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The Impact of External Uncertainty Shocks on the Korean Economy†

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In this paper, we analyze the impact of external uncertainty shocks on the Korean economy, focusing on Russian geopolitical risks and U.S. monetary policy uncertainty. We find that increases in external uncertainties negatively affect the Korean macroeconomy, with a particularly pronounced impact on sectors highly dependent on external markets. Our micro-level analysis reveals that the effects of external uncertainties on exports vary across different countries and sectors. A firm-level analysis further suggests that Russian geopolitical risks primarily impact the economy through real friction, while U.S. monetary policy uncertainty affects it through both real and financial friction. By identifying multiple transmission channels through both a macro- and a micro-level analysis, we provide a comprehensive understanding of how uncertainty affects the real economy. Our findings could offer valuable insights for policymakers when responding to rapidly changing external conditions.

Key Word: Geopolitical Risks, Uncertainty Shocks, Investment, Global trade, Open Economy, Macroeconomics
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I. Introduction

The Russia-Ukraine war and the interest rate hikes in major countries, including the United States, have been major factors in the recent increase in global uncertainty. The uncertainty surrounding the progress of negotiations between Russia and Ukraine, the possibility of expansion of this conflict to other countries, and the global security risks posed by nuclear threats remain high due to the unfolding dynamics of the war. Furthermore, the uncertainty surrounding the normalization of monetary policy has been steadily increasing, further exacerbated by the rise in energy and commodity prices caused by the Russia-Ukraine war. In particular, uncertainty regarding the timing and extent of interest rate hikes by the Federal Open Market Committee (FOMC) of the United States has remained high. As a result, market expectations continue to fluctuate significantly in response to news related to the economy, inflation, and statements by FOMC members. In addition, the uncertainty surrounding the unprecedented rapid increase in interest rates and its effects on the real economy have also been greatly increased.

The direct effects of these events on the economy − disruptions in global supply chains, sharp increases in energy and raw material prices, and rapid interest rate hikes in the United States − are relatively well understood. However, while the increased external uncertainties in the rapidly changing global economy are largely recognized with these events, there is still a lack of a sufficient understanding of how this heightened uncertainty affects the real economy. Nevertheless, previous research (Bloom, 2009) has well established that a rise in uncertainty can significantly impact the economy and present downward risk.

With this motivation, we analyze the impact of external uncertainty on a small open economy, focusing on the effects of geopolitical risks in Russia and uncertainty in US monetary policy on South Korea. South Korea's relatively small size combined to its significant openness to trade (with the share of exports and imports out of the total GDP being 68% in 2023) makes it particularly well suited for identifying and analyzing the effects of global shocks on a small open economy.

An increase in uncertainty can impact the real economy through various channels. According to the literature (Bloom, 2009; Gilchrist *et al*., 2014), uncertainty can contract the real economy by reducing business investments. When uncertainty in the business environment rises, firms tend to delay their investments due to the irreversibility of investments. Moreover, heightened uncertainty can increase firms' default risks, leading to a higher cost of capital and negatively impacting investment decisions. Additionally, if the global economy contracts due to uncertainty, the global demand for Korean export goods is likely to decrease, potentially slowing down an economy centered on exports. Therefore, a comprehensive analysis is essential to gain a complete understanding of the impact of external uncertainties. In light of this, this study examines the impact of increased external uncertainty on real macro variables and then explores transmission channels, in this case exports and corporate investments, using micro data.

In the macro-level analysis, we find that geopolitical risks in Russia and

uncertainty in US monetary policy significantly impact the Korean economy. In particular, investments and industrial production decrease significantly, along with a decline in consumer prices and policy interest rates. This result suggests that the decrease in total demand is more pronounced than the decrease in total supply in response to increased uncertainty. By investigating the impact of uncertainty by sector, we find that the impact of external uncertainty is particularly stronger in sectors highly dependent on external markets, such as exports and manufacturing production. At the same time, most sectors are negatively affected by external uncertainty, even sectors not directly related to external markets, such as domestic demand and service production, though to varying degrees.

We also analyze the role of global demand as a potential transmission channel of external uncertainty on the domestic economy. The impacts of Russian geopolitical risks and US monetary policy uncertainty are not only limited to the Korean economy. As global trade is also negatively affected by external uncertainties, Korea's trading partners could also be affected. Such effects could lead to a slowdown in the Korean economy, particularly centered on export-related sectors. A counterfactual analysis, where uncertainties impact the Korean domestic economy in the absence of the global trade channel, provides supportive evidence that the response of the world trade volume could play an important role in transmitting both Russian geopolitical risks and US monetary policy shocks. Their impact is specifically stronger in sectors with higher external dependence, such as exports and manufacturing. These results suggest the significance of external demand as a primary channel through which external uncertainty affects the Korean economy.

A more detailed micro-level analysis complements the macro-level findings and provides valuable insights into the underlying mechanisms through which external uncertainties are transmitted.

Using transaction-level micro data, we find that Korean exports to regions where uncertainty originates tend to decrease more sharply compared to those to other regions. Moreover, both Russian geopolitical risk and U.S. monetary policy uncertainty have varying impacts on Korean exports depending on the destination country's income level, with low-income countries experiencing a particularly larger negative impact. Additionally, we find that capital goods exports, which are closely tied to physical investments, decrease more significantly than exports of other goods.

Lastly, from the firm-level analysis, we find that the rise in these two uncertainties negatively impacts firms' investment decisions, with the effects varying depending on the affected firm's characteristics. Firms with larger irreversible investments are more likely to be affected, leading to a pronounced "wait-and-see effect," with firms delaying their investments due to increased uncertainty. Additionally, firms with lower credit ratings or higher debt burdens are more susceptible to U.S. monetary policy uncertainty. This finding suggests that the Russian geopolitical crisis primarily exerts its influence through real friction, while U.S. monetary policy uncertainty impacts the economy through both real and financial friction.

This paper provides an extensive analysis of the impact of external uncertainty shocks on a small open economy. By identifying various transmission channels of uncertainty and conducting both macro- and micro-level analyses, it offers a comprehensive understanding of how external uncertainties propagate. The insights gained from our study are highly relevant to policymakers in small open economies

facing rapidly changing external conditions.

The rest of our paper is organized as follows. Section II reviews the literature and provides the contributions of this paper. Section III describes the external uncertainties, specifically Russian geopolitical risks and U.S. monetary policy, investigated here. Section IV explores the impact of external uncertainties on the Korean macroeconomy. Section V analyzes the heterogeneous impacts of external uncertainties on exports and firm investments using micro data. Section VI concludes the paper.

II. Literature Review

There is a vastly growing body of literature on the macroeconomic effects of uncertainty shocks, initiated by the seminal work by Bloom (2009). In his paper, Bloom (2009) argued that uncertainty shocks could be an important factor leading to business cycle fluctuations due to the irreversible nature of investments, which could arise from the fixed costs of investments. As uncertainty in the business environment increases, firms tend to delay their investments due to this irreversibility, leading to a contraction in economic activity. This mechanism is referred to as the real options channel in the literature. On the other hand, Gilchrist, Sim, and Zakrajšek (2014) emphasize the role of financial friction as a main transmission channel of uncertainty shocks. Specifically, uncertainty shocks can increase a firm's default risk, leading to higher borrowing costs. If the cost of funding increases, firms naturally reconsider their investment decisions, meaning that uncertainty shocks negatively affect investments by firms.

Using firm-level micro data, several papers explore the impact uncertainty shocks. Gulen and Ion (2016), using data from listed firms in the US, find that firms holding more capital stocks of an irreversible nature are significantly affected by uncertainty shocks. Alfaro, Bloom, and Lin (2018) reveal that firms that are financially constrained are significantly affected by uncertainty shocks, highlighting the importance of financial friction as a main transmission channel of uncertainty shocks. Kim (2020) showed that larger firms tend to respond less to an increase in uncertainty due to the interaction between accessibility to the internal capital market and the irreversibility of investments, demonstrating that the interaction between real options and financial frictions can dampen or amplify the impact of uncertainty shocks.

Various factors can affect the level of uncertainty in the economic environment. In one study, Baker, Bloom, and Davis (2016) emphasized the importance of economic policy uncertainty, presenting an economic policy uncertainty index based on the frequency of news articles related to uncertainty and confirming that this variable is an important predictor of macroeconomic variables. In several subsequent studies, using the methodology of Baker, Bloom, and Davis (2016), various uncertainty indices were developed and their impacts were analyzed. In particular, Husted, Rogers, and Sun (2020) further refined the uncertainty index of US monetary policy and analyzed the impact of monetary policy uncertainty shocks on macroeconomic variables and firms' investments in the US. Based on the methodology of Baker, Bloom, and Davis

(2016), Caldara and Iacoviello (2022) also developed a geopolitical risk index and confirmed that an increase in geopolitical risk leads to an economic contraction.

Due to the country's high degree of trade openness but relatively small size, South Korea serves as an excellent laboratory for investigating the impact of external uncertainty on a domestic economy. This is particularly relevant, as (i) South Korea is significantly exposed to shocks originating from the global economy, and (ii) South Korea is not large enough to have an influence on such shocks. Therefore, by investigating the impact of external uncertainties on the Korean economy, this study contributes to the literature on the effects of uncertainty shocks on small open economies.

Previous studies by Carrière-Swallow and Céspedes (2013) and Bhattarai, Chatterjee, and Park (2020) analyze the impact of uncertainty shocks as represented by the VIX in the United States on several emerging market countries, including South Korea. Additionally, Park (2017) and Park (2018) narrow the scope of their analysis to the South Korean economy and reaffirm that an increase in VIX could lead to a contraction in Korean economic activity. While these studies provide valuables insights into the impact of VIX-related uncertainty, they do not explore the effects of US monetary policy uncertainty and Russian geopolitical risks, which have become significant drivers of recent global uncertainty.

The importance of US monetary policy uncertainty and geopolitical risks on the Korean economy has been emphasized in several studies. Kim (2018) investigates the impact of US economic policy uncertainty on the Korean domestic economy, confirming that Korean financial markets are highly responsive to US monetary policy uncertainty. While this study is closely related to our work in that it analyzed the impact of US monetary policy uncertainty on the Korean economy, it primarily focuses on the responses of Korean financial markets. Ha, Lee, and So (2022) analyze the macroeconomic impact of geopolitical risks surrounding the Korean Peninsula, illustrating how geopolitical risks can spread through financial channels, potentially leading to an economic contraction in Korea. Although this study is related to our work in that it analyzes the impact of geopolitical risks, it specifically focuses on geopolitical risks stemming from inter-Korean tension.

The present study contributes the literature by analyzing the impact of US monetary policy uncertainty and Russian geopolitical risks on a small open economy in a timely manner. While the importance of US monetary policy has been emphasized in existing studies, analyses of the economic impact of geopolitical risks are relatively recent (Caldara and Iacoviello, 2022). The Bank of England now includes geopolitical risks as part of what they term an "Uncertainty Trinity," along with economic and political uncertainties (Carney, 2016), and as seen in the current Russia-Ukraine crisis, geopolitical risks can have a significant impact on the economy. Given Russia's vast territory, possession of nuclear weapons second only to the US, and considerable energy exports such as oil and natural gas, it is evident that Russia has a substantial influence on global geopolitical risks. In fact, according to a study by Hasan *et al*. in 2018, Russia is known as one of the key countries significantly influencing global geopolitical risks after the US. Hence, this study, focusing on geopolitical risks triggered by Russia, not only presents a timely reflection of recent global situations but also analyzes the impact of geopolitical risks associated with a country of significant geopolitical importance.

Finally, this study broadens our understanding of how external uncertainty affects a country's domestic economy. Through a counterfactual analysis, this paper shows that external uncertainty shocks propagate into the domestic economy by (i) reducing external demand and (ii) decreasing domestic activities such as consumption or investments. It also conducts both macro-scale and micro-scale analyses simultaneously, providing a comprehensive understanding of the propagation of uncertainty shocks.

III. Measures of External Uncertainties

While various types of uncertainties can impact the Korean economy, this study specifically examines those related to US monetary policy and geopolitical risks in Russia, which have had a significant influence on our economy recently. These can be considered as macro uncertainties concerning macro events and variables perceived by the general public, rather than being confined to specific economic agents.

US monetary policy and geopolitical risks in Russia can be considered exogenous shocks to small open economies such as that of South Korea. This makes it easier to identify their impact on the Korean economy. Furthermore, by considering both US monetary policy and geopolitical risks in Russia, we can accurately evaluate the impact of uncertainty shocks, where uncertainties both on the aggregate supply side (i.e., geopolitical risks) and the demand side (i.e., US monetary policy) are increasing.

Various measures of macro uncertainty were developed in previous studies, but some of them reflect uncertainties perceived by specific economic agents rather than the general public. For example, the VIX index, presented by Bloom (2009) is commonly used in the literature but may not accurately reflect the uncertainties perceived by the general public, as it mainly represents uncertainties among financial market participants. Therefore, this study uses an uncertainty index constructed based on the frequency of relevant mentions in the media, addressing such concerns. The media can provide a comprehensive macro uncertainty measure compared to existing measures, as it is a source of information commonly accessed by households, businesses, consumers, and producers. Additionally, the flexibility of this method allows for the derivation of an uncertainty measure for specific events in a straightforward and timely manner.

We employ the geopolitical risk (GPR) index (www.matteoiacoviello.com/gpr.htm) developed by Caldara and Iacoviello (2022). According to these authors, geopolitical risk represents the risk of events such as political conflicts, terrorism, and wars between countries. Geopolitical risk can increase due to specific events or a series of threats that may not necessarily result in actual outcomes. Therefore, geopolitical risk can lead to heightened uncertainty. The escalation of geopolitical risk, particularly due to the Russia-Ukraine war, has significantly contributed to the uncertainties surrounding negotiations between the two countries, the possible spread of the conflict to other nations, and global security concerns stemming from Russia's nuclear threats. For these reasons, the Bank of England now includes

geopolitical risk along with economic and political uncertainty in their "Uncertainty Trinity" (Carney, 2016). Existing studies have defined geopolitical risk and uncertainty as the same concept and conducted analysis with that consideration (Ha *et al.*, 2022; Cascaldi-Garcia *et al.*, 2023). Therefore, in our work, we interpret an increase in geopolitical risk as an increase in uncertainty related to geopolitical events. This measure is derived from the frequency of articles mentioning geopolitical risk in ten major newspapers in the US, UK, and Canada and is also specifically computed based on the country that triggered the risk. Consequently, this study uses the geopolitical risk index triggered by Russia.

For US monetary policy uncertainty, we employ the Economic Policy Uncertainty (EPU) index developed by Baker, Bloom, and Davis (2016) (www.policyuncertainty.com). This index comprehensively captures uncertainties regarding economic policies per se and the impact of economic policies. Therefore, the US monetary policy uncertainty used in our analysis reflects uncertainties about the timing and magnitude of future changes in US target interest rates, shifts in the monetary policy stance, and the real economic impact of the monetary policy. A general measure of economic policy uncertainty is constructed and then differentiated into specific policy categories. In particular, US monetary policy uncertainty is calculated based on the frequency of articles related to economics, uncertainty, politics, and monetary policy in ten major newspapers in the United States.

