Asian Financial Crisis (1997-1998), which coincides with the adoption of inflation targeting in 1998 in Korea. To answer these questions, a nonlinear *STVAR* as well as two distinct measures for uncertainty are considered. Our findings are interesting, and they are as follows: First, we find significant asymmetric responses of inflation and unemployment in recession vs. expansion. The asymmetric empirical evidence from *STVAR* for unemployment and other aggregate variables over different phases of the business cycles implies that linear models baffling recessions and expansion phases might minimize the effects driven by uncertainty shocks. Second, the type of uncertainty shocks matters, and the degree of asymmetry in the responses depends on where the shock is from. When the full sample period is considered, financial market volatility shocks have greater impact on macroeconomic variables than *EPU* shocks. Following inflation targeting, the responses tend to be smoother and less pronounced. Forecast error variance decomposition supports our empirical findings, and shows that financial market volatility has significantly more explaining power over the variables considered. This empirical finding is somewhat in contrast with Baker et al. (2016) and Caggiano et al. (2017), who find significant impacts of *EPU* shocks on the U.S. economy. However, it is consistent with Born and Pfeifer (2014), who show no significant impact of policy risk shock

on the aggregate variables. Following Ludvigson et al. (2015), it seems that news-based uncertainty which is not likely to be a comprehensive measure of uncertainty is not a major source of business cycle fluctuations, while uncertainty from financial markets is a major source, especially in an emerging economy such as Korea, whose financial market is highly integrated with the world financial markets, and which adapted an export-oriented industrial strategy to spur its economic growth. Consistent with the findings in Caldara et al. (2016), Christiano et al. (2014), Gilchrist et al. (2014), and Arellano et al. (2010), the observation in this study indicates that a possible amplification mechanism and source of persistence for the uncertainty shock might be the financial friction channel in Korea.

Viewed as a whole, our empirical results support the view that recessions are usually associated with high uncertainty, while uncertainty originating from financial markets might be a key player in the fluctuations. Although the empirical evidence from *STVAR* shows similar dynamics comparing to a linear *VAR*, when nonlinearity is allowed to play an important role in our model, quantitatively very different asymmetric dynamics are observed. Moreover, while the asymmetric dynamics are apparent over both business cycle regimes-expansion and recession- the impact of an uncertainty shock is more pronounced when economic activity is depressed, especially after shocks originating from the financial market, not from news-driven policy uncertainty in Korea.

VII. Appendix

Following Teräsvirta (1994) and Teräsvirta and Yang (2014), several tests are conducted to test for linearity as well as to confirm correct specification of transition function. The first test allows for the testing of nonlinearity between the exogenous variable and the choice of transition variable. Secondly, it allows to test between the correct choice of transition function: exponential or logarithmic. Consider the general form of the *STAR* model:

$$y_t = \delta_0 + \delta'_1 x_t + \beta'_1 x_t z_{t-d} + \beta'_2 x_t z_{t-d}^2 + \beta'_3 x_t z_{t-d}^3 + \mu_t \quad (A1)$$

where y_t is a scalar, $x_t = (1, y_{t-1}, y_{t-2}, \dots, y_{t-p})'$ and z_{t-d} is an exogenous variable. In this case y_t is inflation rate and z_t is the choice of switching variable, industrial production index for Korea. Under the null hypothesis of linearity: $H_0 : \beta_1 = \beta_2 = \beta_3 = 0$. The *LM* test based on the above type of model is performed as follows:

1. To test for linearity, estimate (A1) under the null hypothesis (restricted model of federal funds rate on its own lags). Collect the residuals (SSR_0). Regress residuals on the regressors for (A1) and collect residuals (SSR_1). The *LM* test now becomes $T(SSR_0 - SSR_1)/SSR_0$ which is distributed χ^2 in large samples, however in small samples it is more appropriate to use *F*-test. The test rejects linearity with a *p*-value of .001. Confirming a high degree of non linearity in the relationship.
2. Under the null hypothesis of $H_0 : \beta_3 = 0$ we would reject the use of exponential transition function in favor of logarithmic. The test rejects the null with *p*-value of .0387. Confirming the use of logarithmic function is well suited for the analysis. In order to

