Policy Analysis 16-02


# IMPLICATIONS OF GLOBAL RECESSION AND STRUCTURAL CHANGES FOR KOREAN ECONOMY

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KIEP Policy Analysis 16-02
Published November 30, 2016 in Korea by KIEP
ISBN 978-89-322-1668-3
978-89-322-1088-9(Set)
Price USD 5

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# Preface

Even before the recent global financial crisis, the Korean economy has experienced a significant decline in its GDP growth. Given that Korea's growth path tends to converge to that of the global economy, Korea's recent growth moderation partly reflects a still-weak global economy. Without the boost by domestic and external demand, the Korean economy will further lose its momentum in robust growth in the future.

Various common and structural factors lie behind the convergence of the Korean economy to the slow growth path of the global economy. Among others, this monograph studies the effects of aging population, rising income inequality, the implementation of China's 13th Five-Year Plan, and Brexit. This research also aims to account for the channel through which these structural factors affect Korea's economic growth and to derive policy implications to face up to these structural changes.

Three researchers at the KIEP have made the main contributions to this monograph. Minsoo Han performed analysis of the model used in this research and wrote all chapters. Subin Kim and Jinhee Lee provided parts of the data analysis. They contributed a great deal of dedication and effort throughout the publication of this research. My sincere thanks are also due to Sung Chun Jung, Dong-Eun Rhee, Jiyoung Choi, Hyelin Choi, Sungbae An, Hyo Sang Kim, and Kwanho Shin. They helped greatly to enhance this study through their detailed knowledge and insightful comments.

The KIEP's publishing unit provided invaluable support in steering this monograph to publication. Thanks are due in particular to Seon-Hee Bae for her patience and enthusiasm, and to Minkyu Chang for his English editing services.

Finally, on behalf of the contributors I extend my appreciation to the three anonymous reviewers for their valuable and constructive comments and to Kanghee Yee for her conscientious assistance in preparing the manuscript.

I hope this research opens up discussions, provides important direction and ideas that can help policy makers to implement policy, and stimulates other researchers to work on these issues.

December 2016
Jung Taik Hyun
President, KIEP

# 1. Introduction

The goal of this work is to analyze the effects of global structural changes on the Korean economy through a quantitative framework. Korea's neighboring countries show considerable heterogeneity. Therefore, there are country specific factors which might affect the Korean economy. Instead of analyzing the country-specific factors country-by-country, however, in our analysis we rather focus on common global factors which might affect the Korean economy significantly.

We start Chapter 2 by closely looking at the recent state of the global and Korean economy in the aftermath of the global recession. This chapter mainly relies on descriptive analysis. First, we compare the recent recession with the previous other global recessions. The recent recession is the deepest. More importantly, the global economy as of 2015 still remains on a slow growth path. With an incipient, short recovery right after the end of the 2009 recession, the global economy exhibits slow growth in 2015. Among the other final demand components of GDP, the global economy especially sees weak investment growth and trade slowdown.

Korea still faces severe headwinds from the weak growth recovery. Since 2013, Korea's growth path tends to converge to that of the global economy. As a result, Korea's recent growth moderation partly reflects a still-weak global economy. A closer look at Korea's final demand components suggests that a recovery in the domestic investment is offset by a weak growth in consumption and a notable slowdown in trade. Therefore, the proximate cause of growth slowdown in Korea differs from that of global growth slowdown. Without the boost by the external demand for Korea's products, the Korean economy would lose the momentum in robust growth. Along with a weak growth in domestic consumption, Korea's substantial export disruption might lead to a further slowdown in the Korean economy in the future.

There might be common and structural global factors lying behind the convergence of the Korean economy to the slow growth path of the global

economy. The structural global factors that we study are aging population, rising income inequality, the implementation of China's 13th Five Year Plan, and Brexit. Our choice of these structural changes is motivated by the recent policy-oriented works. Therefore, we do not attempt to describe why each of the structural global factors should be treated as important. Instead, we take it for granted that all of these structural factors are important and rather focus on their quantitative effects on the Korean economy and analyze the mechanism through which the structural factors affect the Korean economy.

Chapter 3 and 4 are the main parts of this work. The focus of both chapters is an analysis through a quantitative framework. Overall, these two chapters are methodologically similar. Our quantitative procedure in both chapters relies on both reduced form regression analysis and a model based approach. The major difference between chapters is that they employ a different model based approach. In Chapter 3 we use Oxford Economics Global Model Workstation (GMW), while a model based on Eaton, Kortum, Neiman and Romalis (2016) is used to quantify the effects of Brexit in Chapter 4.

