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Articles

Exploring Revenue Trends in Alley Commercial Areas in Seoul, Korea
Hongjai Rhee 1

The Impact of External Uncertainty Shocks on the Korean Economy
Junhyong Kim 19

Structural Reforms to Enhance the Sustainability and Intergenerational Equity of the National Pension System
Kang Koo Lee 67

Financial Projection of the Basic Pension under Selective Eligibility Criteria
Dohun Kim 95

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Exploring Revenue Trends in Alley Commercial Areas in Seoul, Korea

By HONGJAI RHEE*

This study examines changes in sales by business category and area in Korea's small commercial districts. Unlike previous studies that focused primarily on overall sales levels before and after the COVID-19 pandemic, this paper emphasizes temporal variations in the inequality of sales distributions. Using credit-card-based data comprising 392,832 sales records aggregated by (category, area) units, the primary analysis reveals that sales distributions have recently become more dispersed across most categories, underscoring the vulnerability of less-advantaged areas in the post-pandemic period. In a secondary analysis, regression and machine learning models were applied to investigate factors influencing regional sales disparities. The findings indicate that although overall sales, which declined sharply during the pandemic, rebounded rapidly after 2021, they have shown a significant downturn in recent periods. The paper concludes with a discussion of relevant policy implications.

Key Word: Commercial Districts, Sales Growth, Distributional Inequality, COVID-19
JEL Code: L1, L8, C5

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I. Introduction

The COVID-19 pandemic has had a profound impact on local economies, with small neighborhood businesses among the most vulnerable sectors. The COVID-19 pandemic has had a profound impact on local economies, with small neighborhood businesses among the most vulnerable sectors. These businesses, often situated in the hearts of their communities, suffered significant declines in sales due to social distancing measures, mobility restrictions, and shifts in consumer behavior during the pandemic. While existing studies have documented the immediate declines in sales and the challenges faced by these businesses during the pandemic (e.g., Rhee, 2024), there is limited research on the longer-term effects, particularly concerning how the regional distribution of sales has evolved in the recent periods.

This study focuses on alley commercial areas (referred to as "Golmok Sangkwon") in Seoul, Korea, and investigates how regional disparities in sales distributions have changed in recent periods. Specifically, it aims to answer the following questions: How has the distribution of sales for small neighborhood businesses varied across different areas of the city, and what trends have emerged in the regional inequality of sales before and after the pandemic. To address these questions, we use the inter-quartile range (IQR) of the distributions under study, a frequently utilized measure of inequality (Drechsel-Grau *et al*., 2022), to quantify the changes in sales distributions across alley commercial areas.

The results reveal a concerning pattern. While overall sales for alley commercial areas have shown signs of recovery in the post-pandemic period, regional inequalities in sales distributions have worsened substantially. This suggests that the recovery has been uneven, with certain areas rebounding more strongly than others. Such disparities not only highlight the vulnerability of less-advantaged areas but also underscore the potential for long-term socio-economic divides if these trends persist.

This research is significant for several reasons. First, it fills a gap in the literature by moving beyond aggregate analyses of sales recoveries to examine regional variations. Understanding these dynamics is essential for policymakers aiming to design equitable economic recovery strategies. Second, by focusing on the periods before and after the post-pandemic period, the study provides insights into possible structural challenges facing local businesses, offering a basis for policy interventions that can promote balanced regional development.

The perspective of this paper, which examines the distribution of sales revenue across commercial districts, is novel, with few directly related prior studies. However, numerous studies have addressed the socioeconomic effects of COVID-19 in recent years. For macroeconomic implications of pandemic shocks, see Baqaee and Farhi (2022) and Guerrieri *et al*. (2022). For stock market effects, refer to Uddin *et al*. (2021) and Baker *et al*. (2020). Bloom *et al*. (2020) investigate productivity effects using firm survey data, while Alon *et al*. (2020) discuss issues related to gender equality. Brodeur *et al*. (2021) provide a comprehensive survey of the literature.

Chen *et al*. (2021) closely align with our research in terms of data types. Using

credit card and scanner data from China, they revealed a substantial average decline in offline consumption during the initial phase of the COVID-19 outbreak. In the Korean context, Rhee (2024) documented the effects of the pandemic on revenue in Seoul's basic commercial districts across business categories up to 2021 through a counterfactual analysis based on the same dataset used in this paper. Additionally, Park *et al*. (2023) employed a time-series and logistic regression analysis of the period before and after the COVID-19 pandemic to classify alley commercial areas in Seoul into growing and declining districts, confirming that the geographic distribution of these districts differs significantly.

This study extends the analysis to the second quarter of 2024. Moreover, rather than focusing solely on aggregate sales levels, it examines sales inequalities across different business categories within alley districts, offering a distinct contribution. Additionally, the study utilizes a large-scale dataset with 392,832 observations, enabling a more comprehensive and data-driven assessment of regional sales recovery variations. By leveraging a machine learning model with higher predictive power, this study captures patterns more effectively than the traditional regression-based approaches used in prior research.

The structure of this paper is as follows. Section 2 introduces the structure of commercial districts in Seoul and sales data based on credit card transactions. Section 3 examines the quarterly distribution of sales by category across areas and analyzes changes in percentiles. To quantify distribution inequalities, we calculate interquartile ranges and compare the corresponding shifts over time. These results reveal a significant intensification of regional inequalities in sales distributions across most categories. Section 4 employs regression models and machine learning (ML) models to explain regional differences in sales. On the same dataset, the ML models demonstrate nearly twice the explanatory power of the regression models. Notably, to address the seasonality of quarterly sales, we analyze the predicted year-over-year changes in sales by quarter. A striking finding is that, on average across business categories, while sales in Seoul's alley commercial areas have rapidly recovered from the COVID-19 downturn, they now exhibit a sharp decline comparable to that experienced during the pandemic, reflecting the current economic slowdown. Section 5 provides a summary and concludes the study.

II. Data

The data used in this study comprise category-level quarterly sales for 1,090 alley commercial areas in Seoul, Korea, ranging from Q1 2019 to Q2 2024 (22 quarters in total). The revenue data were originally collected from card transaction records of individual stores for each quarter.[1] These figures were then adjusted to include estimated cash sales, calculated using the quarterly cash-to-card transaction ratios

[1]Card sales include both in-store and delivery sales made using personal cards, corporate cards, and debit cards. The number of individual stores included in the dataset varies slightly by quarter, but as of the fourth quarter of 2021, there are a total of 34,756 stores.

reported by the Bank of Korea (The Bank of Korea, 2019).

While the original dataset contains sales figures for individual stores, the publicly available version used in this study is aggregated at the level of business categories within each commercial area to ensure privacy protection. Although card-based sales data may not capture all transactions perfectly, such data were consistently calculated across all commercial districts and categories over the entire period. Therefore, the data are considered adequate for analyzing trends in sales changes.

Seoul's basic commercial districts are divided into a total of 1,638 geographic areas, categorized into four types of zones based on their locations and characteristics. These include tourist zones frequented by foreigners, such as "Myeongdong" and "Itaewon," traditional market zones such as "Gwangjang Sijang," developed zones concentrated around subway stations, and alley zones closest to residential areas. As of the second quarter of 2024, the alley zones analyzed in this study comprise 1,090 areas, accounting for approximately 67% of all basic commercial districts in the city.

The quarterly sales data is aggregated by commercial area and business category. With a total of 81 categories, the ideal number of records in the dataset would be 1090×81×22, where 22 represents the number of quarters. However, the actual number of categories varies across areas, and sales data are missing for certain quarters in some areas. As a result, the total number of district-category pairs with complete sales records across all quarters amounts to 392,832, as summarized by year in Table 1.

Table 2 presents the number and proportion of observations for the top ten categories with the highest total sales across areas.

TABLE 1—SUMMARY OF DATA BY YEAR

Year	#Quarters	#Obs	#Areas	#Categories	Quarterly Revenue (in million KRW)	
					Mean	SD
2019	4	71424	1085	63	940.9	3379.2
2020	4	71424	1085	63	957.1	3155.5
2021	4	71424	1085	63	1006.4	3222.5
2022	4	71424	1085	63	1177.2	3430.1
2023	4	71424	1085	63	1253.7	3398.6
2024	2	35712	1085	63	1187.3	3195.2

TABLE 2—SUMMARY OF DATA BY CATEGORY

Category	No. Obs. (%)	Category	No. Obs. (%)
Korean Restaurant	22110 (5.63%)	Hof & Bar	14762 (3.76%)
Beauty Shop	19712 (5.02%)	General Clothes	13222 (3.37%)
Convenience Store	18436 (4.69%)	Pharmaceuticals	12430 (3.16%)
Coffee & Beverages	17864 (4.55%)	Auto Repair	11902 (3.03%)
Supermarket	17226 (4.39%)	Other	230230 (58.62%)
Snack Shop	14938 (3.80%)	**Total**	392832 (100%)

III. Sales Distribution Across Areas

In this chapter, we analyze temporal changes in sales distributions by business category. Figure 1 illustrates the temporal changes in the percentiles of sales distributions for the Chinese restaurant category (coded as 100002) across areas, as an example. While sales generally show an upward trend across almost all percentiles, the increase is particularly pronounced at higher percentiles, especially after the latter half of 2021, when the impact of COVID-19 began to subside. This pattern is mostly similar across categories.

From the percentiles, we calculated the interquartile ranges (IQR), the gap between the 75th percentile and the 25th percentile, as presented in Figure 2 for twelve example categories. With a few exceptions, most categories exhibit an increase in the IQR over time. When comparing the first eleven quarters (up to Q3 2021) and the latter eleven quarters (from Q4 2021), 48 out of 63 categories (approximately 76.2%) show an increase in the average IQR during the period.[2]

Figure 3 provides a further examination of the distributional changes for the same sample categories redefining the IQR as the difference between the 90th percentile and the 10th percentile. This alternative measure reinforces the robustness of the finding that the distributions have become increasingly dispersed over time.

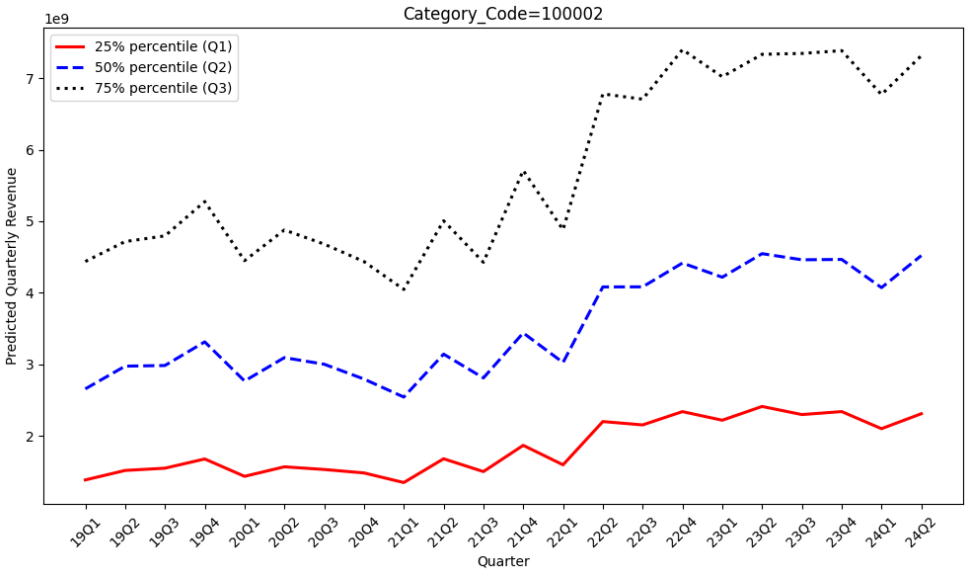

FIGURE 1. CHANGE OF SALES PERCENTILES ACROSS AREAS FOR A SAMPLE CATEGORY

[2]The average increase across all industries amounts to 98.5 million KRW. Alternative inequality measures, such as the Gini coefficient or Theil index, could also be used. When applying the Gini coefficient instead of the IQR, 44 out of 63 categories showed increased inequality over the periods, slightly different from the results presented in Figure 2.

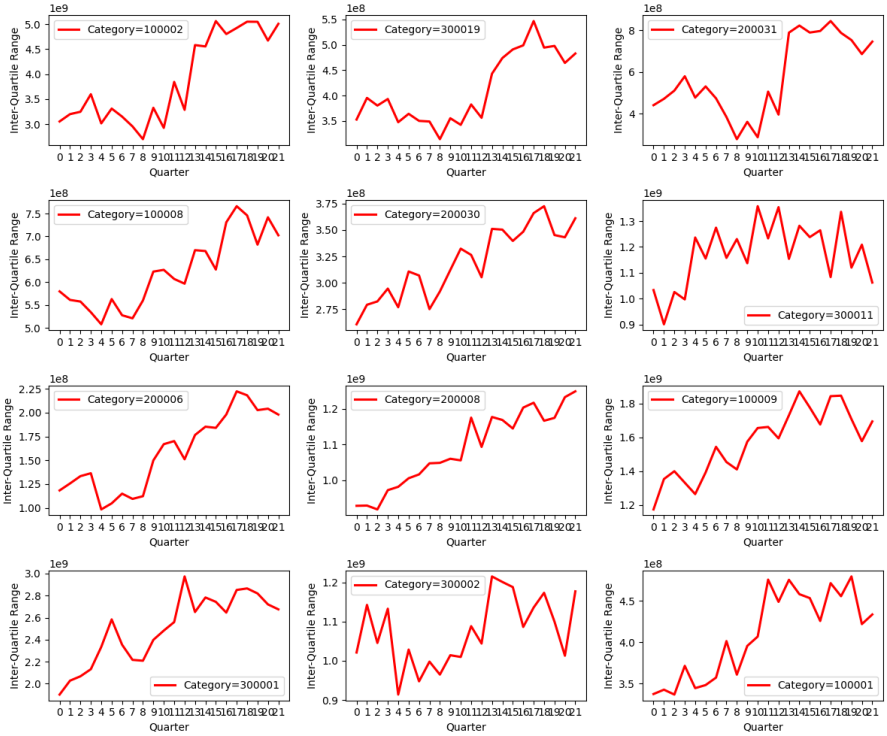

FIGURE 2. CHANGES IN INTER-QUARTILE RANGES (75TH VS. 25TH PERCENTILE)

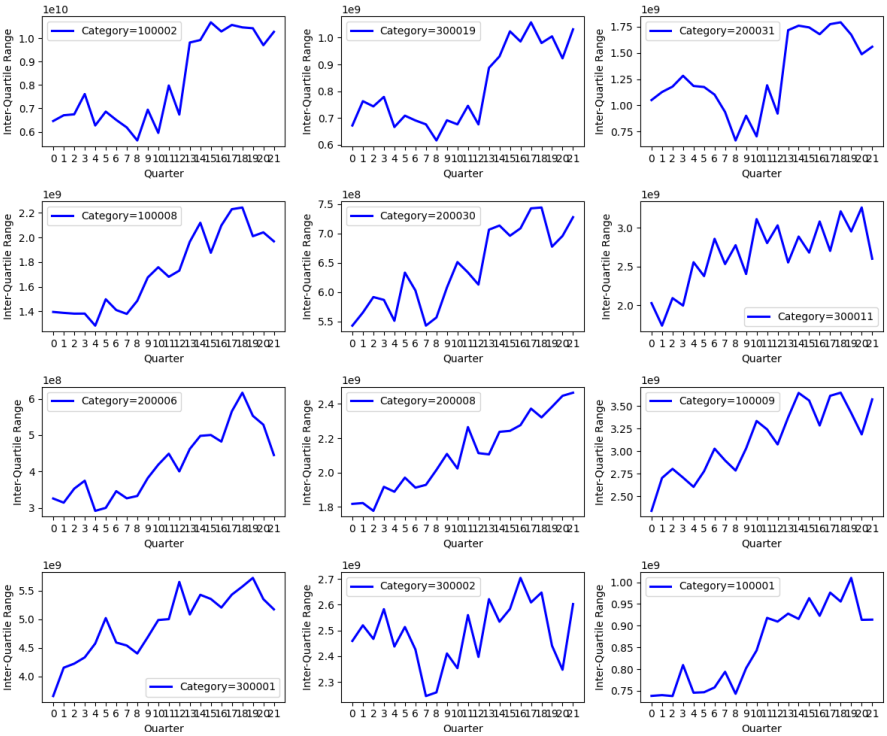

FIGURE 3. CHANGES IN INTER-QUARTILE RANGES (90TH VS. 10TH PERCENTILE)

TABLE 3—SUMMARY OF THE AUXILIARY REGRESSION OF THE IQR

	Estimates	S.E.	P-Value
Intercept	19.69	0.014	0
Quarter Index	-0.0118	0.0003	0
Quarter Index**2	0.00134	1.67e-5	0
Sales Volume (log scale)	0.00138	0.0005	0.01

To examine the pattern of the changes in the IQR over the periods more rigorously, we conducted an auxiliary regression analysis. Table 3 presents the estimation results of a regression analysis where the logarithm of 23,870 IQR values (derived from 1,085 areas over 22 quarters) is the dependent variable. The explanatory variables are the quarter index (ranging from 1 to 22), the square of the quarter index, and the logarithm of the total sales volume across all areas for each category. The R-squared value of the regression is 0.67, and all estimated coefficients are statistically significant.

Figure 4 illustrates the changes in the IQR (on a logarithmic scale) over quarters, calculated by a quadratic equation with the estimated parameters. Consistent with the previous data analysis, the results indicate an increasing trend in the IQR over time.[3] A noteworthy finding from this regression is that categories with larger sales volumes—representing categories that are more popular across many areas—exhibit higher IQR values.

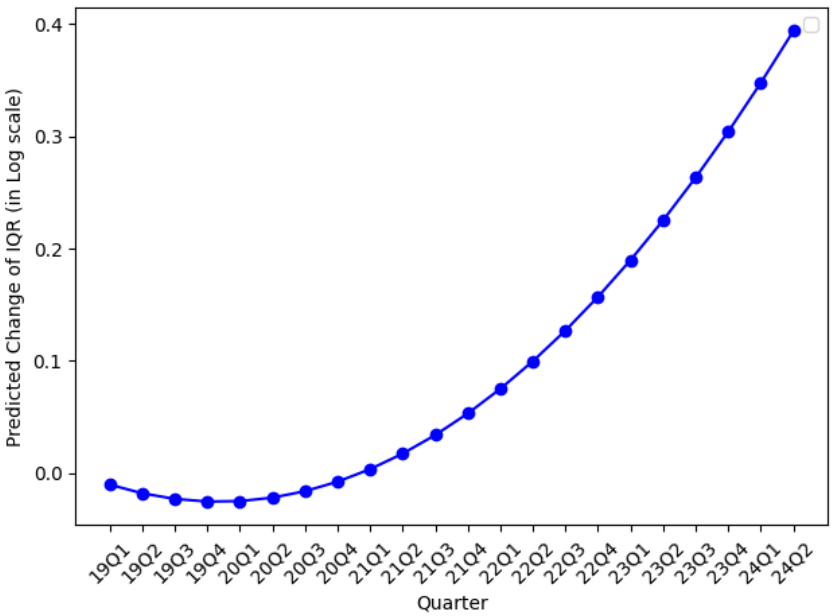

FIGURE 4. PREDICTED CHANGES IN THE IQR OVER PERIODS

[3]The analysis results remain qualitatively consistent even when using an alternative definition of the IQR, as shown in Figure 3.

IV. Analysis of Revenue Differences Across Areas

In this chapter, we explain the sales change patterns in alley districts by means of a traditional regression analysis and with currently popular machine learning models (Athey and Imbens, 2019).

A. *Regression Analysis*

The dependent variable in the regression analysis is the logarithm of sales (in 1,000 KRW), while the explanatory variables encompass dummy variables for category codes and quarters, as well as proxies for area characteristics. These proxies consist of the log values of area size (in square meters), the floating population, the average monthly income of residents in each area, and dummy variables for the administrative districts ('gu') to which each commercial area belongs (25 in total). The results of the analysis are presented in Table 4.

The explanatory power of the regression analysis, as measured by the R-squared value, was 0.503, which is not particularly high; however, all estimated coefficients

TABLE 4—SUMMARY OF REGRESSION RESULTS

	Estimates	SE	P-Value
Intercept	-12.82	0.24	0
Area Size	0.063	0.003	0
Population	0.531	0.004	0
Income Level	0.904	0.015	0
R-Squared		0.503	

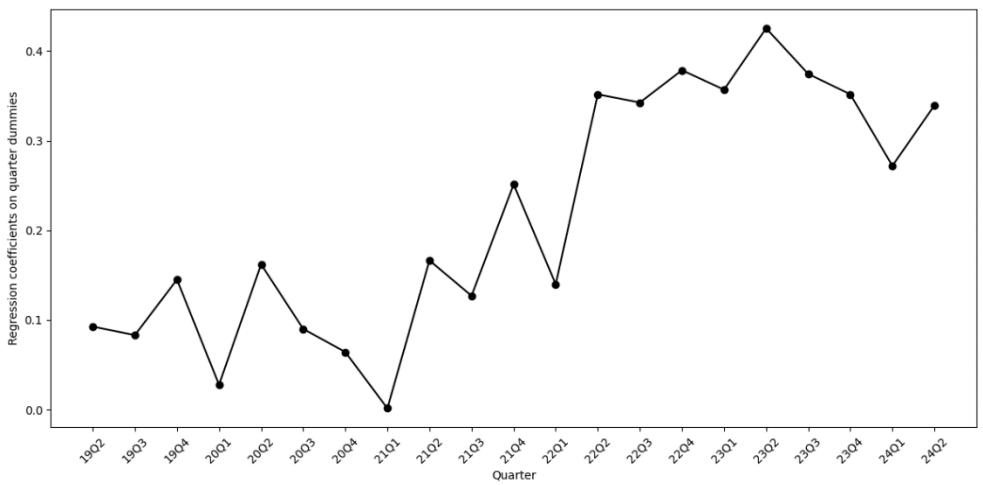

FIGURE 5. ESTIMATED DUMMY COEFFICIENTS FOR THE QUARTER INDEX

were statistically significant. Regarding the area characteristic variables, the results aligned with intuition: larger area sizes, higher populations, and greater resident income levels were associated with higher revenue levels.

Figure 5 visualizes the dummy coefficients for the quarter indices as estimated from the regression model. Assuming no omitted variables and excellent model explanatory power, this represents the overall sales changes by quarter after controlling for other factors. Similar to the data analysis in the previous chapter, the pattern reveals a rapid increase in sales following the COVID-impacted period.

Following Rhee (2024), the growth rate of sales from the same quarter in the previous year was calculated using the estimated quarterly dummy coefficients. This was done because quarterly sales exhibit strong seasonality. Formally, the growth rate of sales from t_1 to t_2 can be derived from equation (1), as follows,[4]

$$\frac{y_{it_2} - y_{it_1}}{y_{it_1}} = \frac{\exp(\beta_{t_2}) - \exp(\beta_{t_1})}{\exp(\beta_{t_1})}, \qquad (1)$$

while β_t represents the dummy coefficient for quarter t.

Figure 6 presents the revenue growth rates (compared to the same quarter in the previous year) calculated using Equation (1). The negative growth rates observed from Q3 2020 to Q2 2021 are clearly attributable to the effects of COVID-19. Subsequently, revenue growth rates increased sharply up to Q1 2023. However, it is

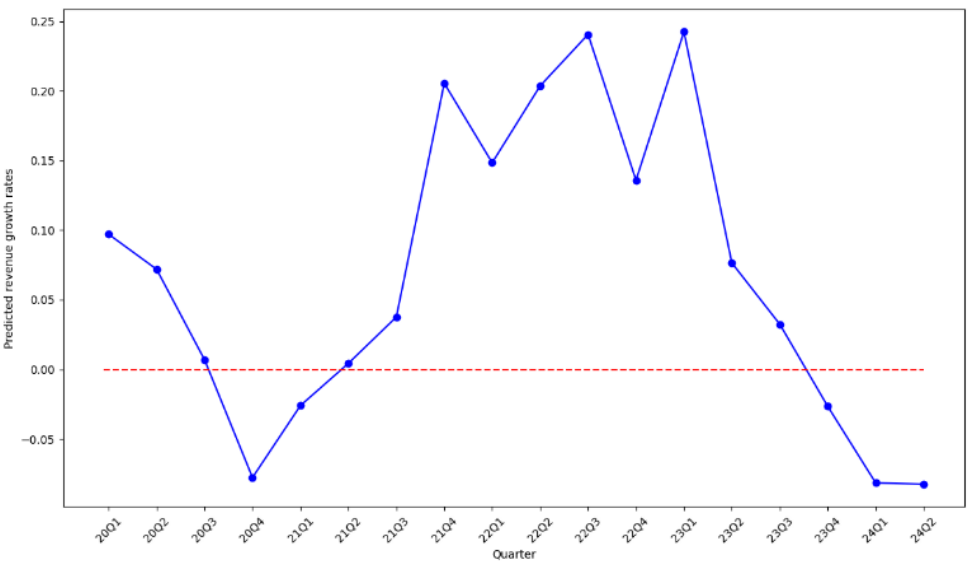

FIGURE 6. ESTIMATED SALES GROWTH RATES BY QUARTER

[4]The exponential function is applied because the dependent variable in the regression analysis was transformed to a log scale.

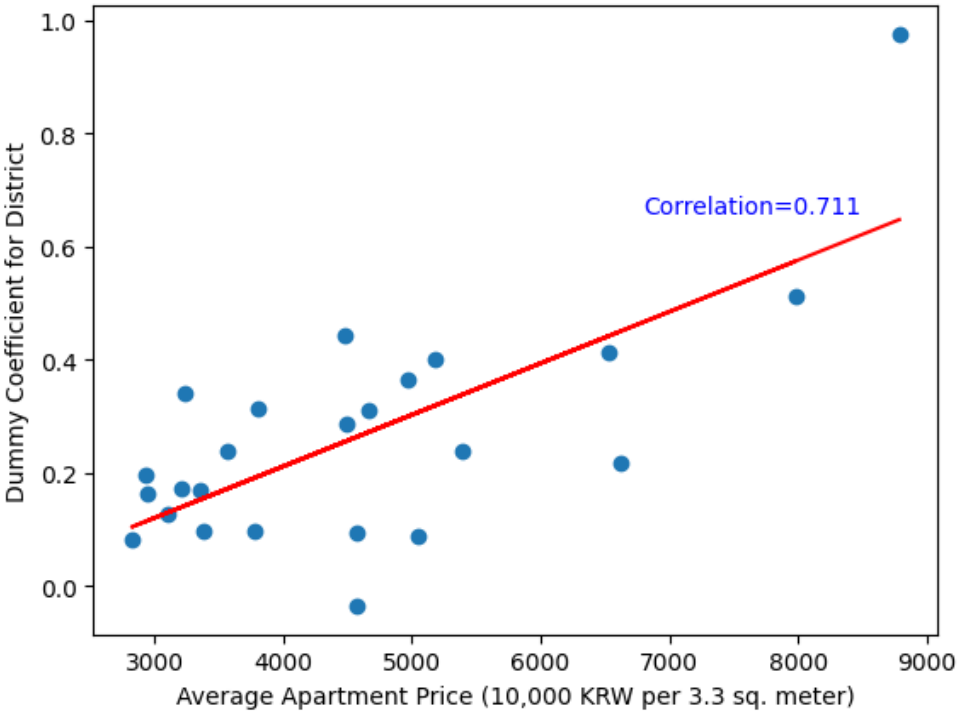

FIGURE 7. RELATIONSHIP BETWEEN DISTRICT COEFFICIENTS AND APARTMENT PRICES

notable that growth rates decelerated and then declined to levels comparable to the COVID-impacted quarters, reflecting the broader slowdown in the Korean economy in recent periods

The revenue differences across administrative districts were found to be statistically significant in most cases. To examine this difference analytically, Figure 7 illustrates the relationship between the average price, per square meter, of the apartments in each district as of February of 2024 and the regression coefficients of district dummy variables. The correlation coefficient is 0.71, indicating a pattern in which wealthier districts generally exhibit higher sales in alley commercial areas.[5]

B. *Machine Learning Analysis*

The primary purpose of incorporating a machine learning model in this section is to assess the robustness of the regression analysis and ensure that our findings are not driven by the limitations of a parametric approach. By comparing the outcomes from both models, we aim to verify whether the key patterns observed in the regression analysis remain consistent within a more flexible, non-parametric framework. If both approaches yield qualitatively similar results, it strengthens the reliability of the findings in this study.

[5]It should be noted that the pattern in Figure 7 does not imply causation and that housing prices may not necessarily have a positive effect on regional sales levels due to the potential influence of unobserved variables.

The ML model we apply in this study is the Random Forest (RF) model (Breiman, 2001b),[6] which is a popular ensemble algorithm that constructs a multitude of decision trees during training. Each tree is built using a random subset of the data (via bootstrapping) and a random subset of features. Predictions are made by aggregating the outputs of all individual trees, typically by means of averaging for regression tasks or majority voting for classification. This randomness in data and feature selection helps the model avoid overfitting and makes it robust across various data scenarios.

Figure 8 presents an example of a decision tree in the RF model. In each branch of the tree, sequential splitting occurs based on the conditions for one of the X variables ('feature'), and at the final branch, the average of the y variable ('target') is calculated for each formed group. The RF model consists of multiple such trees, and the predicted value of the y variable is obtained by taking the average of the values predicted by each tree. As shown in Figure 8, there are numerous alternatives for the cut-off points used in the splitting of the decision trees. Therefore, the RF model, which is formally nonparametric, can also be conceptualized as a model with a possibly infinite number of parameters. This characteristic enables it potentially to provide a superior predictive fit compared to a parametric model such as regression. As usual in ML models, appropriate tuning of the hyperparameters is critical when optimizing the RF model. As is typically done, we optimized the hyperparameters by a grid search over possible alternatives such that we could maximize the predictive accuracy of the model after splitting the data into training (80%) and test sets (20%).

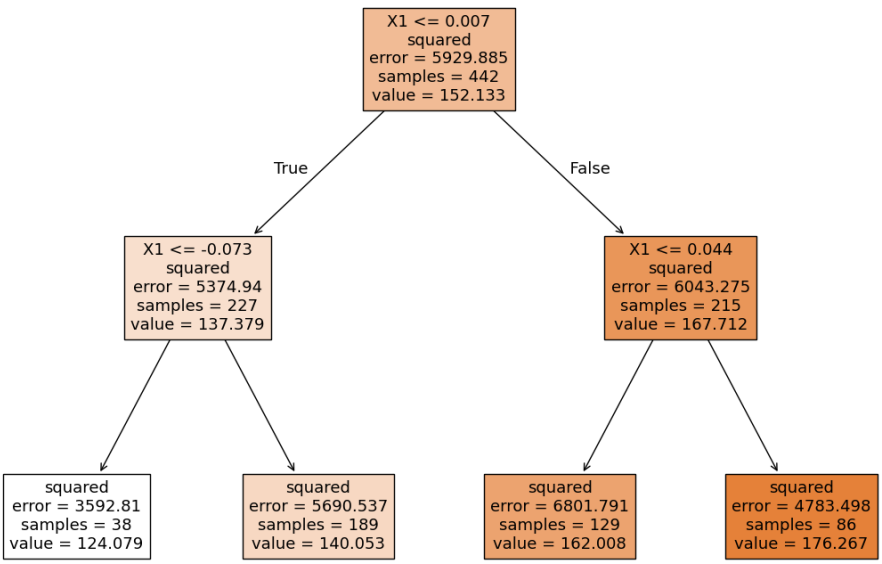

FIGURE 8. SAMPLE DECISION TREE IN THE RF MODEL

[6]Alternatively, one may use other ensemble models, such as the XGBoost model, which may offer several advantages over Random Forest, particularly with regard to feature contribution analysis, handling imbalanced data, and computational efficiency. However, because the RF model is simpler and already provides sufficiently satisfactory predictive power, we did not explore other ensemble models in this study.