confirm nonlinear dynamics at the multivariate level we run the test proposed by Teräsvirta and Yang (2014). The test is similar to the previous, however, augmented to conform to the vector-*STAR* model. Consider the *LSTVAR* model:

$$Y_t = \theta'_0 X_t + \theta'_1 X_t z_t + \epsilon_t \quad (\text{A2})$$

where $X_t = [EPU_t, \pi_t, \mu_t, r_t]'$, $X_t = [VKOSPIX_t, \pi_t, \mu_t, r_t]'$ are the $(p \times 1)$ vectors of endogenous variables, $X_t = [|Y_{t-1}| \dots |Y_{t-1}|\alpha]'$ is the $(k \times p + q)$ vector of exogenous variables, z_t is the choice of transition variables (industrial production) and θ_0 and θ_1 are matrices of parameters. In this case number of endogenous variables $p=4$, the number of lags $k=1$ (via Teräsvirta and Yang (2012)) and the number of exogenous variables $q=1$. Under the null hypothesis of linearity $\theta_1 = 0$. The test is performed as follows:

3. Estimate the restricted model ($\theta_1 = 0$) by regressing Y_t on X_t and collect sum of square residuals $SSR_0 = E'E$.
4. Regress E on the unrestricted model (5) and collect residual sum of squares $SSR_1 = \Psi'\Psi E$.
5. Compute test statistic $LM = T \times \text{trace}(SSR_0 - SSR_1 / SSR_0)$ which is distributed χ^2 with $(p(kp + q))$ degrees of freedom. In this case the degrees of freedom were 20 and the computed LM statistic was 106.7175 and 61.8564 respectively for models with the *VKOSPIX* or *EPU* shocks. The resulting p-values respectively are .0001 and .00001, in which case the null of linearity is rejected. In sum, the tests confirm that linearity is rejected at the single and multivariate level and confirm that a logistic transition function is appropriate.

Figure 1. Volatility of KOSPI and EPU

Note: Shaded parts are Korean recessionary periods based on OECD recession indicators.

Figure 2. Probability of Recession

Note: Shaded parts are Korean recessionary periods based on OECD recession indicators.

Figure 3. Nonlinear VAR for 1991M1-2016M12

Note: Baseline ordering is Uncertainty (VKOSPIX or EPU), Headline Inflation, Unemployment, and Policy Rate. Grey bands represent 95% CI.

Figure 4. Nonlinear VAR for 1998M4-2016M12

Note: Baseline ordering is Uncertainty (VKOSPIX or EPU), Headline Inflation, Unemployment, and Policy Rate. Grey bands represent 95% CI.

Figure 5. Robustness for Core Inflation for 1991M1-2016M12

Note: Baseline ordering is Uncertainty (VKOSPIX or EPU), Core Inflation, Unemployment, and Policy Rate. Grey bands represent 95% CI.

Figure 6. Robustness for Core Inflation for 1998M4-2016M12

Note: Baseline ordering is Uncertainty (VKOSPIX or EPU), Core Inflation, Unemployment, and Policy Rate. Grey bands represent 95% CI.

Figure 7. Robustness for Both KVXO and EPU in the Model for 1991M1-2016M12

Note: Baseline ordering with both VKOSPIX and EPU, Inflation, Unemployment, and Policy rate. Grey bands represent 95% CI.

Figure 8. Robustness for Activity Contingent on Recession for 1998M4-2016M12

Note: Baseline ordering is Uncertainty (VKOSPIX or EPU), Inflation (Core or Headline), Unemployment, Activity (NEER, KOSPI, and Ind. Production), and Policy rate. Grey bands represent 95% CI.

Figure 9. Robustness for VKOSPIX Shocks

Note: Top panel is for recession, middle panel is for expansion, and bottom is for reverse ordering.

Figure 10. Robustness for EPU Shocks

Note: Top panel is for recession, middle panel is for expansion, and bottom is for reverse ordering.