Chapter 3 addresses the issues of aging population and rising income inequality in China, Japan, and the United States, and the implementation of China's 13th Five Year Plan. The first finding in this chapter is that aging population has negative consequences on the Korean economy. Equally importantly, even though aging population in our neighboring countries has significant effects on the Korean economy, aging in Korea itself plays a major role in reducing Korea's GDP.

To further our understanding about the mechanism through which aging population affects Korea's GDP, we decompose the demand side of Korea. We find that aging tends to reduce all three aggregate demand components, private domestic demand, export, and import. Among them, the effect through private domestic demand is the most important channel. Because import tends to decline more than export, net export somewhat off-

sets the negative effects of aging through private domestic demand channel.

We also analyze the effects of rising income inequality in China, Japan, and the United States. Even though the overall effect of inequality is smaller than that of aging, inequality also tends to reduce Korea's GDP. As similar to the decomposition results on aging, the application of the same decomposition reveals that private domestic demand is the main driver of reducing Korea's GDP and net export partly offsets the negative consequences from inequality. Deviating from the decomposition results on aging, export tends to increase and partly offset the overall negative effects of inequality. We conjecture that bigger increase in investment might cause the growth pick up through an increase in export because an increase in top 1% income shares tends to increase investment.

In the last part of Chapter 3, we analyze the effects of the implementation of China's 13$^{th}$ Five Year Plan. We find that China's Plan tends to increase Korea's GDP. The application of the same decomposition reveals that China's implementation has positive consequences through all demand components. Notably, positive effects from China's Plan go through external channel such as net export in the beginning of periods. On the other hand, over time the contribution of private domestic demand continues to increase while that of external demand declines.

We devote Chapter 4 to the quantitative analysis of Brexit. At first glance, our results do not seem to be consistent with the standard gain from trade liberalization. For example, Korea can sometimes lose from an FTA with the United Kingdom. Instead, raising trade barriers against the United Kingdom sometimes benefit Korea's growth. Alothough we are not able to prove it analytically, we conjecture that our seemingly counterfactual results arise from the interaction between capital accumulation and market access versus the substitution effect. In particular, ending an FTA with a certain country might benefit our other trading partners if we import goods from them instead of

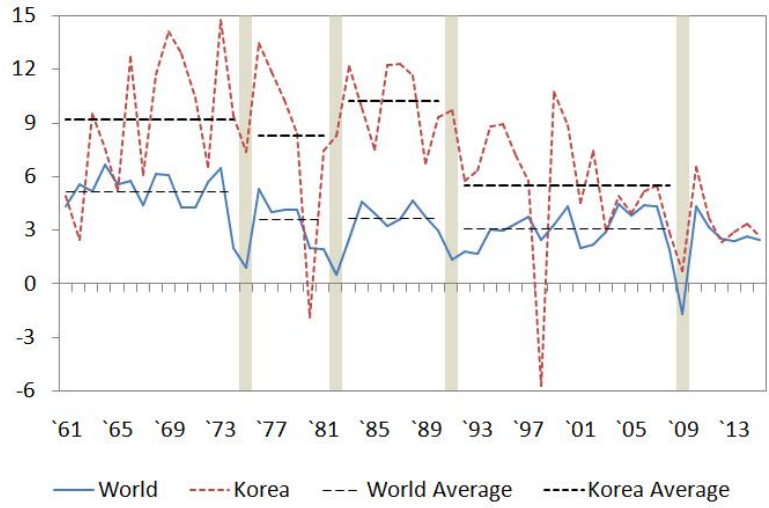
the original exporter. Such substitution effect might be large enough to give us back the benefit especially if the other new trading partners are fast growing economies.

Equally importantly, however, we do not argue that our results are against the general trend in gain from trade liberalization. Instead, we argue that our results confirm the overall trend in gains from trade liberalization again. Depending on factors such as a country's input-output linkages with other countries, moving up and down in global value chains, and whether a country and its trading partners are growing, a country could either gain or lose from an FTA with a specific country.

Chapter 5 provides the summary of our analysis. Grounded by our analysis in Chapter 3 and 4, the policy recommendation will be also provided.

# 2. World and Korean Economy after the Global Recession

Figure 2.1 : GDP Growth Rate, World and Korea




Note: The shaded years (1975, 1982, 1991, and 2009) represent the global recessions as identified by IMF (2009).
Source: World Development Indicators as of August 2, 2016.

We begin by discussing GDP growth in the aftermath of the past global recessions. Figure 2.1 shows the annual GDP growth rate for the world and Korean economy during 1961-2015. The shaded years (1975, 1982, 1991, and 2009) represent the four global recessions as identified by IMF (2009).[1] World and Korea average respectively imply unweighted average of world and Korea GDP growth rate between the global recessions. The solid blue line in the figure shows that the global economy experienced a sharp reduction in growth during all four recessions.