Although Russian geopolitical risks and US monetary policy can be considered to be exogenous to South Korea, there is still a concern that uncertainty indices may be influenced by economic situations or other political/economic factors. For instance, the US monetary policy uncertainty index may increase due to economic downturns caused by external shocks, such as the COVID-19 pandemic. Therefore, if such factors are not properly controlled, there is a possibility that our estimates of the impact of uncertainty shocks could be biased. Therefore, in this paper, we analyze the conditional impact of geopolitical risks in Russia and US monetary policy uncertainty, excluding the movement of other factors explained by economic fluctuations and general economic policy uncertainty, following earlier studies (Bloom, 2009; Husted, Rogers, and Sun, 2020). To do this, US monetary policy uncertainty is defined as follows:

$$mpu_t = \alpha + \sum_{\{k=0\}}^{3} \beta_k \ln(ip_{t-k} / ip_{t-k-12}) + \sum_{\{k=1\}}^{3} \gamma_k \ln(epu_{t-k} / epu_{t-k-12}) + \epsilon_t \qquad (1)$$

In the literature, US economic variables and general economic policy uncertainties were controlled together in a large VAR model to estimate the impact of US monetary uncertainty shocks precisely. However, the relatively short sample period for Korea prevents us from including all relevant variables. Accordingly, we adopted the above approach, where mpu_t denotes the log value of US monetary policy uncertainty, ip_t represents US industrial production index, and epu_t represents the general economic policy uncertainty index by Baker, Bloom, and Davis (2016). The residuals derived from the regression analysis (1) are defined as US monetary

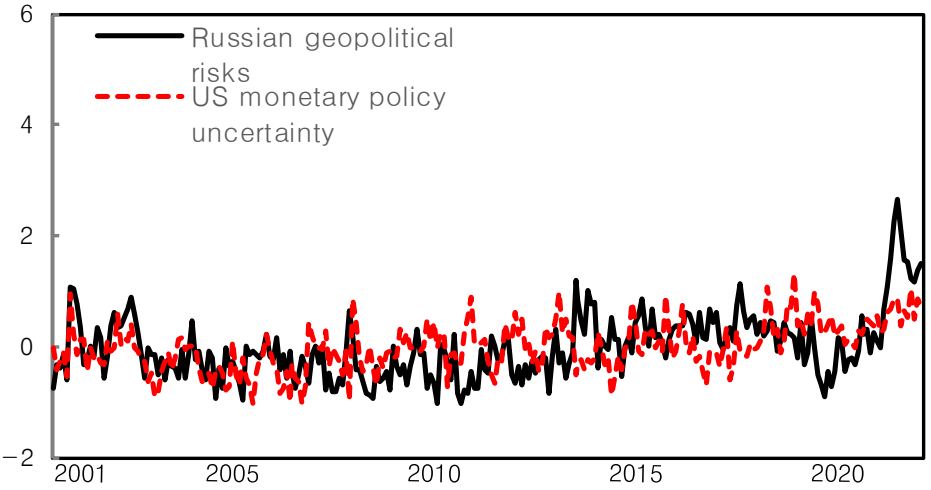

FIGURE 1. IDENTIFIED UNCERTAINTIES

Source: US and Russian industrial production indices were obtained through Fred (https://fred.stlouisfed.org/, last accessed: December 10, 2022).

policy uncertainty shocks for our analysis. This represents a pure shock of US monetary policy uncertainty, controlling for economic fluctuations and general economic uncertainty. Similarly, we identify geopolitical risk for Russia using Russian industrial production and Russia's economic policy uncertainty index.[1] The original series of the two uncertainty measures, prior to the identification, are shown in Figure A1 in the Appendix.

Figure 1 shows the time series of two identified uncertainty shocks. Recently, geopolitical risks triggered by the Russian invasion of Ukraine and uncertainty in US monetary policy have increased significantly. Specifically, after the outbreak of the Russia-Ukraine war in February of 2022, Russian geopolitical risk rose sharply. Over time, the value gradually decreased but still surpasses the previous average level. Similarly, uncertainty in US monetary policy has increased gradually since December of 2021 when the possibility of a policy shift in major countries, including the US, emerged.

The standard deviation of the identified Russian geopolitical risk is 0.47, and that of the identified US monetary policy uncertainty is 0.42, confirming that the volatility levels of the two uncertainties are similar. Both values have remained high recently, but they have shown different historical patterns. In particular, Russian geopolitical risk increased during the Crimea annexation period in 2014, and

[1]Geopolitical risks may be linked to world trade through global supply chain risks (Beningno *et al*., 2022) or trade uncertainty (Caldara *et al*., 2020). However, we find that the correlation between global supply chain risks and the Russian GPU is –0.0138 in our sample period, suggesting that global supply chain risks are not a significant factor in our analysis. Regarding trade uncertainty, we observe a relatively high correlation between trade uncertainty and the Russian GPU in our sample period. However, when we control for trade uncertainty while computing the identified GPU shocks, as in equation (1), our results show little change, indicating that our findings are driven by geopolitical uncertainty rather than by other channels. These results are available upon request.

uncertainty in US monetary policy surged significantly in 2018-19 when the Trump administration expressed opinions about the direction of monetary policy and during the onset of the COVID-19 crisis. Moreover, the correlation coefficient between the two variables from 2000 to 2021 is 0.1646, indicating that factors influencing the overall movements of each type of uncertainty were quite different. Therefore, in order to estimate the recent surge of both types precisely, it is necessary to analyze the impact of each on the Korean real economy separately.

IV. The Impact of External Uncertainties: Macroeconomic Analysis

In this section, we analyze how increases in US monetary policy uncertainty and Russian geopolitical risks affect actual macroeconomic variables in Korea. First, we show that external uncertainties have a significant impact on the Korean domestic economy, after which we examine the possible channels of transmission for these uncertainty shocks.

A. *The Impact of External Uncertainty on Domestic Macroeconomic Variables*

We analyze the impact of external uncertainty shocks on macroeconomic variables in Korea. As discussed in the previous section, while uncertainties have recently increased altogether, they exhibited different historical patterns. Most previous studies focused on the impact of a single type of uncertainty shock, which is limited given the current situation where multiple uncertainties are interacting and escalating. Therefore, in this study, we investigate the impact of the two aforementioned uncertainties separately and in a consistent manner. In particular, we estimate the impact of US monetary policy uncertainty and Russian geopolitical risk within a unified system and derive the results.

1. Empirical Model

We employ a recursive vector autoregression (Recursive VAR) model in order to estimate the impact of external uncertainty on Korean domestic real macroeconomic variables. The baseline model is defined as follows:

$$CY_t = A + \sum_{i=1}^{p} A(i) Y_{t-i} + \varepsilon_t$$

There are seven endogenous variables in the order of Russian geopolitical risk, US monetary policy uncertainty, the global trade volume, equipment investment, industrial production, prices, and interest rates. Specifically, A is a constant vector,

and C is a coefficient matrix representing the contemporaneous relationships between the endogenous variables. Each $A(i)$ is a coefficient matrix capturing the impact of past endogenous variables on current endogenous variables, with p representing the maximum lag. Finally, ε_t is the structural shock vector.

To identify structural shocks, we assume that matrix C is a lower triangular matrix with a diagonal of 1. Specifically, we assume that external shocks initially impact domestic variables. Hence, the external components, consisting of Russian geopolitical risk, US monetary policy uncertainty, and global trade, are placed at the top of the system. In addition, domestic financial variable, i.e., interest rates, is positioned after domestic real variables. This assumption is based on the idea that domestic macro variables immediately impact financial variables, but the impact of domestic financial variables on macro variables occurs with a lag.

Furthermore, given that Korea is a small open economy, we assume that external variables can affect domestic variables, but domestic variables do not affect external variables. This assumption applies not only to contemporaneous relationships but also implies that the movements of external variables in the entire system are independently determined, regardless of Korean domestic variables. Specifically, the matrices representing the impact of past endogenous variables on current endogenous variables can be constructed as shown below.

$$A(i)=\begin{pmatrix} A_{11}(i) & 0 \\ A_{21}(i) & A_{22(i)} \end{pmatrix}, \qquad i=1,\ldots,p$$

Here, $A_{11}(i)$, $A_{21}(i)$, and $A_{22}(i)$ are the block matrices of each $A(i)$. $A_{11}(i)$ represents a coefficient matrix showing the dynamic relationship between external variables. $A_{21}(i)$ is a coefficient matrix that captures the dynamic impact of external variables on domestic variables, and $A_{22}(i)$ is a coefficient matrix representing the dynamic relationships among domestic variables. However, even if Korea is considered a small open economy, there may be concerns that its influence may not be insignificant in the global market. Therefore, we estimated the model without imposing the above assumptions and confirmed that the results are not sensitive to this assumption, as detailed in Figure A2 in the Appendix.

2. Data

The measures of geopolitical risk in Russia and uncertainty in US monetary policy are derived from the previous section. Therefore, the increase in each uncertainty in our analysis can be interpreted as the pure effect of uncertainty while controlling the economic situation of the US and Russia.

Investment is the equipment investment index of Statistics Korea, industrial production denotes all-industry production excluding agriculture and fisheries from Statistics Korea, and the domestic interest rate is the call rate of the Bank of Korea. Prices are sourced from the consumer price index of the Bank of Korea, and the

world trade volume is the real trade volume obtained from the CPB NL World Trade Monitor as of June of 2022.[2]

In order to ensure the stationarity of the time-series data, all variables except for the uncertainty measures and interest rates are expressed as log differences from the previous year. The time period ranges from January of 2000 to December of 2021. Given that we use log differences compared to the previous year, the effective sample period starts in January of 2001. Dummy variables for the global financial crisis are controlled as exogenous variables. Lastly, due to the limited number of observations in the analysis, we constrain the number of endogenous variables by setting the lag to p=3. We confirm that the main results remain consistent even when the lag is set to p=6 (refer to the Appendix).

3. Baseline Analysis: Macro effects

Figure 2 shows the impulse responses of investment and industrial production to a one standard deviation increase of both the Russian geopolitical risk and US monetary policy uncertainty. The solid lines in each graph represent the responses, and the shaded areas indicate the 68% confidence intervals.

The top two figures illustrate how investments respond to shocks from Russian geopolitical risk and US monetary policy uncertainty. Increased uncertainty leads to a decrease in corporate investment, corroborating existing literature. In particular, a one standard deviation rise in Russian geopolitical risk and US monetary policy uncertainty results in a maximum decrease in equipment investment by 1%p and 0.6%p, respectively, with a lag of 5-6 months. The effects of these uncertainties persist for up to a year.

The bottom two figures show the impulse responses of industrial production. A one standard deviation increases in Russia's geopolitical risk and U.S. monetary policy uncertainty results in a maximum reduction in industrial production of 0.24%p and 0.27%p, respectively, with a lag. Similar to the investment responses, the impact of these shocks lasts up to one year. Therefore, despite some differences in magnitude, the impulse responses of investment and industrial production show similar patterns.

A one standard deviation increase in the structural shock of Russian geopolitical risk and US monetary policy uncertainty leads to a 36% and 33% rise in their respective uncertainties. In March of 2022, these shocks escalated by over 100% and 25%, respectively, compared to the average level. Given that the standard deviations of the log differences in investment and industrial production are 10%p and 3%p, respectively, the recent surge in external uncertainty could significantly impact the domestic real economy in Korea.

[2]Bank of Korea (https://ecos.bok.or.kr/, last accessed: November 9, 2022); Statistics Korea (https://kosis.kr/, last accessed: June 16, 2022); CPB NL World Trade Monitor June 2022 (www.cpb.nl/, last accessed: June 16, 2022).

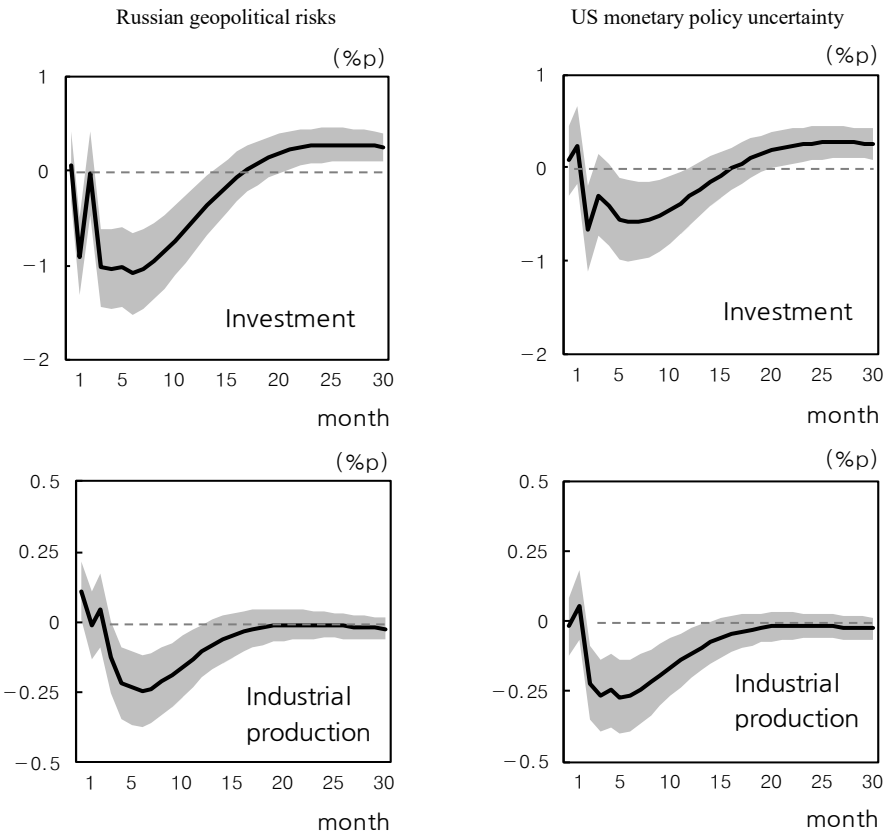

FIGURE 2. IMPACTS OF UNCERTAINTY SHOCKS ON INVESTMENTS AND INDUSTRIAL PRODUCTION

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

As shown by the results above, uncertainty can indirectly impact on the supply side by reducing corporate investment, deteriorating both resource allocation efficiency and aggregate productivity (Bloom, 2009). Additionally, uncertainty can lead to an economic downturn by reducing overall demand (Basu and Bundick, 2017; Leduc and Liu, 2016). Because uncertainty shocks adversely affect both total demand and total supply, policy implications may depend on which aspect is more significantly impacted. For example, if total demand decreases more, economic production will decrease and price levels will fall, requiring an expansionary monetary policy. Conversely, if total supply decreases more significantly, economic production will decline but price levels will rise, potentially necessitating a contractionary monetary policy. Therefore, we investigate the responses of additional variables, specifically consumer prices and policy interest rates from the basic model in order to examine which part of total demand and supply has been more significantly affected by the two uncertainty shocks.

Figure 3 shows the responses of consumer prices and domestic policy interest rates to the uncertainties of Russian geopolitical risks and US monetary policy. The solid line in each graph represents the impulse response function, and the shaded area

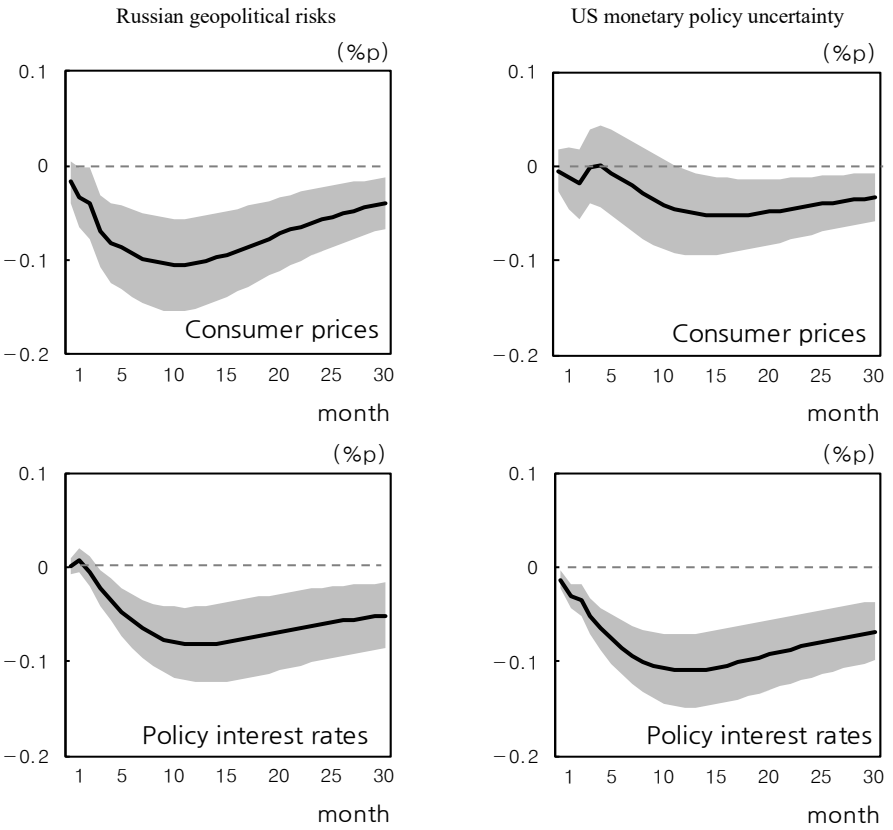

FIGURE 3. IMPACTS OF UNCERTAINTY SHOCKS ON INVESTMENTS AND INDUSTRIAL PRODUCTION

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

indicates the 68% confidence interval.