Table 1. Summary Statistics and Data Sources

Variable	Mean	Min	Max	Source
VKOSPIX	25.78	11.13	72.56	DataStream/Korean Exchange
EPU	102.1	22.5	320.44	www.policyuncertainty.com
Policy Rate	6.43	1.22	25.34	DataStream
Core Inflation	0.28	-0.29	2.11	DataStream
Headline Inflation	0.3	-0.6	2.54	DataStream
REER	108.59	68.36	128.35	FRED Database
KOSPI	0.005	-0.27	0.48	DataStream
IP	0.52	-10.56	7.3	FRED Database
Correlation		Mean		
	VKOSPIX	EPU	(Recession)	Mean (Expansion)
VKOSPIX	1		27.85	20.12
EPU	0.05	1	129.32	85.33

Note: All variables are monthly and span time period 1991M1-2016M12.

Table 2. Forecast Error Variance Decomposition: 24 Month-ahead Forecast Error Variance

Shock/Variable	Inflation	Unemployment	Policy Rate
1991M1 – 2016M12			
VKOSPIX Shock			
Recession	0.13	0.11	0.10
Expansion	0.22	0.32	0.16
EPU Shock			
Recession	0.01	0.01	0.01
Expansion	0.09	0.19	0.03
1998M4 – 2016M12			
VKOSPIX Shock			
Recession	0.18	0.08	0.14
Expansion	0.08	0.05	0.26
EPU Shock			
Recession	0.02	0.01	0.01
Expansion	0.01	0.01	0.37

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<Abstract in Korean>

불확실성 충격의 경기국면별 파급효과

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본고는 경제정책 및 금융시장 불확실성 충격이 우리나라 거시경제변수에 미치는 영향을 분석한다. 불확실성 충격의 영향이 경기 상승 및 하강 국면에 따라 다를 수 있음을 감안하여 경기국면에 따른 파급효과의 비대칭성을 분석할 수 있는 평활전이 벡터자기회귀모형을 이용하였다. 분석결과 불확실성 충격은 실업률 상승 등 실물경제에 부정적 영향을 미쳤으며, 그 영향이 경기상승 국면 보다 경기 하강 국면에 더 큰 것으로 나타났다. 두 불확실성 충격 중 금융시장의 불확실성 확대가 경제정책 불확실성에 비해 우리 경제에 미치는 영향이 전반적으로 큰 것으로 분석되었다. 한편 물가목표제 도입 이후 불확실성의 부정적 영향이 다소 완화된 것으로 나타났다.

핵심 주제어: 불확실성, 평활전이 벡터자기회귀모형, 경기국면별 비대칭성

JEL Classification: C32, E32, E52

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BOK 경제연구 발간목록

한국은행 경제연구원에서는 Working Paper인 『BOK 경제연구』를 수시로 발간하고 있습니다. 『BOK 경제연구』는 주요 경제 현상 및 정책 효과에 대한 직관적 설명 뿐 아니라 깊이 있는 이론 또는 실증 분석을 제공함으로써 엄밀한 논증에 초점을 두는 학술논문 형태의 연구이며 한국은행 직원 및 한국은행 연구용역사업의 연구 결과물이 수록되고 있습니다. 『BOK 경제연구』는 한국은행 경제연구원 홈페이지(<http://imer.bok.or.kr>)에서 다운로드하여 보실 수 있습니다.

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21	US Interest Rate Policy Spillover and International Capital Flow: Evidence from Korea	Jieun Lee • Jung-Min Kim • Jong Kook Shin
제2017 –1	가계부채가 소비와 경제성장에 미치는 영향 – 유량효과와 저장효과 분석 –	강종구
2	Which Monetary Shocks Matter in Small Open Economies? Evidence from SVARs	Jongrim Ha • Inhwan So
3	FTA의 물가 안정화 효과 분석	곽노선 • 임호성
4	The Effect of Labor Market Polarization on the College Students' Employment	Sungyup Chung
5	국내 자영업의 폐업을 결정요인 분석	남윤미
6	차주별 패널자료를 이용한 주택담보대출의 연체요인에 대한 연구	정호성
7	국면전환 확산과정모형을 이용한 콜금리 행태 분석	최승문 • 김병국