[1]IMF (2009) Box 1.1 (p.11-14) picks out only the four economic downturns as global recessions based on a decline in PPP weighted GDP per capita backed up by a look at other macroeconomic indicators, e.g. industrial production, total trade, capital flows, oil consumption, unemployment, per capita consumption, per capita investment.

Compared to all other recessions, however, there are two points to note about the effect of the recent 2009 recession on the global economy. First, the 2009 recession is the deepest quantitatively. Only during the 2009 recession did the global economy exhibit a negative growth rate.

Second, the global economy did not recover to the pre-recession growth level in the aftermath of the 2009 recession. Staying resilient following the 1991 recession, the global economy grew on average at 3.1% until the 2009 recession (long-dashed black line). After the 2009 recession, however, world GDP growth decelerated to 2.9% on average. A closer look at the figure reveals that except for short periods of pick-up in growth, the post-recession growth declines further to 2.5% on average between 2012 and 2015. Due to the compounding effect of changing growth rates, the seemingly small drop in growth might generate a significant decline in the long-run GDP.

Korea also experienced economic downturns around the global recessions. In particular, as the global economy slowed down during the 2009 recession, Korea's growth also became substantially sluggish. Unlike its deepest effect on global economy, however, the effect of the 2009 recession on the Korean economy is not the greatest in terms of severity at the moment of the recession. The effect of the Asian financial crisis, although not identified as one of the global recessions, is nothing but modest for the Korean economy, while its global effect is limited. The short-dashed red line in Figure 2.1 illustrates this point.

Another important implication from Figure 2.1 is that Korea's growth converges to the growth of the global economy. In the past, Korea generally experienced faster GDP growth than the global economy. The volatility in Korea's growth is also higher than global volatility, because in addition to the global shocks, both country-specific and region-specific shocks substantially influence the Korean economy. Since 2003, however, the fluctuation in Korea's growth has been close to that in global growth. As the growth of the

global economy has remained low and flat recently, Korea's growth has also slowed down since the 2009 recession.

So far, we have considered the GDP growth rate of the global and Korean economy. The still-weak recovery of the global and Korean economy since the 2009 recession is associated with final demand faltering. Therefore, we now turn to the final demand side. Figure 2.2 shows the growth rate of each global final demand component during 1971-2015.[2] Average consumption, investment, export, and import imply unweighted average of consumption and investment growth rates between the global recessions.

Several facts stand out in Figure 2.2 . On first glance, the growth rate of consumption, investment, export, and import is procyclical, while that of government expenditure is countercyclical. Countercyclical government expenditure reflects expansionary increase in government consumption during the recessions.

Second, volatility in the growth of investment, export, and import exceeds that in GDP and consumption growth during global recessions. For example, the average growth rates of consumption, investment, export, and import during 1992-2008 are, respectively, 3.2%, 3.4%, 2.8%, and 2.9%. During the 2009 recession, the growth rates of investment, export, and import slow down, respectively by 8.3%, 13.1%, and 14.9% point, to -4.9%, -10.3%, and -12.0%. On the other hand, consumption growth decelerates, only by 3.3% point, to -0.1% because of household consumption smoothing.

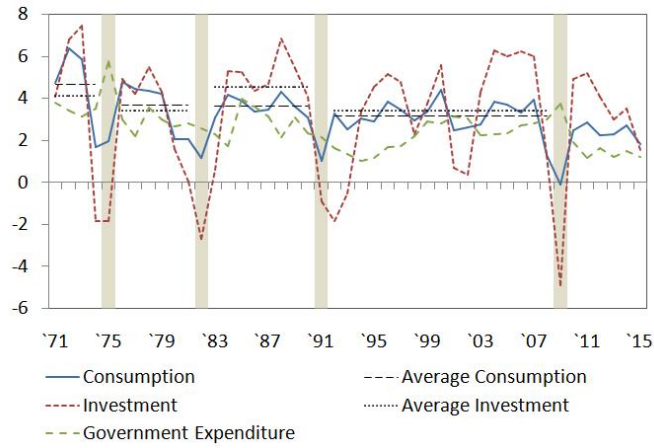
Third, compared to the other previous global recessions, the 2009 recession is distinguished in terms of final demand components. As the 2009 recession is the deepest in terms of a decline in GDP growth, a drop in the growth of all final demand components except for government expenditure is also the biggest during the 2009 recession.