The top two figures show the responses of consumer prices. When the geopolitical risk in Russia and the uncertainty in US monetary policy increase by one standard deviation, the consumer price inflation rate decreases by 0.1%p and 0.05%p respectively. Additionally, each shock has a statistically significant negative impact for up to 30 months after it occurs.

The findings in the bottom two figures are consistent with the results above. Specifically, an increase in geopolitical risk in Russia and uncertainty in US monetary policy leads to a decrease in policy rates by 0.08%p and 0.1%p respectively. Similar to the responses of consumer prices, these rate cuts persist for up to 30 months after each shock occurs.

Our findings suggest that both types of uncertainty lead to a larger decrease in aggregate demand, thereby reducing consumer price inflation. Consequently, monetary policy responds by setting policy rates significantly lower for a considerable period. After controlling for the main driver of high inflation in recent periods, namely oil price fluctuations, the results remain consistent (see Figure A3 in the Appendix for details).

In fact, no significant events directly affecting the supply side, such as disruptions

in Russia's energy supply or major countries imposing trade sanctions, occurred until the end of the analysis period, which was set to 2021. Extending the analysis period to February of 2024 reveals that the statistical significance of consumer price inflation and interest rate responses disappears (see Figure A5 in the Appendix). Therefore, the observed results can be attributed to the increase uncertainty in a context where drastic decreases in total supply due to extreme events, such as war, are not considered.

We also confirm that our results remain robust when (i) extending our sample to February of 2024, (ii) controlling for a COVID-19 dummy variable, (iii) using an alternative measure of MPU from Husted *et al*. (2020) and (iv) applying an alternative ordering of external uncertainties, with MPU placed first, as shown in Figures A5-A7 in the Appendix.

B. *Empirical Analysis: Sectoral Analysis*

The previous analysis confirms that an increase in external uncertainty has a significant impact on the macroeconomy of South Korea. To understand the transmission channels of the uncertainties, we also analyze their effects on exports and domestic demand, as well as production outputs in the manufacturing and service sectors by extending the baseline regression model. Specifically, we divide industrial production into two categories: exports and domestic demand, and production outputs in the manufacturing and service sectors. Each version of the modified models includes a total of eight endogenous variables, as follows:

(i) Russian geopolitical risk, uncertainty in US currency policy, the global trade volume, investment, exports, domestic demand, prices, and interest rates.

(ii) Russian geopolitical risk, uncertainty in US currency policy, the global trade volume, investment, manufacturing production, service production, prices, and interest rates.

The export volume index of the Bank of Korea is used for our export measure, the domestic supply index of Statistics Korea is used for domestic demand, and the sub-indices of the total industrial production index of Statistics Korea are used for manufacturing and service sector production outputs.[3]

Figure 4 illustrates the impact of external uncertainties on exports and domestic demand. Following shocks from Russian geopolitical risk and US monetary policy uncertainty, exports decrease by up to 1%p and 0.9%p, respectively, with a time lag.

[3]Bank of Korea (https://ecos.bok.or.kr/, last accessed: November 9, 2022); Statistics Korea (https://kosis.kr/, last accessed: June 16, 2022).

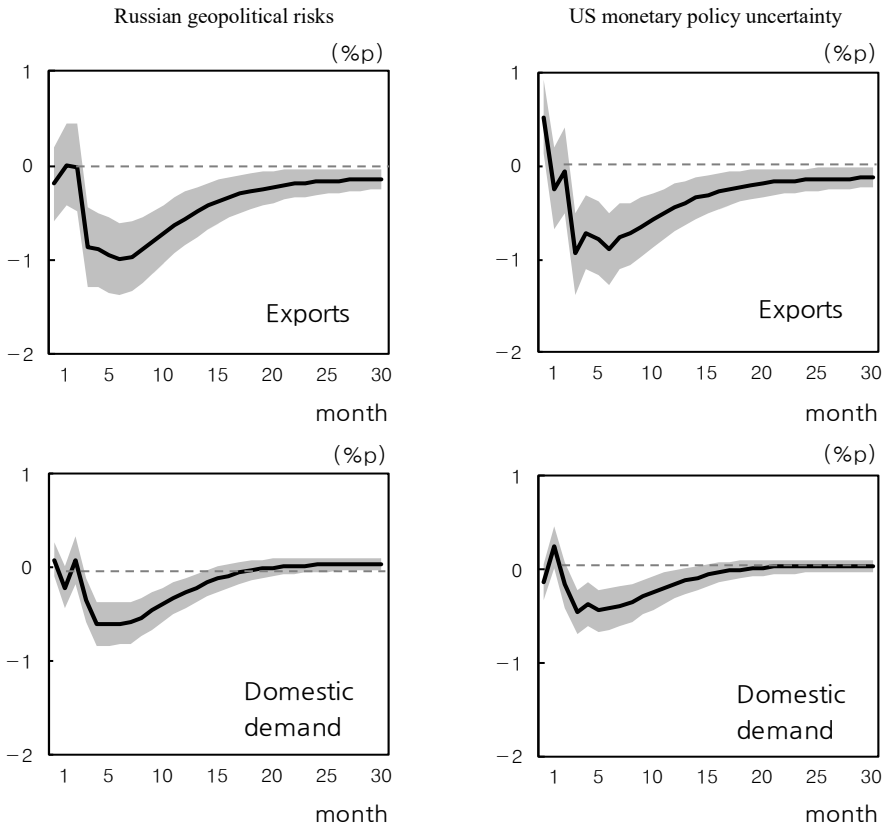

FIGURE 4. IMPACTS OF UNCERTAINTY SHOCKS ON EXPORTS AND DOMESTIC DEMAND

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

Additionally, the impact of these uncertainties on exports remains significant for about a year. On the other hand, the domestic demand response is smaller, with corresponding decreases of 0.6%p and 0.5%p. The responses of domestic demand also persist for about a year. Given that the export sector is more exposed to the global economy, the interpretation of these differential effects is straightforward. Despite the responses of domestic demand being smaller, they are still statistically significant, indicating that an increase in external uncertainties affects the overall economy.

Figure 5 shows the responses of manufacturing and service sector production. Following shocks from Russian geopolitical risk and US monetary policy uncertainty, manufacturing production decreases by 0.9%p and 0.5%p, respectively, with a time lag. Additionally, these impacts remain statistically significant for about a year. On the other hand, service sector production shows smaller responses, with decreases of 0.3%p in each case, and the negative impact on service sector production also persists for about a year.

Similar to the results from the regression with exports and domestic demand, there is a significant decrease in manufacturing production. Although the decline in service industry production is smaller, it remains statistically significant over a considerable

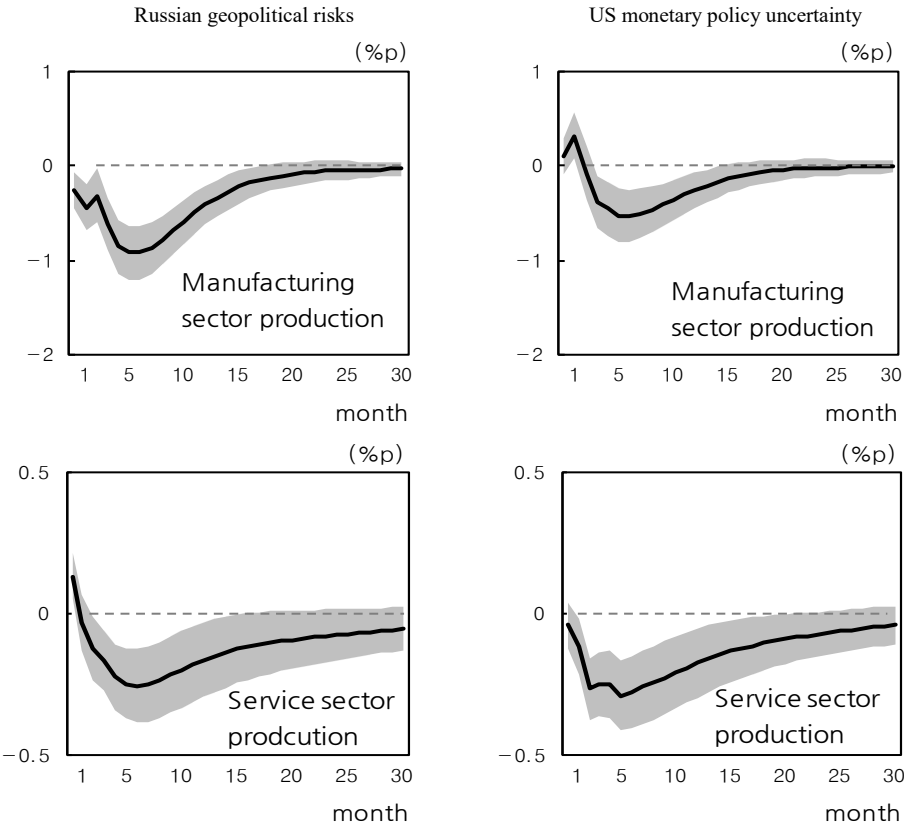

FIGURE 5. IMPACTS OF UNCERTAINTY SHOCKS ON MANUFACTURING AND SERVICE PRODUCTION

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

period. Therefore, we can conclude that an increase in external uncertainties affects not only industries heavily exposed to the global economy but also has a broad effect on the overall economy in Korea.

C. *Transition Path of External Uncertainty Shocks: Focusing on the Global Trade Channel*

We show that Russian geopolitical risks and US monetary policy uncertainty contribute to increased uncertainty in the business environment for Korean firms. This effect can lead to delays in business investments, potentially impacting economic activities overall. Additionally, the impact of external uncertainties is not limited to the Korean economy; Korea's trading partners could also be affected. It could lead to a slowdown in economic activities in Korea, particularly centered on Korean exports. In this way, external uncertainties, as exogenous shocks originating from outside of the Korean economy, can affect the Korean economy through various transmission channels.

Therefore, in this section, we investigate how external uncertainties affect global

demand and how changes in global demand impact Korean domestic real variables. Furthermore, we perform a counterfactual analysis where the transmission channel of external uncertainties through global demand is excluded to understand the extent to which a decrease in global demand amplifies the impact of external uncertainties.

1. Impact of External Uncertainties on Global Trade

Before discussing the transmission channels through which Russian geopolitical risks and US monetary policy uncertainty affect the domestic economy by decreasing external demand, we confirm that external uncertainties have negative impacts on other countries' economic activities, thereby reducing global demand. There are several possible channels through which external uncertainty impacts the global economy. First, it can lead to delays in business investments, which may slow economic activity worldwide. Second, rising uncertainty can slow global trade down through a stronger dollar, which is a key driver of international trade (Gopinath *et al.*, 2020).[4] The global trade volume is used as a proxy for global demand. Hence, without estimating a new regression model, the impact of external uncertainties on the global trade volume is readily available from our baseline regression results.

Figure 6 illustrates a significant decrease in world trade volume in response to shocks that affect Russian geopolitical risks and US monetary policy uncertainty. Specifically, we find that a one standard increase in Russian geopolitical risks and US monetary policy uncertainty leads to a maximum decrease in world trade volume of 0.6%p and 0.5%p, respectively, with a time lag. Furthermore, the response of the global trade volume persists for up to 30 months.

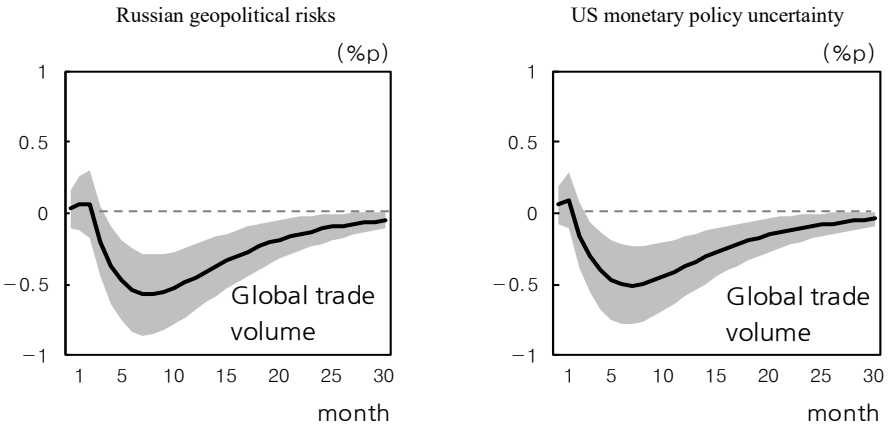

FIGURE 6. IMPACTS OF UNCERTAINTY SHOCKS ON GLOBAL TRADE

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

[4]While analyzing the significance of each channel is important, our paper primarily focuses on the overall impact of uncertainty on global trade.

2. Impact of Global Trade Shocks on the Korean Economy

Now, we explore how shocks to global trade affect the Korean economy. The decrease in external demand, reflected in global trade, will directly impact the Korean economy through exports, ultimately affecting industries as a whole. Specifically, when external demand contracts, Korean exporting firms will experience decreases in the level of demand for their products. This will lead to a

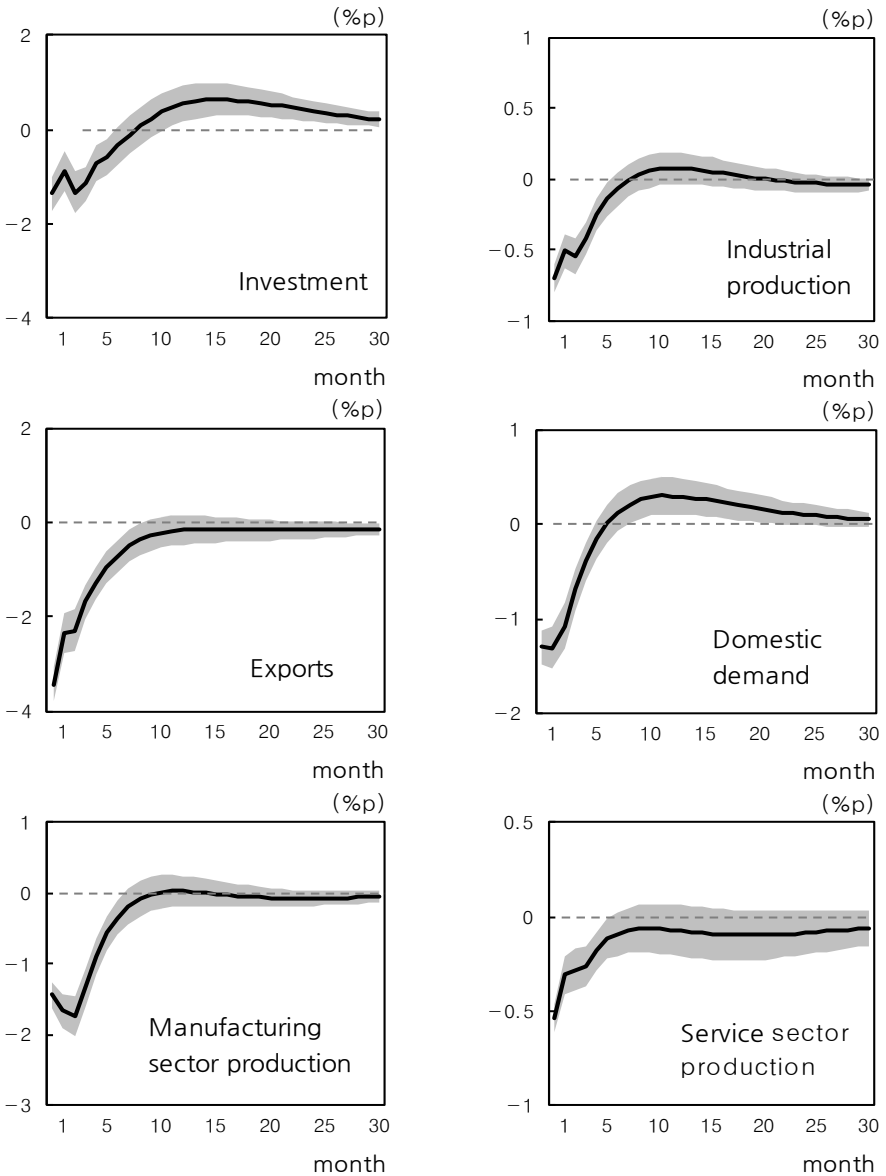

FIGURE 7. IMPACTS OF GLOBAL TRADE SHOCKS ON THE KOREAN ECONOMY

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

contraction in the production activities of Korean firms that supply intermediate goods and services for exporters, negatively impacting the overall domestic economy. Additionally, a decrease in exports may result in reduced household spending or decreased investments by firms due to lower income and revenue levels. Hence, in the following analysis, we investigate how the Korean economy responds to global trade shocks.