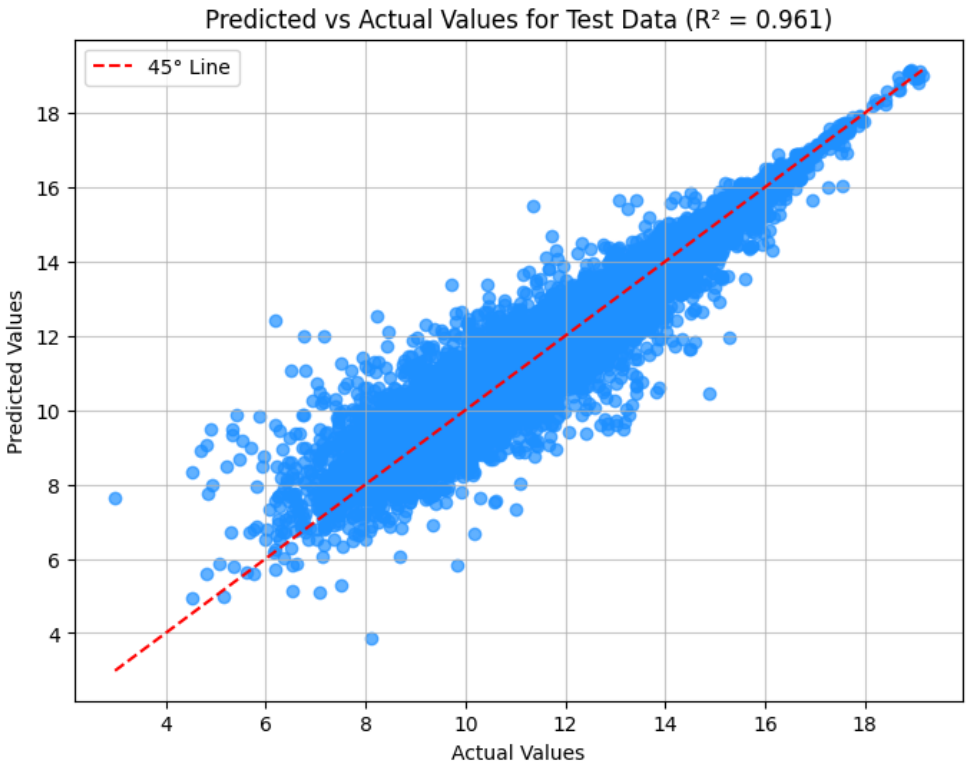

FIGURE 9. PREDICTIVE PERFORMANCE OF RF MODEL FOR THE TEST DATASET

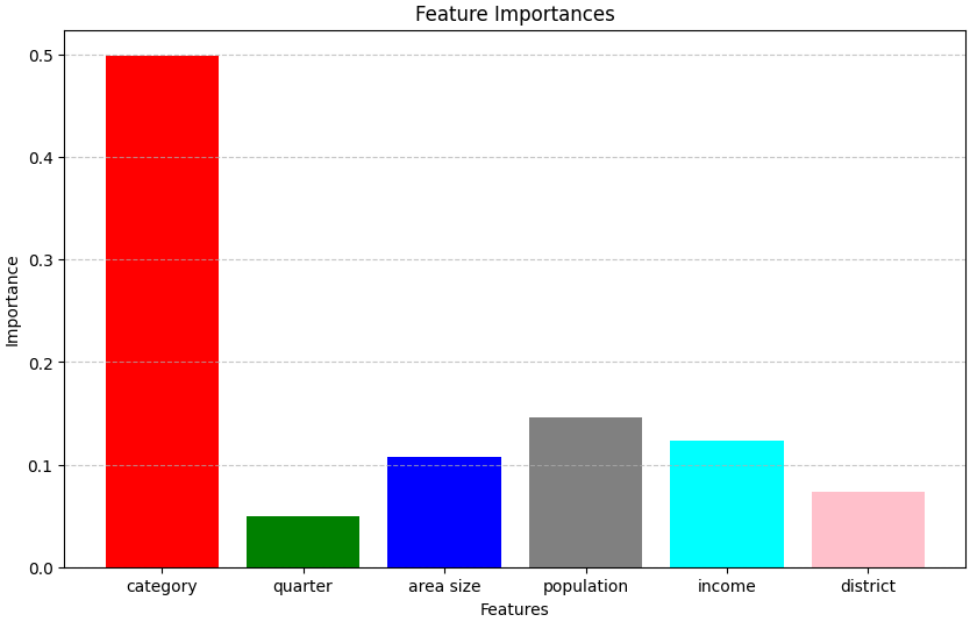

FIGURE 10. FEATURE IMPORTANCE FROM THE RF MODEL

As in the regression model, we set the model's dependent variable ('target') as the logarithm of sales revenues (in 1000 KRW), while the independent variables ('features') are the log values of the area size (in square meter), area population and the average monthly income of the residents, as well as the three sets of label-encoded values identifying 63 business categories, 22 quarter indices, and 25 administrative districts.

In Figure 9, the predictive fit of the optimized RF model is 0.96, which represents a remarkable improvement over the regression model.[7]

In machine learning models, "feature importance" measures the contribution of each explanatory variable relative to the prediction of the target variable. It is typically calculated by assessing how much each feature helps to reduce the prediction error. For example, in a RF model, feature importance is determined by evaluating how much each feature improves the model's performance at each split in the decision trees.

In Figure 10, the contribution of the category indices is the highest, accounting for approximately 50% of the variation in sales. However, when the four area characteristic variables are summed up, they contribute around 45%, emphasizing that area differences also play a significant role in explaining sales differences.[8]

To understand how individual features influence the predictions from a Random Forest (RF) model, we use a technique called Partial Dependence (PD) (Friedman, 2001; Linardatos *et al*., 2020). This method isolates the effect of one feature by holding all other features constant. PD shows, both numerically and graphically, how changes in the chosen feature affect the predicted outcomes, making it easier to interpret the predictions of complex machine learning algorithms. The use of partial dependence plots (PDPs) would provide deeper insights into variable interactions. Machine learning models capture complex relationships among variables, making it difficult to understand their individual contributions fully, unlike in conventional parametric methods. PDPs would help illustrate how changes in individual predictors influence sales predictions while holding other variables constant.

The PDPs in Figure 11 shows significant differences in sales by category, with a pattern of increased average revenue observed for more recent quarters, larger area sizes, higher area populations, and higher average incomes.

Figure 12 clearly illustrates the partial dependence of the quarter variable after averaging out the effects of all other features. To compare with the quarterly dummy coefficients from the regression analysis (shown in Figure 5), predicted sales were adjusted to reflect the difference from sales in the reference period (Q1 2019).

There may be regional differences in the quarterly revenue profile shown in Figure 12. Figure 13 presents a separate analysis according to the administrative district,

[7]The R-squared value for the training data is as high as 0.984, even after controlling for the possibility of overfitting.

[8]As an alternative to feature importance, one may report SHAP (Shapley Additive Explanations) values, a widely recognized method for interpreting machine learning models. One key advantage of SHAP is that it provides both the magnitude and direction of each feature's effect. Although SHAP values could enhance interpretability, this study did not apply them due to computational constraints, particularly given the large dataset used. Nonetheless, the potential application of SHAP values in future research could offer valuable insights. We thank the anonymous reviewer who highlighted this point.

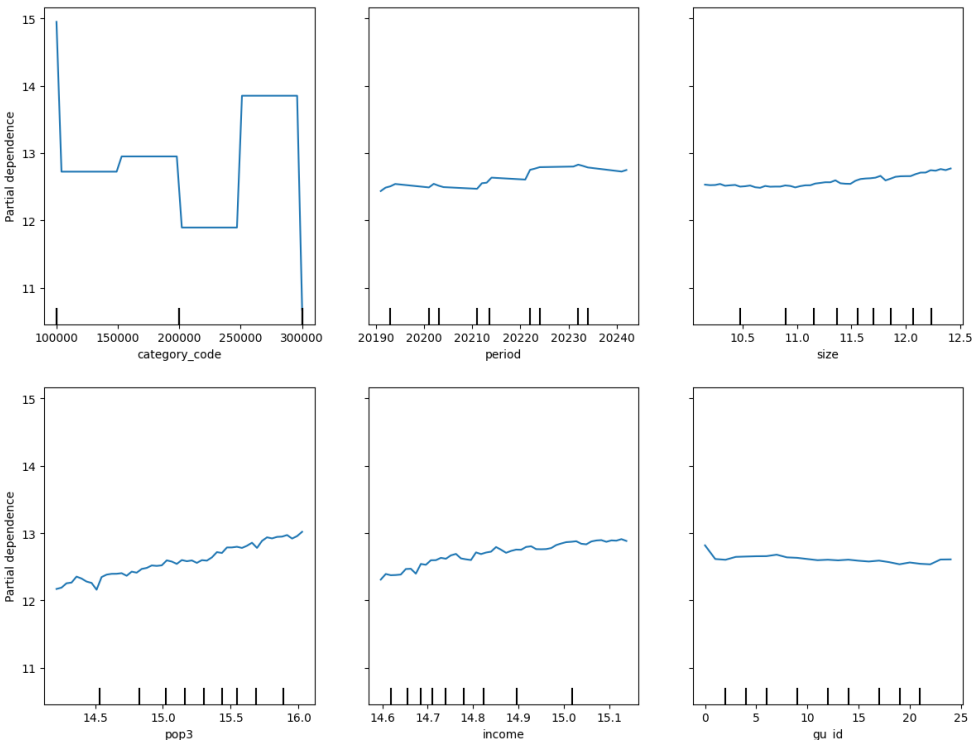

FIGURE 11. PARTIAL DEPENDENCE PLOTS FROM THE RF MODEL

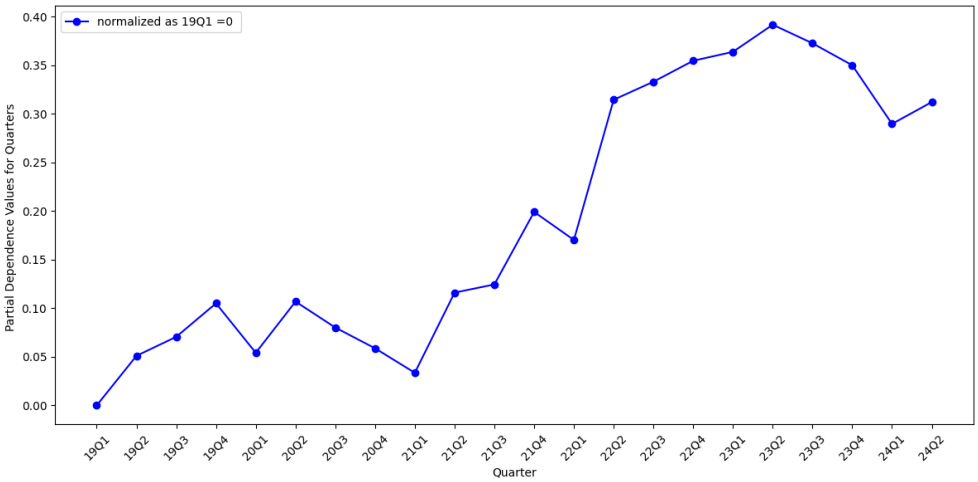

FIGURE 12. PARTIAL DEPENDENCE PLOTS FOR QUARTERS

showing the differences in the sales recovery profiles between Gangnam-gu and Eunpyeong-gu as examples. Significant differences were observed between the districts; however, due to data limitations, the determinants of these regional differences were not fully analyzed in this paper. This issue could be explored further in future research to identify appropriate policy measures.

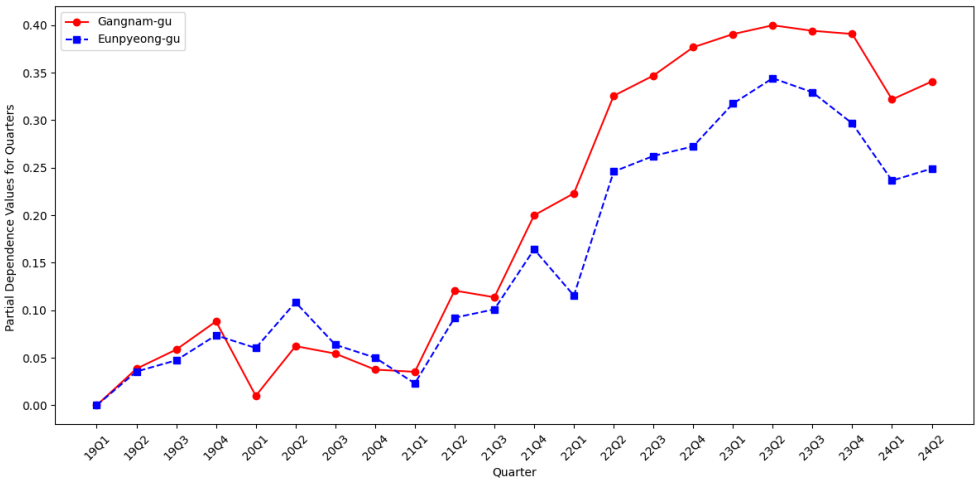

FIGURE 13. COMPARISON OF PARTIAL DEPENDENCE PLOTS FOR QUARTERS BY DISTRICT

FIGURE 14. PREDICTED SALES GROWTH RATES FROM THE RF MODEL

Lastly, Figure 14 illustrates the predicted year-over-year growth rates of sales for each quarter, calculated using the partial dependence from the RF model. Similar to the regression counterpart in Figure 5, the growth rates show a rapid recovery from the initial impact of COVID-19, followed by a recent sharp decline. This pattern highlights the consistency between the RF model and the regression analysis in capturing these trends.

V. Conclusion

In conclusion, this study utilized credit card-based data comprising 392,832 sales records to explore changes in sales distributions. The primary analysis revealed that sales distributions have become increasingly dispersed across most categories, highlighting the growing vulnerability of less-advantaged areas in the post-pandemic period. A secondary analysis, employing both regression and machine learning models, identified key factors driving regional sales disparities and attempted to identify the marginal effects of periods isolated from all other features. The findings suggest that while overall sales, which had declined sharply during the pandemic, showed a rapid rebound after 2021, they have recently experienced a significant downturn.

This study has several limitations, which suggest important directions for future research. First, while we identified a pattern of increasing regional inequality of sales across most categories, the underlying causes remain unclear. Macroeconomic factors such as inflation, government support policies, and shifts in consumer sentiment may have played a crucial role in shaping these trends. Additionally, differences in commercial district types, such as tourist areas, residential zones, and traditional markets, could have contributed to the observed disparities, though our research specifically focuses on residential ("alley") zones. A more detailed exploration of the differences between categories with increasing and decreasing levels of inequality could provide valuable insights into these causes. In addition, to address regional heterogeneity in the model specification, it may also be possible to adopt more advanced time-series methods, such as differencing techniques.

Second, we utilized machine learning models to identify a nonparametric mechanism driving disparities in sales data. However, unlike a regression analysis, ML models are designed primarily for prediction rather than explaining underlying phenomena (Breiman, 2001a), which makes them insufficient for pinpointing causal relationships. Our regression analysis, in contrast, explained approximately 50% of the variation in sales using area-specific characteristics, such as commercial area sizes, administrative districts, average resident income levels, and population levels. While this approach sheds light on correlations, it does not fully address the causal mechanisms. Discovering additional explanatory variables in subsequent analyses, including macroeconomic factors, commercial district characteristics, and shifts in consumer behavior, could improve the model's explanatory power and inform more targeted policy measures to mitigate regional disparities in sales.

Third, we utilized credit-card-based revenue data. Given the limitations of card transaction data in terms of accuracy and transparency, policymakers should be cautious when interpreting the results. With more accurate data, more reliable conclusions could be drawn based on the methods presented in this study.

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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

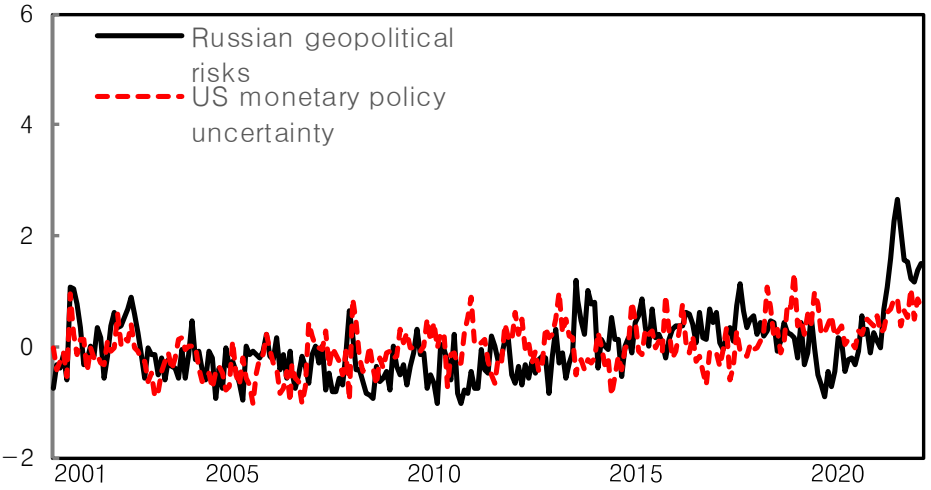

FIGURE 1. IDENTIFIED UNCERTAINTIES

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).

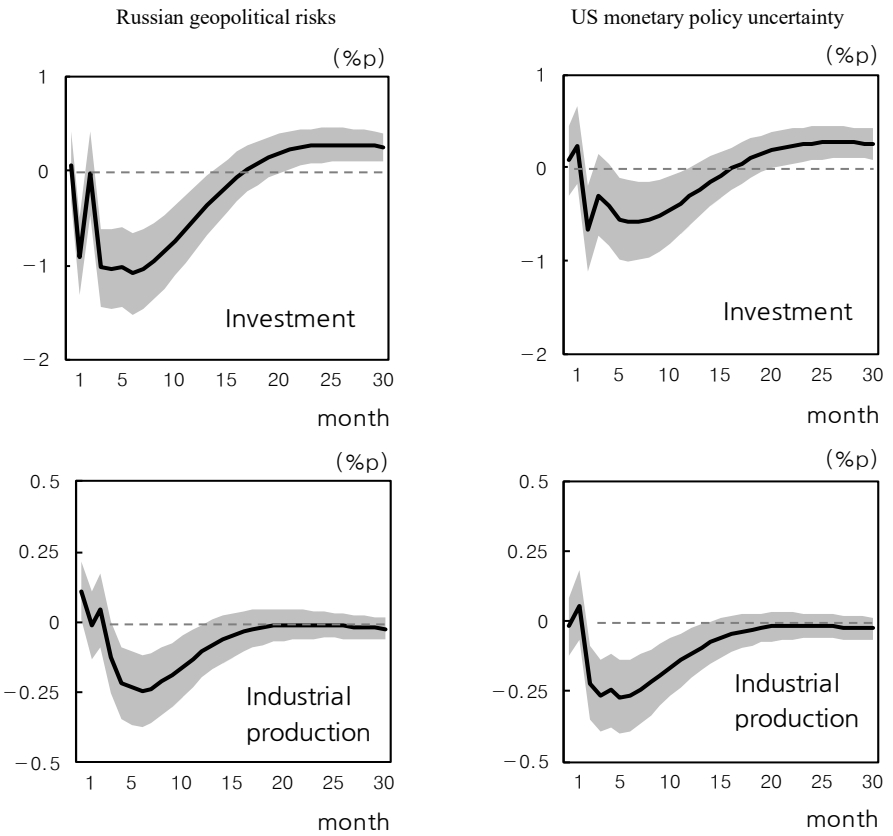

FIGURE 2. IMPACTS OF UNCERTAINTY SHOCKS ON INVESTMENTS AND INDUSTRIAL PRODUCTION

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

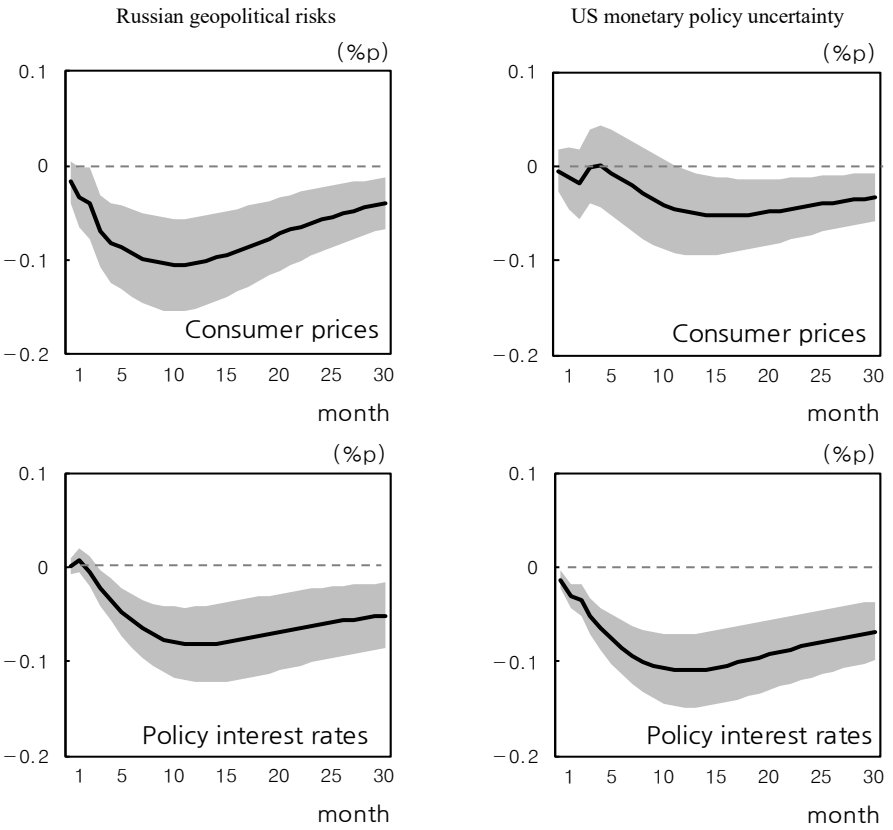

FIGURE 3. IMPACTS OF UNCERTAINTY SHOCKS ON INVESTMENTS AND INDUSTRIAL PRODUCTION

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).

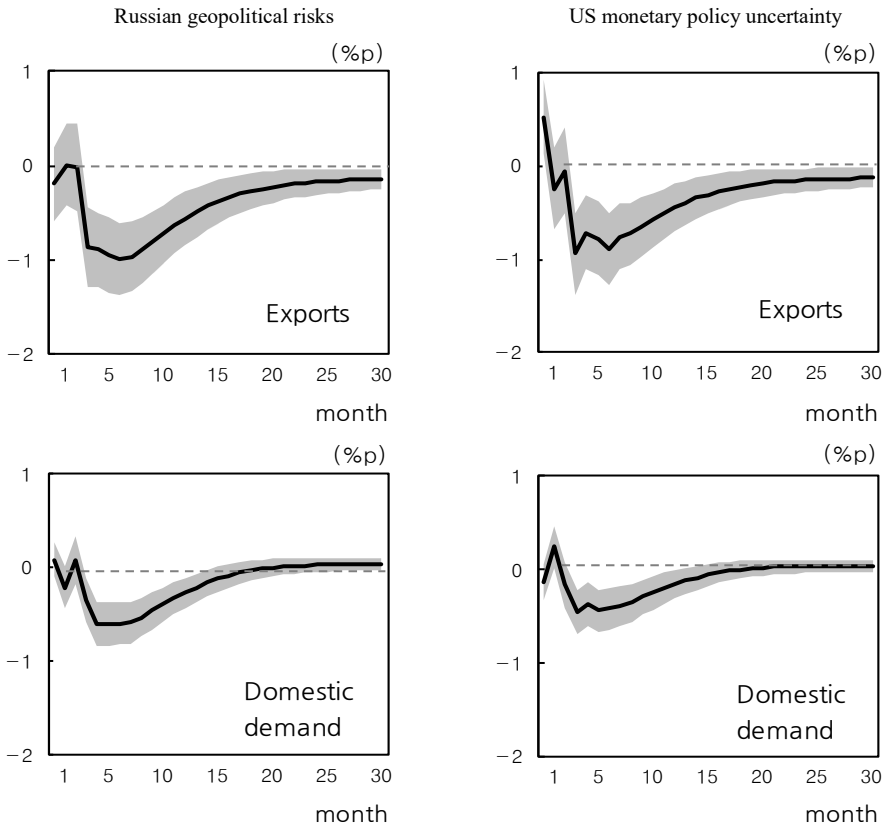

FIGURE 4. IMPACTS OF UNCERTAINTY SHOCKS ON EXPORTS AND DOMESTIC DEMAND

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

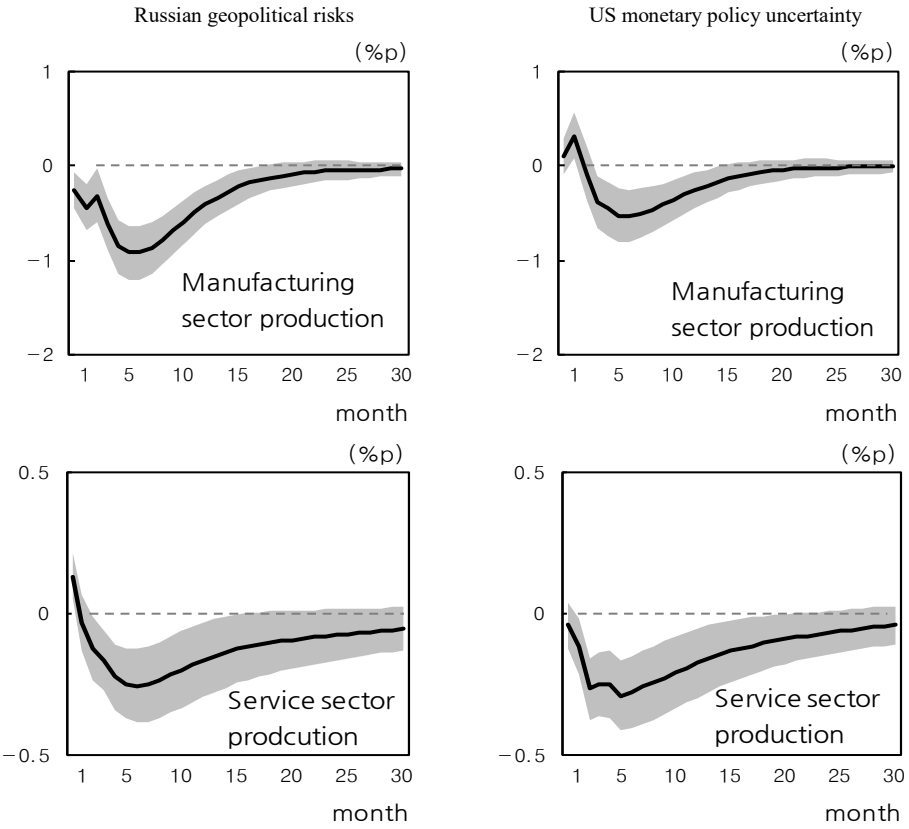

FIGURE 5. IMPACTS OF UNCERTAINTY SHOCKS ON MANUFACTURING AND SERVICE PRODUCTION

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.

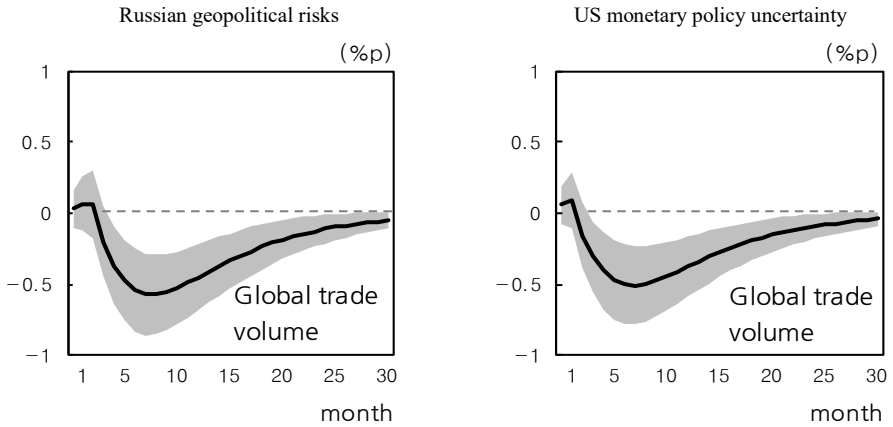

FIGURE 6. IMPACTS OF UNCERTAINTY SHOCKS ON GLOBAL TRADE

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

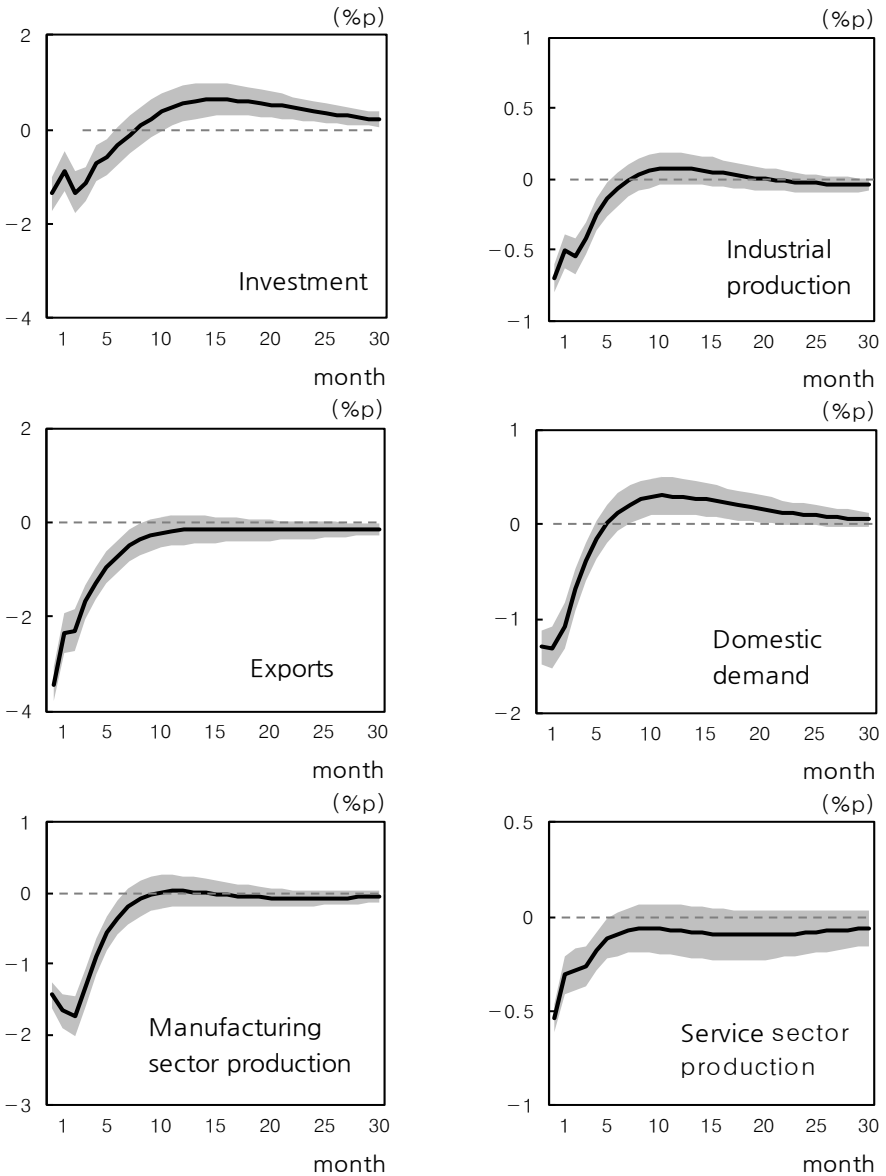

FIGURE 7. IMPACTS OF GLOBAL TRADE SHOCKS ON THE KOREAN ECONOMY

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

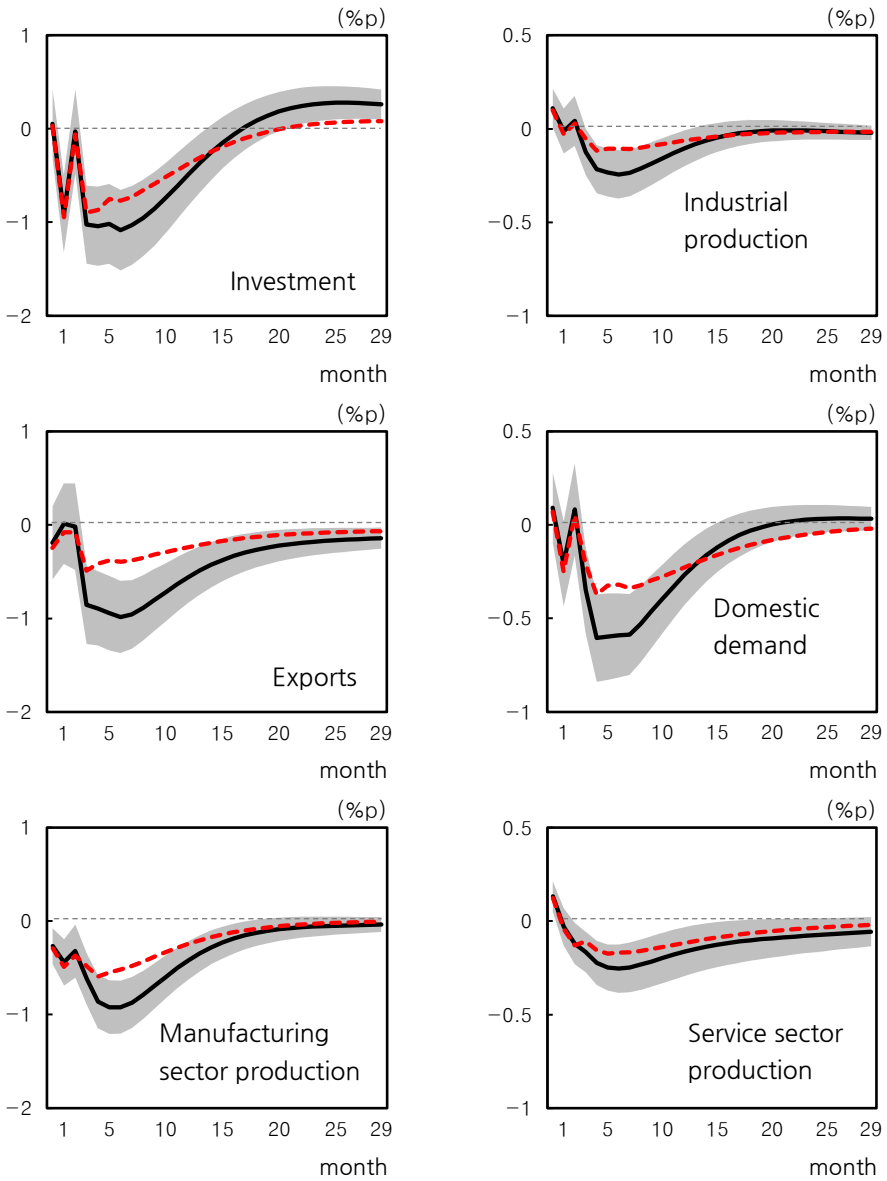

FIGURE 8. BASELINE AND COUNTERFACTUAL RESPONSES TO RUSSIAN GEOPOLITICAL RISKS

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,

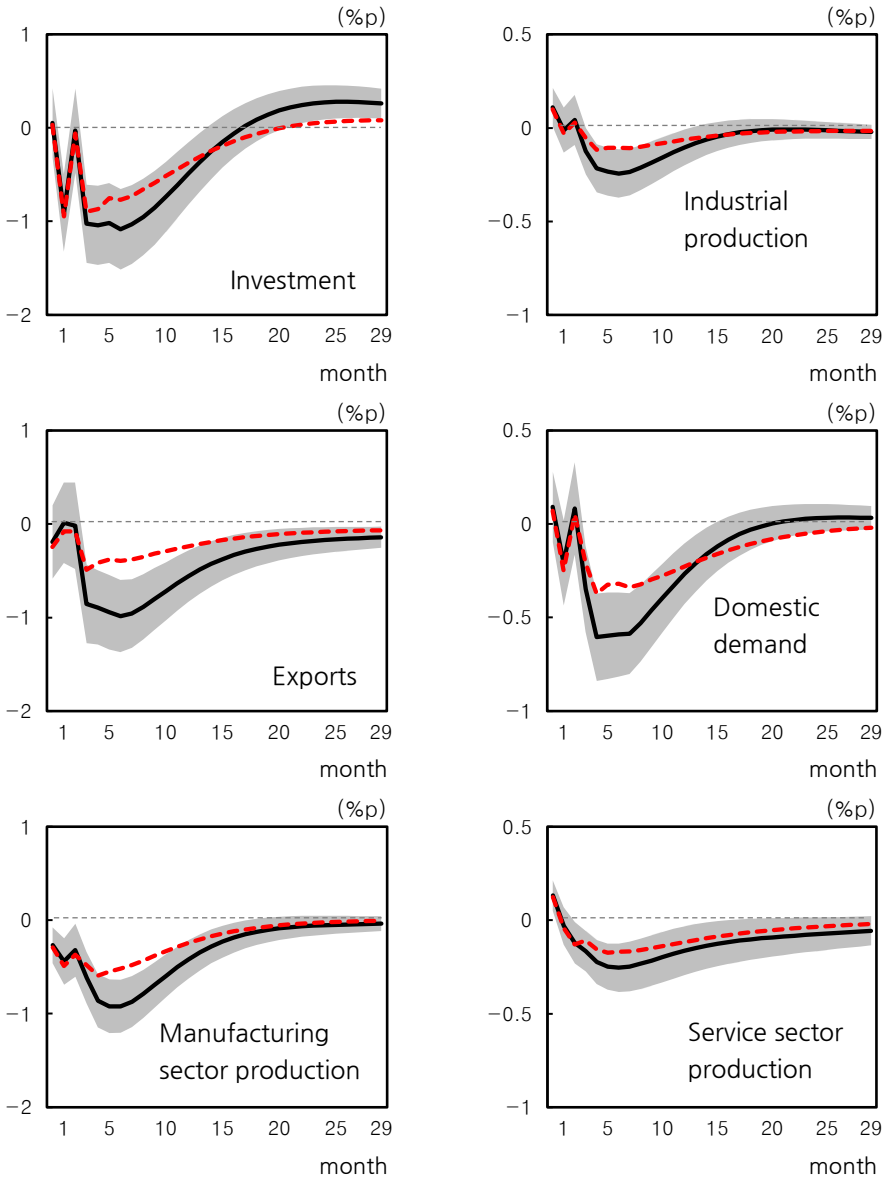

FIGURE 9. BASELINE AND COUNTERFACTUAL RESPONSES TO US MONETARY POLICY UNCERTAINTY

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.