Fourth, looking more closely at the figure, there is some suggestion that

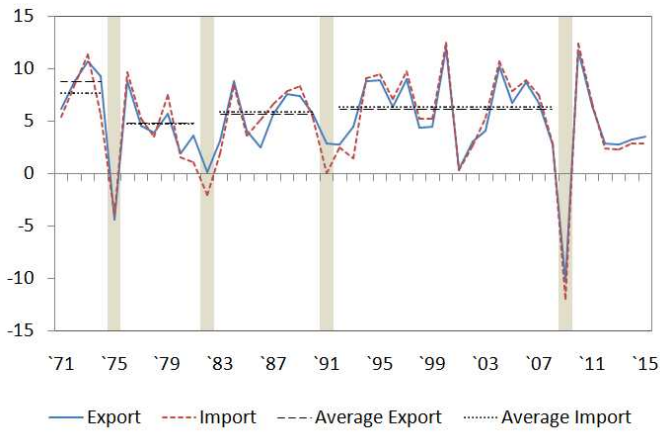
[2]WDI provides data for final demand components only after 1971.

Figure 2.2 : Growth Rate in Final Demand Components, World

(a) Growth rate: domestic




(b) Growth rate: external




Note: The shaded years (1975, 1982, 1991, and 2009) represent the global recessions as identified by IMF (2009).
Source: World Development Indicators as of August 2, 2016.

global trade collapse is more notable during the 2009 recession than the other previous recessions. For example, during the 2009 recession, export and import slow down by 16.4% and 18.4% point respectively, from 6.1% and 6.4% (average growth rate during 1992-2008) to -10.3% and -12.0% respectively, while investment decelerates only by a relatively small 8.3% point from 3.4% (average growth rate during 1992-2008) to -4.9%. On the other hand, during the other previous recessions, a decline in the growth of trade is either relatively close to or smaller than that in the growth of investment.[3]

Finally, the most recent year 2015 sees the slowdown in both domestic and external final demand components, with a short period of recovery right after the 2009 recession. In particular, investment, export, and import grow at 1.6%, 3.5%, and 2.8% in 2015, all of which are almost half of the average growth rate between 1992 and 2008, 3.4%, 6.1%, and 6.4%.

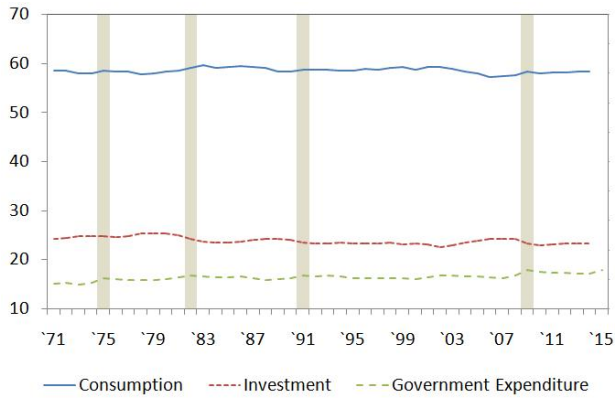
The change in the growth rate of each final demand component leads to a change in their proportions against GDP. In the previous Figure 2.2 , we have seen that the response of the growth rates of investment, export, and import to the negative shocks during the global recessions exceeds that of the growth rates of consumption and GDP. Along with countercyclical government expenditure, this implies that the proportion of consumption and government expenditure against global GDP increases, while that of investment, export, and import decreases during the global recessions. Figure 2.3 illustrates this point. For example, during the 2009 recession, the proportion of investment, export, and import decline by 1.0%, 4.2%, and 4.4% point, respectively.

Figure 2.3 also naturally raises the question of whether the global economy is moving into a new growth pattern. On the one hand, the growth in

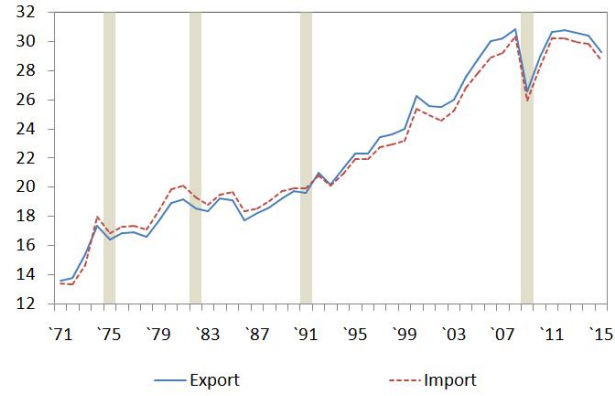
[3]During the previous global recessions, the growth in export (import) declines by 13.1% (11.6%), 5.0% (6.8%), and 2.7% (5.9%) point, while investment decelerates by 5.9%, 6.1%, and 5.5% point, respectively.