In Figure 7, we observe that in response to a one standard deviation shock in the world trade volume, exports and manufacturing production, which are highly exposed externally, show corresponding maximum declines of 3.4%p and 1.7%p, with a delay. Investment and domestic consumption also decrease by up to 1.3%p, while service production and overall industrial production drop by up to 0.5%p and 0.7%p, respectively. These findings suggest that the impact of global trade shocks has effects beyond sectors directly exposed to the global economy, also propagating throughout the broader economy via various transmission channels. The responses of all real variables, except exports, are shown to last for about five to six months, indicating that the impacts dissipate more quickly than those from uncertainty shocks.

The findings above provide evidence of the transmission path of uncertainties through decreased external demand. Subsequently, we analyze the extent to which external demand contributes to the transmission channel of uncertainty through a counterfactual analysis.

3. Transmission Channel of External Uncertainty Shocks – Counterfactual Analysis

In this section, we conduct a counterfactual analysis to understand the role of global demand during the transmission of external uncertainty shocks. Specifically, we consider a scenario in which uncertainties impact the Korean domestic economy in the absence of a global trade channel. We then compare the counterfactual impulse responses to those from the baseline model. The impulse response functions in the baseline model implicitly reflect all possible channels through which external uncertainties affect the Korean economy. Hence, comparing these different impulse responses allows us to evaluate the importance of the transmission channel through decreased external demand. This methodology was widely used in earlier studies (Akinci, Kalmeli-Özcam, and Queralto, 2022; Caldara and Iacoviello, 2022) to identify specific transmission channels of macro shocks.

The method of deriving the counterfactual impulse responses follows Caldara and Iacoviello (2022). The specific steps are as follows. First, we use the estimated baseline model. Next, we increase the structural shocks related to geopolitical risks in Russia or uncertainty in US monetary policy by one standard deviation in each case. To shut down the transmission channel through global trade for each type of uncertainty, we generate counterfactual structural shocks in global trade that prevent global trade from responding. Consequently, in each case of a structural shock related to geopolitical risks in Russia or uncertainty in US monetary policy, the global trade volume remains constant. By muting the response of global trade to each uncertainty shock, we can estimate the impact of external uncertainty without an

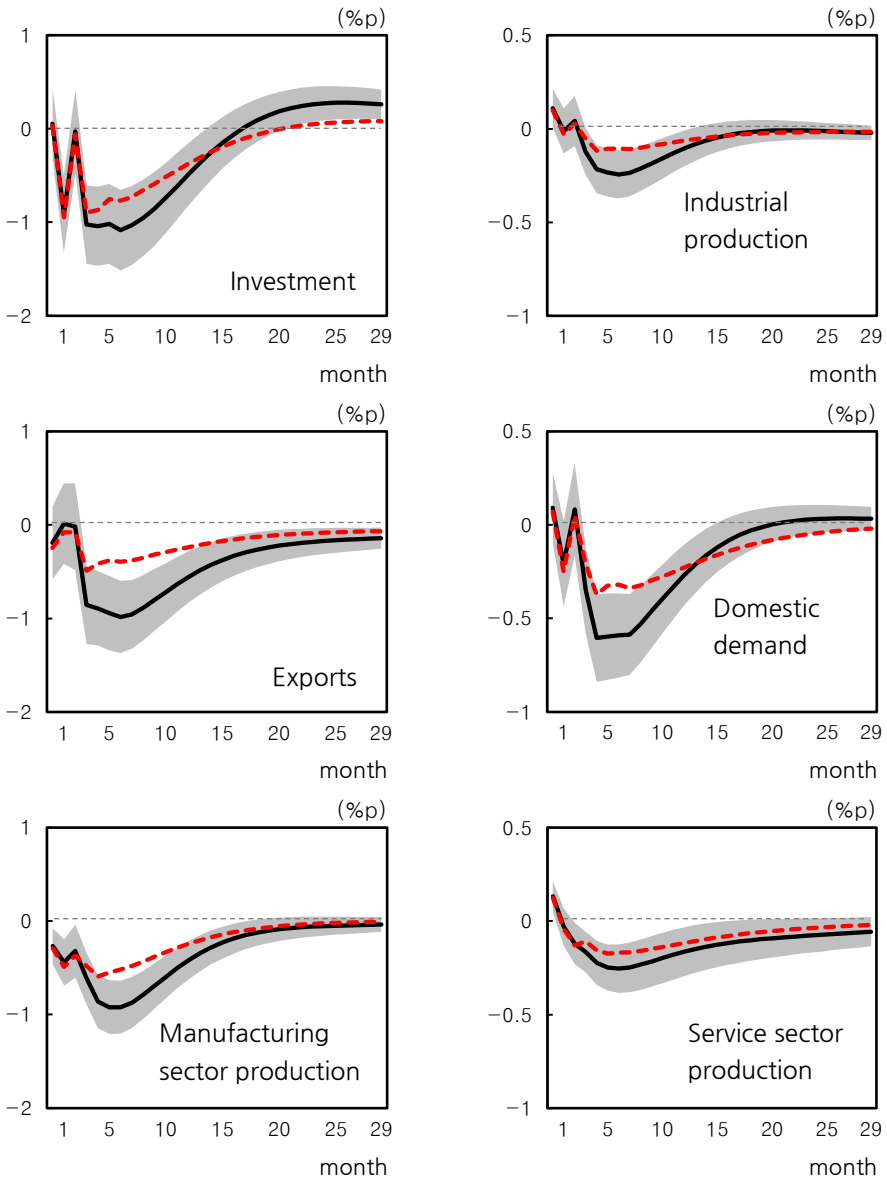

FIGURE 8. BASELINE AND COUNTERFACTUAL RESPONSES TO RUSSIAN GEOPOLITICAL RISKS

Note: 1) Shaded areas show the one standard deviation confidence interval of the impulse response; 2) Red dashed lines depict the counterfactual impulse responses.

external demand channel.

Figure 8 shows the analysis of Russia's geopolitical risk. The black solid line represents the response of domestic real variables derived in the baseline model, while the red dashed line shows a counterfactual response with the world trade volume constant. As shown in all cases, the estimated counterfactual responses are smaller than the responses of the baseline model. In particular, for exports, manufacturing,

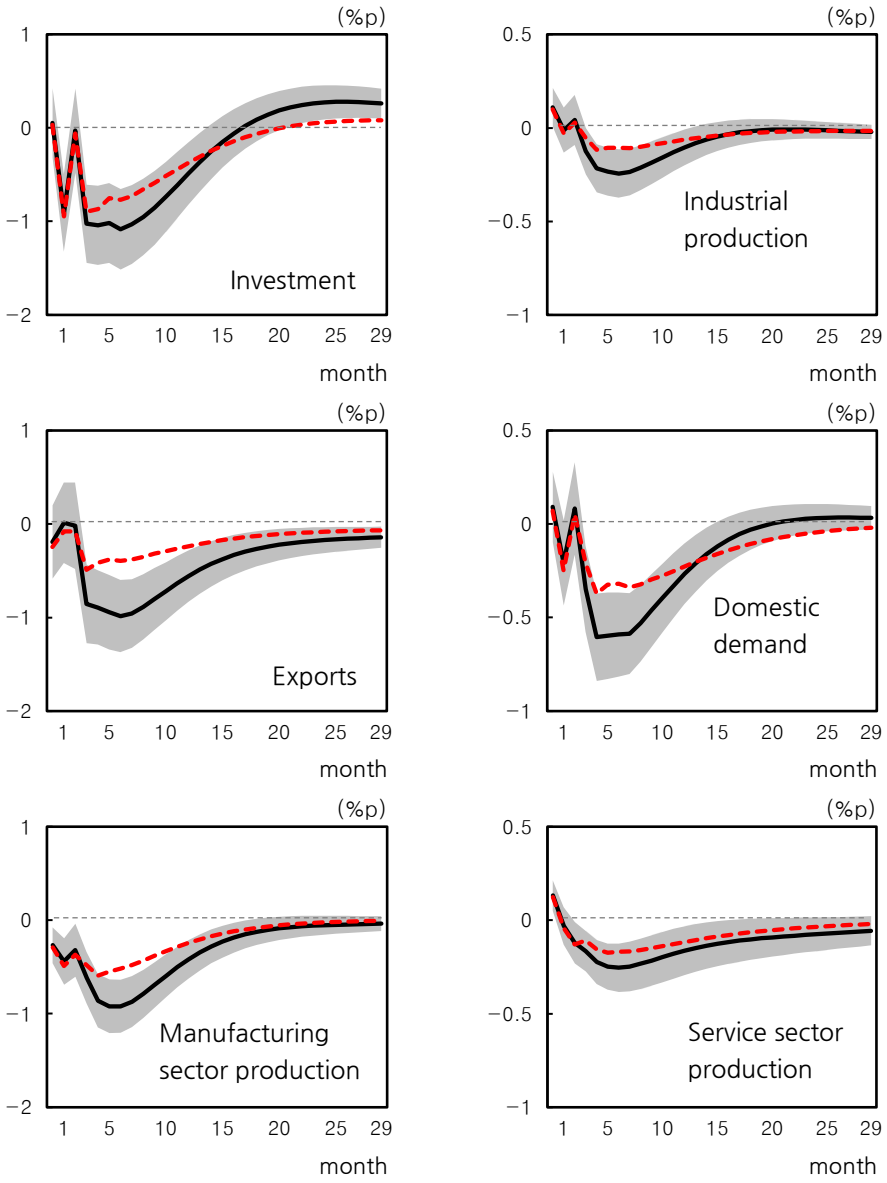

FIGURE 9. BASELINE AND COUNTERFACTUAL RESPONSES TO US MONETARY POLICY UNCERTAINTY

Note: 1) Shaded areas show the one standard deviation confidence interval of the impulse response; 2) Red dashed lines depict the counterfactual impulse responses.

and domestic consumption, the counterfactual response is not included in the confidence interval of the baseline responses, suggesting that the world demand channel would play an important role in transmitting Russia's geopolitical risk. Specifically, for a one standard deviation increase in Russia's geopolitical risk, the counterfactual responses of exports and manufacturing output, as well as domestic consumption, decreased by up to 0.5%p, 0.6%p, and 0.4%p, respectively, compared to the responses of the baseline model (-1.0%p, -0.9%p, -0.6%p). The difference

between the two impulse responses decreases significantly and does not persist for more than a year, disappearing in the short term.

Figure 9 shows the results for US monetary policy uncertainty shocks. Similar to Russia's geopolitical risk, the counterfactual responses of all variables are estimated be smaller than those of the baseline model. The counterfactual responses of exports and manufacturing are not included in the confidence interval of the baseline responses. Specifically, if US monetary policy uncertainty increases by one standard deviation, the counterfactual responses of exports and manufacturing output decrease by up to 0.5%p and 0.2%p, respectively, compared to the decrease in each baseline model (-0.9%p, -0.5%p). Similar to Russia's geopolitical risk, this difference is maximized in the short term, with no sign of a persistent discrepancy.

In sum, our analysis provides supportive evidence that the response of the world trade volume could play an important role in transmitting both Russian geopolitical risks and US monetary policy shocks, especially in sectors with higher external dependence, such as exports and manufacturing. Their impact is maximized for up to five to six months, and over time, the importance of this transmission channel gradually diminishes.

V. Impact of External Uncertainty: Micro-Level Analysis

Given that investments and exports are significantly affected by external uncertainty, these variables are crucial for understanding the transmission channel of external uncertainty shocks. Therefore, we explore in depth the responses of exports and investments using micro-level data.

While it would be ideal to analyze both exports and investments simultaneously, micro-level data that contain sufficient information on both variables are not available. Consequently, we conduct a separate analysis of each. The export analysis employs country- and product- specific data provided by the Korean Customs Service. For the investment analysis, we employ firm-level financial statement data from KIS-VALUE.

A. *Impact of External Uncertainty on Exports*

In this section, we analyze the impact of external uncertainty on exports using micro data. First, we analyze the average response of exports to uncertainty shocks and examine whether the impact of uncertainty can vary depending on the country- and product-specific characteristics.

1. Baseline regression model

In order to investigate the impact of external uncertainty on exports, we estimate the following panel regression model. This model captures the dynamic responses to

specific shocks in a manner similar to the local projection by Jordà (2005); it is also widely used in existing studies using micro data (Caldara and Iacoviello, 2022; Ottonello and Winberry, 2020). First, we estimate the baseline model for the average responses, after which we extend the model to analyze the heterogeneous responses of exports by country and product.

$$y_{p,c,t+h} = \alpha^h_{p,c} + \beta^h_{GPU} GPU_t + \beta^h_{MPU} MPU_t + \Gamma^h X_{c,t} + \Psi^h Z_t + y_{p,c,t-1} + \varepsilon^h_{p,c,t}$$

Here, $y_{p,c,t+h}$ represents the value of the dependent variable after $h \geq 0$ periods, and the dependent variable is the change in the log export volume from the previous year. Index p indicates individual products, c indicates the destination country, and t represents time. The variables GPU_t and MPU_t represent Russian geopolitical risk and the uncertainty of US monetary policy, respectively. $X_{c,t}$ and Z_t refer to macro variables that may affect exports. Specifically, $X_{c,t}$ refers to the industrial production of country c, representing the country- specific demand factor. Z_t includes Korea's industrial production and the USD/KRW exchange rate. All additional control variables are the log differences from the previous year. Products and destination fixed effects are also controlled for, and two-way clustered standard errors, clustered by product × trading country and time, are used. As we find in the previous sections, the responses of macro variables to uncertainty shocks last up one year. Therefore, we examine the dynamic response up to one year after the uncertainty shocks.

2. Data

Data were sourced from the Korea Customs Service.[5] Each product is classified according to the 10-digit level of the Harmonized System Code (HSK), and data for all export destinations of Korea are provided on a monthly basis. Because the export value and export weight (in kg) are available, this study uses the export weight as a proxy for quantity. Although the HSK 10-digit level provides a high level of disaggregation of products, changes in the product composition or quality within the same level may result in weight variations. Therefore, following previous studies (Amiti, Itskhoki, and Konings, 2022), products that have experienced an increase of three times or more or a decrease of a third in the annual unit value from the previous year or less are excluded from the analysis. Additionally, outliers belonging to the top 0.5% or bottom 0.5% of growth rates in export quantity from the same month of the previous year are excluded as well.

Industrial production in trading partner countries and in Korea, as well as the USD/KRW exchange rate (monthly average), are sourced from the International Financial Statistics from the International Monetary Fund (IMF).[6] The data cover

[5]Korea Customs and Trade Development Institute (KDI internal DB, last accessed: September 16, 2022), Korea Trade Statistics Promotion Institute (KDI internal DB, last accessed: September 16, 2022),

[6]https://data.imf.org/, last accessed on September 16, 2022.

the period from January of 2000 to December of 2021. Because we use growth rates of each control variable, the actual period used in the analysis begins in January of 2001. The analysis also controls for the period of the global financial crisis by including a dummy variable for the corresponding period.