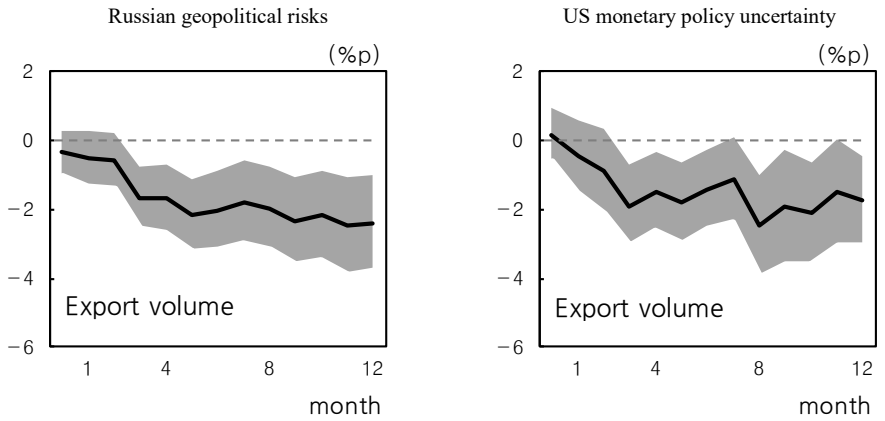

FIGURE 10. IMPACT OF UNCERTAINTY SHOCKS ON EXPORT VOLUMES

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.

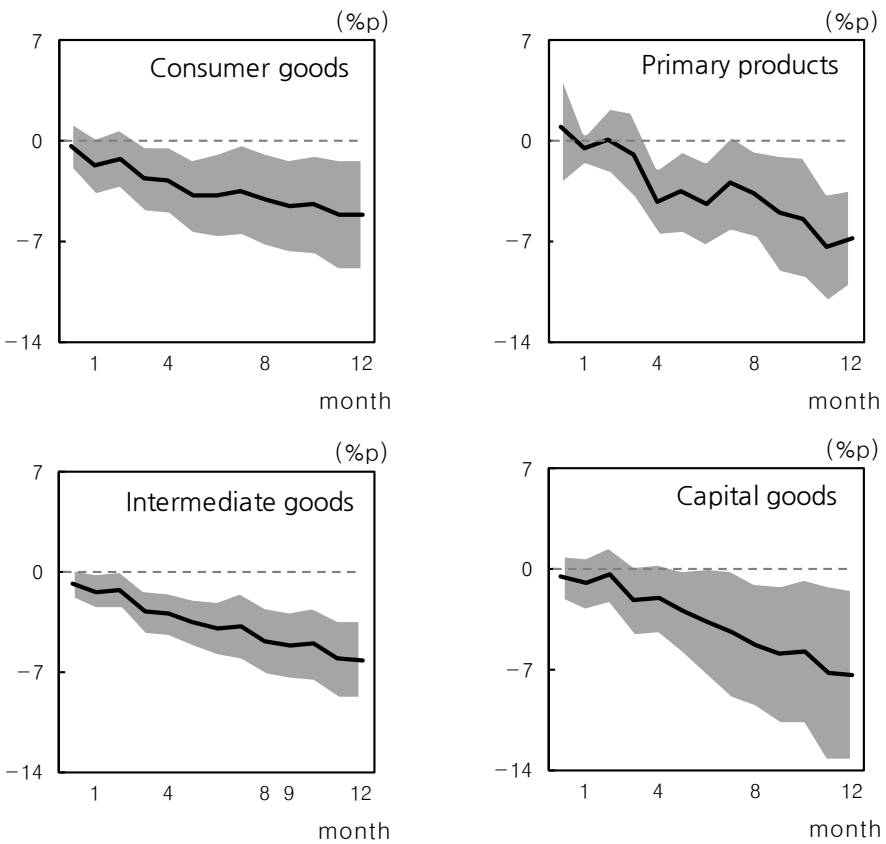

FIGURE 11. DIFFERENTIAL IMPACTS OF RUSSIAN GEOPOLITICAL RISKS BY PRODUCT

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

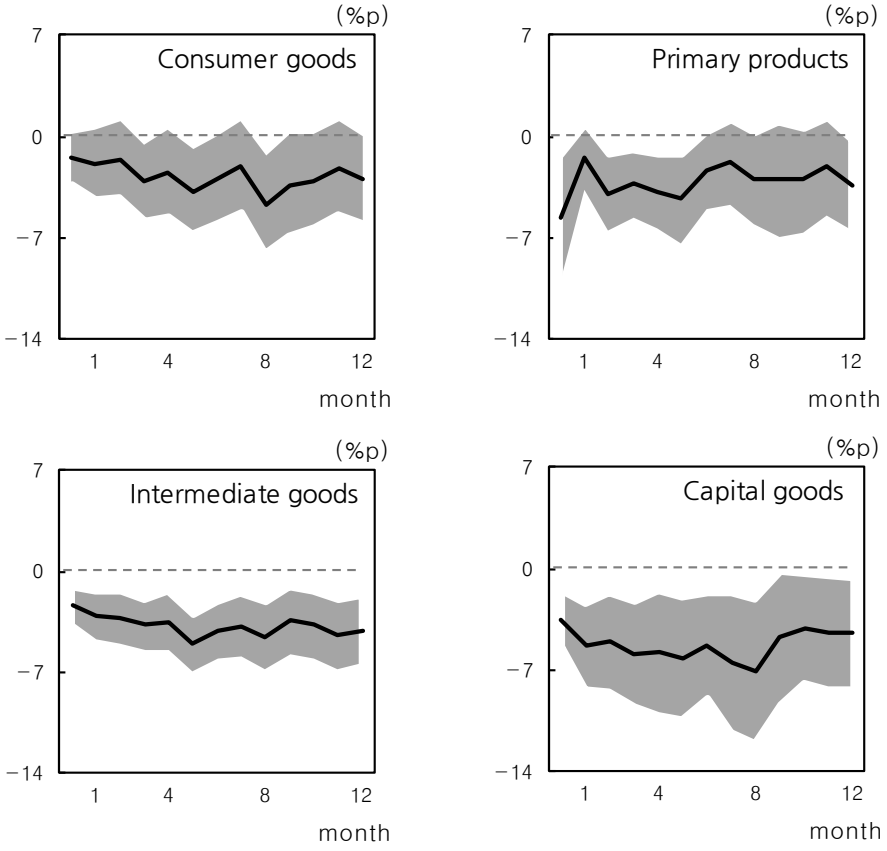

FIGURE 12. DIFFERENTIAL IMPACTS OF US MONETARY POLICY UNCERTAINTY BY PRODUCT

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

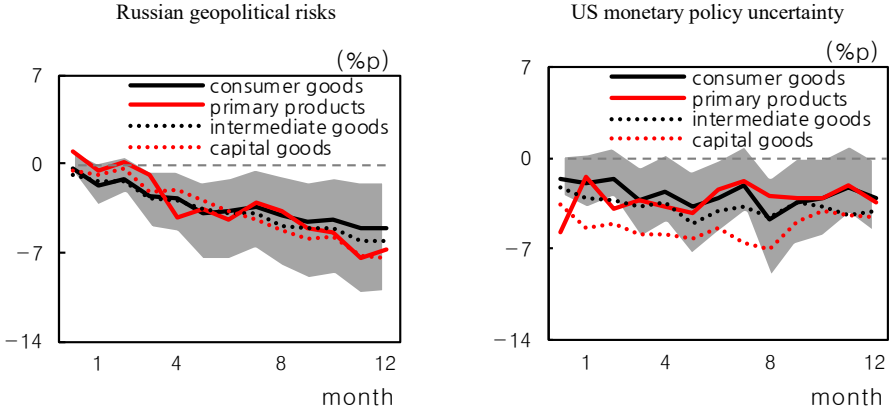

FIGURE 13. DIFFERENTIAL IMPACTS OF UNCERTAINTY SHOCKS BY PRODUCT

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.

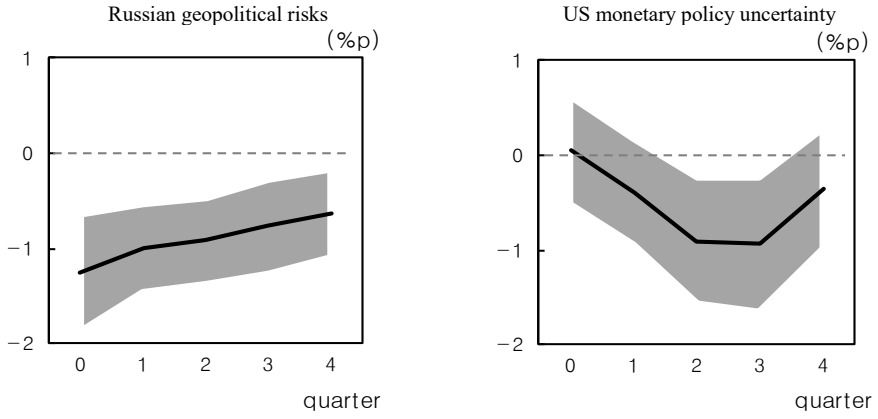

FIGURE 14. IMPACT OF UNCERTAINTY SHOCKS ON INVESTMENT DECISIONS

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.

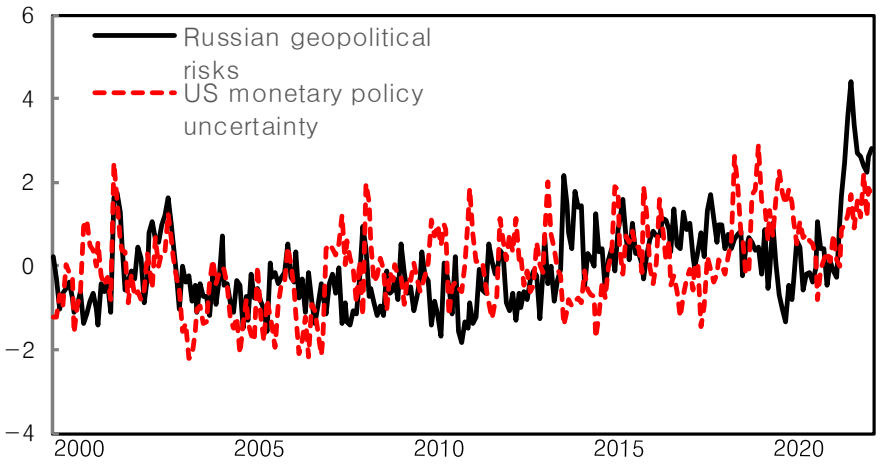

FIGURE A1. RUSSIAN GEOPOLITICAL RISKS AND US MONETARY POLICY UNCERTAINTIES

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

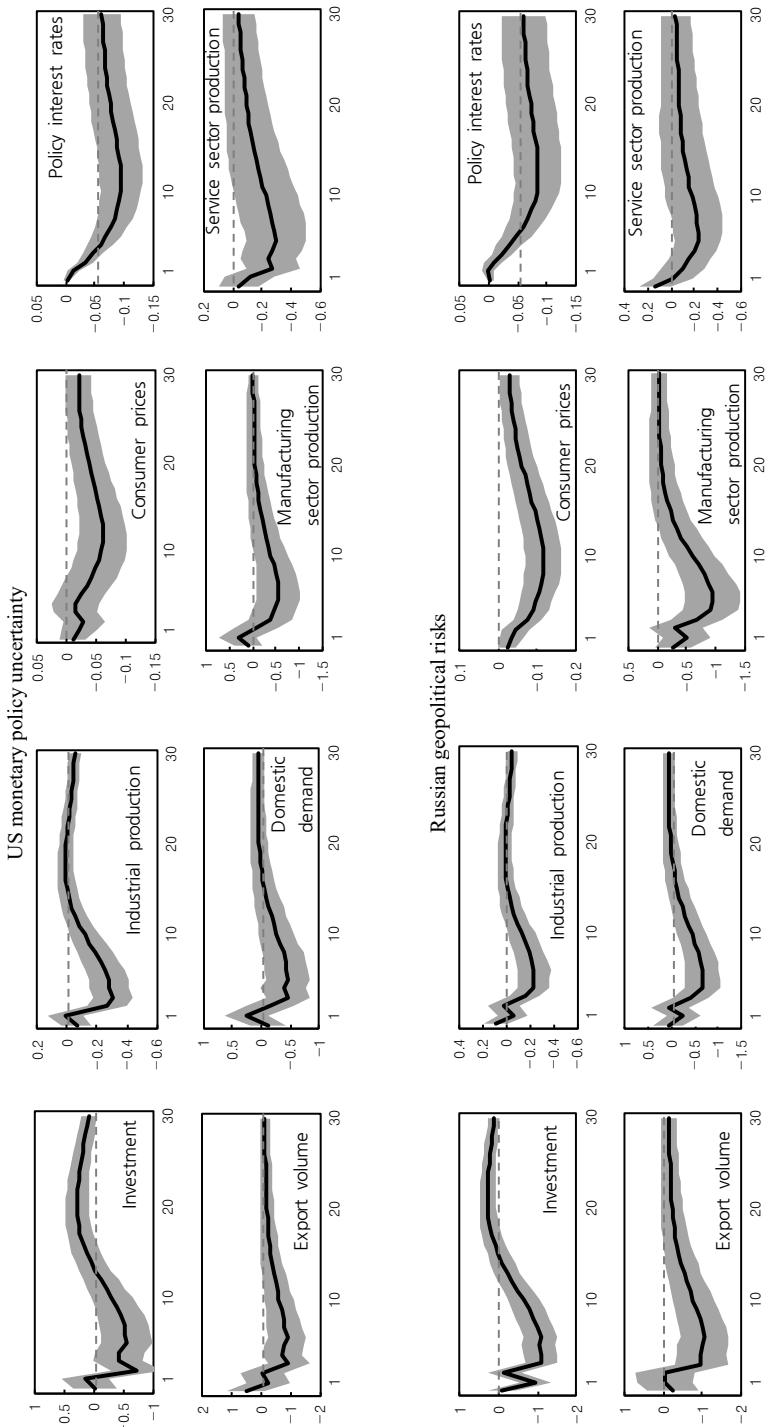

FIGURE A2. IMPULSE RESPONSES WITHOUT THE SMALL-OPEN ECONOMY ASSUMPTION

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

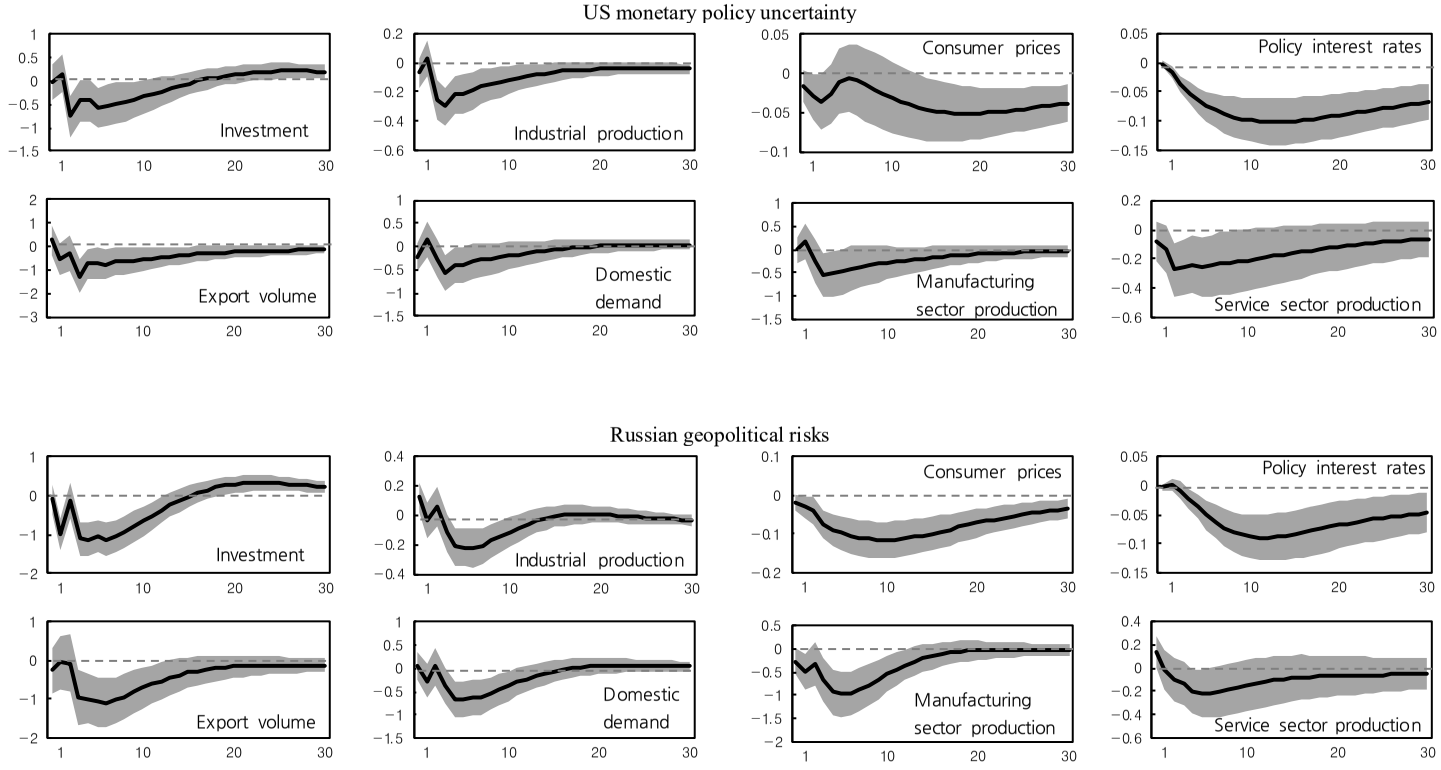

FIGURE A3. IMPULSE RESPONSES CONTROLLING OIL PRICES

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

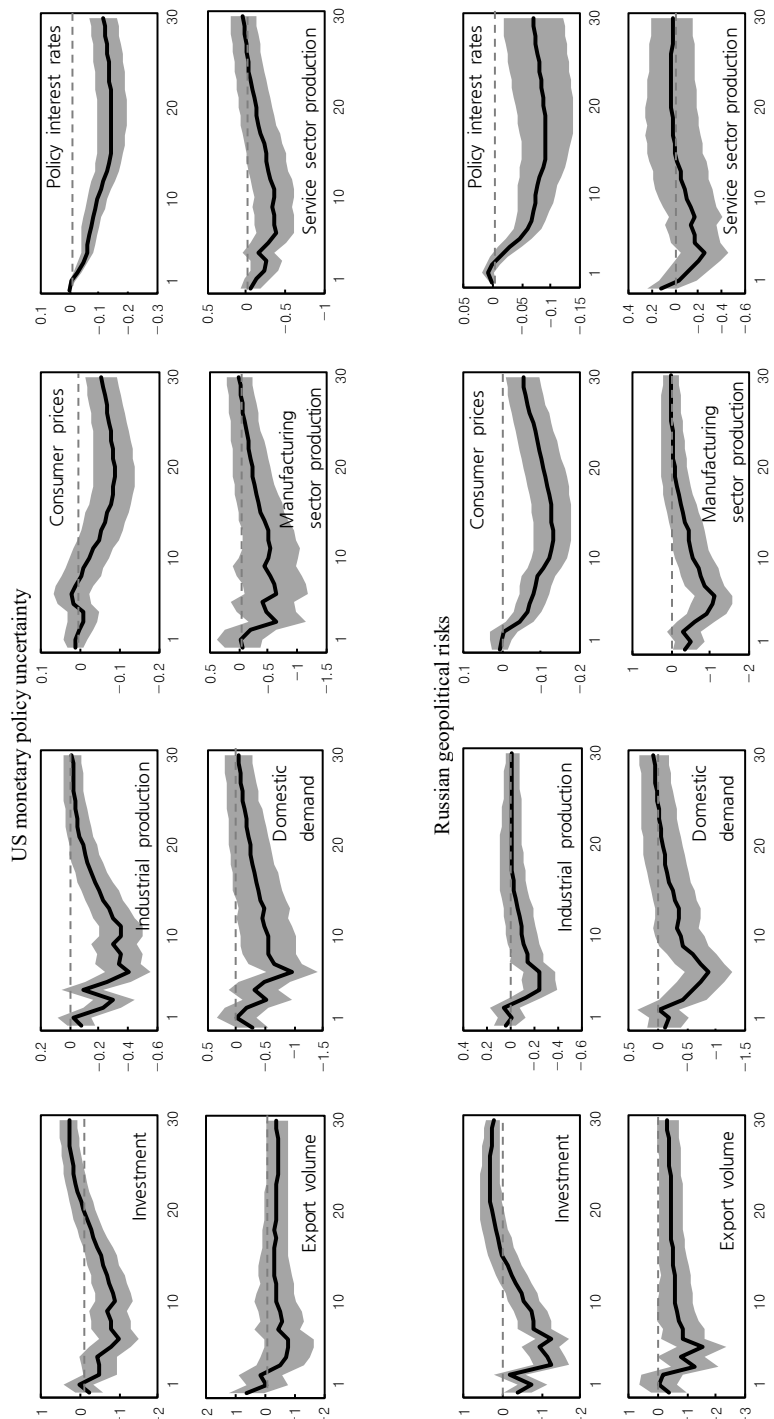

FIGURE A4. IMPULSE RESPONSES INCLUDING THE SAMPLE PERIOD UP TO DECEMBER OF 2021 WITH LAG=6

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

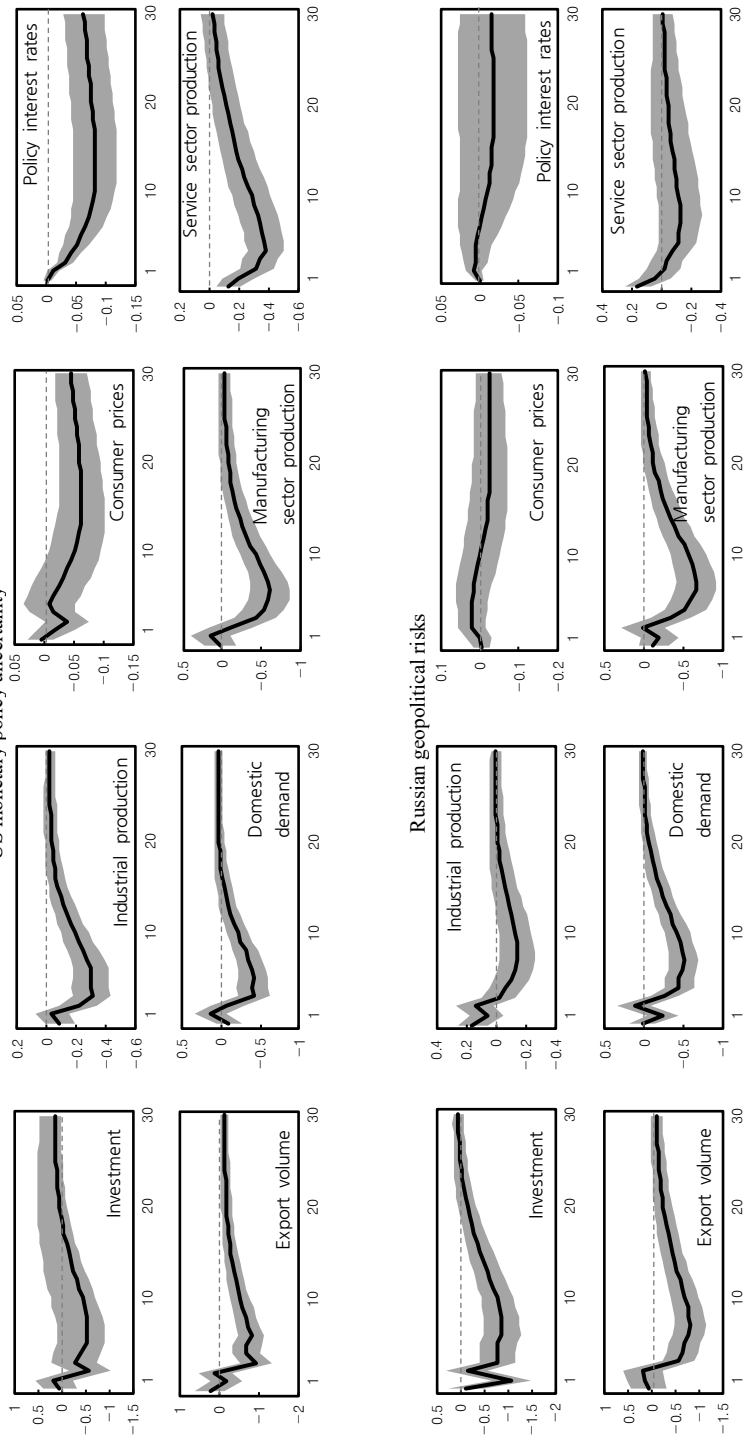

FIGURE A5. IMPULSE RESPONSES INCLUDING THE SAMPLE PERIOD UP TO FEBRUARY OF 2024 WITH THE COVID DUMMY

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

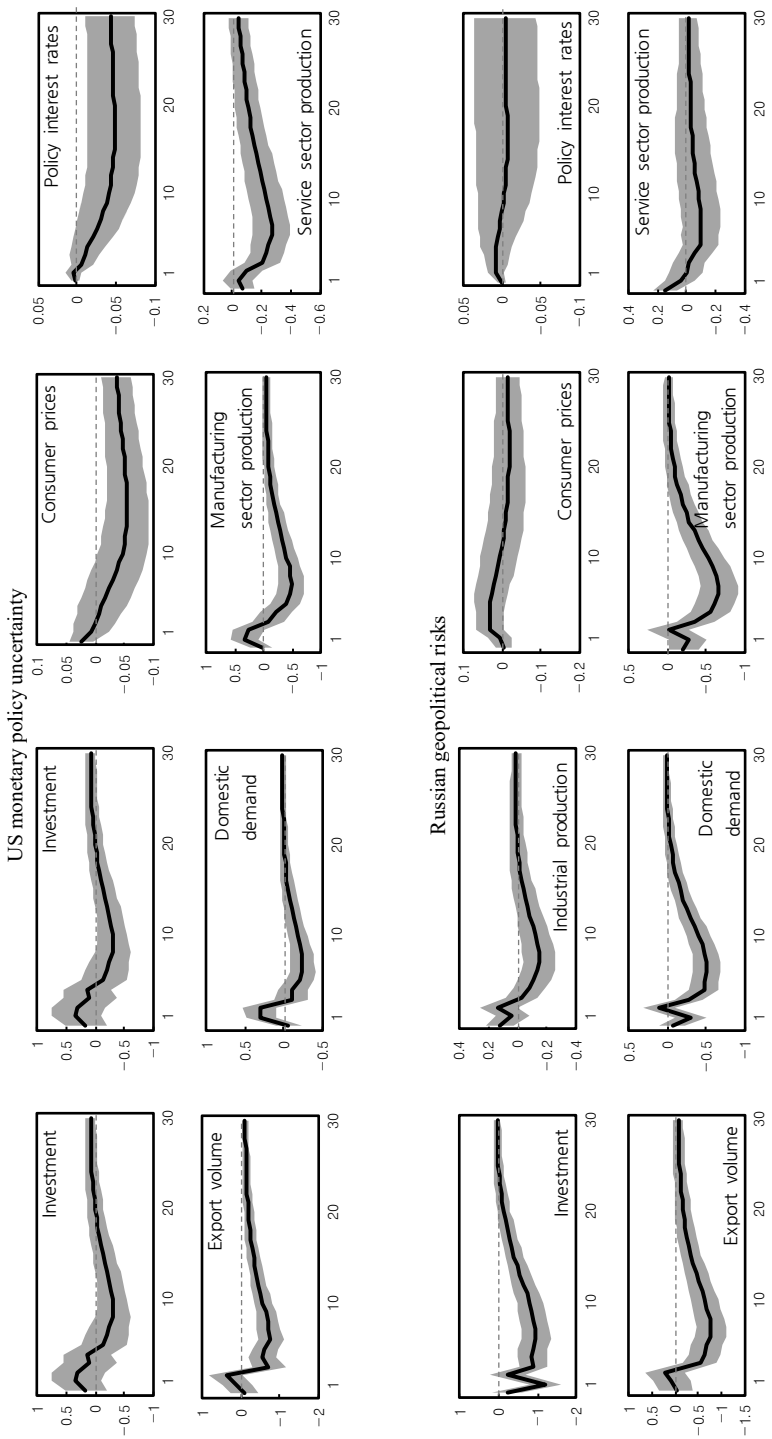

FIGURE A6. IMPULSE RESPONSES INCLUDING THE SAMPLE PERIOD UP TO FEBRUARY OF 2024 WITH THE COVID DUMMY AND DIFFERENT MPUS ACCORDING TO HUSTED *ET AL.* 2020

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

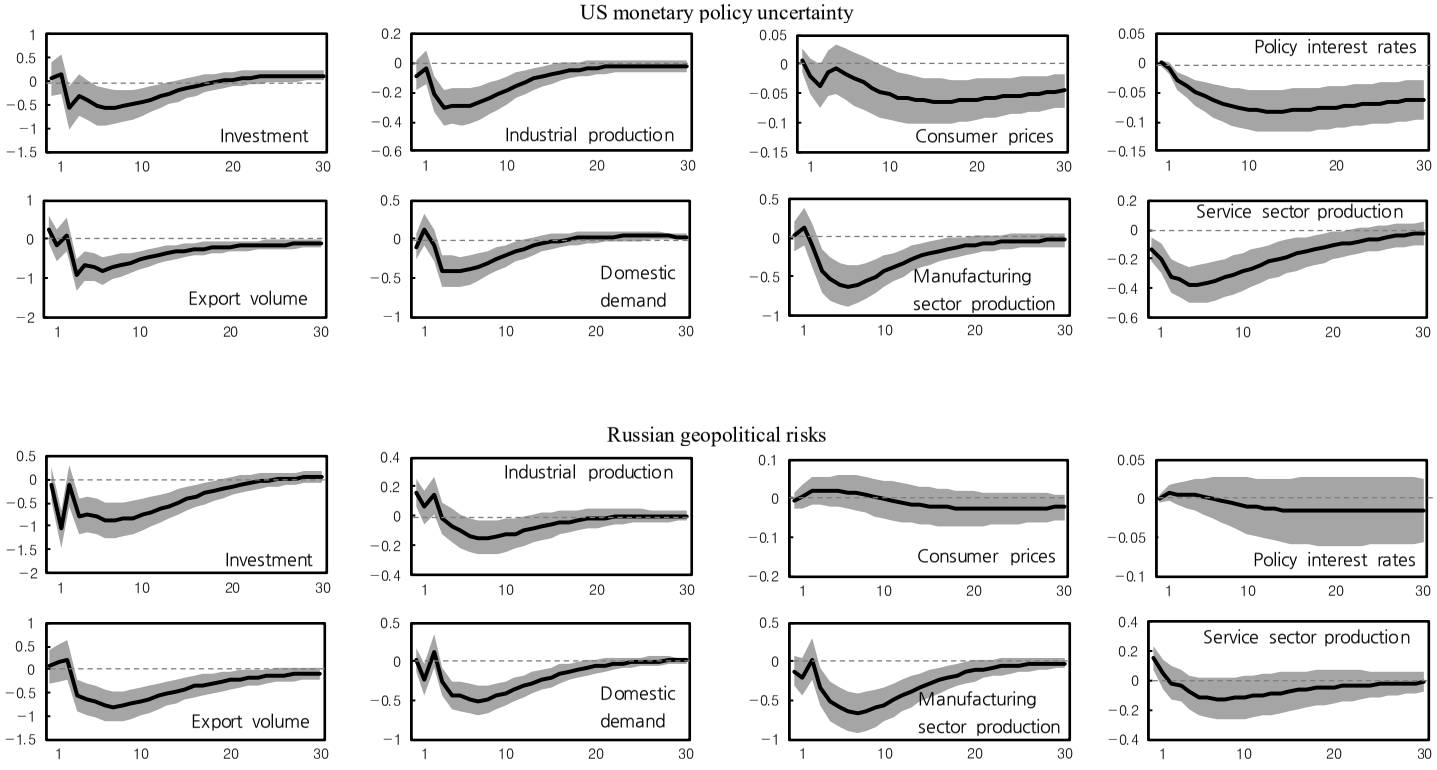

FIGURE A7. IMPULSE RESPONSES INCLUDING THE SAMPLE PERIOD UP TO FEBRUARY OF 2024 WITH THE COVID DUMMY AND ALTERNATIVE ORDERING

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

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Structural Reforms to Enhance the Sustainability and Intergenerational Equity of the National Pension System†

By KANG KOO LEE*

This paper examines reform measures for the National Pension System, analyzing their fiscal impacts. Despite past reforms adjusting contribution and replacement rates, the system faces ongoing sustainability challenges. We forecast that the reserve fund, peaking at 1,972.0 trillion KRW in 2039, will be depleted by 2054. A scenario analysis suggests that raising the contribution rate from 9% to 18% would extend solvency but not maintain long-term stability under the current DB structure, which promises benefits that exceed contributions. This highlights the difficulty of sustaining the fund through rate increases alone.