Figure 2.3 : Proportion of Final Demand Components against GDP, World

(a) % of GDP: domestic




(b) % of GDP: external




Note: The shaded year (1975, 1982, 1991, and 2009) represent the global recessions as identified by IMF (2009).
Source: World Development Indicators as of August 2, 2016.

investment and trade continues to be subdued in the aftermath of the 2009 recession. As a result, the proportion of investment, export, and import remains below the pre-recession level. On the other hand, it is questionable whether the gap between pre- and post-recession level of the proportions is sizable. The proportion of investment is 23.3% in 2014, which is 1.0% point lower than 2008 level and 0.2% point lower than the average investment proportion during 1992-2008.[4] In addition, although a change in the proportions of export and import is remarkable, it might be too early to identify either downward or constant trend in the proportions of export and import from Panel 2.3 b.

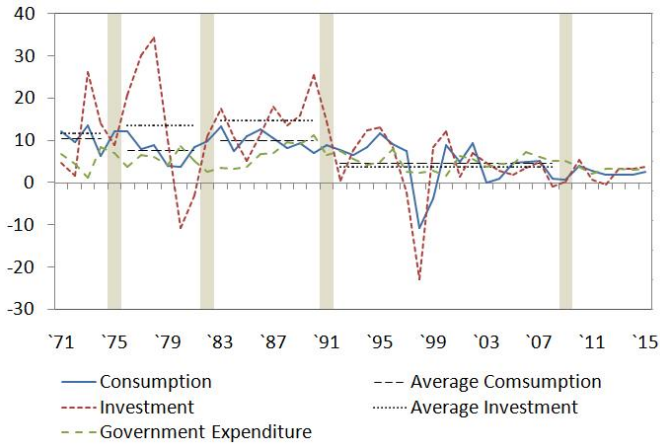
Figure 2.4 shows the growth rate of Korea's final demand components. Despite their similarity, the growth of Korea's final demand components is distinguished from its global counterparts in two respects. First, Korea's growth rate of domestic investment in 2015 almost recovers to the pre-recession rate, average growth rate between 1992-2008. On the contrary, we have seen that the growth rate of global investment in 2015 became less than half of its pre-recession rate.

Second, Korea's export exhibits a clear downward trend since the 2009 recession. As opposed to notable recovery of investment in Korea, Korea's growth rate of export and import in 2015 do not reach the pre-recession rate. Export from Korea and Import to Korea grow on average at 13.6% and 9.9% between 1992 and 2008. In 2015, however, Korea's growth rate of export and import slow to 0.8% and 3.2% in 2015. As we have seen before, global economy also experienced a trade collapse during the 2009 recession and still exhibits sluggish growth rate of export and import, 3.5% and 2.8% respectively. In this sense, Korea's import at least grows at a similar rate as the global growth rate, although it is still sluggish. However, the growth rate of

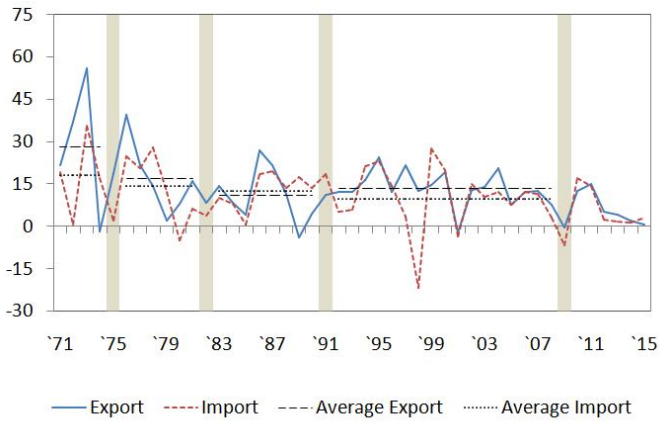
[4]The proportion of consumption and investment against global GDP in 2015 is not available from WDI.

Figure 2.4 : Growth in Final Demand Components, Korea

(a) Growth rate: domestic




(b) Growth rate: external




Note: The shaded year (1975, 1982, 1991, and 2009) represent the global recessions as identified by IMF (2009).
Source: World Development Indicators as of August 2, 2016.

Korea's export is not only lower than the pre-recession average growth rate but the growth rate of global export in 2015.

Figure 2.5 shows Korea's proportion of final demand components against GDP. The most notable change after the 2009 recession is an inverted U shaped drop in the proportion of export and import. For example, the proportion of export against GDP is 24.6% in 1992 and rapidly increases to 50.0% in 2008. After a 2.5% drop during the 2009 recession, it has a peak at 56.3% in 2012. Since then, the proportion of export becomes 45.9%, shrinking by 10.4% point just for 3 years.