3. Baseline Results: Average Impact

Figure 10 shows the results of the average responses. The graph on the left shows the dynamic responses of the export volume to a one standard deviation shock in geopolitical risk. On impact, the export volume does not respond to Russian geopolitical risk. However, with a lag, the export volume gradually decreases, reaching a maximum decrease of up to 2.5%p. The graph on the right in Figure 10 depicts the responses of the export volume to a one standard deviation shock in US monetary policy uncertainty. Similar to the Russian geopolitical risk case, the initial impact of uncertainty is not significant. However, over time, its effect gradually increases, leading to a maximum decrease in exports of up to 2.5%p.

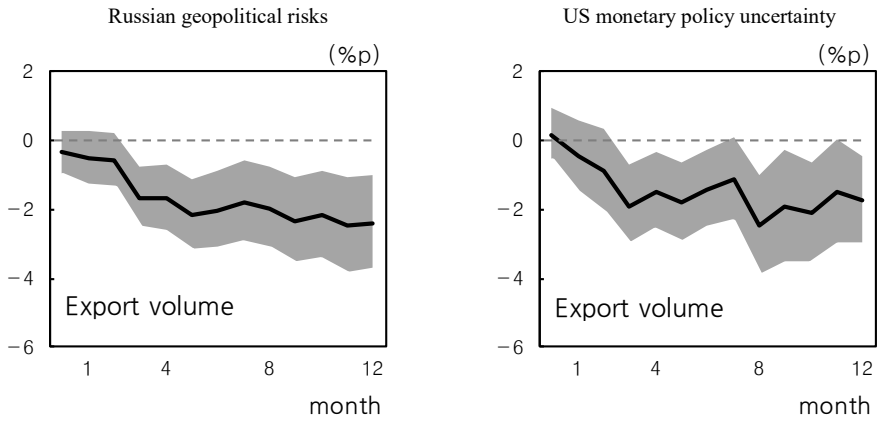

FIGURE 10. IMPACT OF UNCERTAINTY SHOCKS ON EXPORT VOLUMES

Note: Shaded areas show the 90% confidence interval of the impulse response.

4. Additional Results: Heterogeneous Effects by Country

In this section, we explore the heterogeneous impacts of external uncertainties on exports. Specifically, we consider the heterogeneity of exports in two dimensions: export destination countries and export products.

If the overall economic environment of a specific country becomes more vulnerable to external uncertainties, Korean exports to that country are likely to decrease significantly more than those to other regions. The geopolitical risks in Russia and uncertainty in US monetary policy have clear regional origins, suggesting that their effects are relatively strong in Russia and the US, respectively. Therefore, first we investigate whether there is a significant relationship between regional export responses and the regions where external uncertainties originate. To do this,

we include dummy variables for the regions where uncertainty arises, as well as their interaction terms with external uncertainties. Considering that geopolitical risks in Russia may directly impact the Commonwealth of Independent States (CIS) region, we add dummy variables for all countries in the CIS region and corresponding interaction terms with the geopolitical risks in Russia. Similarly, given that uncertainties in US monetary policy may directly affect the North American region, we create dummy variables and corresponding interaction terms with the North American region.

Table 1 shows the results. The interaction terms of geopolitical risks in Russia are estimated to be negative for all lags, and especially after five to six months, the impact becomes statistically significant. This indicates that if geopolitical risks in Russia increase, Korean exports to the CIS countries, which are closely related to Russia, decrease significantly more compared to those to other regions. However, uncertainty in US monetary policy shows somewhat different results. Specifically, the interaction terms are estimated to be positive for all lags and even statistically significant for several lags $(h = 0,1,5,6,7)$.

TABLE 1—HETEROGENEOUS IMPACT OF UNCERTAINTY SHOCKS BY COUNTRY: ORIGIN

	$GPU_t \times Origin$	$MPU_t \times Origin$	R2	Observations
$h = 0$	-0.7951 (-0.62)	1.6538*** (3.11)	0.2729	3,583,452
$h = 1$	-1.2136 (-0.91)	1.30098* (1.78)	0.209	2,988,688
$h = 2$	-1.7052 (-1.11)	1.21129 (1.39)	0.1659	2,951,862
$h = 3$	-2.3105 (-1.42)	0.29666 (0.33)	0.1354	2,914,964
$h = 4$	-3.0198 (-1.60)	0.89712 (0.95)	0.12	2,884,495
$h = 5$	-3.5195* (-1.89)	2.22221** (2.22)	0.1076	2,859,345
$h = 6$	-3.425* (-1.73)	2.1075** (2.30)	0.0959	2,834,634
$h = 7$	-2.4171 (-1.11)	2.01298** (1.98)	0.0906	2,811,562
$h = 8$	-1.6676 (-0.68)	1.31067 (1.21)	0.0855	2,792,760
$h = 9$	-1.9395 (-0.83)	0.96508 (0.75)	0.0865	2,776,649
$h = 10$	-3.5308 (-1.39)	0.71212 (0.59)	0.09	2,761,355
$h = 11$	-3.4152 (-1.33)	1.61258 (1.23)	0.1668	2,888,556
$h = 12$	-4.0894 (-1.60)	1.14341 (1.02)	0.0998	2,861,840

Note: 1) Regressions are weighted by export value; 2) Two-way clustered standard errors by product × trading country and times in parenthesis.

The results are somewhat counterintuitive, as North America is the region where uncertainty is triggered. This suggests the presence of another important country-specific characteristic beyond country of origin that influences the impact of an uncertainty shock. One possible candidate is the country's income level. Carrière-Swallow and Céspedes (2013) find that the impact of uncertainty triggered in the United States (VIX) varies depending on the country's income level. In particular, they confirm that emerging countries are significantly more affected by US uncertainty compared to advanced countries. They attribute this result to the underdeveloped financial markets in emerging countries. Motivated by their findings, we additionally control for the country's income level given that the North American region, including the United States, has a relatively high income level compared to those of other countries.

Table 2 illustrates that the effects of external uncertainty vary depending on a country's income level. In this analysis, we additionally include interaction terms between a country's income level and external uncertainty measures. Specifically, a

TABLE 2—HETEROGENEOUS IMPACT OF UNCERTAINTY SHOCKS BY COUNTRY: ORIGIN AND INCOME LEVEL

	$GPU_t \times Origin$	$MPU_t \times Origin$	$GPU_t \times Income$	$MPU_t \times Income$	R2	Observations
$h=0$	-0.64153 (-0.49)	-0.18138 (-0.27)	0.08464 (0.51)	0.79851*** (3.39)	0.273	3,583,452
$h=1$	-0.94858 (-0.70)	-1.37335 (-1.68)	0.17093 (0.89)	1.15768*** (4.20)	0.2092	2,988,688
$h=2$	-1.48874 (-0.95)	-0.95578 (-1.01)	0.1434 (0.63)	0.93642*** (2.98)	0.1661	2,951,862
$h=3$	-1.97744 (-1.18)	-1.8788* (-1.85)	0.29513 (1.20)	0.92885*** (2.77)	0.1355	2,914,964
$h=4$	-2.73828 (-1.42)	-1.10047 (-1.08)	0.24279 (0.90)	0.85565** (2.26)	0.1201	2,884,495
$h=5$	-3.23819* (-1.70)	0.30801 (0.30)	0.24551 (0.86)	0.81827** (2.36)	0.1077	2,859,345
$h=6$	-3.04213 (-1.49)	0.85723 (0.83)	0.42472 (1.30)	0.51667 (1.53)	0.096	2,834,634
$h=7$	-1.97764 (-0.88)	0.41647 (0.41)	0.47718 (1.22)	0.66645* (1.90)	0.0908	2,811,562
$h=8$	-1.02856 (-0.40)	0.000931 (0.00)	0.75908* (1.81)	0.52327 (1.45)	0.0857	2,792,760
$h=9$	-1.32261 (-0.54)	0.15545 (0.12)	0.75885* (1.90)	0.30521 (0.85)	0.0866	2,776,649
$h=10$	-2.88209 (-1.08)	-0.11691 (-0.09)	0.79842* (1.77)	0.3093 (0.80)	0.0902	2,761,355
$h=11$	-2.56321 (-0.95)	0.04239 (0.03)	1.00776** (2.12)	0.62127 (1.72)	0.1672	2,888,556
$h=12$	-3.26395 (-1.21)	0.02669 (0.02)	1.00223** (2.22)	0.42178 (1.20)	0.1001	2,861,840

Note: 1) Regressions are weighted by export value; 2) Two-way clustered standard errors by product × trading country and times in parenthesis.

variable representing a country's income level is constructed, as follow: countries are classified into five categories, from the bottom 20% to the top 20% for each period, with variables assigned from 1 to the bottom 20% countries to 5 to the top 20% countries.

We find that the effects US monetary policy uncertainty tend to be weaker in exports to countries with higher incomes, with these differential effects being statistically significant for up to seven months. In addition, regarding geopolitical risks in Russia, exports to countries with higher incomes respond less, with this differential effect being statistically significant from the eighth month.

Moreover, the counterintuitive results from the previous analysis - the relatively large decrease in exports to the North American region - are no longer observed. In particular, the interactions between the North American region dummy variable and US monetary policy uncertainty are estimated to be negative, confirming that Korean exports to regions where uncertainty is triggered decreased more significantly. However, both types of geopolitical risk associated with Russia and US monetary policy uncertainty do not show persistently significant different impacts based on the region where the uncertainty originated. Specifically, the responses to Russian geopolitical risks are only statistically significant at $h = 5$, while those to US monetary policy uncertainty are only statistically significant at $h = 3$.

In summary, we find that both Russian geopolitical risk and US monetary policy uncertainty have varying impacts on Korean exports to destination country depending on the country's income level: low-income countries especially experiencing a larger negative impact of these uncertainties. We also find that Korean exports to regions where uncertainty originates tend to decrease relatively more compared to exports to other regions.

5. Additional Results: Heterogeneous Effects by Product

External uncertainty shocks can also have heterogeneous effects on exports according to the product type. From the analysis in the previous section, we observe that an increase in external uncertainty reduces Korea's investments significantly. Assuming that our trading partner countries experience similar conditions, their real investments are also likely to be significantly affected. This would lead to a larger decrease in exports of items used for investments. Therefore, in this section, we examine whether the responses to external uncertainty shocks differ among consumer goods, primary products, intermediate goods, and capital goods. Specifically, we extend our model further by introducing a dummy variable for each export category, and its interaction terms with external uncertainty variables.

Figure 11 shows the effect of geopolitical risk in Russia. We find that most export items are affected by an increase in geopolitical risk in Russia. In particular, the growth rate of capital goods exports decreases by up to 7.39 percentage points compared to other goods, showing a relatively large decrease.

Figure 12 shows the export responses to an increase in uncertainty in US monetary policy. As can be seen in each graph, the growth rate of capital goods exports decreases by up to 7.07 percentage points, showing a relatively large decrease compared to other goods.

Although capital goods exports respond more strongly to both types of uncertainty, whether the difference is statistically significant varies depending on the type of uncertainty. As shown in Figure 13, it is somewhat difficult to distinguish statistically the decrease in capital goods exports due to geopolitical risks in Russia from the decrease in exports of other items. However, regarding the uncertainty in US monetary policy, a statistically significant difference can be observed for a considerable period in the initial stage.

In sum, although a decrease in exports due to increased external uncertainty shows heterogeneous patterns across different items, the difference is not statistically significant with regard to geopolitical risks in Russia. In contrast, it is evident in the case of US monetary policy uncertainty shocks. Specifically, the significant decrease in capital goods exports due to uncertainty in US monetary policy aligns earlier findings in the literature (Bloom, 2009), which suggests that uncertainty propagates to the real economy through reduced investments.

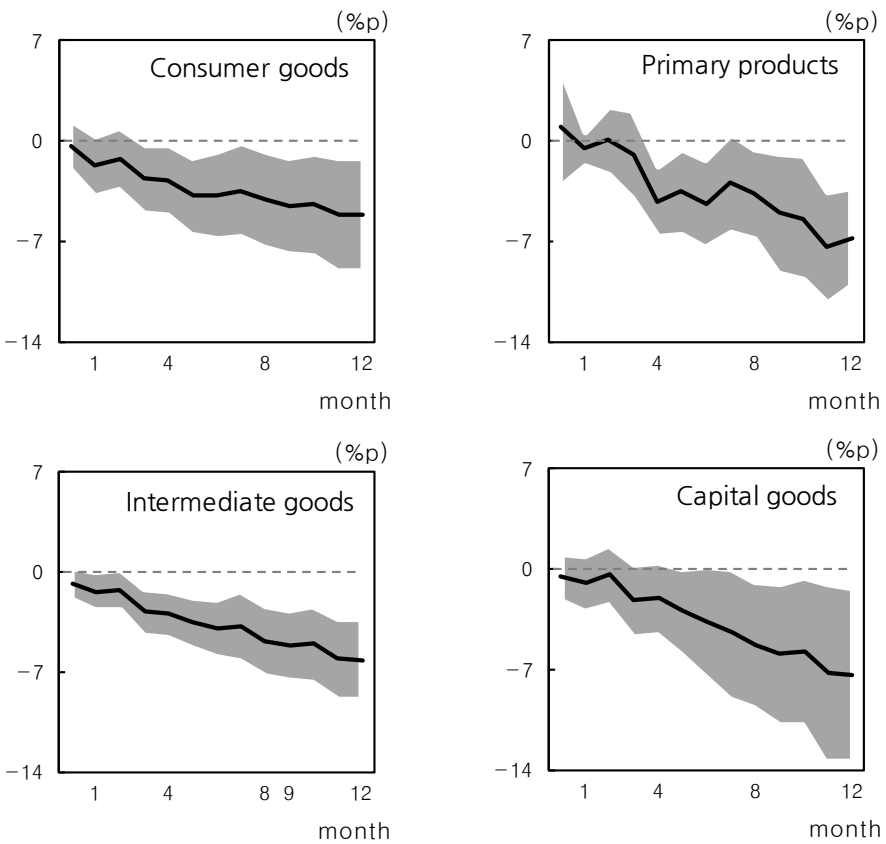

FIGURE 11. DIFFERENTIAL IMPACTS OF RUSSIAN GEOPOLITICAL RISKS BY PRODUCT

Note: Shaded areas show the 90% confidence interval of the impulse response.

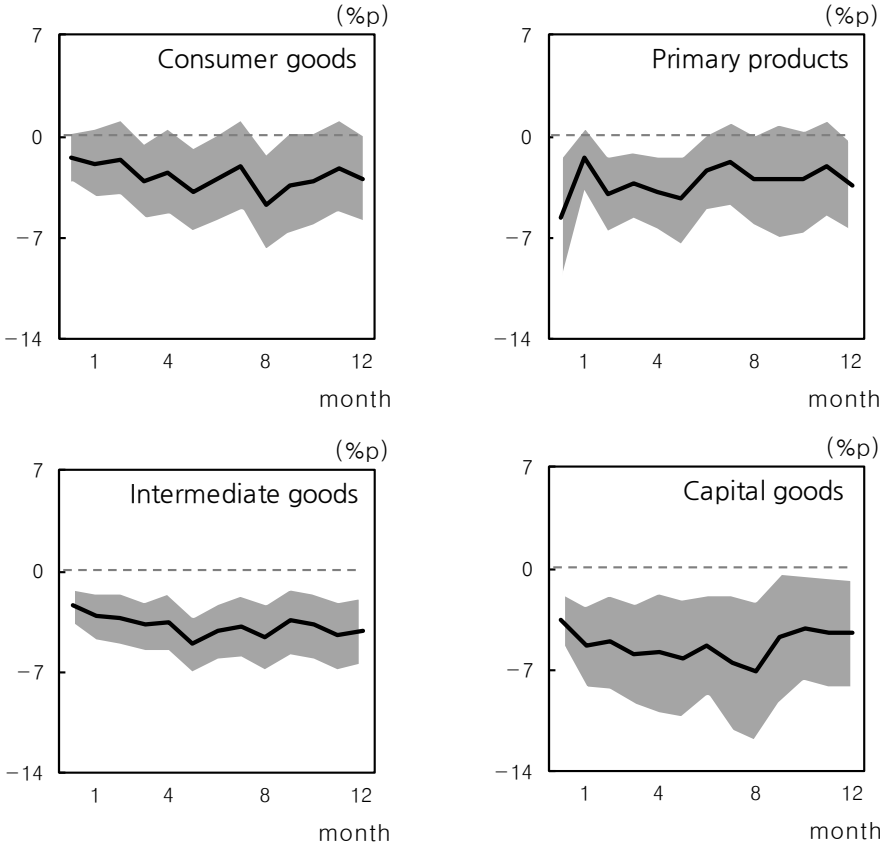

FIGURE 12. DIFFERENTIAL IMPACTS OF US MONETARY POLICY UNCERTAINTY BY PRODUCT

Note: Shaded areas show the 90% confidence interval of the impulse response.