This paper proposes a structural shift to a new cohort-based DC system ("New Pension"), which would provide benefits based on contributions and investment returns, avoiding depletion even with low birth rates. Under this plan, the "Old Pension" deficit would be supported by government funds, ensuring all generations receive at least their contributions back. For the Old Pension, the shortfall is projected to be 609 trillion KRW if limited to contributions through 2023, rising to 869 trillion KRW if extended to 2028. These results stress the importance of early reforms to ease the fiscal burden.

Key Word: Structural Reforms, National Pension System, Defined Contribution, Separation of Old/New Pension Systems
JEL Code: H55, H68, I38

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I. Introduction

The National Pension System in South Korea was introduced in January of 1988. In its early stages, the income replacement rate was set to 70% to emphasize the provision of retirement income during the industrialization era, while the contribution rate was set at only 3% of income. In other words, the National Pension System began without inherent financial sustainability. Since then, efforts have been made to address this financial issue by gradually reducing the income replacement rate to 40% and raising the contribution rate to 9%.

Despite these efforts, the severe financial challenges of the National Pension remain unresolved. Ensuring the financial sustainability of the National Pension is a crucial policy task for a securing stable retirement for all citizens. According to 2022 population projections, the decline in the working-age population has widened (a decrease of 1.77 million over five years), and the total fertility rate is projected to fall to 0.70. Additionally, the results of the 5th National Pension financial recalculation in 2023 moved forward the timeline for the onset of the fiscal deficit (from 2042 to 2041) and the depletion of the reserve fund (from 2057 to 2055) compared to the 4th recalculation five years earlier. Specifically, if the current National Pension system is maintained, the reserve fund is expected to grow until 2040, reaching a peak of 1,755 trillion KRW, but will turn to a fiscal deficit starting in 2041, with the fund projected to be depleted by 2055. Assuming other factors (such as the income replacement rate and enrollment/benefit age) remain unchanged, maintaining the reserve fund through 2093 (the projection period) would require

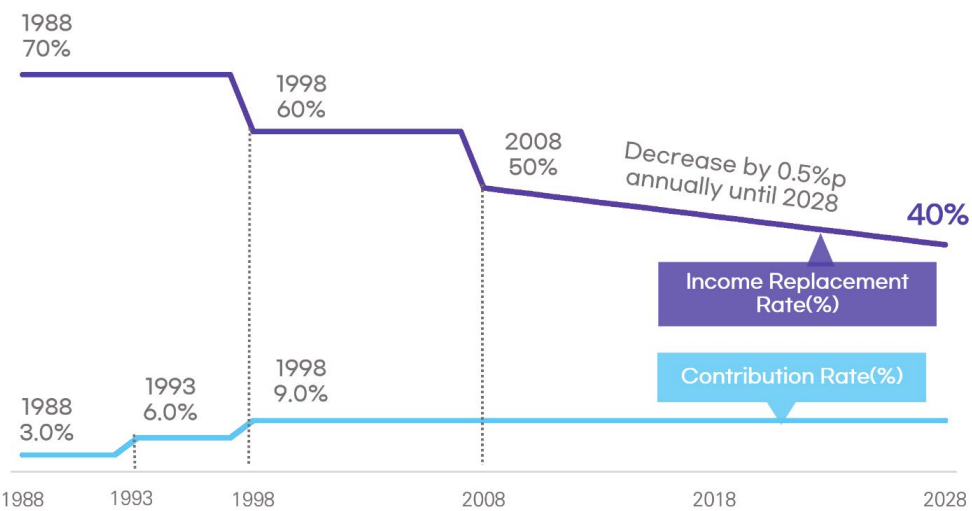

FIGURE 1. CHANGES IN THE CONTRIBUTION RATE AND INCOME REPLACEMENT RATE OF THE NATIONAL PENSION

Source: Prepared by the author, based on data from the National Pension Financial Projection Expert Committee (2023).

raising the contribution rate to 17.9% starting in 2025. The pay-as-you-go cost rate, which represents the contribution rate needed to cover annual benefit expenditures with annual premium revenues, is projected to rise from 6.0% in 2023 to 35.0% in 2078, before decreasing to around 29.7% by 2093.

Therefore, there is an urgent need to develop reform measures to sustain the National Pension system. Reform options for public pensions can be broadly classified into parametric reforms and structural reforms. While current discussions on stabilizing the finances of the National Pension focus on parametric reforms, these measures may alleviate the sustainability issue but do not fully address the problem of intergenerational equity. Relying solely on parametric reforms for public pensions is insufficient to achieve both financial sustainability and intergenerational equity.

In light of this, this paper seeks to explore structural reform measures for the National Pension that can simultaneously secure both financial sustainability and intergenerational equity, differing from previous research. To this end, it compares scenarios involving contribution rate increases with those implementing a DC-type structural reform and evaluates the potential financial outcomes using a National Pension projection model. The Defined Contribution (DC) pension system has already been discussed in several studies, including Park (2023), due to demographic changes in Korea. Park (2023) explores the introduction of a funded DC pension system, citing concerns that parametric reforms aimed at ensuring the long-term fiscal sustainability of the National Pension System may fail to improve intergenerational equity.

However, among the various DC pension system models, the Swedish notional defined contribution (NDC) system is not suitable for countries such as Korea with similar demographic challenges, and the individual account-based DC pension system has the drawback of failing to address the longevity risk when contributors live longer than expected, while also undermining the role of a public pension system as the remaining funds are passed on to heirs if contributors die earlier than anticipated. This paper proposes the introduction of a cohort-based account DC pension system to maintain the functionality of a funded DC pension while preserving the role of a public pension system. Despite the advantages of the proposed new pension system, the suggestion to separate the old and new pension schemes presents a drawback: failing to address the shortfalls in the old pension could undermine the feasibility of the reform. In other words, the structural reform proposed in this study can enhance its feasibility if the current generation is willing to relinquish some of their vested interests for the benefit of future generations.

The structure of this paper is as follows: Chapter 2 constructs the National Pension projection model. Chapter 3 analyzes the projection results of the contribution rate increase scenario, while Chapter 4 reviews the outcomes of structural reform measures for the proposed “New Pension.” Chapter 5 calculates the financial shortfalls arising from the existing “Old Pension” system. The final chapter summarizes the suggested directions for reforming the National Pension system.

II. Construction of the National Pension Projection Model

This chapter constructs a National Pension financial projection model to analyze the impact of reform measures on the pension's finances. A representative international model for public pension projections is the World Bank's PROST (Pension Reform Option Simulation Toolkit). This actuarial model calculates data such as contributors, beneficiaries, pension contributions, benefit expenditures, and reserve funds by inputting demographic, macroeconomic, and policy variables as exogenous factors.

In South Korea, various institutions, such as the National Pension Research Institute, the Korea Institute of Public Finance, the Korea Institute for Health and Social Affairs, and the National Assembly Budget Office, have developed and utilized their own projection models for the National Pension. The academic community has also engaged in research on National Pension projection models.

This paper aims to build a fiscal projection model for the National Pension based on models from the National Pension Research Institute (2017) and the National Assembly Budget Office (2020). These models are selected for their relative simplicity and effectiveness in analyzing the effects of pension reform measures on the financial stability of the National Pension. They can enable estimations of revenues, expenditures, the fiscal balance, and the reserve funds of the National Pension.

A. *Overview of the Projection Model*

The model used in this study, similar to existing National Pension projection models, is structured to estimate the revenues and expenditures of the National Pension based on demographic projections and macroeconomic forecast variables.

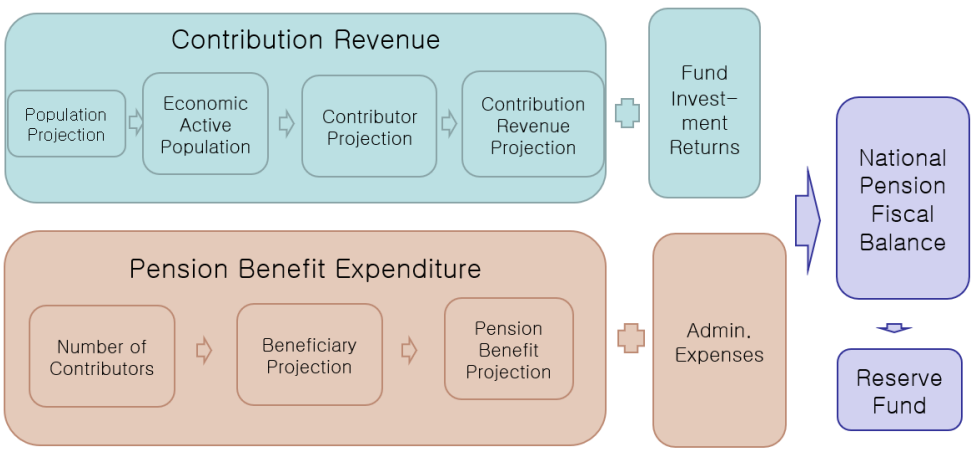

FIGURE 2. OUTLINE OF THE NATIONAL PENSION PROJECTION MODEL

Source: Prepared by the author.

Specifically, the projection of National Pension revenue consists of estimating the number of contributors, contribution income, and investment returns on the reserve fund. On the expenditure side, the model includes estimates of the number of beneficiaries, pension benefit payments, and administrative costs.

B. *Demographic Projections, Macroeconomic Forecasts, and Key Policy Parameters*

The demographic projections are based on *the Future Population Projections* (February 2022) by Statistics Korea, using the medium-variant scenario. These projections are calculated using data from the 2020 Population Census and account for population changes due to births, deaths, and international migration. According to the projections, the total fertility rate is expected to decline from 0.73 in 2023 to a low of 0.70 in 2024, before rebounding to 0.96 by 2030 and then stabilizing at 1.21 from 2046 onward.

The macroeconomic projections applied in the National Pension projection model include variables such as the nominal GDP, consumer price inflation rate, nominal wage growth rate, government bond yields, and labor force participation rate, based on the forecasts provided by KDI.

The policy parameters of the National Pension system include factors such as the participation rates of workplace and regional contributors, exemption rates, new enrollment rates, collection rates, income index, lifetime income scores, disability incidence rates, and survivor rates. These parameters were set based on sources such as materials from the National Pension Financial Projection Expert Committee, the Ministry of Health and Welfare, the National Pension Research Institute, and the National Assembly Budget Office.

The assumed fund return rate is based on figures from the 5th National Pension financial recalculation materials provided by the National Pension Financial Projection Expert Committee (2023). The committee estimated expected returns by asset class based on macroeconomic forecasts and weighted these according to asset allocation ratios to derive the overall investment return rate. The projections for the 2023-2093 period estimate an average annual return rate of approximately 4.5%, breaking down into 4.9% for 2023-2030, 4.6% for 2031-2040, 4.5% for 2041-2060, and 4.4% for 2061-2080. While this indicates a gradual downward trend over time, this study applies the period average rate directly.

Additionally, it is important to note that before a fiscal deficit occurs in the National Pension, long-term investments can be made, allowing for a higher allocation to riskier assets and potentially higher returns. However, after the onset of a fiscal deficit, the need to secure funds for pension payouts would require investments in more liquid and lower-yielding assets, potentially reducing the overall return rate. Although this aspect should ideally be factored into projections, it was not accounted for in the financial projections presented here.

C. *Revenue Projections*

National Pension contribution revenue is calculated by multiplying the annual number of contributors by the contribution rate and the collection rate.

$$\begin{aligned}\text{Contribution Revenue} &= \text{Number of Contributors} \times \text{Standard Monthly Income} \\ &\times \text{Contribution Rate} \times \text{Collection Rate}\end{aligned}$$

Contributors are categorized by gender, type of membership (e.g., workplace, regional, pending contributors), and other characteristics. Based on these categories, projections are made by applying the National Pension participation rate, transition rates between types, new entry rates, and mortality rates by gender and age.

$$\begin{aligned}&\text{Number of Contributors} \\ &= \min\{(\text{Economically Active Population} \times \text{National Pension Participation Rate}), \\ &(\text{Previous Year Contributors} \times \text{Transition Rate by Contributor Type} + \text{New Entrants})\}\end{aligned}$$

For regional members, only those who report income and are not exempt from payments are subject to making contributions. Therefore, projections are adjusted by excluding those with contribution exemptions, calculated by applying the proportion of exempt members by year, gender, and age to regional members.

The total number of contributors is then adjusted to ensure that it does not exceed the economically active population for each year, gender, and age group, by comparing it to the projected number of contributors based on National Pension participation rates.

The contribution unit price is determined differently for workplace and regional contributors. For workplace contributors, it is calculated by applying the nominal wage growth rate to the standard monthly income and then multiplying this value by the contribution rate. For regional contributors, it is calculated by adjusting the standard monthly income using the income ratio between regional and workplace contributors and then applying the contribution rate. During this process, the standard monthly income for both workplace and regional contributors, segmented by gender and age, is estimated using income indices categorized by contributor type, gender, and age. The specific formula for estimating revenue can be found in Appendix A.

The total number of National Pension contributors is projected to decrease from 29.87 million in 2023 to 17.15 million in 2100, in line with declines in both the total population and the economically active population. National Pension revenue is expected to rise from 101.3 trillion KRW in 2023 to 189.3 trillion KRW by 2043,

driven by increases in contributions and investment returns. However, due to a reduction in investment returns, total revenue is projected to decrease to 128.2 trillion KRW by 2055, after which it will gradually increase again as contribution revenue grows. This increase in contribution revenue, despite a decline in the number of contributors, is primarily attributed to a rise in per capita contributions resulting from individual income growth.

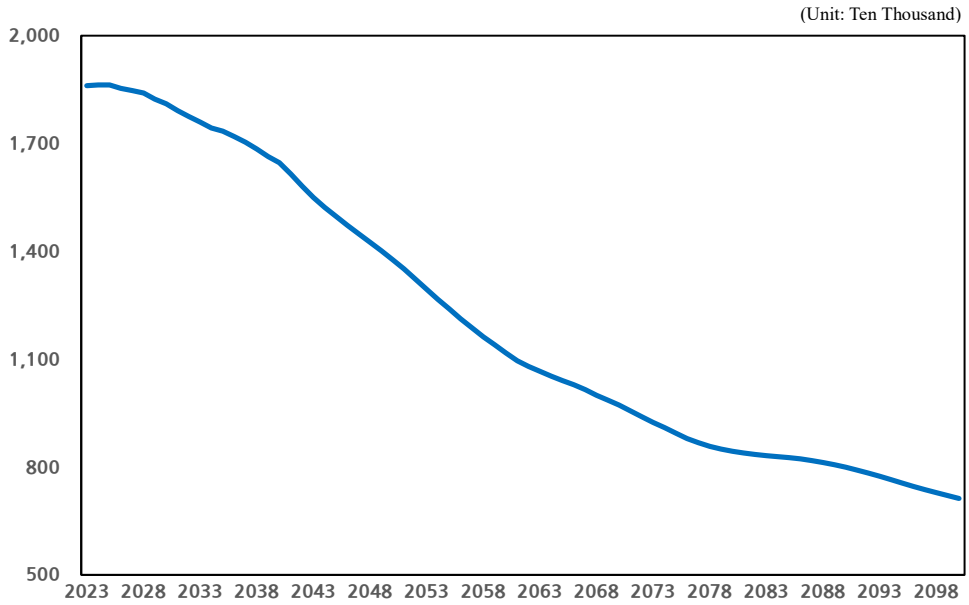

FIGURE 3. PROJECTION OF NATIONAL PENSION CONTRIBUTORS

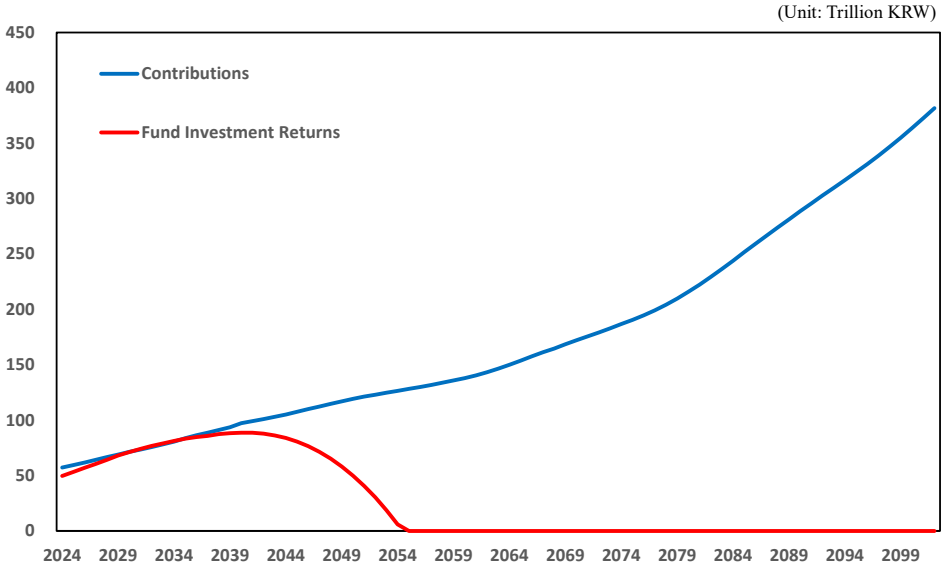

FIGURE 4. BASELINE PROJECTION RESULTS FOR NATIONAL PENSION REVENUE

Fund investment returns, which are influenced by the size of the reserve fund and its yield, are expected to peak at 88.7 trillion KRW in 2040 when the reserve fund reaches its maximum. However, from 2041 onward, as the reserve fund begins to decline, investment returns are also projected to decrease. After the reserve fund is depleted in 2054, no further investment returns are expected.

D. *Expenditure Projections*

The expenditure on National Pension benefits is projected primarily by multiplying the number of beneficiaries by the pension benefit unit price. Pension benefit expenditures are estimated separately for old-age pensions, early old-age pensions, survivor pensions, and disability pensions.

$$\begin{aligned}\text{Total Pension Benefit} &= \text{Old} - \text{Age Pension} + \text{Early Old} - \text{Age Pension} \\ &\quad + \text{Survivor Pension} + \text{Disability Pension}\end{aligned}$$

The number of beneficiaries is projected by applying gender- and age-specific beneficiary incidence rates to contributors as they reach the pension benefit eligibility age. The specific formulas for calculating the number of pension beneficiaries and the benefit unit prices can be found in Appendix B.

Administrative expenses are projected based on the scale of pension benefit payments and the nominal wage growth rate. It is assumed that administrative expenses will maintain a constant proportion of the total pension benefits paid, while increasing at least at the nominal wage growth rate.

The number of National Pension beneficiaries is expected to grow from 5.975 million in 2023 to a peak of 18.111 million in 2053 before declining to 8.812 million by 2100. By beneficiary type, old-age pension recipients are projected to increase from 4.81 million in 2023 to a peak of 15.112 million in 2052 and then decline to 7.741 million by 2100. Survivor pension beneficiaries are expected to grow from 1.066 million in 2023 to 2.88 million in 2055 before decreasing to 1.004 million by 2100. Disability pension beneficiaries are projected to increase from 0.1 million in 2023 to 0.137 million in 2048 and subsequently fall to 0.068 million by 2100.

Comparing the projections for the number of contributors and beneficiaries, the number of contributors is expected to decline continuously due to demographic changes, while the number of beneficiaries will increase until the pension system reaches maturity in 2053, after which it will start to decrease. The number of contributors and beneficiaries is anticipated to equalize around 2042 at approximately 15.74 million. This gap will widen until 2061 and then gradually narrow.

National Pension expenditures are projected to increase from 29.2 trillion KRW in 2023 to 1,368.9 trillion KRW by 2100. By category, old-age pension payments are expected to rise from 25.1 trillion KRW in 2023 to 1,260.4 trillion KRW in 2100. Survivor pension payments are projected to increase from 2.8 trillion KRW in 2023 to 72.3 trillion KRW by 2100, and disability pension payments are expected to

increase from 0.5 trillion KRW in 2023 to 5.4 trillion KRW in 2100, though these amounts will remain smaller compared to old-age pensions. Administrative expenses are expected to grow from 0.8 trillion KRW in 2023 to 20.4 trillion KRW by 2100.

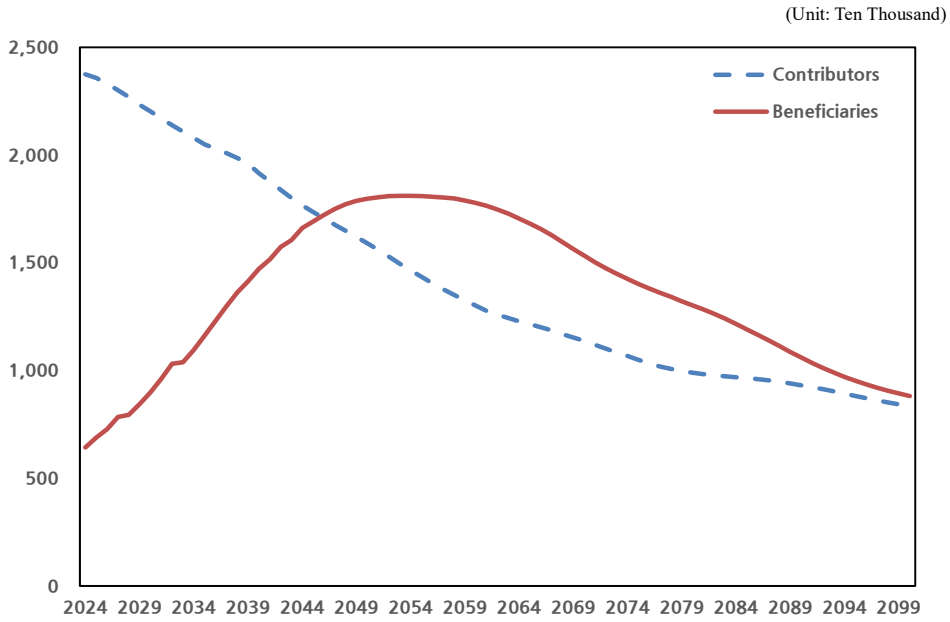

FIGURE 5. COMPARISON OF BENEFICIARY AND CONTRIBUTOR PROJECTIONS

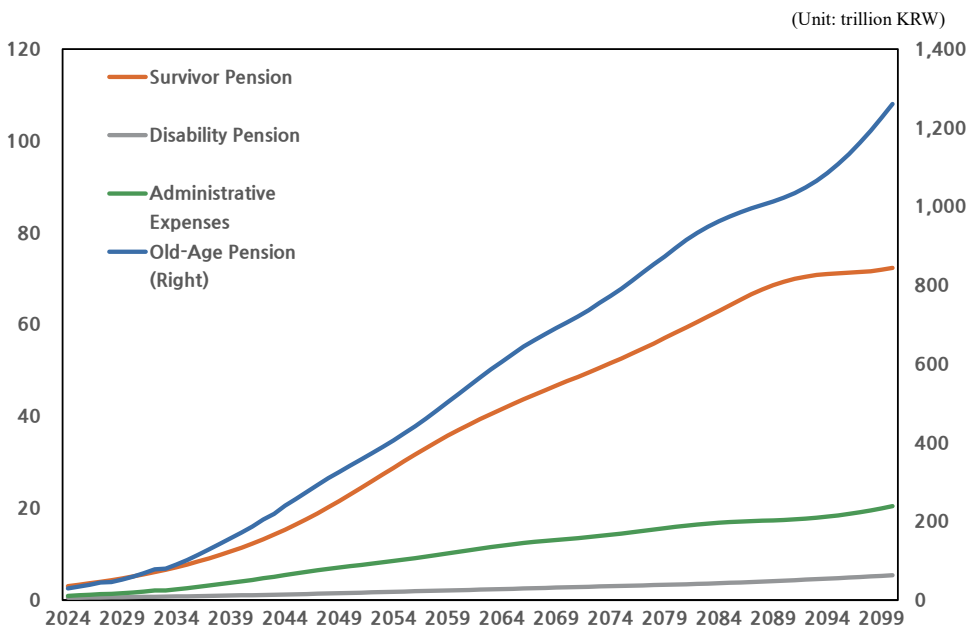

FIGURE 6. PROJECTION RESULTS BY EXPENDITURE CATEGORY

E. *Fiscal Balance and Reserve Fund Projections*

The fiscal balance of the National Pension is projected to shift from a surplus of 72.1 trillion KRW in 2023 to a deficit by 2040, expanding further to a deficit of -1,005.2 trillion KRW by 2100. The fiscal balance as a percentage of GDP is expected to decline gradually from 3.2% in 2023, turning negative in 2040, and increasing to -8.1% by 2080 before slightly recovering to -6.9% by 2100.

The National Pension reserve fund is projected to grow from 1,015.8 trillion KRW in 2023 to a peak of 1,972.0 trillion KRW in 2039, after which it will begin to decline, eventually becoming depleted by 2054. As a percentage of GDP, the reserve fund is expected to rise from 44.8% in 2023 to 54.1% in 2035 before gradually decreasing.

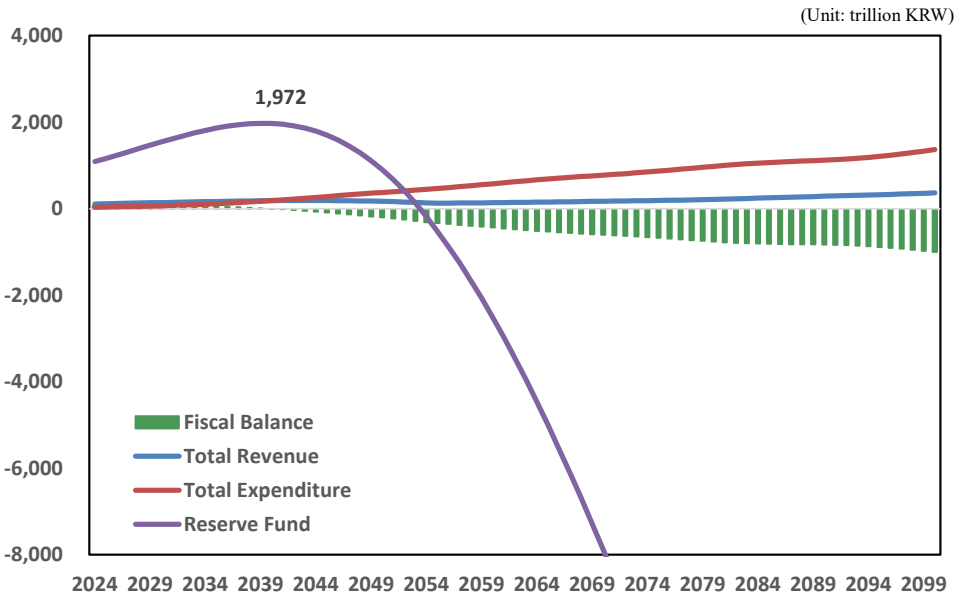

FIGURE 7. PROJECTION RESULTS FOR NATIONAL PENSION FISCAL BALANCE AND RESERVE FUND (CONTRIBUTION RATE: 9%)

III. National Pension Contribution Rate Increase

Since the 1998 reform, the contribution rate for the National Pension has been fixed at 9%. The current contribution rate allows beneficiaries to receive more in benefits than they contribute. According to the Ministry of Health and Welfare (2023), the break-even contribution rate for a 25-year benefit period with a 40% income replacement rate is 19.8%. In other countries with benefit levels similar to those of South Korea, contribution rates are around 18%. According to OECD data (2021), the average contribution rate across OECD countries is 18.2%, placing South

Korea among the lowest in terms of contribution rates among OECD countries.

Therefore, we project National Pension revenue, the fiscal balance, and reserve fund levels in scenarios where the current 9% contribution rate is increased to 18%.

A. *Revenue Projections*

National Pension revenue is projected to increase from 101.3 trillion KRW in 2023 to 542.0 trillion KRW by 2063, driven by growth in contributions and fund investment returns. Following this peak, total revenue may decrease slightly due to a decline in fund investment returns; however, from 2065 onward, overall revenue is expected to rise again due to an increase in contribution income.

Fund investment returns, which are influenced by the reserve fund size and return rates, are projected to reach a peak of 242.8 trillion KRW in 2058, the year following the reserve fund's maximum level. As the reserve fund decreases, investment returns are also expected to decrease, and after the reserve is depleted in 2079, no further investment returns will be generated.

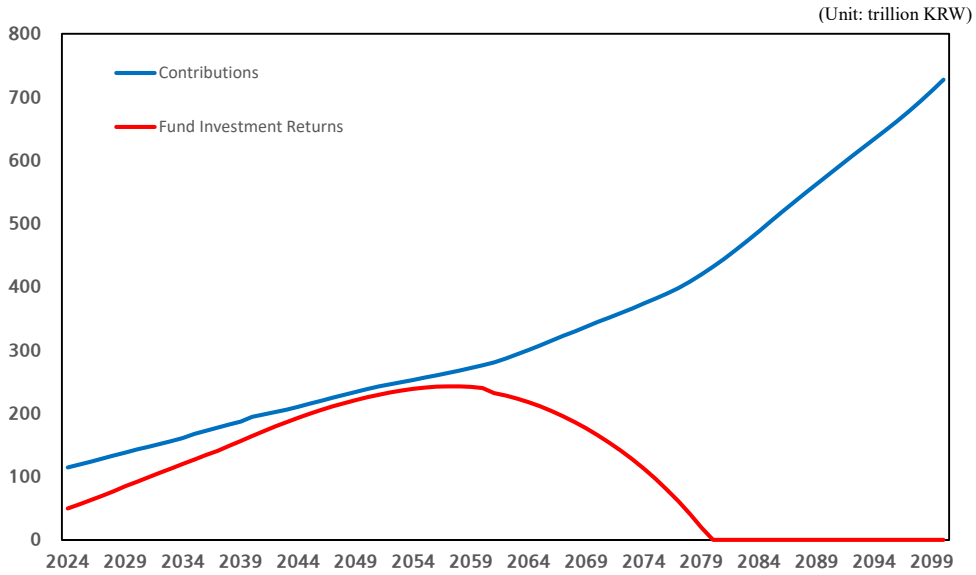

FIGURE 8. PROJECTION RESULTS FOR NATIONAL PENSION REVENUE (CONTRIBUTION RATE: 18%)

B. *Fiscal Balance and Reserve Fund Projections*

In a DB-based benefit system, even if contributions are increased, pension benefits remain unchanged. Therefore, if the contribution rate is raised to 18%, the National Pension's fiscal balance is projected to shift to a deficit by 2057. The fiscal balance as a percentage of GDP is expected to rise from 3.2% in 2023 to a peak of 5.3% in 2035 before gradually declining and turning negative in 2057. By 2100, the deficit is projected to widen to -4.4% of GDP.