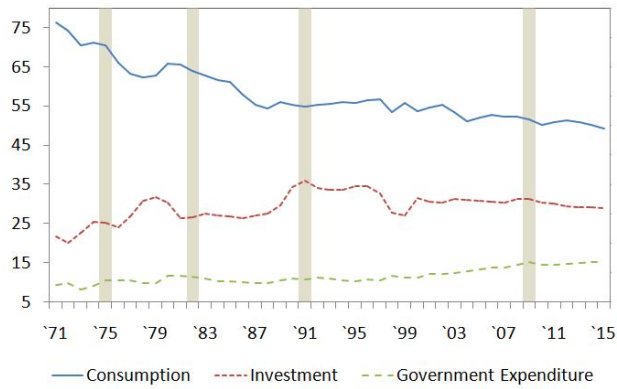
Our preliminary conclusion is that the global economy as of 2015 still remains on a slow growth path and Korea will face severe headwinds from the weak growth recovery. With an incipient, short recovery right after the end of the 2009 recession, the global economy exhibits slow growth in 2015. Among final demand components, the global economy sees weak investment growth and trade slowdown.

Korea's growth path tends to converge to that of the global economy since 2003. Therefore, Korea's recent growth moderation partly reflects a still-weak global economy. A closer look at Korea's final demand components suggests that a recovery in the domestic investment is offset by a weak growth in consumption and a notable slowdown in trade. Therefore, the proximate cause of growth slowdown in Korea differs from that of global growth slowdown. Without a boost by the external demand for Korea's products, the Korean economy would lose its momentum in robust growth. Along with weak growth in domestic consumption, Korea's substantial export disruption might lead to a further slowdown in the Korean economy.

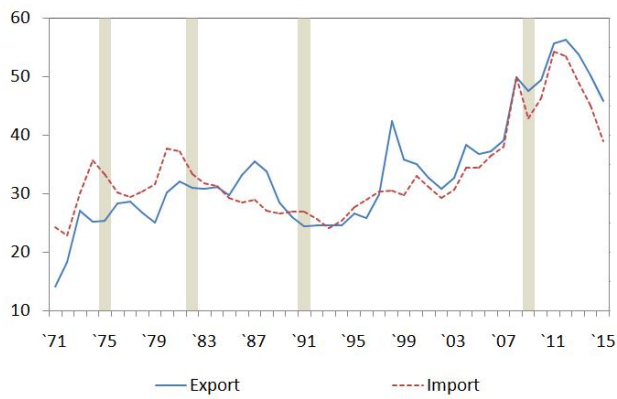
Common and structural global factors would lie behind the convergence of the Korean economy to the slow growth path of the global economy. Among others, we will analyze four structural shocks in the following chapters. First, Chapter 3 analyzes the issues of aging population, rising income inequality,

Figure 2.5 : Proportion of Final Demand Components against GDP, Korea

(a) % of GDP: domestic




(b) % of GDP: external




Note: The shaded year (1975, 1982, 1991, and 2009) represnet the global recessions as identified by IMF (2009).
Source: World Development Indicators as of August 2, 2016.

and China's rebalancing. The choice of four structural changes is motivated by the recent policy-oriented works.[5] Because China, Japan, and the United States are major economies that affect Korea, we focus on the aging population and rising income inequality in these countries. In the previous policy works, the effects of China's rebalancing were analyzed somewhat under an arbitrary assumption. For example, they typically analyze the effect from a decrease in investment and an increase in consumption by a certain percent. Instead, we treat the implementation of China's 13$^{th}$ Five-Year Plan as China's rebalancing and analyze its effect on Korea in our analysis.

Second, we analyze Brexit in Chapter 4. Partly motivated by rising inequality, trade protectionism and regionalism have recently become a pronounced movement in developed countries. Among others, Brexit is such a movement and the topic of this chapter. Through the analysis of Brexit, we attempt to analyze the theme of gains from trade liberalization.

[5]See IMF (2016a) and KDI (2016) for aging population, Jaumotte, Lall and Papageorgiou (2013) and IMF (2016a) for income inequality, Mano (2016) and IMF (2016a) for China's growth and development, and HM Government (2016a), HM Government (2016b), IMF (2016b), IMF (2016c), and Kierzenkowski, Pain, Rusticelli and Zwart (2016) for Brexit.

# 3. Three Structural Changes

This chapter quantifies the effects of three structural changes on the Korean economy. The structural changes which we study in this chapter are aging population and rising income inequality in China, Japan, the United States, and Korea, and the implementation of China's 13th Five-Year Plan (henceforth China's Plan). To quantify the effects, we rely on Global Model Workstation (GMW) by Oxford Economics. For the analysis of aging and rising inequality, we take the following four steps, while for the analysis of China's Plan, we only conduct the last step among the four steps.

First, we relate the empirical proxies corresponding to each county's aging and inequality to its three aggregate variables of consumption, investment, and employment. To do that, we regress the aggregate variables on the proxies corresponding to aging and inequality. Examples of the proxies are the share of old aged population for the analysis of aging and top income shares for the analysis of rising inequality.