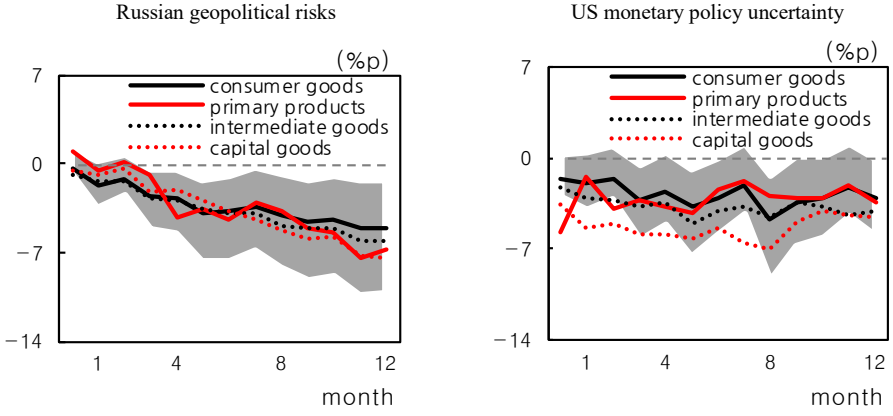

FIGURE 13. DIFFERENTIAL IMPACTS OF UNCERTAINTY SHOCKS BY PRODUCT

Note: Shaded areas show the 90% confidence interval of the impulse response.

B. *Impact of External Uncertainty on Corporate Investment Decisions*

By using firm-level data, we analyze the average corporate investment responses to increasing uncertainty and explore whether the impact of uncertainty shocks varies depending on the firm-level characteristics.

1. Baseline Regression Model

We estimate a panel regression model similar to the previous analysis. First, we estimate the baseline model, which is defined as follows:

$$y_{i,t+h} = \alpha_i^h + \beta_{GPU}^h GPU_t + \beta_{MPU}^h MPU_t + \Gamma^h X_{i,t} + \Psi^h Z_t + \varepsilon_{i,t}^h$$

The dependent variable $y_{i,t+h}$ represents the h-period-ahead value of $y_{i,t}$, and $y_{i,t}$ denotes the change in log real tangible assets. Here, the index i refers to individual firms, and t represents time. GPU_t and MPU_t represent the geopolitical risk in Russia and uncertainty in US monetary policy, respectively. $X_{i,t}$ represents the firm-level characteristics that could affect investment decisions, as noted in the literature (Gulen and Ion, 2016; Husted, Rogers, and Sun, 2020; Caldara and Iacoviello, 2022). It includes the ratio of cash flow to total assets, log growth in real sales, Tobin's Q, and the ratio of exports to total sales. The key macro variables, denoted here by Z_t, are controlled to identify the impact of external uncertainty accurately, including the real-world GDP, the USD/KRW exchange rate (quarterly average), Korean real GDP, Korean CPI, the Korean policy interest rate, and the Korean unemployment rate. All macro variables, except for policy interest rates and unemployment rates, use the log growth rate from the previous year. Furthermore, industry (KSIC 3-digit level) and quarterly fixed effects are included to control for seasonality and industry-specific characteristics. Firm-level fixed effects are included to control for persistent company characteristics. Additionally, two-way cluster standard errors clustered by company and time are used. Because the impact of uncertainty on macro real variables typically lasts up to one year, we examine the dynamic responses up to one year after the uncertainty shocks.

2. Data

We use firm-level financial statements data provided by KIS-VALUE. As discussed earlier, the impact of external uncertainty typically materializes within a few months and generally dissipates within one year. Therefore, to identify the impact of uncertainty rigorously, it is appropriate to use data with a frequency shorter than that of annual data. In this study, our analysis focuses on listed firms that provide quarterly balance sheet information.

Given that manufacturing production is significantly affected by uncertainty, we

limit our analysis to firms in the manufacturing industry. Following existing literature (Ottonello and Winberry, 2020), we perform data cleaning and remove outliers, after which we deflate firm-level variables using GDP deflators or investment deflators. Detailed explanations and sample statistics of the firm-level variables used here are included in the Appendix. In line with existing studies (Jeenas, 2019; Ottonello and Winberry, 2020), we use the change in real tangible assets as a variable representing investment decisions by firms.

The Russian geopolitical risks and US monetary policy uncertainty are identical to those used in the previous analysis. World GDP is downloaded from Global Insight[7] data and Korean macro variables are based on data from Statistics Korea or the Bank of Korea. The sample period is from the first quarter of 2000 to the fourth quarter of 2021. Because we use the growth rate for most variables, the actual sample period begins in the first quarter of 2001. As before, dummy variables for the global financial crisis are also controlled.

3. Baseline Result: Average Effect

Figure 14 shows how a firm's investment decision changes when external uncertainty increases. The graph on the left depicts the impact of a one standard deviation increase in Russian geopolitical risk. Specifically, the growth rate of real tangible assets decreases by up to 1.3%p immediately and then gradually weakens over time.

The graph on the right shows the impact of US monetary policy uncertainty. When US monetary policy uncertainty increases by one standard deviation, the growth rate of real tangible asset decreases by up to 1.0%p with a lag, and the impact disappears within a year. Unlike Russian geopolitical risk, the immediate effect of US monetary policy uncertainty is not statistically significant. However, a negative impact gradually expands from the second quarter onwards.

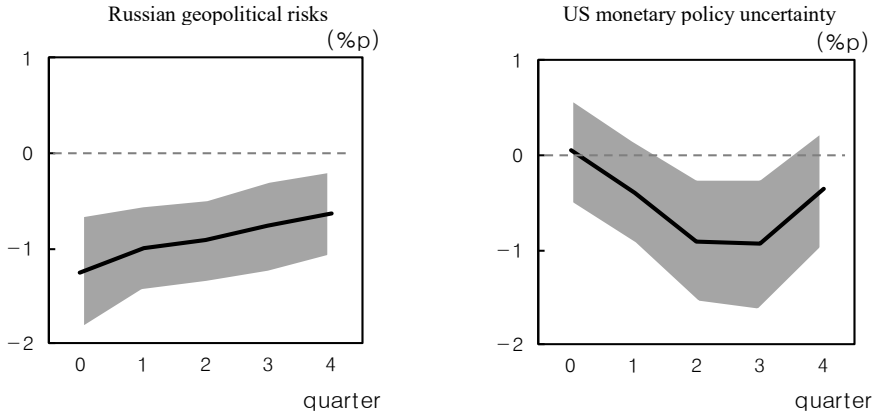

FIGURE 14. IMPACT OF UNCERTAINTY SHOCKS ON INVESTMENT DECISIONS

Note: Shaded areas show the 90% confidence interval of the impulse response.

[7]Global Insight (KDI internal DB, last access date: November 10, 2022); Bank of Korea (https://ecos.bok.or.kr/, last access date: November 9, 2022); Statistics Korea (https://kosis.kr/, last access date: June 16, 2022).

4. Additional Results: Heterogeneous Effects by Firm

In this section, we investigate whether the impact of uncertainty varies depending on the firm-level characteristics. Existing literature suggests that an increase in uncertainty affects a firm's investments through two main mechanisms. The first is the real option channel, as proposed by Bloom (2009), mainly due to the irreversibility of investments. Investment decisions typically involve a certain amount of fixed costs. Accordingly, as uncertainty in the business environment increases, firms tend to delay their decisions. The second channel is the financial friction mechanism proposed by Gilchrist, Sim, and Zakrajšek (2014). Increased uncertainty in the business environment can lead to higher bankruptcy risks and raise a firm's financial costs. Higher financing costs cause firms to reconsider their decisions on investments, thereby negatively impacting investments. Therefore, in this section, we explore as well the transmission channels of uncertainty by specifically controlling for firm-level variables related to the two main channels above.

To capture the nature of irreversibility, we employ variables suggested in the literature (Gulen and Ion, 2016; Husted, Rogers, and Sun, 2020; Kim *et al*., 2022). First, we use the ratio of fixed assets to total assets, indicating that firms with a higher ratio tend to make large investments with high fixed costs. Based on previous studies, firms are classified into five categories according to their fixed assets ratio at each time period, assigning values ranging from 1 to the bottom 20% to 5 to the top 20%. The variable, labelled irre1, can be interpreted as increasing capital irreversibility as the value rises. The second variable is based on the fact that capital subject to rapid depreciation or leased from other firms may have relatively low sunk and fixed costs. Specific variables reflecting these factors are generated according to the literature (Kim *et al*., 2022). After calculating depreciation and lease costs relative to total fixed assets, firms are divided into three groups at each time point. A value of 3 is assigned to firms with low depreciation and low lease costs, 2 to firms with either high depreciation and low lease costs or low depreciation and high lease costs, and 1 to firms with high depreciation and high lease costs. This variable, defined as irre2, is associated with increasing capital irreversibility as its value increases. Table 3 reports the coefficient estimates of interaction terms between the degree of these types of irreversibility and uncertainty shocks, illustrating the differential impact of uncertainty shocks across different firms.

Specifically, firms with high investment irreversibility (irre1) are strongly affected by uncertainty. Geopolitical risks in Russia have heterogeneous effects until the third quarter after a shock, while uncertainty in US monetary policy continues to have differential impacts until the fourth quarter. Similarly, firms with high investment irreversibility (irre2), based on depreciation and lease costs, also exhibit a strong response to uncertainty. The heterogeneous effects are statistically significant up to the third quarter after a shock for geopolitical risks in Russia and up to the second quarter after a shock for uncertainty in US monetary policy.

We also investigate the financial channel of uncertainty shocks. We employ firm-level credit ratings and leverage, as presented in earlier studies (Alfaro, Bloom, and Lin, 2018; Ottonello and Winberry, 2020), to capture the degree of financial constraints.

TABLE 3—HETEROGENEOUS IMPACTS OF UNCERTAINTY SHOCKS BY FIRM: REAL OPTION CHANNEL

		$h=0$	$h=1$	$h=2$	$h=3$	$h=4$
Irre1	GPU_t	-0.70894*** (-3.21)	-0.58649*** (-2.71)	-0.41658** (-2.03)	-0.34542* (-1.74)	-0.19809 (-0.90)
	MPU_t	-0.57196*** (-3.14)	-0.71064*** (-3.53)	-0.55652*** (-2.77)	-0.3753* (-1.90)	-0.37517* (-1.93)
	R2	0.16	0.1149	0.1215	0.123	0.1471
	Observations	70,796	65,823	64,202	64,421	63,150
Irre2	GPU_t	-0.96917*** (-3.45)	-0.75544*** (-2.66)	-0.566* (-1.93)	-0.6777** (-2.12)	-0.56692 (-1.55)
	MPU_t	-0.89153*** (-3.05)	-0.92943*** (-2.89)	-0.63314** (-2.05)	-0.19298 (-0.66)	-0.21098 (-0.68)
	R2	0.1354	0.1123	0.1199	0.1122	0.1184
	Observations	70,796	65,823	64,202	64,421	63,150

Note: Two-way clustered standard errors by firm and time in parenthesis.

TABLE 4—HETEROGENEOUS IMPACTS OF UNCERTAINTY SHOCKS BY FIRM: FINANCIAL CHANNEL

		$h=0$	$h=1$	$h=2$	$h=3$	$h=4$
Rating	GPU_t	-0.01182 (-0.07)	0.02937 (0.14)	0.00676 (0.03)	0.15649 (0.54)	-0.11397 (-0.42)
	MPU_t	-0.19724 (-1.19)	-0.39293** (-1.97)	-0.37072* (-1.86)	-0.38676* (-1.78)	-0.20278 (-1.03)
	R2	0.1278	0.1107	0.1199	0.1116	0.115
	Observations	70,796	65,823	64,202	64,421	63,150
Lev	GPU_t	-0.08218 (-0.67)	-0.05926 (-0.41)	-0.1814 (-1.15)	-0.16436 (-0.90)	-0.16992 (-0.94)
	MPU_t	-0.26445** (-2.30)	-0.29252** (-2.43)	-0.18648 (-1.52)	-0.03864 (-0.30)	0.01415 (0.10)
	R2	0.1283	0.1107	0.1206	0.1136	0.1187
	Observations	70,796	65,823	64,202	64,421	63,150

Note: Two-way clustered standard errors by firm and time in parenthesis.

We compute the interaction terms between the degree of financial friction and uncertainties to identify heterogeneous effects. Credit ratings, provided in KIS-VALUE, are divided into a total of ten grades. Consistent with the previous analysis, these grades are divided into five categories. A higher value of the constructed variable indicates a low rating and a higher level of financial constraint. Furthermore,

the leverage of each firm is defined as total debt divided by total assets. Based on the debt ratio at each time point, companies are divided into five groups, with values ranging from 1 assigned to the bottom 20% to 5 to the top 20%. Therefore, an increase in this variable indicates a high debt burden level, which can be interpreted as a high level of financial constraints.

Table 4 shows the heterogeneous effect of uncertainty based on financial friction. Unlike investment irreversibility, heterogeneous effects of Russian geopolitical risk are not observed. However, heterogeneous effects based on credit ratings are statistically significant from the second quarter to the third quarter after the shocks to US monetary policy uncertainty. Additionally, heterogeneous effects based on debt burden are statistically significant from the immediate aftermath of shocks to the first quarter.

In sum, we find that both the geopolitical risk of Russia and the uncertainty of US monetary policy reduce investment. This effect is particularly pronounced for firms with high irreversibility of their investments. Investment irreversibility, primarily caused by fixed costs, is considered as a real friction in the literature. Therefore, both types of uncertainty lead to a contraction in the domestic real economy due to real friction. However, the geopolitical risk of Russia is largely unrelated to financial friction factors, whereas the uncertainty of US monetary policy impacts the real economy through financial friction channels. The uncertainty of US monetary policy may have a greater impact on the financial markets compared to other uncertainties, making this result somewhat intuitive.

VI. Conclusion

This paper examines the impact of external uncertainties, with a focus on geopolitical risks in Russia and U.S. monetary policy uncertainties, on the Korean real economy.

At the macro level, our analysis shows that the impact of external uncertainty is particularly pronounced in sectors highly dependent on external markets, such as exports and manufacturing production. At the same time, sectors not directly linked to external markets, such as domestic demand and service production, are also negatively affected by external uncertainties, though to varying degrees. Our counterfactual analysis provides some evidence that the slowdown in global trade could be a significant transmission mechanism of external uncertainties.

The detailed micro-level analysis reveals that Korean exports, especially capital goods, are significantly impacted. Exports to countries where uncertainty originates are found to decline more sharply, with low-income countries experiencing a greater negative effect.

The firm-level analysis further demonstrates that firms with larger irreversible investments are more affected by both external uncertainties. However, firms with lower credit ratings or higher debt burdens are more susceptible specifically to U.S. monetary policy uncertainty. This suggests that the primary effect of the Russian geopolitical crisis if real friction, while U.S. monetary policy uncertainty affects both

real and financial types of friction.

Overall, this paper provides valuable insights into how external uncertainties propagate into small open economies, based on both macro- and micro-level analysis. These insights are crucial for policymakers, supporting the design of effective responses to global uncertainty and the mitigation of the risks posed by unpredictable external shocks.