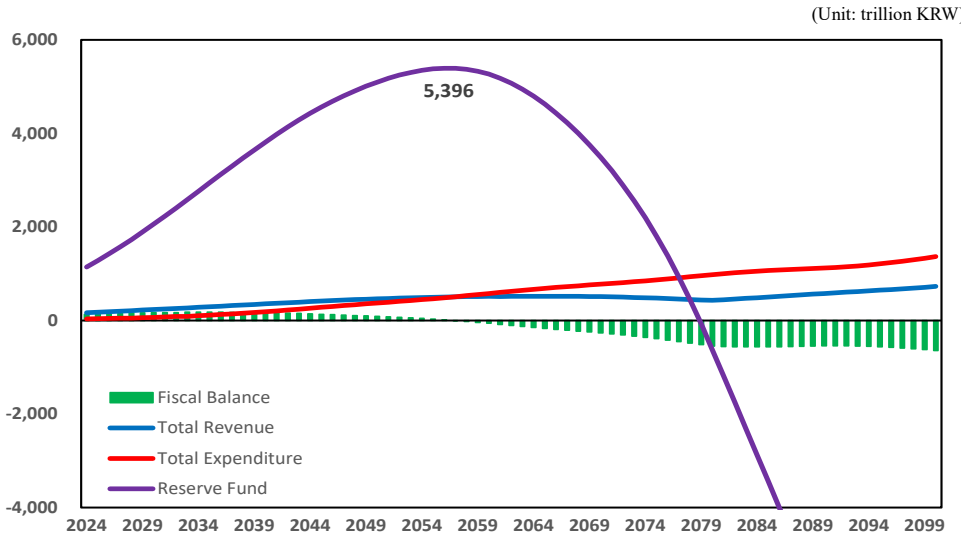

FIGURE 9. PROJECTION RESULTS FOR THE NATIONAL PENSION FISCAL BALANCE AND RESERVE FUND (CONTRIBUTION RATE: 18%)

The National Pension reserve fund is expected to reach its peak of 5,396.0 trillion KRW in 2056 before gradually declining and ultimately becoming depleted by 2079. The reserve fund as a percentage of GDP is projected to rise to 100.6% in 2047 and then gradually decrease. In contrast, under the 18% contribution rate scenario from the 5th National Pension Financial Projection Committee's fiscal stability scenario, the reserve fund is projected to last until 2082. This discrepancy is primarily due to differences in the projected numbers of contributors and beneficiaries.

While the 5th fiscal recalculation anticipates a decrease in National Pension contributors from 21.99 million in 2023, this study projects a decrease from 18.61 million contributors in 2023. This difference in contributor numbers affects the projected number of beneficiaries. For instance, in 2080, the 5th fiscal recalculation projects 13.47 million old-age pension beneficiaries, while this model estimates 11.211 million.

C. *Implications*

In the National Pension contribution increase scenario, the important point is that even if the contribution rate is raised above the current level, the National Pension system is still not sustainable. The Private Advisory Committee of the National Assembly's Special Committee on Pension Reform (2023) proposed two options: Plan 1 suggests raising the contribution rate to 13% and the income replacement rate to 50%, while Plan 2 suggests raising the contribution rate to 12–15% and lowering the income replacement rate from the current 42.5% to 40%. The Special Committee reported that under Plan 1, the fund depletion point would be 2062, and under Plan 2, with a 15% contribution rate, the fund depletion point would be 2071.

Raising the current contribution rate (9%) would be a highly challenging reform

in practice. However, even if such a difficult reform were implemented, the current DB-based National Pension system structure would remain unable to maintain the reserve fund within the projection period, as pension benefits are paid under a DB model with a benefit-cost ratio exceeding 2, regardless of contributions made. Consequently, it would be challenging to guarantee pension payments for future generations after the reserve fund is depleted.

IV. Application of Structural Reform Measures

A. *Structural Reform with a DC System*

Public pension systems are broadly categorized based on funding methods into pay-as-you-go (PAYG) and funded systems. In a PAYG system, pensions for retirees are financed by contributions collected from the current working generation. In a funded system, pension contributions are invested to generate a fund that covers retirement benefits.

When categorized by benefit calculation methods, public pensions are typically divided into defined benefit (DB) and defined contribution (DC) schemes. In a DB scheme, benefits are determined based on an individual's work history (such as income history and years of contribution). In a DC scheme, benefits are based on the contributions made by the individual (plus interest/returns and expected life expectancy at retirement).

The core issue behind the depletion of South Korea's National Pension reserve fund lies in the current DB-based benefit calculation. As analyzed in the projection model, the old-age pension benefits in the National Pension are calculated based on a basic pension amount. The calculation formula combines (1) the average income of all contributors (the average over the three years before pension receipt, "A value") with (2) the individual's average income (income-proportional "B value") and applies a proportional constant (40% → 1.2; a constant used to achieve a 40% income replacement rate). Finally, (3) the contribution period (with a 5% increase for each additional year based on a 20-year subscription) is considered.

In the current system, for 20-year beneficiaries, the benefit-cost ratio exceeds 1 across all income levels, meaning that recipients receive considerably more than their paid contributions. Thus, the system guarantees a predetermined pension amount based on contribution periods, independent of the total contributions paid. This structure relies on intergenerational transfers, where future generations' contributions fund the shortfall in benefits for the current generation.

Currently, many countries operate modified combinations of basic pension models. For instance, Germany and Japan (semi-PAYG, semi-DB systems) incorporate balance indices (macroeconomic adjustments) to integrate PAYG elements (income = expenditure), allowing for limited reserves or state subsidies, while partially compromising the principles of DB and PAYG. Sweden (semi-PAYG + Notional Defined Contribution, NDC) operates a quasi-PAYG system that maintains the "income = expenditure" principle. In the NDC model, individual

accounts accrue assets proportional to earned income, which are annuitized, and the financial burden of increased life expectancy is offset by benefit reductions.

Adopting an automatic stabilization mechanism, as seen in Finland, Japan, and Germany—where DB systems adjust benefits in response to demographic conditions—would not solve the sustainability issues of South Korea's National Pension. This is primarily due to South Korea's exceptionally low total fertility rate, which is unprecedented globally. Even with an automatic stabilization mechanism, the decline in future generations would result in contributions from fewer individuals being used to pay for the pensions of earlier generations, creating a high risk of a scenario in which future retirees do not receive their pensions.

In South Korea, simply raising the contribution rate while maintaining the current structure of the National Pension system, which faces potential fund depletion, is unlikely to gain support from younger generations. It is crucial to instill confidence that increased contributions will serve as a reliable source of retirement funds for contributors themselves in the future. To achieve this, a modified defined contribution (DC) system that accounts for cohort-specific life expectancies should be introduced as a "New Pension" after structural reform of the National Pension. The existing defined benefit (DB) system would then be designated as the "Old Pension," and any shortfalls in the "Old Pension" benefits would be covered through general government funds to ensure that all generations receive at least the principal repayment (an expected return ratio of 1) or more.

B. *Construction of the Projection Model for the New Pension (DC System)*

This section develops a financial projection model for the National Pension under a restructured defined contribution (DC) system, referred to as the "New Pension," starting in 2024.

National Pension contribution revenue is calculated by multiplying the annual number of contributors by the contribution rate and collection rate. The number of contributors, contribution rates, and collection rates for each year are also estimated following the existing projection model.

If the pension system transitions from a defined benefit (DB) model to a DC model in 2024, contributors aged 18-59 would continue paying contributions to the DB-based "Old Pension" until the end of 2023. Starting in 2024, all National Pension contributors will shift to the DC-based "New Pension." Thus, contributors aged 18-59 in 2024 will all be enrolled in the New Pension. When they reach retirement age and begin receiving old-age pension benefits, contributors who are 59 in 2024 will receive DB benefits, based on the existing formula and RI, A-value, and B-value, for contributions made up to age 58, while contributions made at age 59 will be governed under the DC model and provide DC benefits. It is assumed that there will be no provision for a lump-sum payment under the New and Old Pensions, similar to the current integration in public pension systems, even for individuals with fewer than ten years of contributions.

The DC model here adopts a cohort collective defined contribution (CCDC) approach, which provides an age-specific or cohort-specific insurance structure, ensuring a fixed annuity until death. This structure calculates contributions for each

cohort and distributes payments for each age group until death. In this design, the accumulated funds of deceased households within each cohort are transferred to the annuities of surviving members of the same age group. The cohort account remains invested, generating returns, and when all members of a particular cohort pass away, the remaining balance is fully depleted. This setup reflects social solidarity within each cohort, allowing those who pass away earlier than the average life expectancy to transfer income to those who live beyond it. It thus mitigates the risk of income gaps for individuals who live longer than the average life expectancy. This aspect differentiates the CCDC public pension model from the fully funded defined contribution (FDC) private pension system, which is based on individual accounts.

This paper examines the annual total income, total expenditures, the fiscal balance, and the reserve fund of the cohort-based DC pension model.

Table 1 below presents the projected revenue and expenditures of cohort virtual accounts and the resulting reserve fund.

In Table 1, I_t represents the average pension contribution amount for age t, r denotes the fund's investment return rate, M is the mortality rate, Ω represents the reserve fund, and d refers to the old-age pension benefit amount for cohort t. The value of d can be derived to bring the end-of-year reserve fund in cohort virtual accounts to zero by the final period $n+m$.

TABLE 1—RESERVE FUND OF COHORT VIRTUAL ACCOUNTS

t	Beginning of Year Fund	End of Year Cohort Account
1	0	$I_1(1-M_1)$
2	Ω_1	$I_1(1-M_1)(1+r_1)+I_2(1-M_1)(1-M_2)$
3	Ω_2	$I_1(1-M_1)(1+r_1)(1+r_2)+$ $I_2(1-M_1)(1-M_2)(1+r_2)+$ $I_3(1-M_1)(1-M_2)(1-M_3)$
⋮	⋮	⋮
n (Pre-Retirement Pension Eligibility)	⋮	$\Omega_n \equiv I_1\left[(1-M_1)(1+r_1)\cdots(1+r_{n-1})\right]$ $+\cdots+I_n\left[(1-M_1)\cdots(1-M_n)\right]$
$n+1$ (Pension Benefit Start)	Ω_n	$\Omega_n(1+r_n)-d(1-M_{n+1})$
$n+2$	Ω_{n+1}	$\Omega_n(1+r_n)(1+r_{n+1})-d(1-M_{n+1})(1+r_{n+1})$ $-d(1-M_{n+1})(1-M_{n+2})$
⋮	⋮	⋮
$n+m$ (Final Cohort Period)	Ω_{n+m-1}	$\Omega_n\left[(1+r_n)\cdots(1+r_{n+m-1})\right]-d(1-M_{n+1})[(1+r_{n+1})\cdots(1+r_{n+m-1})]$ $-\cdots-d[(1-M_{n+1})\cdots(1-M_{n+m})]$

$$\Omega_n\left[(1+r_n)\cdots(1+r_{n+m-1})\right]-d(1-M_{n+1})\left[(1+r_{n+1})\cdots(1+r_{n+m-1})\right]$$
$$-\cdots\cdots-d\left[(1-M_{n+1})\cdots(1-M_{n+m})\right]=0$$

$$d=\frac{\Omega_n\left[(1+r_n)\cdots(1+r_{n+m-1})\right]}{(1-M_{n+1})\left[(1+r_{n+1})\cdots(1+r_{n+m-1})\right]+\cdots+\left[(1-M_{n+1})(1-M_{n+2})\cdots(1-M_{n+m})\right]}$$

$$d=\frac{\Omega_n}{\frac{(1-M_{n+1})}{(1+r_n)}+\frac{(1-M_{n+1})(1-M_{n+2})}{(1+r_n)(1+r_{n+1})}+\cdots+\frac{\left[(1-M_{n+1})\cdots(1-M_{n+m})\right]}{\left[(1+r_n)\cdots(1+r_{n+m-1})\right]}}$$

If the "New Pension" under the cohort-based DC model begins in 2024, contribution revenue is expected to grow from 60.1 trillion KRW in 2024 to 1,204.2 trillion KRW by 2100. For example, members of the 1965 cohort who make a single year's contribution in 2024 will reach age 64 in 2029, at which point they will be eligible to start receiving pension benefits. Consequently, benefit expenditures will initially be minimal, rising from 12.4 trillion KRW in 2040 to 764.0 trillion KRW by 2100.

A key point is that in the cohort-based DC New Pension, individuals receive only the contributions they have made, along with investment returns, as pension benefits. As a result, the reserve fund will not be depleted, even with lower birth rates or an extended projection period.

In the cohort-based CDC "New Pension" system, if the contribution rate is increased from 9% to 18% in 2024, contribution revenue would rise from 120.2 trillion KRW in 2024 to 2,407.9 trillion KRW by 2100—exactly double the amount projected under the 9% contribution rate. Benefit expenditures would also increase from 24.9 trillion KRW in 2040 to 1,528.0 trillion KRW by 2100, again precisely double the expenditures in the 9% scenario. Unlike the DB pension model, where an increase in the contribution rate does not affect benefit expenditures, the cohort-based CDC model ensures that a doubling of the contribution rate results in a doubling of pension benefits.

TABLE 2—PROJECTION RESULTS FOR THE NATIONAL PENSION UNDER THE COHORT CDC SYSTEM (CONTRIBUTION RATE: 9%)

(Unit: Trillion KRW)

Category	2024	2030	2040	2050	2060	2070	2080	2090	2100
Revenue	60.1	96.4	177.3	285.8	412.5	549.9	714.5	937.1	1,204.2
Expenditure	0.0	0.4	12.4	57.0	155.2	303.0	460.9	563.4	764.0
Balance	60.1	96.1	164.8	228.8	257.3	247.0	253.6	373.7	440.2
Reserve Fund	60.1	542.7	1,870.3	3,877.2	6,383.9	8,842.4	11,383.9	11,481.8	18,765.8

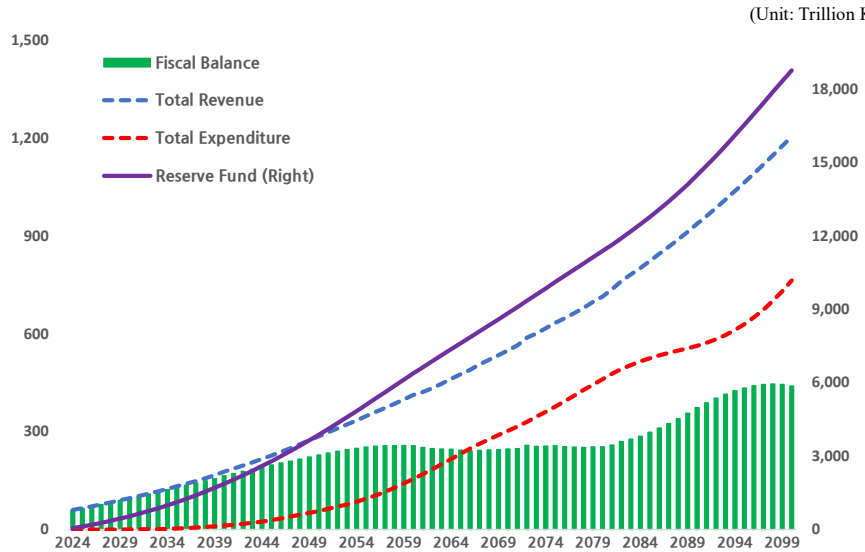

FIGURE 10. ANNUAL FISCAL BALANCE AND RESERVE FUND UNDER THE COHORT CDC SYSTEM BY YEAR (CONTRIBUTION RATE: 9%)

TABLE 3—PROJECTION RESULTS FOR THE NATIONAL PENSION UNDER THE COHORT CDC SYSTEM (CONTRIBUTION RATE: 18%)

(Unit: Trillion KRW)

Category	2024	2030	2040	2050	2060	2070	2080	2090	2100
Revenue	120.2	192.8	354.5	571.5	824.9	1,099.7	1,428.8	1,873.8	2,407.9
Expenditure	0.0	0.7	24.9	114.1	310.4	605.9	921.8	1,126.8	1,528.0
Balance	120.2	192.1	329.6	457.4	514.4	493.7	507.0	747.0	879.9
Reserve Fund	120.2	1,084.9	3,739.2	7,751.8	12,763.5	17,678.4	22,759.2	28,951.8	37,515.5

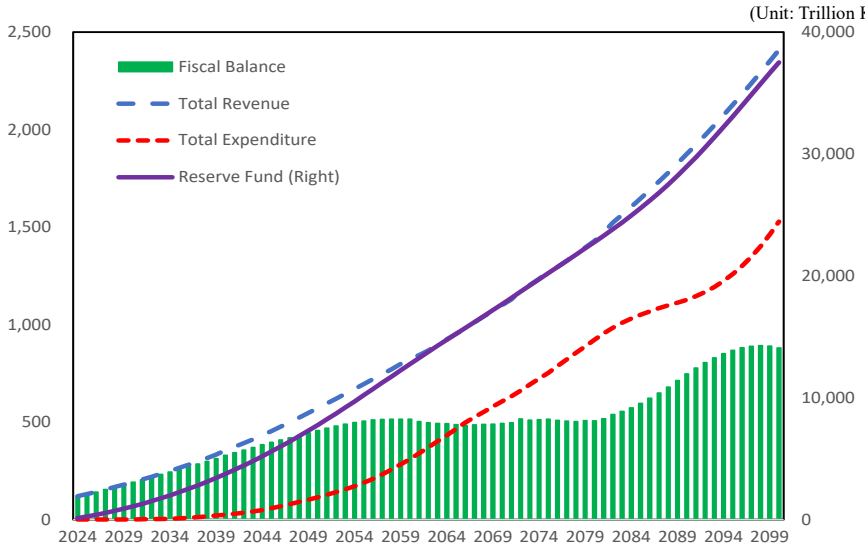

FIGURE 11. ANNUAL FISCAL BALANCE AND RESERVE FUND UNDER THE COHORT CDC SYSTEM BY YEAR (CONTRIBUTION RATE: 18%)

V. Estimation of the Financial Shortfall in the National Pension

A. *Methods for Estimating the Financial Shortfall in Public Pensions*

The approaches used to estimate financial shortfalls in public pensions can be categorized as the "closed group without future accruals," "closed group with future accruals," and "open group" types, depending on whether future participants are included in the scope of the assessment.[1]

The "closed group without future accruals" approach excludes new entrants and assumes that current participants, as of the evaluation date, will neither contribute further nor accrue additional benefits. The financial shortfall in this model is defined as the present value of future benefits owed to current beneficiaries and contributors at the evaluation date, less current reserves.

The "closed group with future accruals" approach, while also excluding new participants, assumes that current contributors will continue to make contributions beyond the evaluation date. Here, the financial shortfall is defined as the difference between the present value of entitlements for current beneficiaries, as well as the future benefits corresponding to both the past and projected contributions of existing participants, minus present and anticipated reserves.

The "open group" approach includes both current and future participants, assuming that the system will persist into the extended future. This method evaluates whether the combination of present assets and future contributions will be adequate to meet future benefit obligations fully.

The "closed group" approach is suitable for calculating transition costs in the context of a system overhaul or structural reform, such as transitioning to a new scheme. Conversely, if the public pension system is expected to continue under a pay-as-you-go or partially funded structure, the "open group" approach, which considers both current and prospective participants' contributions and entitlements, provides a comprehensive means by which to evaluate pension liabilities.

B. *Estimation of the Financial Shortfall in the "Old Pension" using the Closed Group Method*

If current contributors start contributing to the "New Pension" from the point of National Pension reform, it is necessary to calculate the financial shortfall of the "Old Pension" based solely on the benefits corresponding to the contributions made by current beneficiaries and contributors up to the reform date (using the "closed group without future accruals" method).

If benefits are funded only by contributions made through 2023, the benefit shortfall

[1]OECD (van den Noord and Herd, 1993), World Bank (Holzmann *et al*., 2004).

TABLE 4—ESTIMATED BENEFIT SHORTFALL BY NATIONAL PENSION REFORM TIMING

(Unit: Trillion KRW, %, %p)

Reform Year	2024 Reform (A)	2029 Reform (B)	Difference (B-A)
Benefit Shortfall (Unfunded Liability) (% of GDP)	609.0 (26.9)	869.9 (38.4)	260.9 (11.5)

is estimated to be 609.0 trillion KRW (26.9% of GDP, present value as of 2023[2]). Park (2023) estimated the unfunded liabilities as of 2021 as 599 trillion KRW using the same closed group method, with differences from this study primarily due to variations in the base year and benefit projection methods.[3] The shortfall in the "Old Pension" benefits should not be covered by the "New Pension" reserve fund. Instead, it would be prudent to consider gradually injecting general revenue equivalent to 1% of GDP per year over the next 25 years to improve the sustainability of the National Pension system.

If National Pension reform is delayed by five years, and benefits are funded by contributions paid through 2028, the benefit shortfall would be 869.9 trillion KRW (38.4% of GDP, present value as of 2023[4]). This represents an increase of 260.9 trillion KRW (an additional 11.5 percentage points of GDP) compared to the implementation of the structural reform in 2024.

C. *Estimation of the Financial Shortfall using the Open Group Method*

If the National Pension system continues for an extended period without reform, it is necessary to estimate the increase in the financial shortfall (unfunded liability) using the open group method. In this method, if the evaluation period is t, assets are defined as the sum of the current reserve fund at the evaluation date and the present value of total contributions over t years from the evaluation date. Liabilities are defined as the present value of total benefit expenditures over t years from the evaluation date. The financial shortfall (unfunded liability) is then calculated by subtracting the assets from the liabilities at the evaluation date.

As of 2023, the estimated financial shortfall for the next 77 years (until 2100) is as follows[5]: the current reserve fund is 1,015.8 trillion KRW, the present value of

[2]In this calculation, the benefit shortfall is derived by applying the fund's investment return rate as the discount rate across all periods. If the three-year government bond rate is used as the discount rate instead, the shortfall is estimated to be 1,525.5 trillion KRW (67.3% of GDP, present value as of 2023). Additionally, this calculation only considers old-age pension benefits. Including survivor and disability pension benefits would increase the total benefit shortfall.

[3]Park (2023) employs an indirect estimation method for calculating unfunded liabilities using an intergenerational net benefit model. This approach estimates the total expected pension benefits and total contributions to be paid during the employment period. The unfunded liabilities are then calculated by assuming that, at the point of pension reform, only a portion of the total pension benefits corresponding to the ratio of contributions already paid is guaranteed.

[4]Similarly, if the three-year government bond rate is applied as the discount rate across all periods, the benefit shortfall is estimated to be 2,213.4 trillion KRW (97.6% of GDP, present value as of 2023).

[5]Here, the discount rate applied is the fund's investment return rate used in this study, to allow for comparisons with previous research.

contributions over 77 years (until 2100) is 2,245.3 trillion KRW, and the present value of benefit expenditures over 77 years (until 2100) is 5,582.3 trillion KRW.[6] Therefore, the financial shortfall is calculated as 2,321.3 trillion KRW (102.4% of GDP).

Shin and Choi (2022) used the results of the 4th fiscal recalculation to estimate unfunded liabilities using the "open group" method, yielding a value of 1,735 trillion KRW for the next 70 years (2018–2088) and 3,453 trillion KRW for the next 150 years (2018–2168), based on the present value as of 2022.

D. *Policy Implications of the Financial Shortfall*

If the transition to a defined contribution (DC) scheme introduces a "New Pension" to ensure the long-term sustainability of the pension fund, it will be necessary to establish a plan for continued pension payments under the "Old Pension" for current beneficiaries and existing contributors whose contributions were made under the defined benefit (DB) system. Additionally, the shortfall in the "Old Pension" should not be covered by the reserve fund of the "New Pension." Instead, it would be prudent gradually to allocate general fiscal resources, secured through taxes or expenditure restructuring, to the "Old Pension" to enhance the sustainability of the National Pension system.

The analysis in this study indicates that the financial shortfall of the "Old Pension" increases rapidly the longer pension reform is delayed. To reduce the burden on general government finances related to the shortfall in the pension fund, it is advisable that reform of the National Pension be implemented as soon as possible.

VI. Conclusion

As examined in Chapter III, while raising the contribution rate is necessary for ensuring the sustainability of the National Pension system, such a strategy is insufficient to resolve the issue of fund depletion on its own. The primary reasons for this are the rapidly aging population and an unprecedentedly low birth rate, which significantly impact the demographic structure.

Therefore, it is crucial to not only increase the contribution rate but also to transition to a funded defined contribution (DC) system. This approach would allow the pension system to better adapt to demographic changes while also ensuring intergenerational equity and enhancing long-term sustainability. As discussed in Chapter 4, a DC-type structure would prevent the depletion of the pension fund even if the demographic situation deteriorates beyond current projections. In a DC system, the adequacy of retirement income would largely depend on the level of the contribution rate increase.

[6]Here, only old-age pension benefits are considered. Including survivor and disability pension benefits could increase the benefit shortfall.

If the sustainability of the National Pension can be secured through a DC-based "New Pension," it would be necessary to consider covering the financial shortfall of the "Old Pension" through general government revenues. The key point is that pension reform should be implemented as soon as possible to minimize the burden on public finances caused by the shortfall in the pension fund.

In a cohort-based DC system, it is possible to incorporate an income redistribution function or to establish it as income-proportional. However, it is evident, even without a detailed analysis, that even with an income redistribution function, the pension benefits for low-income retirees under a cohort-based DC system are likely to fall short of providing a minimum level of retirement income compared to the current DB system.

Therefore, to ensure adequate retirement income for low-income retirees, it is essential to discuss reforms to the Basic Pension system alongside reforms to the National Pension.

APPENDIX

A. *Detailed Revenue Projection Method*

The detailed method for projecting the number of contributors follows the equations below.

$$Ins_t(i,j) = pop_t(i,j) \times epop_t(i,j)$$
$$Ins_t(i,j,k) = Ins_{(t-1)}(i,j-1,k) \times move(i,j,k) + emem_t(i,j,k) \times npop(i,j,k)$$

Here, $emem$ represents the economically active population, pop denotes the total population, $epop$ is the labor force participation rate, Ins indicates the number of contributors, $move$ represents the transition rate, and $npop$ denotes the new entrant rate. Additionally, i indicates gender (m for male, f for female), j represents age (18–59 years), and k classifies contributor types (w for workplace, r for regional, h for pending contributors).

The contribution unit price for workplace contributors is calculated by applying the nominal wage growth rate to the standard monthly income and then multiplying this value by the contribution rate. For regional contributors, the unit price is calculated by applying the income ratio of regional contributors relative to workplace contributors' income to the standard monthly income and then multiplying by the contribution rate. In this calculation, the standard monthly income for both workplace and regional contributors, segmented by gender and age, is estimated using income indices categorized by contributor type, gender, and age.

$$Income_t(i,j,k) = A_t \times Income_index(i,j,k)$$

In this equation, $Income$ represents the standard monthly income, calculated by gender, age, and contributor type. $Income_index$ is the income index, categorized by gender, age, and contributor type, showing its relationship to the value A, which represents the average income of all National Pension contributors over the past three years. Similar to contributors, i indicates gender (m for male, f for female), j represents age (18–59 years), and k denotes contributor type (w for workplace, r for regional, h for pending).

Based on this, contribution revenue can be reorganized as follows:

$$\text{Contribution Revenue} = \sum_{i=1}^{2}\sum_{j=18}^{59}\sum_{k=1}^{3} Ins_t(i,j,k) \times Income_t(i,j,k) \times 9\% \times Collection\ Rate_t(k)$$

Fund investment returns are calculated by multiplying the reserve fund at the end of the previous year by the fund investment return rate. The investment return rate is based on the projections provided in the 5th National Pension Financial Calculation results.

B. *Detailed Expenditure Projection Method*

First, the number of old-age pension beneficiaries is projected by applying the pension eligibility age and gender-based contribution period fulfillment rates.

$$\begin{aligned}&\text{Old-Age Pension}\\ &= \text{number of Old-Age Pension Beneficiaries} \times \text{Old-Age Pension Unit Price}\\ &= \sum_{i=1}^{2}\sum_{j=S}^{100} amem_t(i,j) \times age_t(i,j)\end{aligned}$$

Here, $amem$ represents the number of old-age pension beneficiaries, and age denotes the old-age pension unit price. i indicates gender (m for male, f for female), and j represents age (S~100 years, where S is the starting age for old-age pension benefits).

The number of old-age pension beneficiaries is calculated by excluding deceased individuals from the previous year's old-age pension beneficiaries,

$$amem_t(i,j) = amem_{(t-1)}(i,j-1) \times (1 - M_t(i,j))$$

where M represents the mortality rate.

The old-age pension unit price at the start of pension receipt is calculated by combining the annual income replacement rate during the contribution period with the average income of all contributors over the three years preceding benefit receipt (A-value) and the income by gender and contribution period for beneficiaries (B-value). For contribution periods exceeding 20 years, an additional 5% is added. After the pension begins, the pension amount is assumed to increase annually based on the inflation rate projected by KDI.

$$age_t(i,j) = RI \times (A_t(i,j) + B_t(i,j,k)) \times (1 + 0.05 \times n)$$
$$age_t(i,j) = age_{(t-1)}(i,j-1) \times (1 + CPI_t)$$

In this equation, RI represents the income replacement rate at the time of enrollment, A is the average standard monthly income for the past three years (the A-value), B is the average standard monthly income of the contributor (the B-value), n represents the period exceeding 20 years, and CPI stands for the consumer price inflation rate.

For early old-age pensions, the number of beneficiaries is projected by multiplying the number of eligible contributors by the gender- and age-specific benefit take-up rate.

$$\begin{aligned}&\text{Early Old-Age Pension}\\&= \text{Number of Early Old-Age Pension Beneficiaries}\\&\qquad \times \text{Early Old-Age Penson Unit Price}\\&= \sum_{i=1}^{2} \sum_{j=(S-5)}^{100} emem_t(i,j) \times eage_t(i,j)\end{aligned}$$

Here, $emem$ represents the number of early old-age pension beneficiaries, and $emem$ denotes the early old-age pension unit price.

The number of early old-age pension beneficiaries is calculated by multiplying the number of contributors by the early old-age pension take-up rate. Subsequently, the number of beneficiaries is adjusted each year by excluding deceased individuals from the pool of initial beneficiaries.

$$emem_t(i,j) = Ins_t(i,j) \times EP_t(i,j)$$
$$emem_t(i,j) = emem_{(t-1)}(i,j-1) \times (1 - M_t(i,j))$$

Here, EP represents the early old-age pension take-up rate, M denotes the mortality rate, i stands for gender (m for male, f for female), and j represents age (from the early old-age pension eligibility age onward).

For the early old-age pension unit price, a rate between 70% and 94% of the standard old-age pension amount is applied, depending on the period by which the pension is advanced:

$$eage_t(i,j) = age_t(i,j) \times \varepsilon$$
$$eage_t(i,j) = eage_{(t-1)}(i,j-1) \times (1 + CPI_t) \ ,$$

where ε represents the early old-age pension payment rate (70–94%) and CPI denotes the consumer price inflation rate.

The survivor pension is calculated by multiplying the number of survivor pension beneficiaries by the survivor pension unit price.

$$\begin{aligned}&\text{Survivor Pension}\\&= \text{Number of Survivor Pension Beneficiaries}\\&\qquad \times \text{Survivor Penson Unit Price}\\&= \sum_{i=1}^{2}\sum_{j=ba}^{100} dmem_t(i,j) \times dage_t(i,j) + \sum_{i=1}^{2}\sum_{j=ba}^{100} dIns_t(i,j) \times dage_t(i,j)\end{aligned}$$

In this equation, $dmem$ represents the number of survivor pension beneficiaries upon the death of an old-age pension recipient, $dIns$ represents the number of survivor pension beneficiaries upon the death of a National Pension contributor, and $dage$ denotes the survivor pension unit price.

The number of survivor pension beneficiaries is projected by applying the gender- and age-specific survivor rate to cases in which a contributor or pension recipient passes away and meets the eligibility conditions for the survivor pension.

$$dmem_t(i,j) = amem_t(i,j) \times M(i,j) \times f_a$$
$$dmem_t(i,j) = dmem_{(t-1)}(i,j-1) \times (1 - M_t(i,j))$$
$$dIns_t(i,j) = Ins_t(i,j) \times M(i,j) \times f_a$$
$$dIns_t(i,j) = dIns_{(t-1)}(i,j-1) \times (1 - M_t(i,j))$$

Here, f_a represents the survivor rate, and i indicates gender (m for male, f for female), while j represents the age of the survivor pension recipient.

The survivor pension unit price is calculated by applying a rate of 40% to 60% of the deceased contributor's or former contributor's (pension recipient's) benefit, depending on the length of their contribution period:

$$dage_t(i,j) = age_t(i,j) \times \beta$$
$$dage_t(i,j) = dage_{(t-1)}(i,j-1) \times (1 + CPI_t)$$

where β represents the survivor pension payment rate, applied as a percentage of the basic pension amount: 40% for less than 10 years of contribution, 50% for 10 to 20 years, and 60% for more than 20 years of contribution.

A beneficiary eligible for dual benefits arises when a survivor pension recipient reaches the old-age pension eligibility age. Whether they qualify for dual benefits depends on the proportion of old-age pension recipients at that age. Based on the projected number of old-age pension recipients by year and gender, the proportion of those eligible for dual benefits is calculated by year, gender, and age. This proportion is then applied to the number of survivor pension recipients reaching the old-age pension eligibility age to estimate the number of dual-benefit recipients.

The rate at which old-age pensions are chosen among eligible dual-benefit recipients is determined by the length of the contribution period and the gender of the survivor. If the old-age pension is chosen, 30% of the survivor pension amount is added to the recipient's full old-age pension, making up the total benefit amount for dual-benefit recipients. Conversely, if the survivor pension is chosen, the recipient does not receive an old-age pension and thus does not qualify for dual benefits.

The disability pension is calculated by multiplying the number of disability pension beneficiaries by the disability pension unit price.

$$\begin{aligned}&\text{Disability Pension}\\&\quad=\text{Number of Disability Pension Beneficiaries}\\&\qquad\times\ \text{Disability Pension Unit Price}\\&=\sum_{i=1}^{2}\sum_{j=da}^{100} pmem_t(i,j) \times page_t(i,j)\end{aligned}$$

Here, $pmem$ represents the number of disability pension beneficiaries, and $page$ denotes the disability pension unit price.