Second, we predict the future path of the proxies corresponding to aging and inequality. In particular, we use each country's average changes in the proxies during recent times as our prediction.

Third, we apply the predicted path of the proxies corresponding to aging and inequality, obtained from the second step, into the estimated relationship between the proxies and three aggregate variables, obtained from the first step. As an output, we construct the path of three aggregate variables arising from either aging or rising inequality.

Finally, we plug the predicted path of three aggregate variables arising from each structural change into GMW and solve the model. For the analysis of aging and rising inequality, the constructed path of the aggregate variables in step 3 is our predicted path of the aggregate variables. On the other hand, for the analysis of China's Plan, we refer to the report on China's Plan and use what we can plug into GMW as our predicted changes from China's Plan. Then the solution from the model with our new implementation of our

predicted path of three aggregate variables represents an economy undergoing structural changes. We compare these GMW solutions to the benchmark solution which we derive from the original GMW in the absence of any changes. In this way, we quantify the effects of structural changes.

## 3.1. Model

GMW covers 45 countries with approximately 500 quarterly and annual aggregate variables. Therefore, the model allows us to conduct various counterfactual analysis. In addition, the model builds on reliable and recent data from each country's national statistical office and central bank. In particular, our analysis in this chapter relies on the most recent version of GMW, which was updated in December 2016.

The model is a system of simultaneous equations representing an aggregate economy in a reduced form. As a result, it is often hard to directly interpret the results from the model. In our analysis, we partially overcome the weakness inherent in the model by applying the decomposition framework to the counterfactual outputs from the model.

To conduct the counterfactual analysis, we plug the predicted path of the aggregate variables arising from structural changes into GMW. In particular, we replace the original equations involved with consumption, investment, and employment with our predicted path of these aggregate variables arising from structural changes.

## 3.2. Constructing Counterfactual Scenarios

In the following, we illustrate how the model can be used to construct counterfactual scenarios for each of our three structural changes more specifically.

### 3.2.1. Aging Population

We relate the empirical proxies corresponding to aging with consumption, investment, and employment. Data on consumption (*rconna*), investment (*rinvna*), and employment (*emp*) are available from PWT9.0 by Feenstra, Inklaar and Timmer (2015). The proxies corresponding to aging population are the age dependency ratio of the old aged population (percent of working-age population), population ages 65 and above (percent of total), and fertility rate (births per women). The annual data on these proxies is available from the World Bank's World Development Indicator (WDI).

To construct the relationship between the proxies for aging and each country's consumption, investment, and employment, we estimate the following reduced form equations:

$$\begin{aligned}
\log C_{n,t} &= \alpha_1 + \alpha_2 \log AgeDep_{n,t} + \alpha_3 \log PopOld_{n,t} \\
&\quad + \alpha_4 Fertility_{n,t} + \alpha_{5n} + \varepsilon_{n,t}, \quad (3.2.1) \\
\log I_{n,t} &= \beta_1 + \beta_2 \log AgeDep_{n,t} + \beta_3 \log PopOld_{n,t} \\
&\quad + \beta_4 Fertility_{n,t} + \beta_{5n} + \varepsilon_{n,t}, \quad (3.2.2) \\
\log E_{n,t} &= \gamma_1 + \gamma_2 \log AgeDep_{n,t} + \gamma_3 \log PopOld_{n,t} \\
&\quad + \gamma_4 Fertility_{n,t} + \gamma_{5n} + \varepsilon_{n,t}, \quad (3.2.3)
\end{aligned}$$

where $C_{n,t}$, $I_{n,t}$, $E_{n,t}$, $AgeDep_{n,t}$, $PopOld_{n,t}$, and $Fertility_{n,t}$ are country $n$'s consumption, investment, employment, age dependency ratio, share of old age population, and fertility rate at year $t$ respectively. Each $\alpha$'s, $\beta$'s, and $\gamma$'s are constant term, coefficient, and the dummy variable for $n$. $\varepsilon_{n,t}$ is the error term. We separately run the regression of (3.2.1), (3.2.2), and (3.2.3) applying STATA fixed effect regression command *xtreg* with the robust estimator of variance *vce(r)* to data since 1990.