APPENDIX

A. *Trade Data*

The data is provided by the Korea Customs Service Following previous studies (Amiti, Itskhoki, and Konings, 2022), products that have experienced an increase of three times or more or a decrease of one-third in the annual unit value from the previous year are excluded from the analysis. Additionally, outliers belonging to the top 0.5% or bottom 0.5% of YoY growth rates in export quantity are excluded as well. In order to exploit within-country and product-level variations, we restrict each country-product observation to those with at least twelve data points.

TABLE A1—COUNTRY SUMMARY STATISTICS

Country	Avg. # of Product per Year	Avg. # of T per Country and Product	Country	Avg. # of Product per Year	Avg. # of T per Country and Product
China	30642	95	Russia	7966	66
Japan	27975	96	Canada	7786	66
United States	25250	91	Italy	6996	68
Vietnam	17677	73	Mexico	6913	65
Hong Kong SAR	14552	74	Netherlands	6163	63
Chinese Taipei	13830	70	United Arab Emirates	6124	60
Thailand	13223	77	France	5913	62
Indonesia	12698	75	Turkey	5698	65
Singapore	11193	69	Spain	5238	61
India	10915	76	Brazil	5230	62
Malaysia	10771	70	New Zealand	4405	56
Australia	10692	72	Poland	4170	59
Germany	9773	72	Saudi Arabia	4123	54
Philippines	9569	62	South Africa	3870	61
United Kingdom	8478	68	Israel	3458	56

TABLE A2—PRODUCT SUMMARY STATISTICS

Product Category	Total # of Obs.	Ave # of Country per Year
Primary Products	94802	78
Intermediate Products	5288979	193
Capital Products	1417828	162
Consumption Products	1623125	184

B. *Firm-Level Data*

In this study, we use firm-level financial statement data provided by KIS-VALUE. Following the methodology used by Ottonello and Winberry (2020), we perform data cleaning. We also remove observations in the top 0.5 percent and bottom 0.5 percent of the dependent variables to mitigate concerns about outliers. The detailed data processing steps are as follows:

First, the following firms are excluded from the analysis:

Firms

not belonging to the manufacturing industry

with a debt-to-total-assets ratio of 10 or higher

with a current-assets-to-total-assets ratio of 10 or higher, or -10 or lower

with a quarterly sales growth rate of 100 percent or higher, or -100 percent or lower

with a cash-to-total-assets ratio in the top 0.5 percent or bottom 0.5 percent

with non-positive or missing total assets

with non-positive or missing sales

with non-positive or missing total liabilities

Additionally, to adjust each variable to real terms, sales and total assets are normalized using a GDP deflator, and tangible assets are normalized using an investment deflator. If tangible assets show missing values, they are supplemented by linear interpolation using the previous and subsequent quarter values. If one of the values for the previous or subsequent quarters is missing, no supplementation is performed.

TABLE A3—SUMMARY STATISTICS: MARGINAL DISTRIBUTION

	Mean	Median	Standard Deviation	Bottom 5%	Top 5%
Change in Real Tangible Assets	0.021	-0.014	0.419	-0.303	0.508
Cash to Total Asset Ratio	0.005	0.008	0.052	-0.056	0.054
Change in Log Real Sales	0.008	0.023	0.442	-0.579	0.552
Tobin's Q	4.525	0.989	939.489	0.4605	2.864
Export to Sales Ratio	0.334	0.22	0.34	0	0.995

TABLE A4—SUMMARY STATISTICS: CORRELATIONS

	Irre1	Irre2	Rating	Lev
Irre1	1			
Irre2	0.6831	1		
Rating	-0.0035	-0.0080	1	
Lev	-0.0078	-0.0101	0.5345	1

C. *Regression Model in Section V-A*

In addition to the baseline model for the average responses, we estimate the following model to analyze the heterogeneous responses of exports by country and product.

(i) Heterogeneous effects by origin country

$$y_{p,c,t+h} = \alpha^h_{p,c} + \beta^h_{GPU} GPU_t + \beta^h_{MPU} MPU_t + \beta^h_{GPU,O} GPU_t \times Origin_c + \beta^h_{MPU,O} MPU_t \times Origin_c + \Gamma^h X_{c,t} + \Psi^h Z_t + y_{p,c,t-1} + \varepsilon^h_{p,c,t}$$

(ii) Heterogeneous effects by origin country and country income level

$$y_{p,c,t+h} = \alpha^h_{p,c} + \beta^h_{GPU} GPU_t + \beta^h_{MPU} MPU_t + \beta^h_{GPU,O} GPU_t \times Origin_c + \beta^h_{MPU,O} MPU_t \times Origin_c MPU_t + \beta^h_{GPU,I} GPU_t \times Income_{c,t} + \beta^h_{MPU,I} MPU_t \times Income_{c,t} + \Gamma^h X_{c,t} + \Psi^h Z_t + y_{p,c,t-1} + \varepsilon^h_{p,c,t}$$

(iii) Heterogeneous effects by product

$$y_{p,c,t+h} = \alpha^h_{p,c} + \beta^h_{GPU} GPU_t + \beta^h_{MPU} MPU_t + \sum_{i=1}^{3} \beta^h_{GPU,i} GPU_t \times I(p \in Category_i) + \beta^h_{MPU,i} MPU_t \times I(p \in Category_i) + \Gamma^h X_{c,t} + \Psi^h Z_t + y_{p,c,t-1} + \varepsilon^h_{p,c,t}$$

where $I(p \in Category_i)$ is an indicator function which equals 1 if product p is classified as an i-category product. There are four different categories, i.e., consumer goods, intermediate goods, primary products, and capital goods. When we estimate the equation, we set capital good as a reference group.

$y_{p,c,t+h}$ represents the value of the dependent variable after $h \geq 0$ periods, and the dependent variable is the change in the log export volume from the previous year. Index p indicates individual products, c indicates the destination country, and t represents time. The variables GPU_t and MPU_t represent the Russian geopolitical risk and the uncertainty of US monetary policy, respectively. $X_{c,t}$ and Z_t refer to macro variables that may affect exports. Specifically, $X_{c,t}$ refers to the industrial production of country c, representing the country- specific demand factor. Z_t includes Korea's industrial production and the USD/KRW exchange rate. All additional control variables are the log differences from the previous year. Products and destination fixed effects are also controlled for, and two-way clustered standard errors, clustered by product × trading country and time, are used.

D. *Regression Models in Section V-B*

In addition to the baseline model for the average responses, we estimate the following model to analyze the heterogeneous responses of investment by firms.

$$\begin{aligned} y_{i,t+h} = {} & \alpha_i^h + \beta_{GPU}^h GPU_t + \beta_{MPU}^h MPU_t \\ & + \beta_{GPU,C}^h GPU_t \times char_{i,t} + \beta_{MPU,C}^h MPU_t \times char_{i,t} + \Gamma^h X_{i,t} \\ & + \Psi^h Z_t + \varepsilon_{i,t}^h \end{aligned}$$

Here, $char_{i,t}$ denotes the firm-specific characteristics, which represent the degree of irreversibility or financial friction.

The dependent variable $y_{i,t+h}$ represents the h-period-ahead value of $y_{i,t}$, and $y_{i,t}$ is the change in the log real tangible assets. Here, index i refers to individual firms, and t represents time. GPU_t and MPU_t represent the geopolitical risk in Russia and uncertainty in US monetary policy, respectively. $X_{i,t}$ represents the firm-level characteristics that could affect investment decisions. It includes the ratio of cash flow to total assets, the log growth in real sales, Tobin's Q, and the ratio of exports to total sales. The key macro variables Z_t are controlled to identify the impact of external uncertainty accurately, including the real-world GDP, USD/KRW exchange rate (quarterly average), Korean real GDP, Korean CPI, Korean policy interest rate, and Korean unemployment rate. All macro variables, except for policy interest rates and unemployment rates, use the log growth rate from the previous year. Furthermore, industry (KSIC 3-digit level) and quarterly fixed effects are included to control for seasonality and industry-specific characteristics. Firm-level fixed effects are included to control for persistent company characteristics. Additionally, two-way cluster standard errors clustered by company and time are used. Given that the impact of uncertainty on macro real variables typically lasts up to one year, we examine the dynamic responses up to one year after an uncertainty shock.

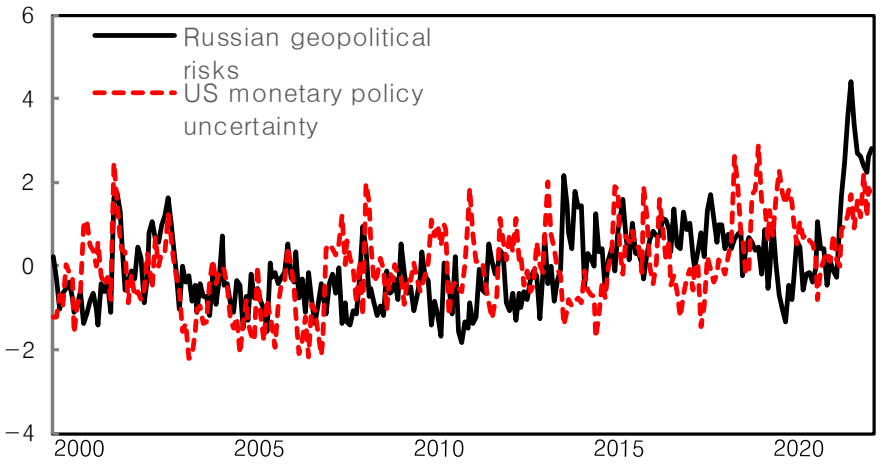

FIGURE A1. RUSSIAN GEOPOLITICAL RISKS AND US MONETARY POLICY UNCERTAINTIES

Note: Both measures are standardized by taking the logarithm of the original data, subtracting the mean, and dividing by the standard deviation.