The number of disability pension beneficiaries is projected by applying the disability incidence rate by gender and age to the pool of National Pension contributors, based on their contribution periods:

$$pmem_t(i,j) = Ins_t(i,j) \times p(i,j)$$
$$pmem_t(i,j) = pmem_{(t-1)}(i,j-1) \times (1 - M_t(i,j)) \ ,$$

where p represents the disability incidence rate, with i indicating gender (m for male, f for female) and j representing the age of the disability pension beneficiary.

The disability pension unit price is calculated by applying a rate of 60% to 100%, depending on the severity level of the disability.

$$page_t(i,j) = age_t(i,j) \times \gamma$$
$$page_t(i,j) = page_{(t-1)}(i,j-1) \times (1 + CPI_t)$$

In this equation, γ represents the disability pension payment rate, applied as a percentage of the basic pension amount: 100% for Grade 1, 80% for Grade 2, 60% for Grade 3, and 225% (as a lump-sum compensation amount) for Grade 4.

Once beneficiaries are assigned to each disability grade, their numbers decrease annually by applying gender- and age-specific mortality rates.

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Financial Projection of the Basic Pension under Selective Eligibility Criteria†

By DOHUN KIM*

This study conducts a financial projection of the basic pension in Korea, which provides cash assistance to the bottom 70% of elderly individuals aged 65 and over. The projection is carried out under both expansion and selective eligibility criteria, with particular emphasis on the latter. Specifically, the study examines two well-discussed selective eligibility criteria: 1) fixing the eligibility threshold at the 2024 value and adjusting it according to the inflation rate, and 2) linking the eligibility threshold to the median household income figure. To estimate the number of recipients under these selective scenarios, the study projects the future income evolution of the elderly, assuming the continuation of past income trends. Using the financial model of the basic pension developed by Shin and Kim (2021), the study finds that total fiscal spending could be reduced by 22% under the first selective scenario and by 17% under the second selective scenario, relative to the current system, in real terms between 2024 and 2070. With these fiscal savings, the study concludes that the full benefit amount could be increased from the current level of 334,810 won to 435,000 won under the first scenario and to 405,000 won under the second scenario by 2025.

Key Word: Basic Pension, Selective Eligibility Criteria, Pension Reform, Elderly Poverty, Financial Model of Basic Pension
JEL Code: H53, H55, I31, J10

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I. Introduction

Although Korea has experienced rapid economic growth over the past few decades, the poverty rate among the elderly ranks at the highest level among OECD countries. One of the main reasons for this high poverty rate can be attributed to the immature national pension system of Korea, which was introduced only in 1988. Due to the short history of the pension system, older generations did not have enough time for the national pension benefit to mature and were unable to prepare for an adequate amount of retirement income. To tackle the high poverty rate of the elderly, the government implemented a basic pension, a non-contributory pension system that provides monthly cash payments to elderly individuals aged 65 and above whose recognized amount of income (hereafter, RAI) falls below the top 70% of their age group.[1]

From 2014 to 2024, the maximum benefit amount of the basic pension has increased by nearly 62%, from 200,000 won to 334,810 won. Moreover, due to the aging population, the number of basic pension recipients has increased by 45%, from approximately 435,000 to nearly 624,000 recipients. As both the benefit amount and the size of the elderly population aged 65 and above have increased significantly, the expenditure on the basic pension has also risen substantially. As of 2023, the basic pension system has become one of the largest welfare programs in Korea, accounting for 1% of GDP, and it is projected to increase even further.

Recently, the current selection criteria of the basic pension, which targets the poorest 70% of the elderly aged 65 and above, have received criticism for not being a cost-effective way to address the high poverty rate among the elderly. In particular, there is no clear rationale behind why the basic pension should target 70% of the elderly population despite the fact that the economic condition of the new elderly generation reaching age 65 has improved significantly. For instance, while the bottom 70% threshold income amount that determines the eligibility for the basic pension was only 56% of the median income in 2015, it increased to 94% of the median income by 2023, implying that the elderly covered by the basic pension system have become more affluent relative to the past.

The OECD pension report on Korea suggested a narrowing down of basic pension recipients and an increase the benefit amount to tackle the poverty rate of the elderly more effectively (OECD, 2022). The Basic Pension Adequacy Evaluation Committee, an advisory body to the Minister of Health and Welfare, also suggested that the current selection criteria be transformed from a target population method to absolute criteria so that the number of recipients can gradually decline as the economic condition of the new elderly generation improves relative to the overall population. There have been several specific proposals by different researchers to make the selection criteria more selective. For instance, Yun (2023) suggested fixing the eligibility threshold amount at the year of 2023 and adjusting it according to the

[1]The "Recognized Amount of Income" is the weighted average of various monthly income sources and assets converted into a monthly income value, which is then used to determine eligibility for the basic pension.

inflation rate. Others suggested setting the eligibility threshold line relative to the median income (Basic Pension Adequacy Evaluation Committee, 2023).

Despite the importance of conducting financial projections based on selective scenarios, there has been limited research on this subject. While NABO (2018; 2023a) considers a selective scenario in which the benefit amount varies across different RAI levels among the elderly, it does not perform a financial projection for a scenario in which the target group is gradually narrowed. Although Ryu *et al*. (2022) does consider a scenario in which the target group is gradually reduced, the size of the target group is artificially adjusted from 70% to 30%. However, under the aforementioned selective eligibility criteria, the number of recipients is determined by the evolution of the RAI distribution among the elderly and the median household income. Therefore, it is crucial to compute the size of the recipient group within the model based on this mechanism. One approach is to forecast the evolution of both the RAI distribution and median household income.

In this study, utilizing the financial projection model of basic pension developed by the Shin and Kim (2021), I conduct a financial projection under both expansion scenarios, in which the benefit amount and size of the recipient pool increase relative to the base case and selective scenarios in which the number of recipients is narrowed down. In particular, this study focuses on two well-discussed selective scenarios: 1) fixing the eligibility threshold amount at the year of 2024, and adjusting it according to the inflation rate (selective scenario 1), and 2) linking the eligibility threshold at the median household income (selective scenario 2).[2] These selection scenarios have strength in that as the economic condition of future generations improves, the number of recipients will gradually decrease. Furthermore, existing recipients will continue to receive benefits, therefore facing less political resistance as opposed to if the number of recipients was dramatically reduced.

This study makes a strong contribution to the literature by linking the selection criteria for basic pension eligibility to the evolution of the RAI distribution and median household income. To achieve this, it projects the future distribution of the RAI assuming that past trends will continue into the future. Specifically, it calculates the RAI for each percentile of the elderly population from 2014 to 2021 using data from the National Survey of Tax and Benefit (NaSTaB) and predicts the future evolution of the RAI for each percentile by means of linear projection. Similarly, the future evolution of median household income is forecasted based on the assumption that historical trends in the median income will persist. This information is then used to estimate the proportion of recipients under selective scenarios, serving as input for the basic pension model developed by Shin and Kim (2021) to make financial projections of expenditures.

The findings demonstrate that under the current system, the total accumulated fiscal expenditure between 2024 and 2070 amounts to 1,891 trillion won in real terms. Under the expansion scenario, where the benefit amount increases from 334,810 won to 400,000 won, the total accumulated fiscal expenditure rises to 2,236 trillion won, which is 18% higher than that of the current system. Moreover, under

[2]The eligibility threshold for a single household is 2.13 million won, and for couple households, it is 3.408 million won in 2024. In this study, as will be explained in the main section, the eligibility threshold for couple households is used to project the size of recipients under selective scenarios.

the expansion scenario, where the eligibility criteria are expanded to include all elderly individuals on top of the increase in the benefit amount from 334,810 won to 400,000 won, the total accumulated fiscal expenditure rises to 3,191 trillion won, which is 69% higher than that of the current system. On the other hand, under the selective scenarios, as the proportion of recipients gradually declines from 70% to nearly 50% of elderly individuals aged 65 and above between 2024 and 2070, the total accumulated fiscal expenditure also decreases significantly. Specifically, the total accumulated fiscal expenditure declines by 22% relative to the current system under selective scenario 1 and by 17% under selective scenario 2. Utilizing the savings from each selective scenario, this study demonstrates that the full benefit amount of the basic pension can be increased to 435,000 won and to 405,000 won in 2025 under selective scenarios 1 and 2, respectively, without incurring additional fiscal spending compared to the current system. These results indicate that implementing selective eligibility criteria can provide the government with the financial flexibility to increase benefit amounts by specifically targeting the poorer group in relative terms among the elderly.

The paper is divided as follows: section 2 provides an overview of the basic pension, including the history of the institution and detailed information pertaining to the selective eligibility criteria. Section 3 explains the forecast model of the basic pension and the method used to forecast the future distribution of the RAI using data from the National Survey of Tax and Benefit. Section 4 presents the financial projection results of the basic pension under both expansion and selective scenarios. Finally, section 5 discusses the results and concludes the paper.

II. Overview of Basic Pension Income

A. *History of the Basic Pension*

Due to its relatively short history, the national pension system in Korea, which was only introduced in 1988 and later extended to cover the entire population, has not yet matured enough to serve fully as an old-age income security system. Given that a large portion of the elderly did not have sufficient time to contribute to the system and secure an adequate pension, the government introduced a cash assistance program in 1991 to supplement the income of the poor elderly in the form of an old-age allowance. However, this program was criticized for its limited effectiveness in reducing the high elderly poverty rate due to the small benefit amounts and restricted target group.

In 2008, the government introduced what was termed the basic old-age pension system, the predecessor of the basic pension.[3] It is a non-contributory public pension program that provides monthly cash assistance to elderly individuals whose RAI falls within the bottom 70% among those aged 65 and over. The benefit amount was set

[3]The major difference between the old-age pension and the basic pension in terms of system operation is that, under the former, government had the discretion to reduce the number of recipients based on budget constraints.

to the 5% of the A value, which is the average salary of national pension contributors over the last three years, and it included a 20% reduction rate for the married-couple households. As of 2014, the benefit amount was 99,100 won for single households and 158,600 won for married-couple households. It also introduced an income-reverse prevention-reduction scheme which reduces the basic amount to prevent cases in which a beneficiary's income exceeds the income of non-beneficiaries after accounting for the basic pension.

The discussion on introducing the basic pension system began due to growing social concern over elderly poverty and gained momentum during the 18th presidential election when candidates proposed introducing the system to expand income security for the elderly. As a result, the basic pension system was introduced following the enactment of the Basic Pension Act, which expanded the existing basic old-age pension system. While maintaining the eligibility criteria for elderly individuals aged 65 and over whose RAI falls within the bottom 70%, the basic pension system further enhanced old-age income security by increasing the full benefit amount from 5% to 10% of the A value. Consequently, the full benefit amount increased to 200,000 won for single households and 160,000 won for married-couple households. While retaining the income-reversal prevention-reduction scheme, the basic pension also introduced a reduction scheme in the benefit calculation for recipients who concurrently receive the national pension. The reduction rate varied according to the A value of the national pension. The history of the basic pension is summarized in Table 1.

TABLE 1—HISTORY OF THE BASIC PENSION

System	Old-Age Allowance	Senior Pension	Basic Old-Age Pension	Basic Pension
Year of Implementation	1991	1998	2008	2014
Beneficiaries	Low-income seniors aged 70 and above → seniors aged 65 and above who are eligible for livelihood protection	Low-income seniors aged 65 and above	Seniors aged 65 and above in the bottom 70% income bracket	Seniors aged 65 and above in the lowest 70% income bracket
Benefit Amount	35,000~50,000 won	20,000~50,000 won	5% of the A value of the National Pension	10% of the A value of the National Pension
Reduction	-	12.5% reduction for a couple two beneficiaries	20% reduction for a couple of two beneficiaries, income-reversal prevention adjustment	20% reduction for a couple of two beneficiaries, income-reversal prevention adjustment, reduction linked to the National Pension
Benefit Adjustment	-	-	Adjusted according to the National Pension A value	Linked to the national consumer price index (CPI) fluctuation rate; adequacy evaluation conducted every five years

Source: NABO, "2018-2027 Estimation of the Expenditure for the Basic Pension," 2018, p.10.

TABLE 2—FORMULA FOR THE RAI CALCULATION

RAI = Income Assessment Amount 1) + Assets Converted Income 2)	
1) RAI = {0.7 * (Labor Income – Labor Income Deduction amount) + other income*	
*	The labor income deduction amount is the amount of income that is deducted to ensure that work motivation is not hindered and it is based on the minimum income level (1.8 million Korean won as of 2023).
**	Other income is the sum of business income, public transfer income, imputed rent income and property income, with an annual deduction of 40,000 won applied to interest income included in property income.
2) Asset-converted income = [{(general assets – basic asset amount*) + (financial assets – 20 million won) – liability}× income conversion rate for assets** ÷ 12] + P***	
*	The basic asset amount refers to the minimum amount required for housing maintenance (as of 2023, metropolitan cities: 135 million won, medium-sized cities: 85 million won, rural areas: 72.5 million won)
**	4% annual rate
***	value of luxury automobiles (over 3,000cc or over 40 million won) and membership rights

Source: Ministry of Health and Welfare, "2023 Basic Pension Program Guidelines," 2023.

The eligibility criteria for the basic pension are based on the elderly whose RAI falls below the 70th percentile among those aged 65 and over. However, civil servants and military pension recipients, as well as their spouses, are excluded from eligibility. The RAI, which serves as the basis for determining eligibility, is calculated by summing the assessed income amount, including labor, business, and asset income, as well as the income-converted amounts of assets. The exact process for calculating the RAI is detailed in Table 2. RAI amounts are calculated separately for single-person households and married-couple households.

Meanwhile, as the economic conditions and national pension benefits for the new elderly generation have improved, the eligibility threshold, which is set at the 70th percentile of the RAI among those aged 65 and over, has continued to increase, as shown in Figure 1. For instance, in 2014, the eligibility threshold for single-person households was 870,000 won, and for married-couple households, it was 1,392,000 won. By 2024, these amounts had increased to 1,392,000 won and 3,230,000 won, respectively.

The full basic pension amount refers to the maximum pension that recipients can receive if they are not subject to any reduction schemes, such as 1) a National-Pension-linked reduction, 2) the income-reversal prevention reduction, and 3) a spousal reduction. The National-Pension-linked reduction applies to recipients who receive a national pension benefit that exceeds 150% of the full basic pension amount. The proportion of national pension recipients among basic pension recipients increased from 30.4% in 2014 to 46.6% in 2022 (Kim, 2023). The income-reversal prevention reduction is applied when the sum of the benefit amount and pre-benefit RAI exceeds the eligibility threshold; this is done to minimize the income reversal between beneficiaries and non-beneficiaries. Approximately 3% of recipients are subject to the income-reversal prevention reduction. The spousal reduction applies to married couples, imposing a 20% reduction on each individual's benefit.

The full basic pension amount is adjusted relative to the inflation rate and has been gradually increasing due to a few jumps in 2018 and 2021. While the full basic pension amount is fixed at the 10% of the A value, which is the average salary of

national pension contributors in last three years, it increased to 11% of the A value (250,000 won) in 2018 and 11.8% of the A value (300,000 won) in 2021, as shown in Figure 2.

The number of basic pension recipients increased gradually from 4.35 million in 2014 to 6.23 million in 2022 due to rapid aging, as shown in Table 3. As a result, the financial expenditure of the basic pension has more than doubled, rising from 9.68 trillion won in 2015 to 20.09 trillion won in 2022.

(Unit: 10,000won)

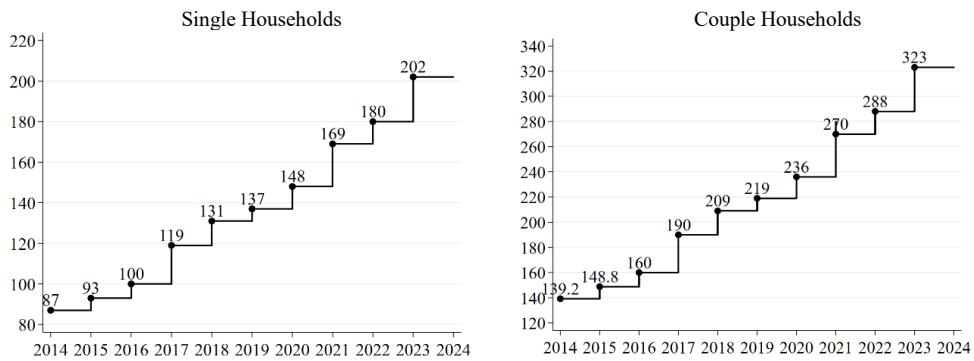

FIGURE 1. ANNUAL ELIGIBILITY THRESHOLD OF THE BASIC PENSION

Source: NABO, "2018-2027 Estimation of the Expenditure for the Basic Pension," 2018, p.10; Ministry of Health and Welfare, "Basic Pension Program Guidelines," 2014-2024.

(Unit: won)

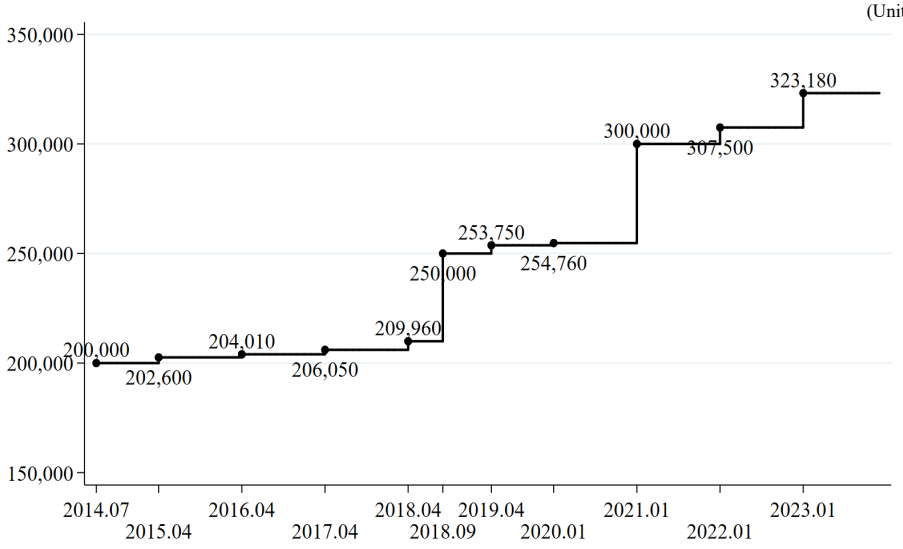

FIGURE 2. ANNUAL FULL BENEFIT AMOUNT OF THE BASIC PENSION

Source: NABO, "2018-2027 Estimation of the Expenditure for the Basic Pension," 2018, p.12; *Public Pension Reform and Long-term Projections I*, 2023a, p.14.

TABLE 3—NUMBER OF BENEFICIARIES AND FINANCIAL STATUS OF THE BASIC PENSION EXPENDITURE

(Unit: Thousands, 10 Billion won)

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of Beneficiaries	4,353	4,495	4,581	4,869	5,216	5,346	5,660	5,973	6,239
Expenditure	462	968	991	1,053	1,196	1,478	1,669	1,890	2,009

Source: NABO, *2018~2027 Estimation of the Expenditure for the Basic Pension*, 2018, p.8; *Public Pension Reform and Long-term Projections I*, 2023a. pp.13~14.

B. *Selective Eligibility Criteria*

The purpose of the basic pension was to provide a secure income for poor elderly people in order to address the high elderly poverty rate in Korea, which is mainly due to the immature national pension system.

However, the current eligibility criteria for the basic pension, which targets the bottom 70% of the RAI among those aged 65 and over, is not cost-effective with regard to how well it addresses the high poverty rate among the elderly. In that the basic pension targets 70% of the elderly population, increasing the benefit amount of the basic pension will result in large fiscal expenditures in the future. For example, fiscal expenditure on the basic pension is projected to reach 1.5% of GDP by 2050 and 1.2% of GDP by 2070, even if the benefit amount remains fixed in real terms at the current level due to Korea's rapid aging population (NABO, 2023a). Although the basic pension system has a reduction mechanism that reduces the benefit amount for those whose national pension income exceeds 150% of the maximum basic pension benefit, this reduction system has become less effective in fulfilling its role, as the maximum basic pension benefit has increased substantially, outpacing the increase in national pension income such that only a small proportion of the elderly receiving a national pension are actually subject to the reduction system (Ryu *et al*., 2022).

Moreover, as the national pension system has matured and economic conditions have improved, relatively economically well-off elderly households have become eligible for the basic pension. In particular, the eligibility threshold, which is the bottom 70% of the RAI, has been rising. For example, while the bottom 70% of the RAI among the elderly amounted to only 50% of the median household income in 2015, it increased to almost 93% of the median household income in 2023. At the current rate, the eligibility threshold is projected to exceed the median household income level.

Therefore, in order to make the basic pension system more cost-effective in terms of its ability to address the high poverty rate in Korea, one approach is to make the eligibility criteria more selective by setting an absolute eligibility threshold. Currently, several proposals in relation to this exist in the literature. For example, Yun (2023) suggested setting the eligibility criteria at the level of 2023 and then increasing the benefit amount according to the inflation rate. The Basic Pension Adequacy Evaluation Committee suggested setting the eligibility line at 50% or 100% of the median household income. In both cases, the number of beneficiaries will decrease compared to the current system as the income of the elderly improves.

In this study, I carry out financial projections of two selective criteria: 1) setting the eligibility threshold at 2023 levels and increasing it by the rate of inflation, and 2) setting the eligibility threshold at 100% of the median income level.[4] The first proposal has the advantage of gradually reducing the size of the beneficiary population, as new retirees receive relatively high retirement incomes. In addition, this proposal would not exclude current beneficiaries, which may be advantageous in terms of gaining social acceptance to promote the reform. However, one concern with this proposal is that the number of beneficiaries may decrease significantly, and there is no lower limit. Therefore, it is imperative to establish a floor. I set this as 50% of the median household income, which is often used as a measure of relative poverty, for the present proposal. The second proposal has the advantage of making the eligibility condition relative to the median household income, which is often used as a welfare eligibility criterion. Therefore, the basic pension may be more consistent in terms of eligibility criteria with other welfare programs. However, it is possible that if the growth rate of the median household income exceeds the growth rate of the RAI for the elderly, the number of recipients under second selective scenario may in the future become higher than in the current system.

III. Financial Projection Model of the Basic Pension

A. *Literature Review of the Financial Projection Model of the Basic Pension*

Notable studies that develop basic pension projection models and conduct fiscal projections include NABO (2018, 2023a) and Shin and Kim (2021). These studies employ a stock approach to forecast the future fiscal expenditures of the basic pension system, achieved by multiplying the number of recipients by the average benefit amount, as determined by the following methodology.

First, these studies categorize recipients into eight distinct groups, reflecting differences in the benefit calculation for: 1) married couples, 2) those who concurrently receive both the national and basic pensions (hereafter referred to as concurrent recipients), and 3) those subject to income-reversal prevention measures. The number of recipients in each group is estimated using future population projections from the National Statistics Office, projections of the number of pension recipients from the fourth National Pension Financial Estimation Committee, projections of the future proportion of pension recipients among basic pension recipients, and historical ratios for each group as provided by Shin and Kim (2021). The average benefit amount for each group is then calculated by applying a reduction rate or an actual reduction formula to the maximum benefit amount.

Meanwhile, Shin and Kim (2021) sought to reflect the projection process more accurately compared to existing models by more fully accounting for the fact that the proportion of concurrent beneficiaries and the average benefit amount increase

[4]I assume the second selective eligibility criteria, which links the eligibility threshold to the median income, only takes in effect when the original eligibility criteria, which is 70th percentile of RAI exceeds the median income.

as the national pension system matures. Specifically, to project the number of concurrent beneficiaries among the bottom 70% more precisely, first they estimated the number of concurrent beneficiaries in the top 30% and then subtracted this figure from the total number of pension beneficiaries projected in the fourth National Pension Financial Estimation Committee. They chose to focus on the top 30% rather than the bottom 70% because the former shows a more consistent trend. The future number of concurrent beneficiaries among the bottom 70% is more uncertain, as this group includes a significant number of elderly individuals over 70 who receive a special pension introduced specifically for those who were already too old to satisfy the minimum contribution period when the national pension system was established in 1988. As the number of these elderly individuals receiving the special pension decreases, the number of concurrent beneficiaries among the bottom 70% may decrease rapidly.

Moreover, the strength of Shin and Kim's (2021) projection model lies in its use of an actual formula for calculating the reduction rate for simultaneous recipients. The reduction rate is applied to simultaneous recipients when the national pension benefit exceeds 150% of the maximum basic pension benefit. This rate is applied differentially depending on the portion of the national pension benefit associated with the A value.[5]

In contrast, NABO (2018) does not use an actual reduction formula for concurrent recipients. Instead, it applies a reduction rate derived from historical data that is based on the strong assumption that the reduction rate applied to concurrent recipients will remain consistent over time. However, merely applying a constant reduction rate rather than an actual reduction formula fails to capture the potential non-linear relationship between the maximum basic pension benefit and the reduction rate. This non-linear relationship can be accurately modeled by incorporating an actual reduction formula into the projection model.

Another distinguishing feature of Shin and Kim's (2021) projection model is its ability to incorporate differentiation strategies for gender, age, and type of national pension (early old-age pension, special pension, normal old-age pension) when calculating the reduced benefit amount. Because benefit levels vary according to these characteristics, the reduction size associated with each category should also differ. Therefore, it is crucial to forecast the reduction size by categorizing concurrent recipients into these distinct groups.

For the reasons stated above, this study employs the basic pension model implemented by Shin and Kim (2021). However, due to data limitations, the study applies a simplification process. First, because information pertaining to estimated old-age national pension benefits is lacking, this study uses the most recent estimates of the national pension (early old-age pension, special pension, normal old-age pension), assuming they increase according to the inflation rate. Consequently, the estimated old-age national pension benefits used in this study to project fiscal spending may be lower than the actual estimates, as the national pension system in Korea is maturing. This implies that the reduction level applied to simultaneous

[5]The national pension benefit consists of two parts: 1) the part associated with the A value, which is the average monthly salary of the pension participant, and 2) the part associated with the B value, which is the average monthly income of the individual during the contribution period.

recipients may be underestimated, which could result in an overestimation of fiscal spending. Therefore, caution is warranted when interpreting the fiscal spending estimates in this study.

Second, the proportions of recipient types apart from concurrent recipients are based on the values as of June of 2021. One caveat when using previously determined numbers of recipient types introduces a disadvantage in that such an approach does not reflect the trend over time of the size of each group. To do this, it is necessary to the access National Pension Administrative Data to find and use previous size calculations for each recipient type. However, such data are not made available to the public.

B. *Basic Pension Projection Model Formula*

The model is based on the fiscal projection model developed by Shin and Kim (2021). To project the fiscal expenditure of the basic pension, this study categorizes recipients into eight different types according to the following criteria: 1) the status of their reception of national pension benefits, 2) family type (singles or married couples), and 3) whether the income-reversal prevention-reduction scheme applies. While the eligibility criterion for the basic pension is set as the lower 70% of the RAI for elderly individuals aged 65 and over, the rate of reduction applied to the benefit level varies for each type.

First, for those receiving a national pension benefit, the basic pension is reduced by the amount of the national pension's A benefit for each individual. Second, if both spouses receive benefits simultaneously, the benefit amount for each spouse is reduced by 20% to reflect the difference in the cost of living between single and couple households. Third, if the total amount of the basic pension and the RAI exceeds the 70th percentile of the RAI, an income reduction rate is applied.

The number of each type of recipient as of June of 2021 is shown in Table 4. There are several points to note. First, only three percent of all beneficiaries are subject to the income-reversal prevention reduction. Second, females make up a larger share of non-pensioners, who are not recipients of the national pension, compared to the number of males. However, as the duration of female enrollment to the national pension increases, the share of females among concurrent recipients is expected to increase.

The fiscal expenditure on the basic pension is calculated through the following steps. First, I calculate the population aged 65 and over. Second, I determine the number of concurrent beneficiaries among the recipients of the basic pension. Third, I calculate the average benefit amount for the national pension in each of the following four cases: 1) early old-age pension, 2) special pension, 3) normal pension with less than 20 years of contributions, and 4) normal pension with at least 20 years of contributions. Fourth, I categorize basic pension beneficiaries into eight different types, as explained above, and calculate the average basic pension benefits by applying the reduction rate for each type. The specific procedures are as follows.

TABLE 4—NUMBER OF EACH TYPE OF INDIVIDUAL RECIPIENTS (AS OF JUNE OF 2021)

Type	Classification	Spousal-Reduction	Income-Reversal Prevention Reduction	Number of Individuals in Each Type (as of June 2021)	
				Male	Female
Type 1	Non-Pensioner	○	○	8,928	36,268
Type 2		○	×	462,971	938,372
Type 3		×	○	5,155	19,372
Type 4		×	×	487,312	1,728,965
Type 5	Concurrent Beneficiary	○	○	45,021	17,683
Type 6		○	×	728,065	252,814
Type 7		×	○	25,507	12,932
Type 8		×	×	522,410	526,857

Source: Shin and Kim (2021).

Step 1: Calculation of the Number of Basic Pension Beneficiaries

For every year (t), the number of basic pension recipients (BPR) can be computed by taking 70% of the population projection of the elderly aged 65 and over.

$$N_{BP}(t) = Population_{age\geq 65}(t) \times 0.7$$

Step 2: Calculation of the Number of Concurrent Recipients

In order to forecast the number of concurrent recipients (CR), one technically needs to calculate the number of national pension recipients (NPR) among the elderly whose RAI is below the 70th percentile. However, Shin and Kim (2021) proposed a more effective means of determining the number of concurrent recipients that involves subtracting the number of elderly individuals whose RAI is in the upper 30th percentile from the total number of national pension recipients. The number of concurrent recipients can then be calculated using the proportion of national pension recipients within the upper 30% of the RAI, as provided by Shin and Kim (2021). I denote the proportion as $\alpha(t)$. The formula for calculating the number of concurrent recipients is as follows.

$$N_{CR}(t) = N_{NP}(t) - Population_{age\geq 65}(t) \times 0.3 \times a(t)$$

For selective scenarios, the number of basic pension beneficiaries is not fixed at 70% of the elderly population but gradually decreases as the RAI of the elderly improves, resulting in a smaller proportion of beneficiaries. To compute the size of

concurrent recipients under such selective scenarios, it is necessary to determine the proportion of national pension recipients whose RAI is above the kth percentile of the elderly, where k is greater than 30. For example, if the number of beneficiaries of the basic pension decreases to 60%, the number of concurrent recipients among those 60% of the elderly can then be calculated by subtracting the number of national pension recipients whose RAI is above the upper 40th percentile from the total number of national pension recipients. However, information that would inform us of the proportion of national pension recipients whose RAI is above the kth percentile of the elderly is not publicly available.

To address this, I derive the proportion of national pension recipients whose RAI is above the kth percentile of the elderly through a weighted average of two proportions: the proportion of national pension recipients among all elderly aged 65 and over, $\alpha(t)$, and the proportion of national pension recipients in the upper 30th percentile, $\alpha_{30}(t)$. I assign weights to each part of the equation based on the distance of $q_s(t)$ from 70. The closer $q_s(t)$ is to 30, the more weight is assigned to $\alpha_{30}(t)$. On the other hand, the closer $q_s(t)$ is to 70, the more weight is assigned to $\alpha(t)$. For instance, if $q_s(t)$ is equal to 0.6, the weight that is assigned to $\alpha_{30}(t)$ is then 60/70 and the weight that is assigned to $\alpha(t)$ becomes 10/70. The formula is as follows.

$$N_{CR}(t) = N_{NP}(t) - Population_{age\geq 65}(t) \times (1 - q_s(t)) \times \left\{ \alpha_{30(t)} \times \frac{q_s(t) \times 100}{70} + \alpha(t) \times \frac{70 - (q_s(t) \times 100)}{70} \right\}$$

Step 3: Calculation of Basic Pension Benefits for Each Type

Before presenting the detailed formulas for each type, first I will explain the three fundamental elements that form the basis of these formulas. First, for Type 4, which includes non-pensioners and is not subject to the income-reversal reduction, the basic pension benefit is equivalent to the full basic pension benefit without any reduction. The full basic pension benefit amount is 334,810 won as of 2024 (Ministry of Health and Welfare, 2024). Second, for types 1, 3, 5, and 7, where income-reversal prevention reduction is applied, the basic pension amount is calculated using the ratio of the reduced basic pension amount relative to the maximum basic pension amount based on actual figures from 2020 (Shin and Kim, 2021).

The formula for the basic pension benefit is as follows: when the national pension amount is 150% or less of the full basic pension amount, recipients receive the full basic pension amount. However, when the national pension amount exceeds 150% of the full basic pension amount, recipients receive a benefit amount between the full amount and half of the full amount. Specifically, when the national pension amount exceeds 200% of the full basic pension amount, the basic pension amount is reduced according to the person's A benefit of the national pension, which represents the income redistribution portion of the national pension.

The scenario in which the national pension amount exceeds 200% can be further

divided into three cases. First, if the A benefit is less than 75% of the full basic pension amount, the person receives the full basic pension amount. Second, if the A benefit falls between 75% and 150% of the full basic pension amount, the person receives a benefit amount between the full basic pension and half of the full amount. Third, if the A benefit exceeds 150% of the full basic pension amount, the person receives 50% of the full basic pension. When the national pension amount lies between 150% and 200%, the basic pension amount is the greater of the basic pension amount reduced according to the A benefit or 250% of the full basic pension amount.