제2017-8	Behavioral Aspects of Household Portfolio Choice: Effects of Loss Aversion on Life Insurance Uptake and Savings	In Do Hwang
9	신용공급 충격이 재화별 소비에 미치는 영향	김광환 · 최석기
10	유가가 손익분기인플레이션에 미치는 영향	김진용 · 김준철 · 임형준
11	인구구조변화가 인플레이션의 장기 추세에 미치는 영향	강환구
12	종합적 상환여건을 반영한 과다부채 가계의 리스크 요인 분석	이동진 · 한진현
13	Crowding out in a Dual Currency Regime? Digital versus Fiat Currency	KiHoon Hong · Kyounghoon Park · Jongmin Yu
14	Improving Forecast Accuracy of Financial Vulnerability: Partial Least Squares Factor Model Approach	Hyeongwoo Kim · Kyunghwan Ko
15	Which Type of Trust Matters?: Interpersonal vs. Institutional vs. Political Trust	In Do Hwang
16	기업특성에 따른 연령별 고용행태 분석	이상욱 · 권철우 · 남윤미
17	Equity Market Globalization and Portfolio Rebalancing	Kyungkeun Kim · Dongwon Lee
18	The Effect of Market Volatility on Liquidity and Stock Returns in the Korean Stock Market	Jieun Lee · KeeH.Chung
19	Using Cheap Talk to Polarize or Unify a Group of Decision Makers	Daeyoung Jeong
20	패스트트랙 기업회생절차가 법정관리 기업의 이자보상비율에 미친 영향	최영준
21	인구고령화가 경제성장에 미치는 영향	안병권 · 김기호 · 육승환
22	고령화에 대응한 인구대책: OECD사례를 중심으로	김진일 · 박경훈

제2017 -23	인구구조변화와 경상수지	김경근 · 김소영
24	통일과 고령화	최지영
25	인구고령화가 주택시장에 미치는 영향	오강현 · 김솔 · 윤재준 · 안상기 · 권동휘
26	고령화가 대외투자에 미치는 영향	임진수 · 김영래
27	인구고령화가 가계의 자산 및 부채에 미치는 영향	조세형 · 이용민 · 김정훈
28	인구고령화에 따른 우리나라 산업구조 변화	강종구
29	인구구조 변화와 재정	송호신 · 허준영
30	인구고령화가 노동수급에 미치는 영향	이철희 · 이지은
31	인구 고령화가 금융산업에 미치는 영향	윤경수 · 차재훈 · 박소희 · 강선영
32	금리와 은행 수익성 간의 관계 분석	한재준 · 소인환
33	Bank Globalization and Monetary Policy Transmission in Small Open Economies	Inhwan So
34	기존 경영자 관리인(DIP) 제도의 회생기업 경영성과에 대한 영향	최영준
35	Transmission of Monetary Policy in Times of High Household Debt	Youngju Kim · Hyunjoon Lim
제2018 -1	4차 산업혁명과 한국의 혁신역량: 특허자료를 이용한 국가기술별 비교 분석, 1976-2015	이지홍 · 임현경 · 정대영
2	What Drives the Stock Market Comovements between Korea and China, Japan and the US?	Jinsoo Lee · Bok-Keun Yu
3	Who Improves or Worsens Liquidity in the Korean Treasury Bond Market?	Jieun Lee

제2018-4	Establishment Size and Wage Inequality: The Roles of Performance Pay and Rent Sharing	Sang-yoon Song
5	가계대출 부도요인 및 금융업권별 금융취약성: 자영업 차주를 중심으로	정호성
6	직업훈련이 청년취업률 제고에 미치는 영향	최충 · 김남주 · 최광성
7	재고투자와 경기변동에 대한 동학적 분석	서병선 · 장근호
8	Rare Disasters and Exchange Rates: An Empirical Investigation of South Korean Exchange Rates under Tension between the Two Koreas	Cheolbeom Park · Suyeon Park
9	통화정책과 기업 설비투자 - 자산가격경로와 대차대조표경로 분석 -	박상준 · 육승환
10	Upgrading Product Quality: The Impact of Tariffs and Standards	Jihyun Eum
11	북한이탈주민의 신용행태에 관한 연구	정승호 · 민병기 · 김주원
12	Uncertainty Shocks and Asymmetric Dynamics in Korea: A Nonlinear Approach	Kevin Larcher · Jaebeom Kim · Youngju Kim