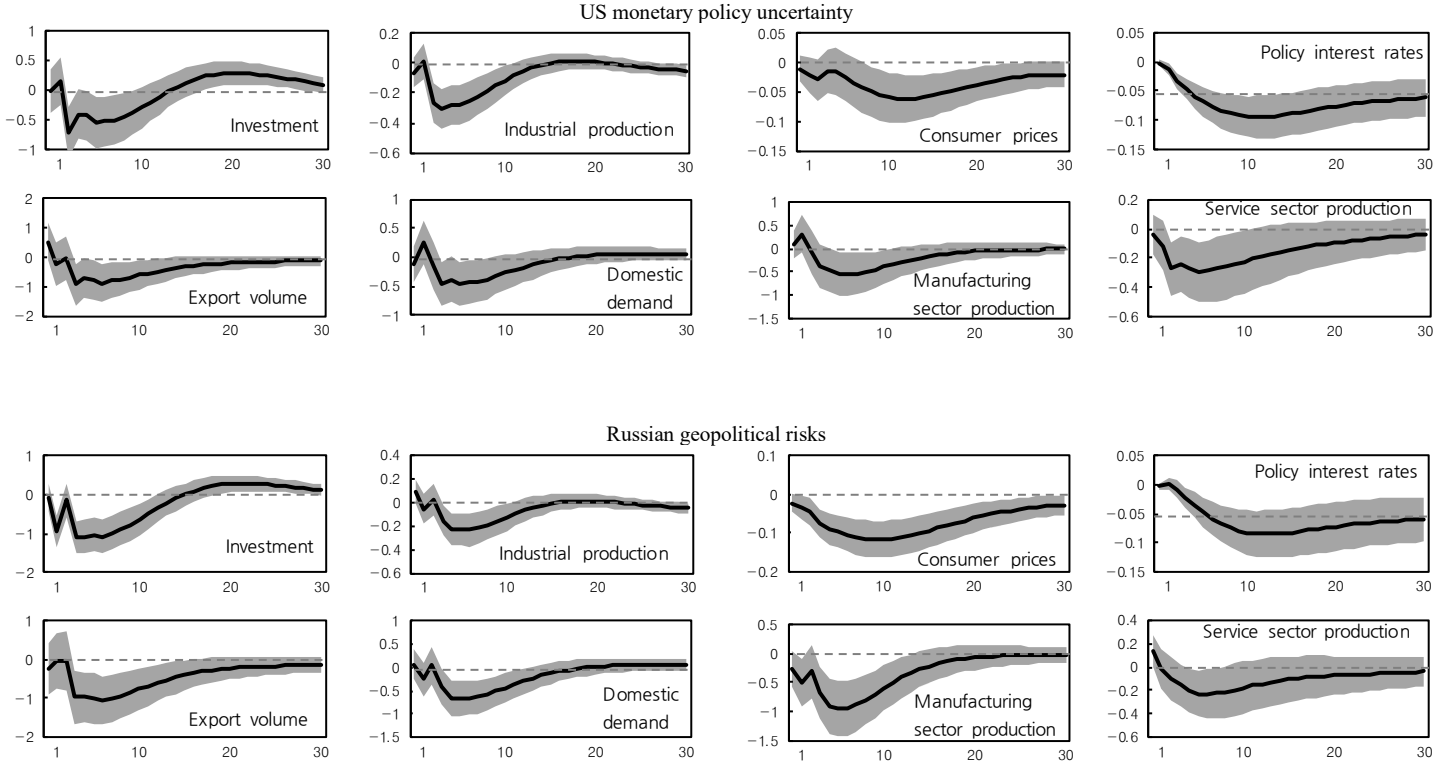

FIGURE A2. IMPULSE RESPONSES WITHOUT THE SMALL-OPEN ECONOMY ASSUMPTION

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

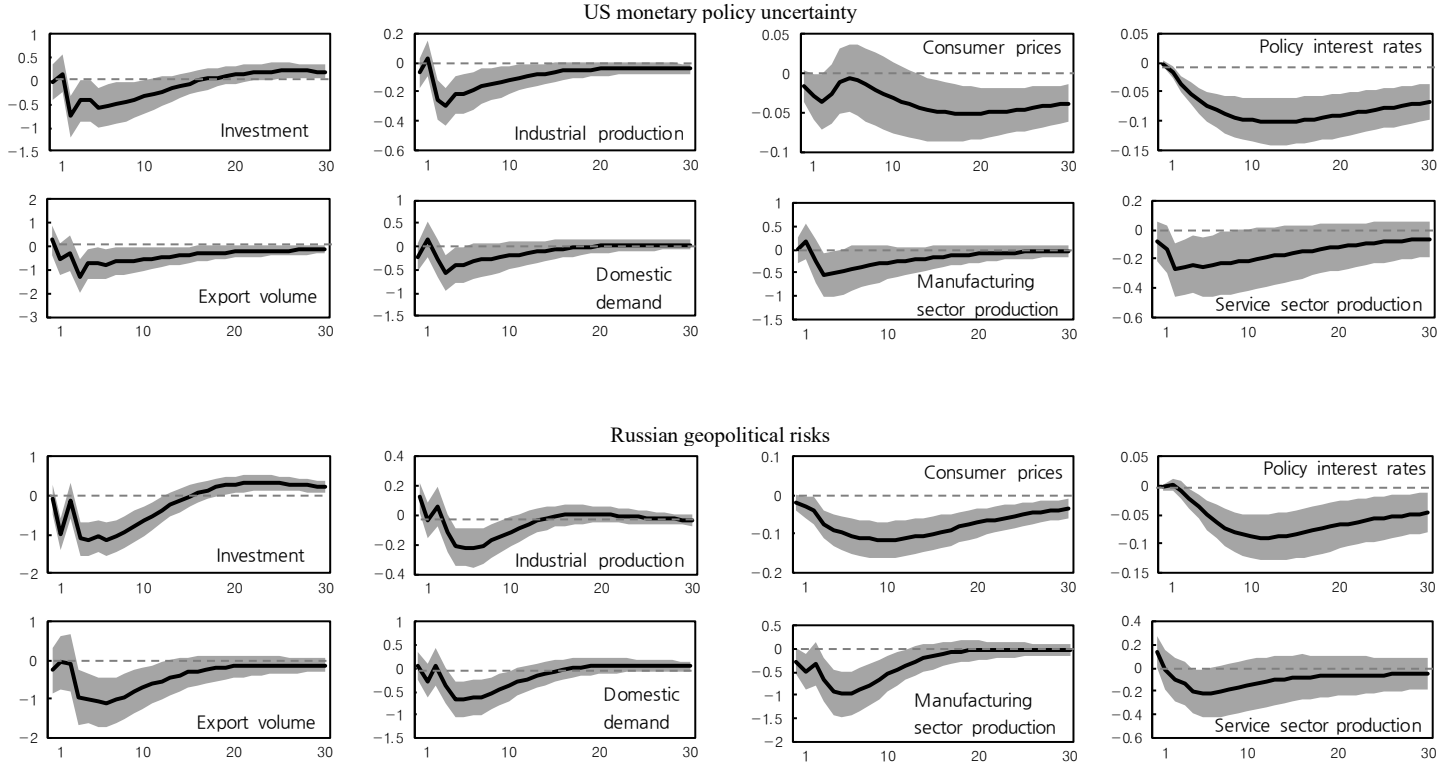

FIGURE A3. IMPULSE RESPONSES CONTROLLING OIL PRICES

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

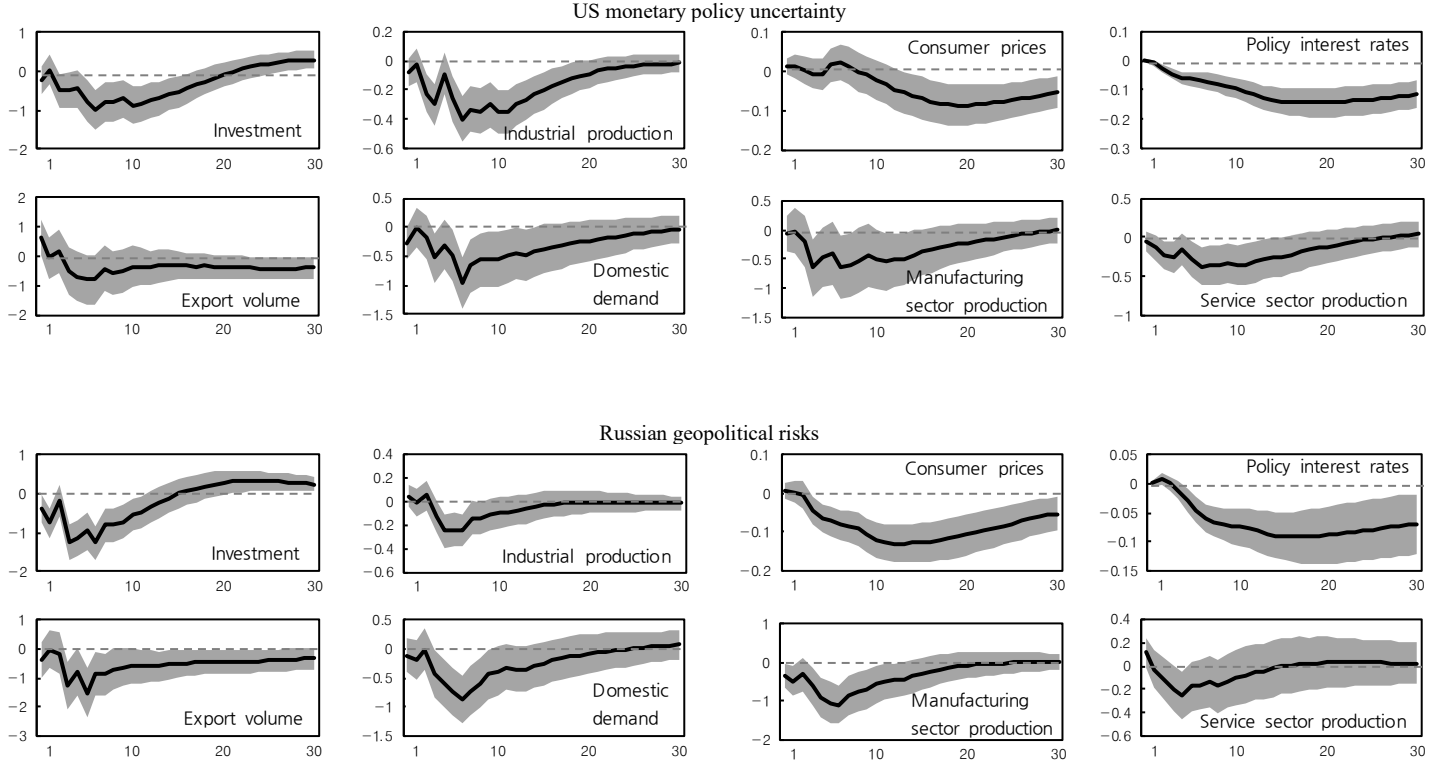

FIGURE A4. IMPULSE RESPONSES INCLUDING THE SAMPLE PERIOD UP TO DECEMBER OF 2021 WITH LAG=6

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

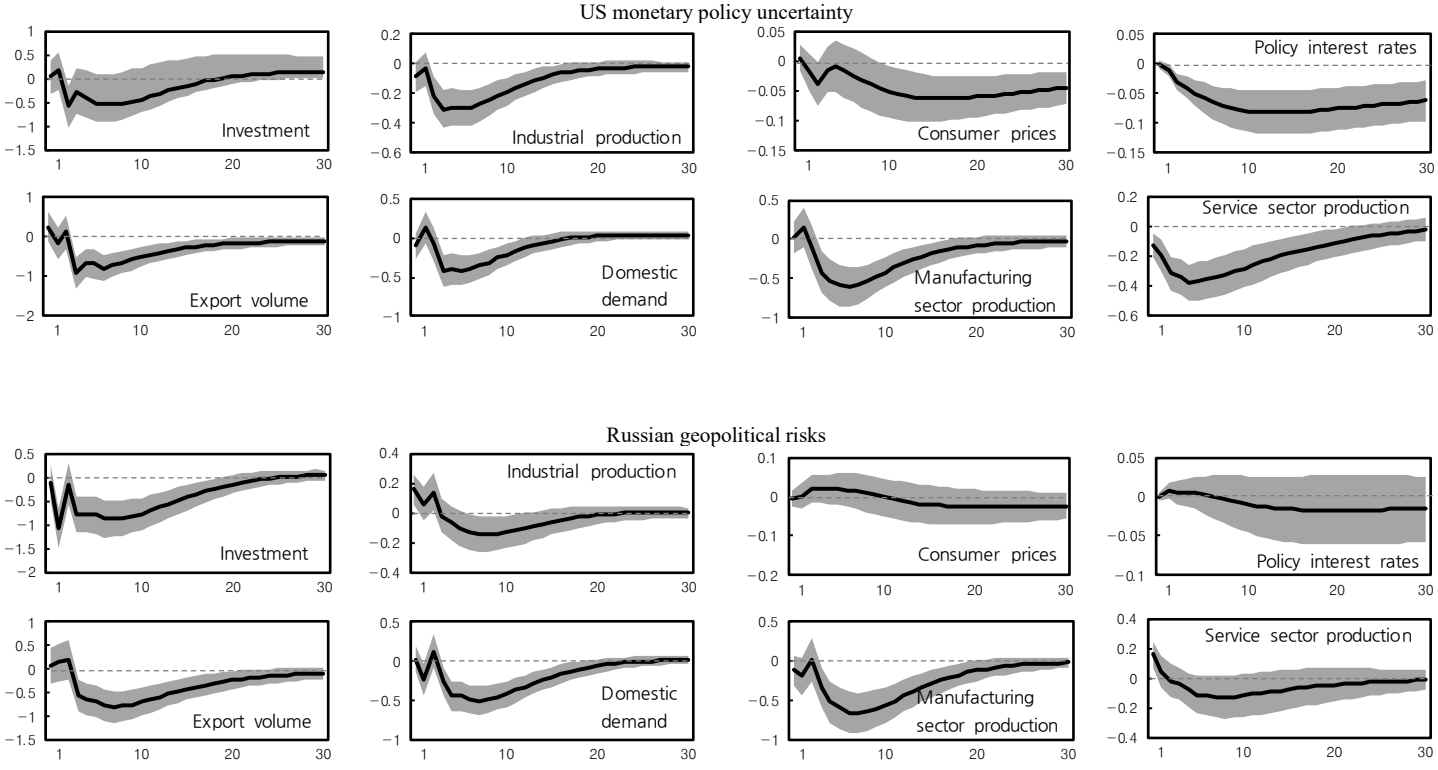

FIGURE A5. IMPULSE RESPONSES INCLUDING THE SAMPLE PERIOD UP TO FEBRUARY OF 2024 WITH THE COVID DUMMY

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

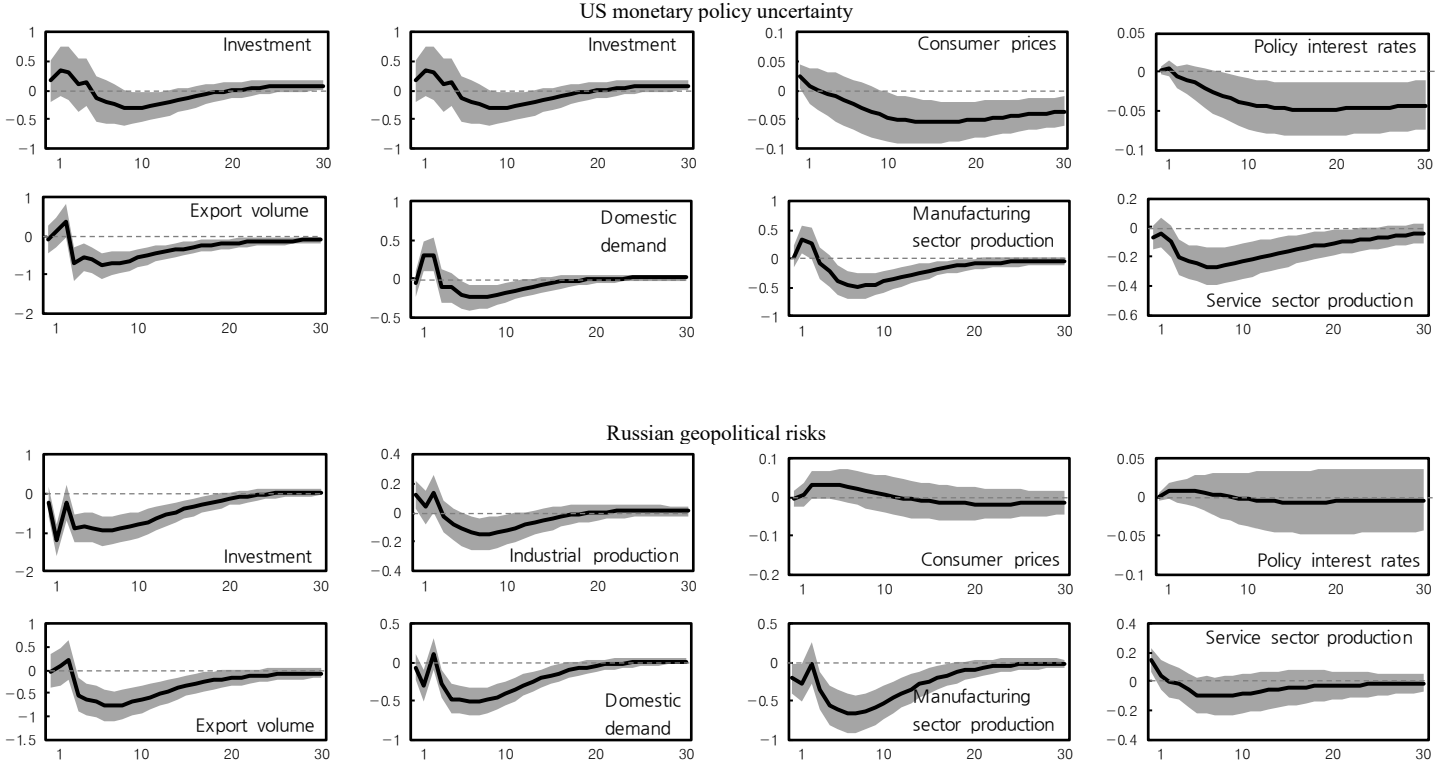

FIGURE A6. IMPULSE RESPONSES INCLUDING THE SAMPLE PERIOD UP TO FEBRUARY OF 2024 WITH THE COVID DUMMY AND DIFFERENT MPUS ACCORDING TO HUSTED *ET AL*. 2020

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

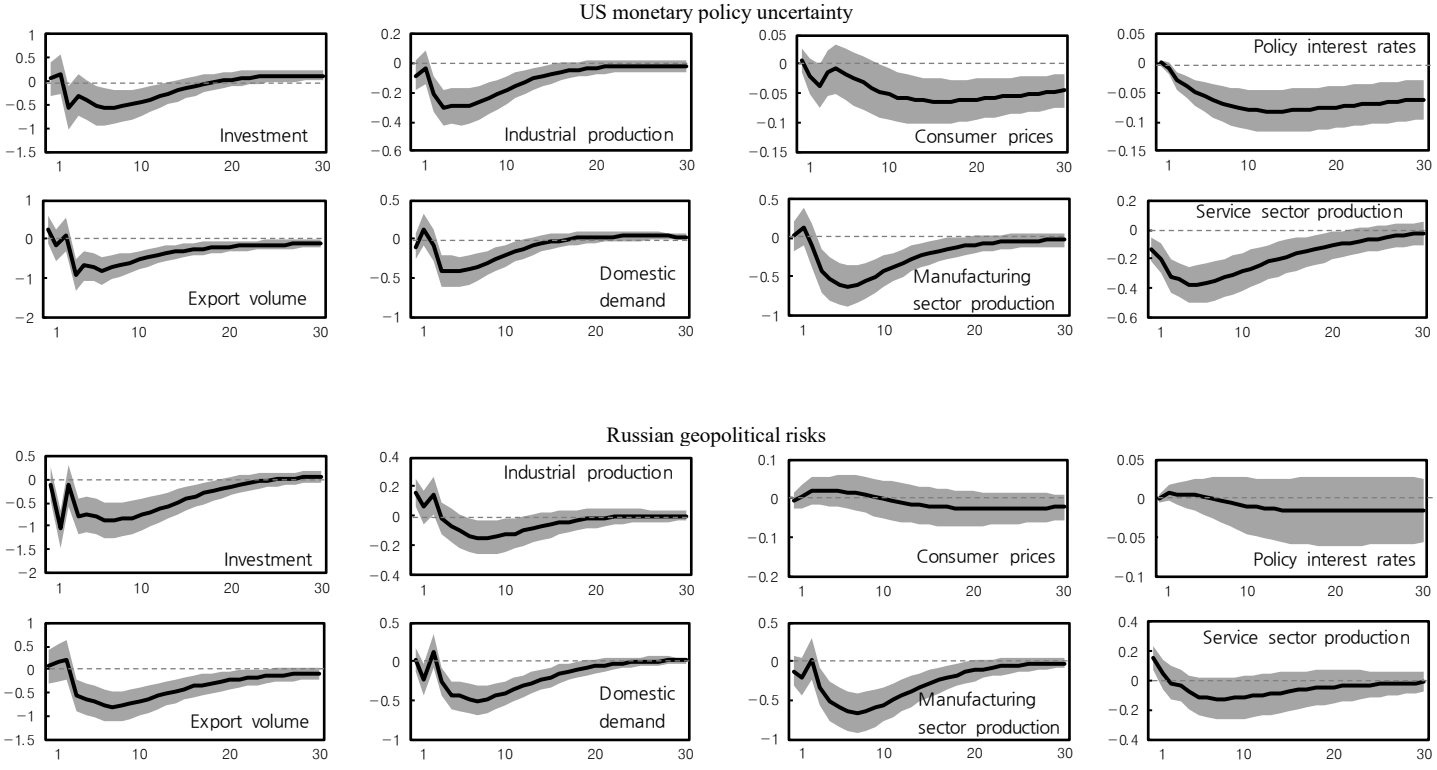

FIGURE A7. IMPULSE RESPONSES INCLUDING THE SAMPLE PERIOD UP TO FEBRUARY OF 2024 WITH THE COVID DUMMY AND ALTERNATIVE ORDERING

Note: Shaded areas show the one standard deviation confidence interval of the impulse response.

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