The formula for the basic pension amount explained above is as follows. Specifically, the basic pension amount is calculated differentially depending on the range in which the national pension benefit amount falls: below 150%, between 150% and 200%, and over 200% of the full basic pension amount. In the formula below, BPA refers to the basic pension amount, FBPA refers to the full basic pension amount, and NatPA likewise is the national pension amount. K represents the full basic pension amount, A refers to the A benefit of the national pension, and X denotes the basic pension amount reduced according to the A benefit. Regarding the subscripts, t represents the year, a represents age, and s represents gender.

$$BP[t]=\begin{cases} FBP[t] & \text{if } NP[t,a,s] \le 1.5FBP[t] \\ \max(X[t,a,s],\ 2.5FBP[t]-NP[t]) & \text{if } 1.5FBP[t] < NP[t,a,s] \le 2FBP[t] \\ X[t,a,s] & \text{if } 2FBP[t] < NP[t,a,s] \end{cases}$$

Meanwhile, the basic pension amount, referred to as X, which is reduced based on the A benefit, is calculated as follows: X is a value between the full basic pension amount and half of that amount, depending on the value of the A benefit. As the A benefit from the national pension increases, X decreases, falling between the full basic pension amount and 50% of that amount.

$$X[t,a,s]=\begin{cases} FBP[t] & \text{if } 0 < A[t,a,s] \le \frac{3}{4}FBP[t] \\ FBP[t]-\frac{2}{3}A[t,a,s]+\frac{FBP[t]}{2} & \text{if } \frac{3}{4}FBP[t] < A[t,a,s] \le \frac{3}{2}FBP[t] \\ \frac{FBP[t]}{2} & \text{if } \frac{3}{2}FBP[t] < A[t,a,s] \end{cases}$$

The basic pension benefits for concurrent recipients vary according to the A value of the national pension benefits, as described in the formula above. Because the national pension can be broadly classified into four types based on the amount of the

pension benefit – i.e., early national pension, special pension, and normal old-age pension with less than and at least 20 years of contributions - it is important to classify recipients into these four types. The information pertaining to the proportion of recipients and the average benefit amount for each type by age and gender is taken from the 2020 National Pension Annual Report. I then use the ratio of the A benefit to the national pension benefit amount to calculate the A benefit from the average benefit amount for each type by age and gender (Shin and Kim, 2021). Then, the benefit amount for concurrent recipients can be calculated by applying the average benefit amount by gender and age and the A benefit to the reduction formula of the basic pension benefit for each type of national pension.

The fiscal expenditure of the basic pension is projected separately for each of the eight types of recipients under the assumption that the proportion of each type remains constant at the June 2021 level, as provided by Shin and Kim (2021). To predict future trends in the proportions of each type, administrative data from a source such as the National Pension Database, which is not publicly accessible, would be required. The specific procedures for the fiscal projection are included in the Appendix.

C. *Previous Financial Projection Scenarios and Results*

Previous studies presented financial projection results for the basic pension based on two scenarios: universal eligibility criteria, where the basic pension is expanded to all elderly, and selective eligibility criteria, where the target group gradually shrinks over time and the benefit amount varies according to the RAI. For example, NABO (2018; 2023a) projects that the financial expenditure of the basic pension will increase to 109.8 trillion won under the current system. In the universal eligibility scenario, where the criteria are expanded to include all elderly aged 65 and over and the benefit amount increases to 400,000 won as of 2024, the additional financial expenditure relative to the current system is projected to amount to 61 trillion won by 2090.

While NABO (2018; 2023a) did not conduct a financial projection under selective criteria where the target group gradually shrinks, it did consider selective criteria where the benefit amount is differentially paid according to the RAI. For instance, while maintaining 70% of the elderly as the eligibility criteria, it considered a selective case in which the benefit amount increases to 450,000 won for those in the bottom 40% in terms of the RAI and 400,000 won for the remaining 30% of the elderly. These results show that by 2090, the expenditure declines by 15 trillion won compared to the universal criteria case.

Ryu *et al*. (2022) conducted financial projections under selective criteria, where the size of the recipient pool shrinks only for the new generation of elderly who begin receiving the basic pension, while ensuring a minimum income level for the poor elderly by introducing a supplemental income program on top of the basic pension. Specifically, their study considered a scenario in which the basic pension amount is adjusted to 12% of the A value starting in 2023, equivalent to 326,000 won in 2023, while gradually lowering the eligibility criteria from the bottom 70% in terms of the RAI to the bottom 30% of the RAI. Under this scenario, the study shows that under

the current system, the projected expenditure amounts to 360 trillion won by 2092, whereas under the selective criteria, 195 trillion won could be saved compared to the current case by 2092.

The selective criteria considered in earlier studies are limited in that they artificially reduce the size of the recipient pool over time, rather than linking it to the income distribution of future generations. The size of the recipient pool under the currently discussed selective criteria, which either fixes the threshold at the 2023 value in real terms or links it to median household income, depends on the future evolution of the income distribution among the elderly. Therefore, this study uses the basic pension financial projection model by Shin and Kim (2021) to conduct financial projections under selective criteria, where the size of the recipient pool is determined by the evolution of the RAI distribution over time. This projection is made under the strong assumption that the future linear trend of the RAI distribution will remain consistent with the trend observed between 2014 and 2021.

D. *Forecasting the Number of Recipients under Selective Criteria*

Previous studies conducted financial projections of the basic pension under selective criteria by artificially reducing the pool of basic pension recipients over time. However, this approach has a limitation in that the pool of basic pension recipients is exogenously determined at the discretion of the researcher rather than through the actual process involving selective eligibility criteria.

Here, I explain the specific procedures for forecasting the proportion of basic pension recipients under the two aforementioned types of selective eligibility criteria: fixing the eligibility RAI threshold at the 2024 level and linking it to the inflation rate (selective scenario 1), and setting the eligibility RAI threshold to 100% of the median household income for two-person families (selective scenario 2). The critical information needed to predict the proportion of basic pension recipients under these selective scenarios is the future distribution of the RAI of the elderly, as the evolution of the number of basic pension recipients will depend on the evolution of the future distribution of the RAI.

First, the RAI for each elderly household between 2014 and 2021 can be measured using National Survey of Tax and Benefit (NaSTaB) data from 2014 to 2021 based on the RAI formula for single and couple households, as described in the Appendix. Figure 3 shows the 70th percentile of the measured RAI using panel data and the 70th percentile of the actual RAI, representing the publicly announced eligibility criteria for the basic pension by the government between 2014 and 2023 for single and married-couple households. It turns out that the accuracy of the 70th percentile of the measured RAI is much higher for couple households compared to single households. For instance, in 2022 and 2023, the measured 70th percentile RAI corresponds to 2.93 million won and 3.13 million won for couple households, very similar to the actual 70th percentile of the RAI, 2.88 million won and 3.23 million won, respectively. However, for single-person households, the discrepancy between the 70th percentile of the measured RAI and the actual RAI is relatively large compared to that for married-couple households. Hence, for simplicity, throughout the analysis here, I focus on married-couple households when estimating the future

(Unit: 10,000won)

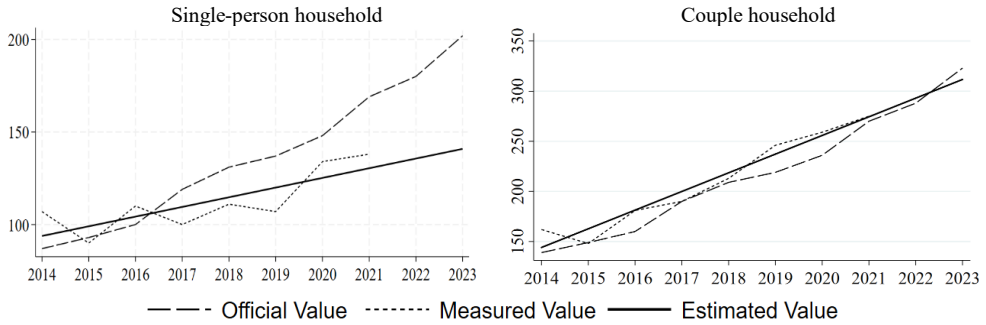

FIGURE 3. ELIGIBILITY THRESHOLD OF THE BASIC PENSION: 70TH PERCENTILE OF RAI FOR EACH HOUSEHOLD TYPE

Source: Calculated using the data from the 7th to 14th waves of the NaSTaB survey by the Korea Institute of Public Finance.

distribution of the RAI and the proportion of recipients. I assume that the future proportion of single-person households will follow that of couple households.

Second, for each year, the measured RAI is divided into percentiles. Using this measured RAI for each percentile, I run the following linear regression to derive the predicted value of the future RAI for each percentile and year.

$$\text{RAI}_{s,t} = \beta_0 + \beta_{1,s} t + \varepsilon_{s,t}$$

In this equation, s represents the percentile and t represents the year. For each percentile of the measured RAI, I use eight samples from 2014 to 2021 to estimate β_1. Table 5 reports the coefficient values, β_1, corresponding to married-couple households in each tenth percentile of the RAI. As shown in the table, β_1 increases as the percentile of the RAI increases. This implies that the growth rate of the RAI increases with the percentile of the RAI. Using the estimated coefficients from the linear regression, I predict the future RAI for each percentile for 47 periods from 2024 to 2070.

It should be noted that this analysis estimates the future distribution of the RAI under the strong assumption that each percentile of the RAI will grow linearly at a rate identical to the linear growth rate observed between 2014 and 2021. Thus, it

TABLE 5—COEFFICIENT VALUES PER EACH 10TH PERCENTILE

Percentile	10th	20th	30th	40th	50th	60th	70th	80th	90th	100th
β_1	4.774	5.049	6.167	9.0814	12.756	15.613	18.629	22.707	29.107	87.433
SE	0.626	0.444	0.324	0.603	0.682	1.137	1.725	3.804	5.679	42.993
Number of Obs.	8	8	8	8	8	8	8	8	8	8

Source: Calculated using data from the 7th to 14th waves of the NaSTaB survey by the Korea Institute of Public Finance.

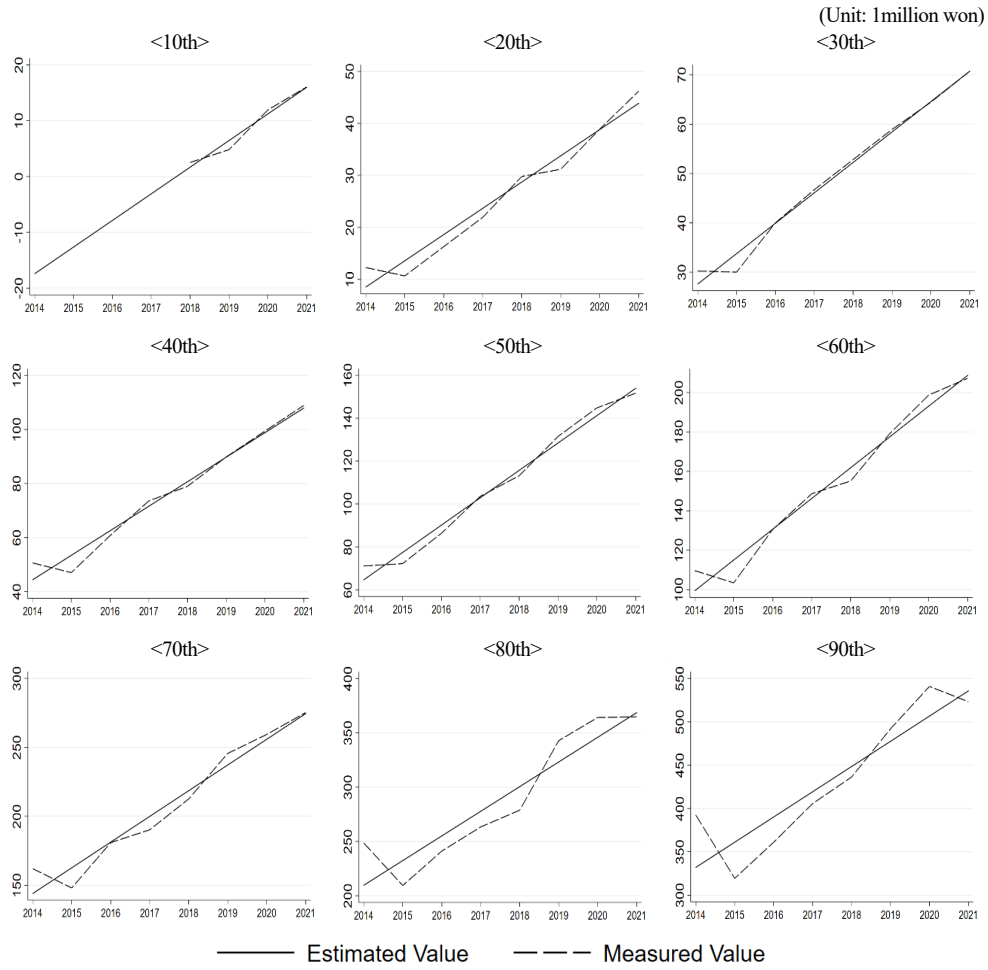

FIGURE 4. MEASURED AND ESTIMATED RAI OF COUPLE FAMILIES PER 10TH PERCENTILE (2014-2021)

Source: Calculated using the data from the 7th to 14th waves of the NaSTaB survey by the Korea Institute of Public Finance.

implicitly assumes that the changes in the inflation rate, economic growth rate, and income distribution structure observed from 2014 to 2021 will continue into the future.

Figure 4 shows both the estimated and predicted values of the RAI between 2014 and 2021 for each tenth percentile of the RAI. Because the estimated RAI increases linearly over the years, the predicted RAI, which was derived from the linear regression, matches the level and trend of the estimated RAI fairly well.[6]

Figure 5 illustrates the model fit by showing the official, measured, and estimated values for the 70th percentile of the RAI between 2014 and 2024. The official values

[6]The estimated RAI at the 80th and 90th percentiles fluctuates somewhat over the years; therefore, the difference between the predicted and estimated RAI is greater than that at the lower percentiles. However, the predicted value of the RAI at the 80th and 90th percentiles is rarely used to predict the proportion of basic pension recipients under the selective eligibility criteria.

for the 70th percentile of the RAI, reported annually by the Ministry of Health and Welfare of South Korea, represent the figures used to determine the actual eligibility criteria for the basic pension. The measured values for the 70th percentile of the RAI refer to the values obtained from NaSTaB, while the estimated values are those predicted by means of an OLS regression. The left side of Figure 5 shows the yearly official, measured, and estimated values for the 70th percentile of the RAI between 2014 and 2024, while the right side of Figure 5 displays the percent difference between the estimated and official values. The model fit for the values from 2022 to 2024 demonstrate the performance of out-of-sample forecasts, as these values are not used to estimate the parameter values of the OLS.

As shown on the left side of Figure 5, the yearly estimated and official values for the 70th percentile of the RAI exhibit a similar trend. The similarity in the level can be more accurately assessed by comparing the difference between the estimated and official values, as shown on the right side of Figure 5. The average difference between the estimated and official values from 2014 to 2024 is approximately 5.7%. When examining the yearly differences, the model's prediction performance improves as the data points become more recent.[7] Since 2021, the percentage difference has fallen below 5%. Notably, the differences are 1.8%, 3.5%, and 3.1% in 2022, 2023, and 2024, respectively, indicating relatively high forecast accuracy in out-of-sample periods.

Figure 6 shows the predicted value of the RAI for married-couple households. Specifically, the figure on the left shows the 70th percentile of the predicted RAI between 2015 and 2060 and that on the right shows the distribution of the predicted RAI between the tenth and 90th percentiles in nominal value for the years 2023, 2033,

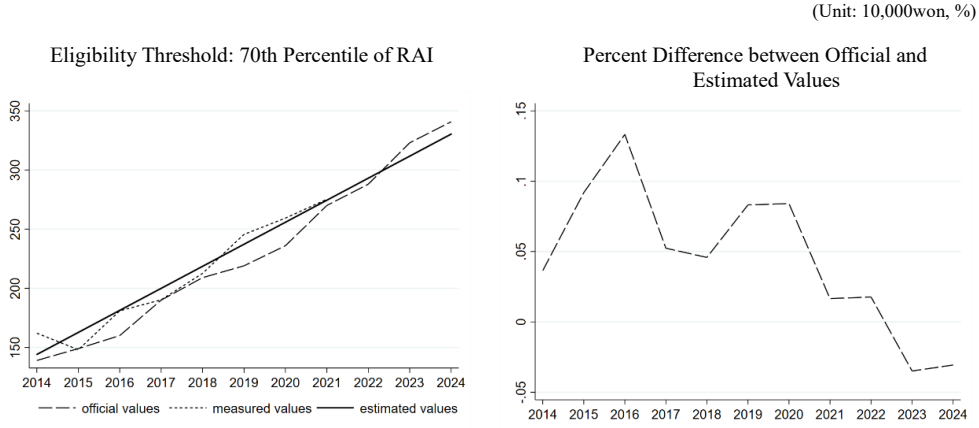

FIGURE 5. OFFICIAL, MEASURED AND ESTIMATED ELIGIBILITY THRESHOLD AND CORRESPONDING PERCENT DIFFERENCES

Source: Calculated using data from the 7th to 14th waves of the NaSTaB survey by the Korea Institute of Public Finance.

[7]The source of the difference between the estimated and the official values can be decomposed into the difference between the measured and official values and the model misspecification from the fact that linear regression is used to derive the estimated values.

(Unit: 10,000won)

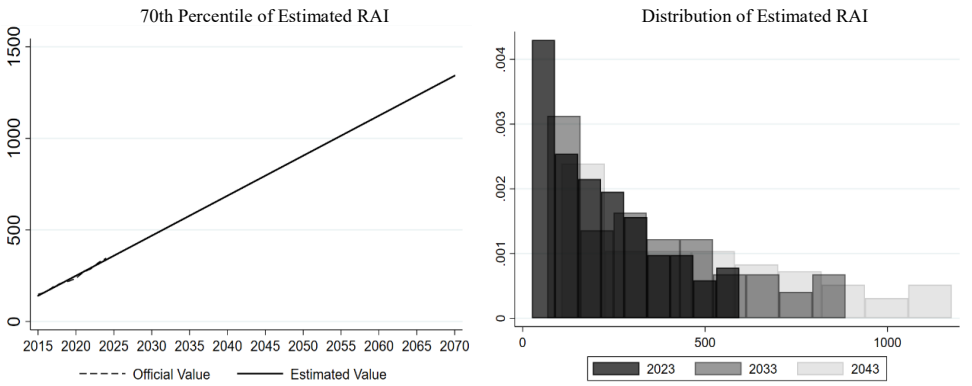

FIGURE 6. ESTIMATES OF ELIGIBILITY THRESHOLD AND DISTRIBUTION OF RAI

Source: Calculated using data from the 7th to 14th waves of the NaSTaB survey by the Korea Institute of Public Finance.

and 2043. The figure on the left shows that the eligibility threshold, the 70th percentile of the RAI, is predicted to increase to 13.4 million won for married-couple households in nominal terms in 2070, which is more than three times the 70th percentile of the RAI in 2024 at 3.408 million won. The figure on the right indicates that the distribution of the predicted RAI shifts to the right over time, which reflects the improving economic situation of future generations of the elderly.

Thus far, I have explained the specific procedures used to estimate the RAI for each percentile using National Survey of Tax and Benefit data from 2014 to 2021 and the predict the future RAI sourced from linear regression analyses. In order to derive the proportion of elderly under selective scenario 1, I calculate the proportion of the elderly below the 70th percentile of the predicted RAI in 2024 value in nominal terms, which is 3.408 million won.

Figure 7 shows the estimated proportion of recipients. Specifically, the figure on the left depicts the proportion of married-couple households below the eligibility criteria threshold in 2024 (3.408 million won), while the figure on the right shows the proportion of married-couple households below the median household income. As illustrated in the figure on the left, the proportion of married-couple households below the eligibility threshold of 3.408 million won in 2024—adjusted for 2% inflation annually—declines from 70% to 50% between 2024 and 2050 as the living standards of the new elderly generation improve. After 2050, this proportion stabilizes at 50%. This stabilization occurs because the estimated nominal value of the threshold line in 2023 follows a convex pattern due to the annual 2% increase, while the future RAI per percentile is projected under a linear trend. Consequently, my projection of recipients under selective scenario 1 may overestimate the number of recipients if the future inflation rate is lower than 2% or if the true trend of RAI is convex rather than linear.[8]

[8]The projection results from Lee, Kim, and Shin (2023) differ from those in this study because Lee, Kim, and Shin (2023) predict the 2023 threshold line by assuming a linear trend in the real-term values of the 2023 threshold

The right side of Figure 6 shows the proportion of recipients whose incomes are lower than the median income for two-person households. These results indicate that the proportion of households below the median household income gradually converges from 70% to 52% between 2024 and 2070. It is important to note that the proportion of recipients remains at 70% until 2026 because the original eligibility threshold, which is the 70th percentile of the RAI, is lower than the median income of two-person households until 2026. Therefore, selective scenario 2 only takes effect after 2026, when the 70th percentile of the RAI is projected to surpass the median income. Afterward, the rate declines gradually throughout the period between 2024 and 2070, as both the median income and the RAI are estimated under a linear trend.

The proportion of recipients declines at a faster rate under selective scenario 1 compared to scenario 2 in the short term. Figure 6 shows that the proportion of recipients under selective scenario 1 reaches 0.5 much earlier than it does under selective scenario 2. This occurs because, in the short term, the growth rate of median income exceeds the inflation-adjusted value of the eligibility threshold set in 2024. Overall, the proportion of recipients under selective scenario 1 remains lower than that under selective scenario 2. Meanwhile, it is important to assess whether the inflation-adjusted value of the 2024 eligibility threshold ever falls below 50% of the median income for two-person households, which is the poverty line and which also serves as the lower boundary for selective scenario 1. The analysis shows that, throughout the period between 2024 and 2070, the inflation-adjusted threshold line from 2024 never falls below 50% of the median income.

(Unit: %)

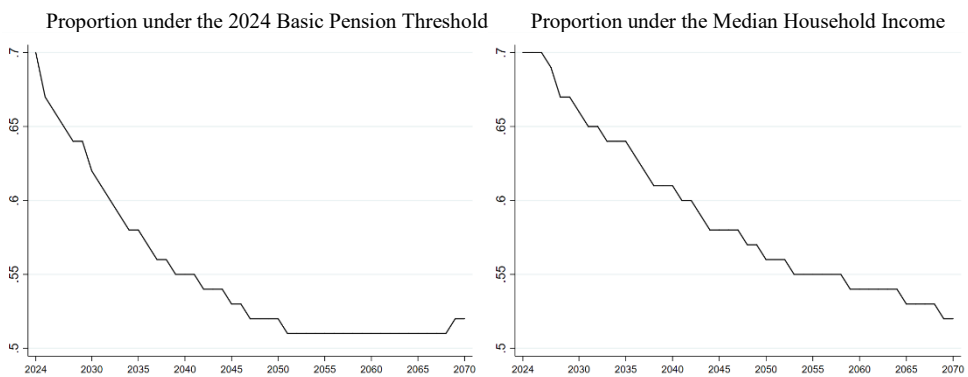

FIGURE 7. PROPORTIONS OF RECIPIENTS UNDER SELECTIVE SCENARIOS

Source: Calculated using data from the 7th to 14th waves of the NaSTaB survey by the Korea Institute of Public Finance.

line in the past, rather than applying a 2% inflation rate to the eligibility threshold line.

IV. Financial Projection under Various Pension Reform Scenarios

A. *Explanation of Pension Reform Scenarios*

In this study, I conduct financial projections under different scenarios that vary in two aspects: eligibility criteria and benefit levels. The baseline scenario follows the current eligibility criteria, which target the bottom 70% of the RAI, and the benefit amount, which is set at 334,810 won in 2024 and evolves according to an inflation rate of 2% thereafter.

For the alternative scenarios, I assume that the benefit amount increases to 400,000 won starting in 2025. I consider two alternative scenarios. The first is the expansion of old-age income security (hereafter the expansion scenario). These expansion scenarios are characterized by an increase in both the coverage and the level of benefits compared to the basic pension scheme. Specifically, I consider two expansion scenarios: in the first such scenario, the benefit amount is increased to 400,000 won in 2025 and adjusted according to the inflation rate (expansion scenario 1); in the second scenario, in addition to the benefit increase, the eligibility criteria are expanded from the bottom 70% to the bottom 100% of the population (expansion scenario 2).

The second type of alternative scenario includes selective eligibility criteria (hereafter referred to as the selective scenario), designed to reduce the number of basic pension beneficiaries as the economic situation of the elderly improves. I consider two selective scenarios as well. The first sets the eligibility criteria threshold at the 70th percentile of the RAI among married-couple households in 2024, which is 3.408 million won, and then inflates this threshold in subsequent years (hereafter, selective scenario 1). The second selective scenario sets the RAI threshold at the median income for two-person families (hereafter, selective scenario 2). It should be noted that selective scenario 2 only takes effect when the original eligibility threshold, which is the 70th percentile of the RAI, surpasses the median income of two-person households.

TABLE 6—PROJECTION SCENARIOS

Scenario	Full Benefit Amount	Eligibility Criteria Threshold
Baseline Scenario	334,810 won in 2024 inflation adjusted value (~2024)	70th percentile of RAI
Expansion Scenario 1	334,810 won in 2024 400,000 won (2025) inflation adjusted value (~2025)	70th percentile of RAI
Expansion Scenario 2	334,810 won in 2024 400,000 won (2025) inflation adjusted value (~2025)	100th percentile of RAI
Selective Scenario 1	334,810 won in 2024 inflation adjusted value(~2024)	Inflation Adjusted Value of 2024 Eligibility Criteria Threshold (3.408 million won)
Selective Scenario 2	334,810 won in 2024 inflation adjusted value (~2024)	Median Income of Two-Person Households

B. *Financial Projection under the Baseline Scenario*

Before projecting the financial expenditure under the baseline case, first I present the population of elderly individuals aged 65 and over, basic pension recipients, and concurrent recipients, as doing so is essential for forecasting financial expenditure in Figure 8. Due to rapid aging, the population of elderly individuals aged 65 and over rises significantly, increasing by 1.9 times from ten million in 2023 to 19 million in 2050. However, due to the low fertility rate, the population size decreases slightly after 2050, reaching 17.5 million, which is still 1.75 times higher than the 2023 level. Similarly, the number of basic pension recipients, which is 70% of the elderly population, reaches its peak in 2050 and then begins to decline. Conversely, for concurrent beneficiaries, as the ratio of national pension recipients to the total population increases over time, there is an upward trend until 2070, although the growth rate slows somewhat after 2050.

Figure 9 illustrates the financial projection results under the current system. Figure 9 shows that the financial expenditure for the basic pension amounts to 25 trillion won in 2024, 76 trillion won in 2050, and 102 trillion won in 2070. Relative to the nominal GDP, these expenditure levels reach 1% in 2024, 1.5% in 2050, and 1.3% in 2070.

It is evident that while the number of recipients declines after 2050, the financial expenditure continues to rise even beyond 2050. This is due to the expenditure being presented in nominal terms. When converting the financial expenditure to real terms, as shown on the right side of Figure 10, there is a slight decline after 2050. Over time, the proportion of financial expenditure contributed by concurrent beneficiaries increases as their numbers grow.

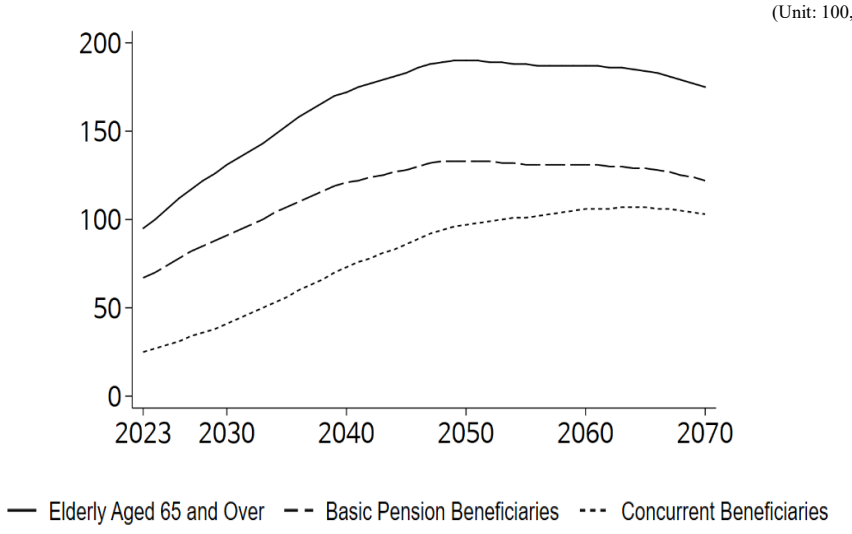

FIGURE 8. YEARLY POPULATION PROJECTIONS

Source: Calculated based on population projections by the Department of Statistics and the basic pension formula.

(Unit: Trillion won, %)

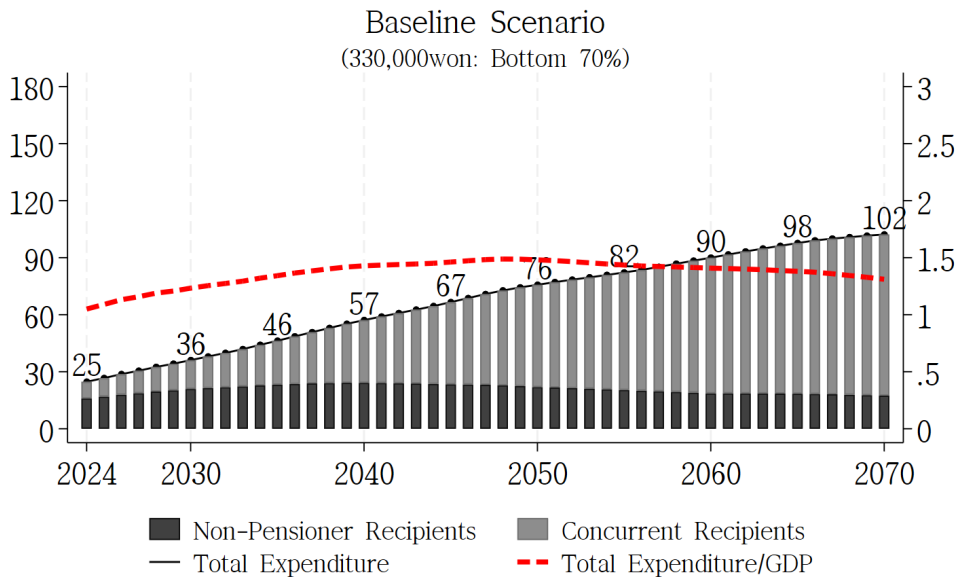

FIGURE 9. FINANCIAL PROJECTIONS UNDER THE BASELINE SCENARIO

Note: Calculated based on the basic pension formula.

(Unit: %)

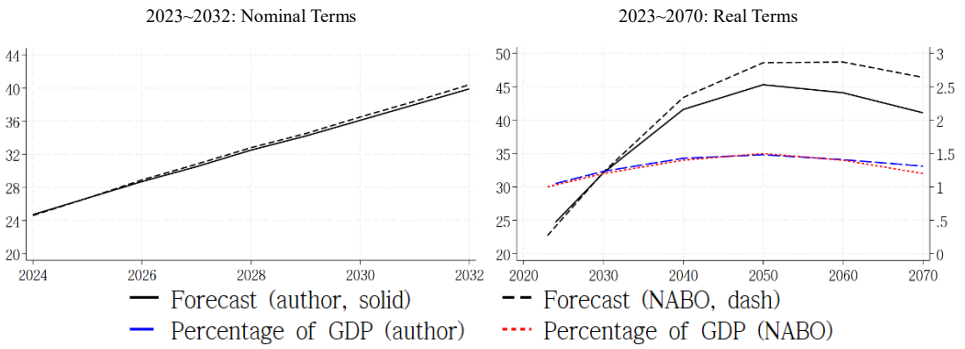

FIGURE 10. COMPARISON WITH FINANCIAL EXPENDITURE FROM NABO (2023a)

Note: The figure on the left is based on current prices and that on the right is based on 2023 constant prices.

Source: Basic pension financial projection results calculated by the author and NABO (2023a).

To assess the adequacy of the financial projections in this study, I compare them with the results from NABO (2023a). As shown on the left side of Figure 10, the result from NABO (2023a) and this study exhibit similar levels and trends between 2023 and 2032.[9] For instance, NABO (2023a) predicts that the financial expenditure

[9]For a valid comparison with earlier studies that used projections from 2023, I make the financial projection assuming 2023 as the most recent year In the main results of this study, I use actual data from 2024 for the full

for the basic pension will amount to 30.8 trillion won and 40.4 trillion won for the two respective years, while this study's projections amount to 30 trillion won and 39.2 trillion won for the same years.

The right side of Figure 10 compares the financial expenditure projections from this study with those of NABO (2023a) between 2023 and 2070 in real terms. Although both studies show similar trends over the period, the results begin to diverge as time elapses. For example, NABO (2023a) projects financial expenditure levels for 2050, 2060 and 2070 to be 48.6, 48.7 and 46.4 trillion won, respectively, while this study projects corresponding values of 43.6, 42.5 and 39.6 trillion won, resulting in differences ranging from approximately five to seven trillion won. The divergence in real terms may be due to the different inflation rates used in the projections.[10] In contrast, when comparing financial expenditure levels relative to GDP, this study's financial projections align quite closely with those of NABO (2023a).

C. *Financial Projection under Expansion Scenarios*

First, I present the financial projection results based on two scenarios that expand old-age income security: 1) increasing the basic pension to 400,000 won starting in 2025 while keeping the eligibility threshold at the bottom 70% of the elderly aged 65 and over (expansion scenario 1), and 2) extending the recipients from the bottom 70% to 100% of those aged 65 and over (expansion scenario 2). Given that both scenarios either increase the benefit level or both increase the benefit level and expand the number of recipients relative to the current system, the expenditure increases significantly compared to the base case.

Figure 11 shows the projection results. The figure on the left displays the expenditure per year under each scenario, while the figure on the right shows the change in expenditure per year relative to the current system. As the results indicate, under expansion scenario 1, the expenditure rises to 31 trillion won in 2025, which is approximately 1.3% of GDP, and then gradually increases to 121 trillion won, which is equivalent to 1.6% of GDP, by 2070 in nominal terms. Relative to the current system, the additional expenditure is about five trillion won in 2025 and increases to 19 trillion won in 2070.

Under expansion scenario 2, where on top of the increase in the benefit amount, all elderly aged 65 and over become eligible for the basic pension, the expenditure increases to 45 trillion won, which is equivalent to 1.8% of GDP in 2025, and 173 trillion won, which is equivalent to 2.2% of GDP in 2070. Relative to the current system, the expenditure is about 18 trillion won higher in 2025 and 71 trillion won higher in 2070. This shows that expanding the number of recipients to all elderly aged 65 and over can amplify fiscal spending on the basic pension.

benefit amount and the 70th percentile RAI.

[10]This study assumes a future inflation rate of 2% whereas, NABO(2023a) employed an internally determined inflation rate, which is not disclosed in the document.

(Unit: Trillion won, %)

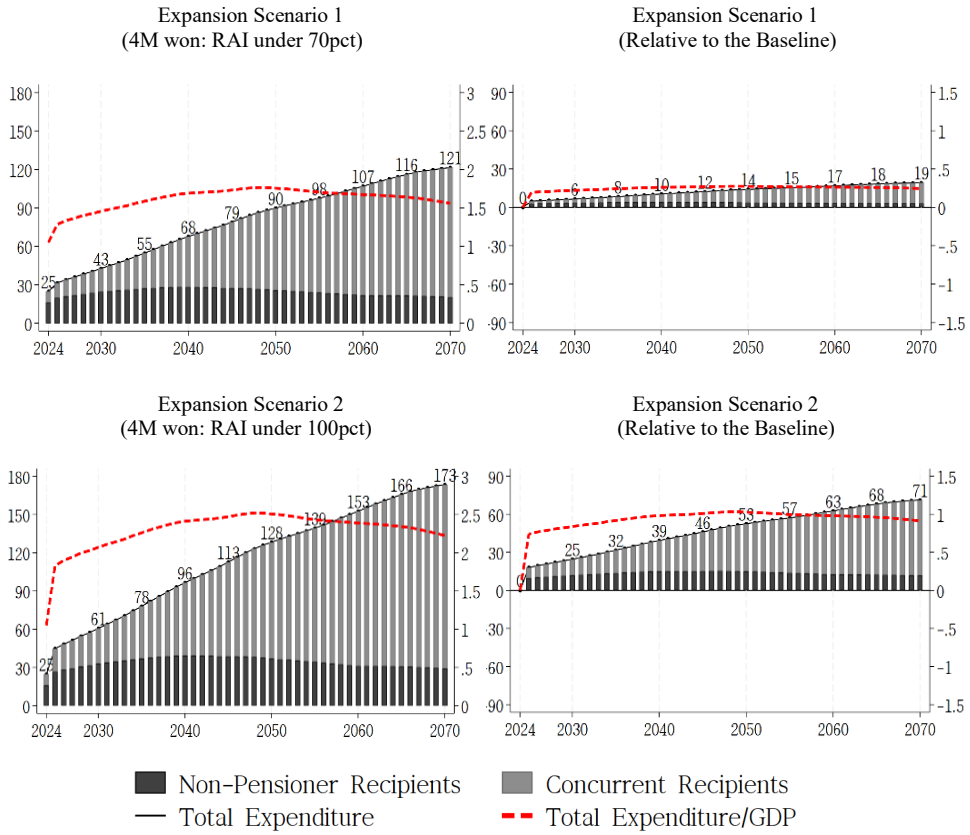

FIGURE 11. FINANCIAL PROJECTIONS UNDER THE EXPANSION SCENARIOS

Note: Calculated based on the basic pension formula.

D. *Financial Projections under the Selective Scenarios*

Under the selective eligibility criteria, the proportion of recipients will decline as the RAI of the new generation of elderly improves. Consequently, over the long term, with the decrease in the proportion of recipients, the expenditure relative to the current system will also decrease.

Firstly, as shown on the left side of Figure 12, under selective scenario 1, where the eligibility threshold is fixed at the 2024 level, the basic pension expenditure is projected to increase from 26 trillion won in 2025 (approximately 1% of GDP) to 76 trillion won in 2070 (around 0.97% of GDP) in nominal terms. Compared to the base case scenario, the financial expenditure gradually decreases, resulting in a reduction of 26 trillion won in nominal terms by 2070.

Secondly, under selective scenario 2, the expenditure initially aligns with the base case scenario because the 70th percentile of the RAI remains below the median income of two-person households until 2026. Selective scenario 2 only takes effect when the original eligibility criteria, based on the 70th percentile of the RAI, exceed

(Unit: Trillion won, %)

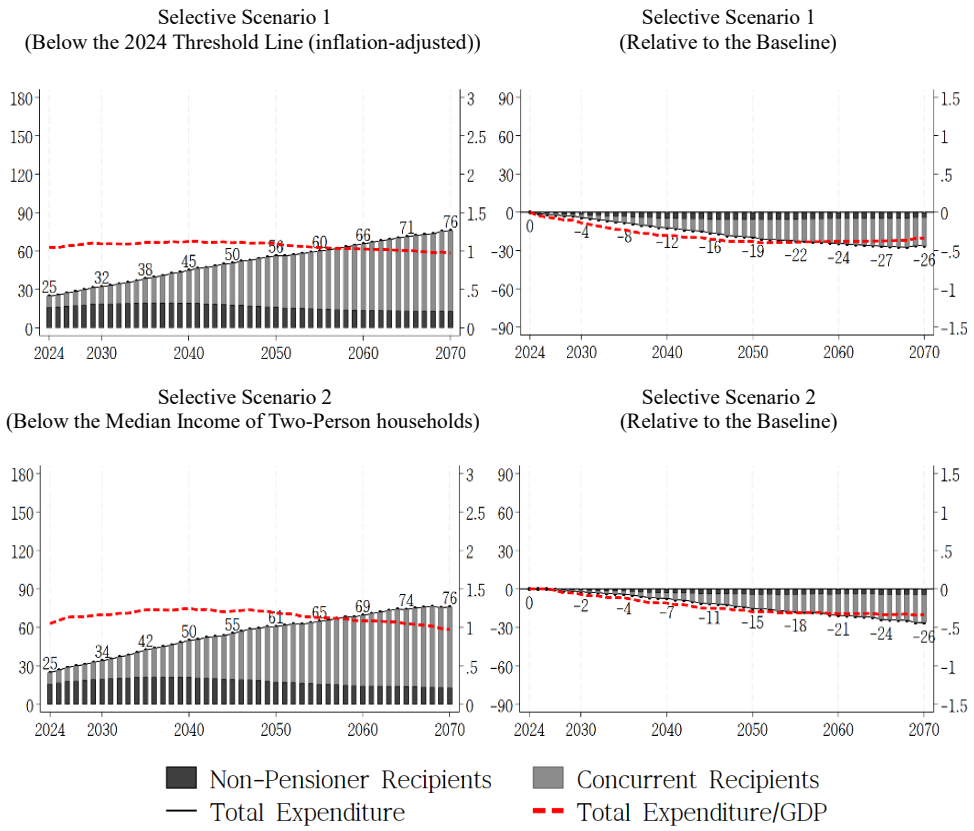

FIGURE 12. FINANCIAL PROJECTIONS UNDER THE SELECTIVE SCENARIOS

Note: Calculated based on the basic pension formula.

the median income for two-person households. After 2026, as the 70th percentile of the RAI surpasses the median income of two-person households, the proportion of recipients falls below the median household income, resulting in a smaller proportion of recipients compared to the base case scenario. This leads to a decrease in financial expenditure relative to the base case scenario. By 2070, financial expenditure is projected to decline by 26 trillion won.

E. *Total Fiscal Expenditure*

Table 7 shows the total fiscal expenditure, or accumulated fiscal expenditure, under each scenario. The total fiscal expenditure is calculated as the sum of all fiscal expenditures from 2024 to 2070. Under the baseline scenario, the total fiscal expenditure is 3,173 trillion won in nominal terms and 1,891 trillion won in real terms. Under scenario 1, where the benefit amount rises to 400,000 won in 2024, the total fiscal expenditure rises to 2,236 trillion won in real terms, which is approximately 18% higher than the expenditure under the baseline scenario (i.e.,

TABLE 7—TOTAL FISCAL EXPENDITURE FOR EACH SCENARIO

(Unit: Trillion Won)

Category	Base Scenario	Expansion Scenario		Selective Scenario	
		1	2	1	2
Nominal Value	3,173	3,756	5,363	2,420	2,590
Real Value	1,891	2,236	3,191	1,467	1,575

Note: Present value is converted assuming an inflation rate of 2%.

Source: Calculated by the author using the basic pension projection model.

(2236-1891)/1891). Scenario 2, in which the eligibility criteria are extended to all elderly people in addition to the benefit amount being increased to 400,000 won, has the highest total fiscal expenditure of 3,191 trillion won in real terms, about 69% higher than the expenditure under the baseline scenario (i.e., (3191-1891)/1891).

Under selective scenarios 1 and 2, as recipients decline from 70% to nearly 50%, the total fiscal expenditure decreases relative to the base case. Specifically, under selective scenario 1, the total fiscal expenditure declines by 424 trillion won in real terms, which is nearly 22% lower than that of the base case (i.e., (1891-1467)/1891). Under selective scenario 2, the total fiscal expenditure declines by 311 trillion won, which is approximately 17% lower than that of the base case (i.e., (1891-1575)/1891). Under selective scenario 1, the decline in the total fiscal expenditure exceeds that of selective scenario 2 because the proportion of recipients declines at a much faster rate under selective scenario 1 compared to selective scenario 2 until 2050.

F. *Revenue Neutral Analysis*

Subsequently, I calculate how much the government can increase the full benefit amount, keeping the eligibility criteria as in selective scenario 1, to achieve revenue neutrality with the base case scenario. Figure 13 shows the difference in fiscal

(Unit: Thousand won)

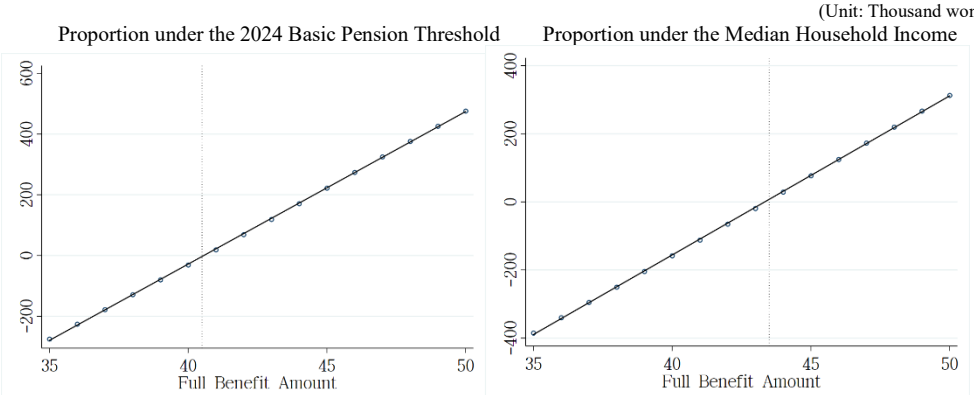

FIGURE 13. DIFFERENCES IN TOTAL FISCAL EXPENDITURE LEVELS ACROSS VARIOUS BASIC PENSION AMOUNTS

expenditure between the base case scenario and selective scenario 1 when the benefit amount is gradually increased by 10,000 won from 350,000 and 700,000 won from 2025. As shown in the figure, the benefit amount can be increased to approximately 435,000 won in order to maintain the same total fiscal expenditure as in the baseline scenario between 2024 and 2070. This means that under the eligibility criteria of scenario 1, the government can increase the benefit amount to 435,000 won to achieve a total fiscal expenditure level similar to that of the baseline scenario. Likewise, under selective scenario 2, the government can increase the full benefit amount to approximately 405,000 won to keep the revenue neutral, as in the base case. These results indicate that under selective eligibility criteria, the government would have greater flexibility to increase the benefit amount to 400,000 won, a proposal included as one of the 120 key national tasks and discussed in the 2023 Fifth Comprehensive National Pension Plan (Ministry of Health and Welfare, 2023).

V. Discussion and Conclusion

The basic pension benefit system has been criticized for being cost-ineffective with regard to its ability to address the high poverty rate among the elderly, largely due to its broad target group and low benefit amounts. It was implemented out of necessity to supplement income, as the national pension system had not yet matured enough to provide secure income for the elderly. However, because eligibility criteria are set to the bottom 70% of the RAI among the elderly aged 65 and over, as the national pension system in Korea matures and the economic condition of the elderly improves, newly entering basic pension recipients are relatively less poor compared to past recipients. For instance, while the eligibility threshold for a married-couple household—set at the 70th percentile of the RAI among elderly married-couple households—was 55.9% of the median income for a two-person household in 2015, it increased to 93.4% of the median income for a two-person household by 2023. At the same time, as the basic pension targets 70% of the elderly, the corresponding financial burden is projected to increase due to rapid aging and the low fertility rate. In particular, because the target group is wide, there is less financial flexibility to increase the benefit amount.

Hence, it is imperative to readjust the eligibility criteria of the basic pension to be more selective, and this can be done by narrowing down the target group and increasing the benefit level. This study has conducted financial projections under two selective eligibility criteria: 1) fixing the threshold line at the level of 2024 and readjusting the benefit level according to the inflation rate, and 2) setting the eligibility criteria as the median household income. In order to forecast the financial expenditure of the basic pension, this study forecast the projection of the RAI distribution of the elderly under the assumption that the linear trend of the past RAI between 2012 and 2021 will be consistent in the future. The result shows that under selective scenario 1, the accumulated financial expenditure can decline by 424 trillion won in real terms while under selective scenario 2, the accumulated financial expenditure can decline by 311 trillion won in real terms between 2024 and 2070.

Using the financial savings from narrowing down the number of recipients, the benefit amount can increase to 435,000 won in selective scenario 1 and can increase to 405,000 won in selective scenario 2 from 2025.

To implement the selective basic pension system successfully, it is important to strengthen the national and private pension systems. To narrow down the target group for the basic pension, the national and private pension systems must be reinforced to provide secure income for the majority of the elderly. Therefore, if the basic pension becomes selective, the government must work to reduce blind spots in the national pension system. In particular, the government must develop an action plan to increase the contribution periods for income-vulnerable women, low-wage workers, and the self-employed, who typically have shorter contribution periods compared to average contributors. Although the government has initiated social insurance subsidy programs such as Durunuri to encourage low-wage workers and small business owners to participate in the national pension system, recent studies, such as Kwon *et al*. (2022), have found that these programs do not effectively increase the number of contributors. The government needs to analyze the reasons behind the ineffectiveness of these subsidy programs and improve them to ensure their effectiveness. Moreover, the National Pension Childbirth Credit, which grants additional contribution periods to women who have given birth, is currently only available to those who have had a second or subsequent child. This credit should be extended to women upon the birth of their first child to help improve their contribution periods. At the same time, while the fund for the Childbirth Credit is currently financed at a rate of 30% from the national treasury and 70% from the National Pension Fund (NABO, 2023b), the proportion of the budget that is financed by the national treasury may need to be increased to reduce the financial burden on future generations.

A limitation of this study is that it projects future financial expenditure for the basic pension based on the assumption that the past linear trend of the RAI will continue into the future, without considering the underlying structural processes driving RAI evolution. This approach implicitly assumes that the economic growth and income distribution structure observed between 2014 and 2021 will remain unchanged in the future. However, under different scenarios, the projection results may vary. For instance, if income distribution among the elderly worsens compared to the period between 2014 and 2021, the proportion of the elderly eligible for the basic pension will increase, leading to higher financial expenditures in the future relative to the current scenario. This could occur if the growth rate of the average pension amount for the new generation of the elderly weakens or there are fewer elderly employment opportunities compared to corresponding trends observed between 2014 and 2021. Conversely, if the income distribution among the elderly improves, the proportion of those eligible for the basic pension will decrease, resulting in a lower future financial expenditure level compared to the current scenario. Moreover, if median household income rises faster than the income of the elderly, the proportion of elderly whose RAI falls below the median income will also be lower than projected. I leave the task of making financial projections for the basic pension under a structural model that incorporates the fundamental elements determining RAI evolution and median household income to future researchers.

APPENDIX

A. *Calculation of RAI*[11]

This section explains the procedure for calculating the RAI. To estimate the long-term proportion of basic pension recipients under the selective eligibility criteria, it is necessary to project the future distribution of the RAI. The future distribution is forecasted based on the linear trend of past RAI levels, under the assumption that the growth rate of this index will remain consistent.

The RAI is calculated separately for single and married-couple households. When elderly individuals live with their parents, each household is considered to be a separate unit. In this study, household types are divided into three categories: those with a household head, those with the household head's spouse, and those of the parents of either the household head or the household head's spouse, each defined as a distinct household unit. It should be noted that while recipients of occupational pensions who meet exclusion criteria or special exceptions may still be eligible to receive the basic pension, this study did not consider these special cases and excluded individuals receiving occupational pensions.

RAI refers to the combined value of the income assessment amount (IAA) and the converted value of assets (CVA). It is calculated based on the individual's income and assets for single households and based on the combined income and assets of both the individual and their spouse for couple households. The formula for the RAI is given below.

$$RAI = Income\ Assessment\ Amount + Income\ Converted\ Asset\ ,$$

where

$$\begin{aligned} &Income\ Assessment\ Amount \\ &= \{0.7 \times (Labour\ Income - Earned\ Income\ Deduction)\} \\ &\quad + \begin{pmatrix} Business\ Income + Public\ Transfer\ Income + \\ Imputed\ Rent\ Income + Property\ Income \end{pmatrix} \end{aligned}$$

and

[11]The RAI is calculated by Choo SeokHyeon, a research staff member at KDI.

$$Income\ Converted\ Asset = \left[\frac{\left\{\begin{array}{l}(General\ Property - Basic\ Property\ Amount) + \\ (Financial\ Asset - 20million\ won) - Liability\end{array}\right\} \times Property\ Income\ Conversion\ Rate}{12months}\right] + Value\ of\ Luxury\ Cars\ and\ Memberships$$

1. Method for Calculating the Income Assessment Amount

To calculate the income assessment amount, one needs to compute labor income, business income, public transfer income, imputed rent, and property income. First, labor income refers to income from employment for three consecutive months with a fixed monthly salary (Ministry of Health and Welfare, 2023). In this context, income from public jobs or self-sufficiency work is excluded from labor income. However, in practice, NaSTaB lacks information with which one can identify whether the individual worked continuously for more than three months in the previous year. Therefore, in this study, the average monthly labor income is calculated by dividing labor income from the previous year by the number of months worked in the previous year.

Business income is the sum of rental income and other business-related income. Annual rental income is converted into a monthly value by dividing the yearly rental income by 12. To calculate other business income on a monthly basis, the annual net business income is divided by the number of months worked. Property income consists of the sum of interest income and private pension income combined. Interest income is calculated using annual interest, dividends, and capital gains, with a deduction applied for amounts up to 40,000 KRW per month. Private pension income is derived from the total private pension insurance income.

Public transfer income includes national pension income, industrial accident insurance benefits (such as sickness benefits, disability benefits, survivor benefits, occupational disease compensation pensions, pneumoconiosis compensation pensions, and pneumoconiosis survivor pensions), as well as benefits paid to veterans and other individuals eligible for national merit and honor. Therefore, public transfer income is calculated as the sum of national pension income (including old-age pensions, disability pensions, survivor pensions, and divided pensions), industrial accident insurance benefits (including occupational injury sickness benefits, occupational disability benefits, and occupational accident survivor pensions), and veteran benefits from NaSTaB.

Imputed rent income refers to the amount calculated as the rental income equivalent for residing in a high-value property owned by a first-degree lineal descendant, such as a child. However, this is excluded from the current analysis.

2. Method for Calculating Imputed Income from Assets

The value of each individual's automobile assets is determined by applying the

type of car, engine displacement information, and the year of purchase by the residual value rates according to the vehicle age as provided by the National Pension Service. Vehicles with an engine displacement of less than 3,000 cc or valued below 40 million won are classified as general assets. Additionally, cars used by individuals with disabilities for living purposes should not be counted as automobile assets; however, this level of detail is not considered in this study.

Differentiated basic asset values and imputed income conversion rates according to the metropolitan areas, for medium-sized cities, and for rural areas are derived from the official annual values provided in the Basic Pension Program Guidelines. General assets include land, buildings, housing, aircraft and ships, rental deposits, forest resources and fishing rights, as well as automobile assets (vehicles with an engine displacement of less than 3,000 cc or valued below 40 million won) (Ministry of Health and Welfare, 2023). General assets are derived from data on the market value of real estate, the market value of ships, rental deposit amounts, and automobile assets (vehicles with an engine displacement of less than 3,000 cc or valued below 40 million won). To distinguish the general assets of basic pension recipients accurately, it is necessary to identify the asset holder within the family. However, because it is difficult to distinguish these asset holders using NaSTaB data, this study utilizes family-level information on general assets.

Financial assets include cash, checks, bonds, promissory notes, stocks, government and public bonds, deposits, savings accounts, insurance, investment securities, and pension insurance (Ministry of Health and Welfare, 2023). In this study, the value of financial assets is calculated by summing all of the financial asset variables provided by NaSTaB. However, national and private pensions received as a lump sum are not included in the calculation of financial assets for this study.

Liabilities include loans obtained from financial institutions such as first-tier banks, second-tier banks, and lending companies (Ministry of Health and Welfare, 2023). This study calculates liabilities by summing the total amount of family liabilities from NaSTaB.

B. *Procedures for Projecting Fiscal Expenditure by Recipient Types*

Type 1: Non-pension recipients who are subject to both the income-reversal prevention reduction and the spousal reduction for married couples.

The number of Type 1 recipients is calculated by multiplying the number of non-pension recipients (NonP)—derived by subtracting the number of concurrent beneficiaries from the total number of basic pension recipients—by the proportion of non-pension recipients who are subject to both the income-reversal prevention reduction and the spousal reduction for married couples. This proportion is based on the actual figures from 2021, as recorded in Table 4.

$$N_{Type1}(t,s) = N_{NonP}(t,s) \times \frac{N_{Type1}(2021,s)}{N_{NonP}(2021,s)}$$

The total fiscal expenditure for Type 1 can be derived by multiplying the number of Type 1 recipients by the full basic pension amount. Specifically, since Type 1 is subject to both the income-reversal prevention and spousal reductions, I multiply the actual ratio of the full basic pension benefit to the average basic pension amount paid to Type 1 recipients, using the 2021 values provided by Shin and Kim (2021). Although Shin and Kim (2021) provide age-specific ratios, given that there is little variation by age, I apply the ratio at age 65 uniformly across all ages in the calculation, which I denote as g(2021, 65) in the formula.

$$Exp_{Type1}(t,s) = FBP(t) \times g_{Type1}(2021,s,65) \times N_{Type1} \times 12$$

$$\text{where,} \qquad g_{type1}(2021,s,65) = \frac{BP_{Type1}(2021,s,65)}{FBP(t)},$$

Since the full basic pension amount (FBP) is calculated on a monthly basis, it is multiplied by 12 to convert it into the annual expenditure.

Type 2: Non-pension recipients who are subject to the spousal reduction for married couples.

To calculate the number of recipients who are Type 2 recipients, we multiply the proportion of non-pension recipients who are subject to the spousal reduction for married couples but not subject to the income-reversal prevention reduction by the total number of non-pension recipients.

$$N_{Type2}(t,s) = N_{NonP}(t,s) \times \frac{N_{Type2}(2021,s)}{N_{NonP}(2021,s)}$$

Since the spousal reduction rate is 20%, Type 2 recipients receive 80% of the pension amount.

$$Exp_{Type2}(t,s) = FBP(t) \times N_{Type2}(t,s) \times 0.8 \times 12$$

Type 3: Non-pension recipients who are subject to income reverse prevention reduction.

To calculate the number of recipients who are Type 3 recipients, we multiply the

proportion of non-pension recipients who are subject to the income-reversal prevention reduction but not subject to the spousal reduction for married couples by the total number of non-pension recipients.

$$N_{Type3}(t,s) = N_{NonP}(t,s) \times \frac{N_{Type3}(2021,s)}{N_{NonP}(2021,s)}$$

The basic pension expenditure for Type 3 is then calculated by multiplying the number of Type 3 recipients by the product of the full basic pension amount and the actual ratio of the full basic pension benefit to the average basic pension amount paid to Type 3 recipients, based on the 2021 data provided by Shin and Kim (2021).

$$Exp_{Type3}(t,s) = FBP(t) \times N_{Type3}(t,s) \times g_{Type3}(2021,s,65) \times 12$$

Type 4: Non-pension recipients who are not subject to the spousal reduction for married couples or the income-reversal prevention reduction.

To calculate the number of recipients who belong to Type 4, multiply the proportion of non-pension recipients who are neither subject to the income-reversal prevention reduction nor the spousal reduction for married couples by the total number of non-pension recipients. This proportion is based on actual 2021 data provided by Shin and Kim (2021).

$$N_{Type4}(t,s) = N_{NonP}(t,s) \times \frac{N_{Type4}(2021,s)}{N_{NonP}(2021,s)}$$

The basic pension expenditure for Type 4 is calculated by multiplying the number of Type 4 recipients by the full benefit amount. This figure is then multiplied by 12 to convert it into an annual value.

$$Exp_{Type4}(t,s) = FBP(t) \times N_{Type4}(t,s) \times 12$$

Type 5: Concurrent recipients who are subject to the income-reversal prevention reduction and the spousal reduction for married couples.

Number of Type 5 recipients can be calculated by the product of the concurrent

recipients and the ratio of Type 5 recipients among the concurrent recipients. This proportion is based on the actual figures from 2021, as recorded in Table 4.

$$N_{Type5}(t,s) = N_{CR}(t,s) \times \frac{N_{Type5}(2021,s)}{N_{CR}(2021,s)}$$

Then the basic pension expenditure for Type 5 is calculated by multiplying the number of Type 5 recipients by the product of the full basic pension amount and the actual ratio of the full basic pension benefit to the average basic pension amount paid to Type 5 recipients, based on the 2021 data provided by Shin and Kim (2021).

$$Exp_{Type5}(t,s) = FBP(t) \times g_{Type5}(2021,s,65) \times N_{Type5} \times 12$$

Type 6: Concurrent recipients who are subject to the spousal reduction for married couples.

Number of Type 6 recipients can be calculated by the product of the concurrent recipients and the ratio of Type 6 recipients among the concurrent recipients. This ratio is based on the actual figures from 2021, as recorded in Table 4.

$$N_{Type6}(t,s) = N_{CR}(t,s) \times \frac{N_{Type6}(2021,s)}{N_{CR}(2021,s)}$$

Then the basic pension expenditure for Type 6 is calculated by multiplying the number of Type 6 recipients by the product of the basic pension amount and the 80% discount that is applied to the spousal reduction. Here, the basic pension amount is calculated based on the benefit formula for concurrent recipients as mentioned in section 3.

$$Exp_{Type6}(t,s) = BP(t) \times N_{Type6}(t,s) \times 0.8 \times 12$$

Type 7: Concurrent recipients who are subject to the income-reversal prevention reduction.

Number of Type 7 recipients can be calculated by the product of the concurrent recipients and the ratio of Type 7 recipients among the concurrent recipients. This

ratio is based on the actual figures from 2021, as recorded in Table 4.

$$N_{Type7}(t,s) = N_{CR}(t,s) \times \frac{N_{Type7}(2021,s)}{N_{CR}(2021,s)}$$

The basic pension expenditure for Type 7 is calculated by multiplying the number of Type 7 recipients by the product of the basic pension amount and the actual ratio of the full basic pension benefit to the average basic pension amount paid to Type 7 recipients, based on the 2021 data provided by Shin and Kim (2021).

$$Exp_{Type7}(t,s) = FBP(t) \times N_{Type7}(t,s) \times 12$$

Type 8: Concurrent recipients who are subject to neither the income-reversal prevention reduction nor the spousal reduction

Number of Type 8 recipients can be calculated by the product of the concurrent recipients and the ratio of Type 8 recipients among the concurrent recipients which is based on the actual figures from 2021, as recorded in Table 4.

$$N_{Type8}(t,s) = N_{CR}(t,s) \times \frac{N_{Type8}(2021,s)}{N_{CR}(2021,s)}$$

The basic pension expenditure for Type 8 is then calculated by multiplying the number of Type 8 recipients by the product of the basic pension amount, which is calculated based on the benefit formula for concurrent recipients, as mentioned in section 3.

$$Exp_{Type8}(t,s) = BP(t) \times N_{Type8}(t,s) \times 12$$

C. *Method for Estimating Median Income*

To convert the RAI derived in this study into a ratio relative to the median income, it is necessary to estimate future median household income trends. Assuming the trend in median household income remains consistent between 2015 and 2024, this study estimates median household income from 2025 onwards. First, the officially reported median household income data from 2015 to 2024 are used to predict future

FIGURE A1. OFFICIAL AND ESTIMATED VALUE OF MEDIAN INCOME OF TWO-PERSON HOUSEHOLDS

Note: Official values for the median income are reported by the Ministry of Health and Welfare.

values from 2025 onwards. Specifically, ordinary least squares (OLS) regression is applied to predict median household income from 2025 onwards using the official values for two-person households. The estimation results indicate that the median income for a two-person household is projected to increase from 3.61 million KRW in 2025 to 8.27 million KRW in 2070.

D. *Comparing the forecast performance between OLS and ARIMA*

In this section, I compare the forecast performance outcomes of linear regression and the autoregressive integrated moving average (ARIMA) model when used to estimate the RAI distribution. The ARIMA models are denoted as ARIMA (p,d,q), where p represents the number of lags, d stands for the degree of differencing, and q is the order of the moving-average model (Wikipedia Contributors, 2024). I selected ARIMA (1,1,0) because it has the lowest AIC and BIC compared to other ARIMA models, with p and q values that are less than or equal to 2, and with d equal to 1. I forecast the 70th percentile of the measured RAI using both ARIMA (1,1,0) and linear regression, and I report the yearly estimates for each model on the left side of Appendix Figure A2 and the percent difference between the official and estimated values for each model on the right side.

The forecast performance outcomes of the OLS and ARIMA models vary in the earlier period. However, after 2021, the forecast performances of both models converge, with the percent difference between the official and estimated 70th percentile of the RAI falling below 5% for both models, as shown on the right side of the figure. When comparing future projections using the OLS and ARIMA models up to 2070, both exhibit a similar linear trend, as illustrated in Appendix Figure A3. This suggests that the long-term forecast performance capabilities of OLS and ARIMA do not differ significantly. Therefore, for the purposes of this paper, I use OLS regression to predict the RAI distribution.

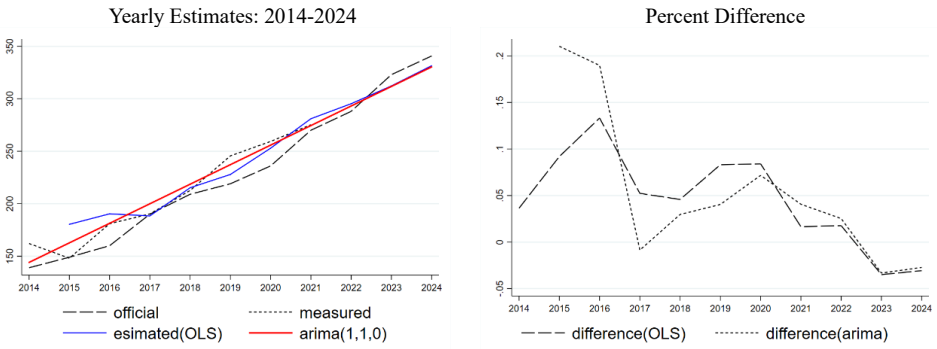

FIGURE A2. YEARLY ESTIMATES AND PERCENT DIFFERENCE UNDER OLS AND ARIMA

Source: Calculated using data from the 7th to 14th waves of the NaSTaB survey by the Korea Institute of Public Finance.

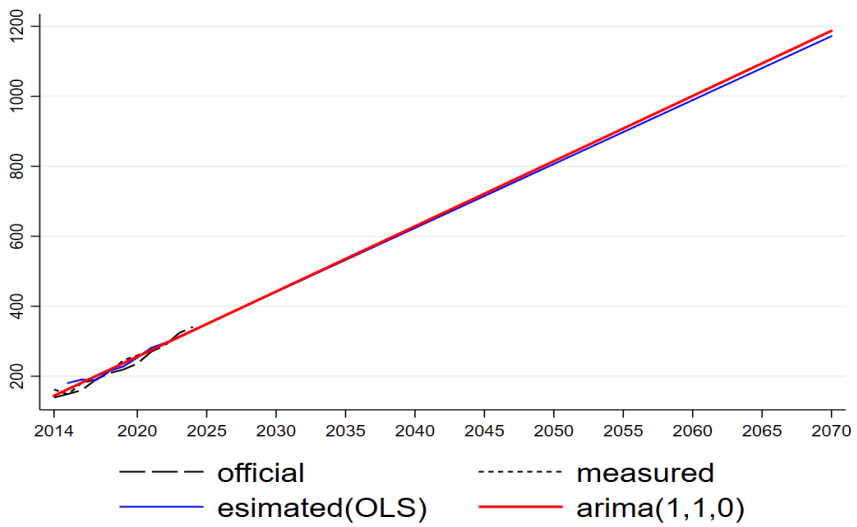

FIGURE A3. YEARLY ESTIMATES UNDER OLS AND ARIMA: 2014-2070

Source: Predicted using data from the 7th to 14th waves of the NaSTaB survey by the Korea Institute of Public Finance.

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