Table 3.2.1 shows the regression results. Column (1) of the table shows

Table 3.2.1 : Aging Regression

| | (1) $\log C$ | (2) $\log I$ | (3) $\log E$ |
|---|---|---|---|
| $\log AgeDep$ | -0.889** | -0.392 | -1.013*** |
| | (-2.08) | (-0.34) | (-3.66) |
| $\log PopOld$ | 0.631 | -0.105 | 0.475* |
| | (1.30) | (-0.09) | (1.90) |
| $Fertility$ | -0.047 | -0.203* | -0.104*** |
| | (-1.45) | (-1.83) | (-5.23) |
| Constant | 11.415*** | 10.705*** | 2.673*** |
| | (42.94) | (17.38) | (11.19) |
| Year Dummy | Y | Y | Y |
| Observations | 4,071 | 3,897 | 4,036 |
| Adjusted $R^2$ | 0.735 | 0.414 | 0.741 |

Note: (1) *t* statistics in parentheses

(2) * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's estimation

that the larger proportion of old aged population (age 65 and above) relative to working aged population (age 15-64) tends to imply less consumption. Column (2) shows that a higher number of children per woman tends to have a negative effect on investment.

Column (3) of Table 3.2.1 shows that there might be opposing forces at work in the effect of aging on employment. In particular, an increase in the age dependency ratio of old aged population tends to decrease employment. On the other hand, either decline in the fertility rate or increase in the percent share of old aged population over total population tend to increase employment. As a result, our counterfactual effect of aging on employment depends on the predicted path of these three proxies weighted by the estimated coefficient.

Overall, the results in Table 3.2.1 seem to be consistent with our intuition. First, the old aged population is not a part of the labor force and therefore an increase in its relative size reduces employment. In addition, the old aged population, representing people who are retired and earn less income, might consume less regardless of their marginal propensity of consumption. This explains the negative coefficients for *AgeDep* in column (1) and (3).

The negative coefficient for *Fertility* in column (2) and (3) might be due to complementarity between labor supply and capital in production. If women have more babies, they tend to supply less labor (less employment) and therefore investment might also decline.

Even if the positive coefficient for *PopOld* does not seem to be reasonable at first glance, a slight reformulation can make it consistent with our intuition. We apply the definition of $AgeDep = Old/Working$ and $PopOld = Old/Pop$ to eq.(3.2.3), where $Old$, $Working$, and $Pop$ denote the size of old

aged population, working aged population, and overall population.[6] Because the estimated coefficients from Table 3.2.1 imply that $\hat{\gamma}_2 + \hat{\gamma}_3 = -0.538$ and $-\hat{\gamma}_2 = 1.013$, the size of employment tends to increase with the size of working aged population and decrease with the size of old aged population.

Table 3.2.2 shows the average change in the age dependency ratio of old population, the share of old aged population, and fertility rate between 1990 and 2014. To be consistent with our regression (3.2.1), (3.2.2), and (3.2.3), we calculate the percent change in the age dependency ratio and the share of old aged population and the difference in the fertility rate. The table illustrates the overall trends in population aging in all four countries. In particular, both the age dependency ratio and the share of old aged population have increased, while the fertility rate has declined. We use the historical changes as our predicted changes in these proxies and apply them to the estimated relationship of eq. (3.2.1), (3.2.2), and (3.2.3).

In Table 3.2.3 , we apply the results in Table 3.2.1 and 3.2.2 to eq.(3.2.1), (3.2.2), and (3.2.3) and calculate the predicted change in consumption, investment, and employment arising from aging. Therefore, Table 3.2.3 summarizes our inputs which we plug into GMW for our counterfactual analysis on the effect of aging. The table shows that consumption is predicted to decrease as the age dependence ratio increases, while investment is predicted to increase as the fertility rate decreases. The table also shows that depite the opposing sign of the estimated coefficients in column (3) of Table 3.2.1 , employment is predicted to decrease.

[6] Reformulating eq.(3.2.3)

$$\begin{aligned} \log E_{n,t} &= \gamma_1 + \gamma_2 \log AgeDep_{n,t} + \gamma_3 \log PopOld_{n,t} + \dots \\ &= \gamma_1 + (\gamma_2 + \gamma_3) \log Old_{n,t} - \gamma_2 \log Working_{n,t} - \gamma_3 \log Pop_{n,t} + \dots \end{aligned}$$

Table 3.2.2 : Changes in Aging Related Proxies

| Country | Variable | Period | Average Change |
|---|---|---|---|
| China | Age Dependency Ratio | 1990-2014 | 1.81% |
| China | Ages 65 and above | 1990-2014 | 2.28% |
| China | Fertility Rate | 1990-2014 | -0.04 |
| Japan | Age Dependency Ratio | 1990-2014 | 3.80% |
| Japan | Ages 65 and above | 1990-2014 | 3.24% |
| Japan | Fertility Rate | 1990-2014 | -0.01 |
| Korea | Age Dependency Ratio | 1990-2014 | 3.75% |
| Korea | Ages 65 and above | 1990-2014 | 3.97% |
| Korea | Fertility Rate | 1990-2014 | -0.02 |
| United States | Age Dependency Ratio | 1990-2014 | 0.55% |
| United States | Ages 65 and above | 1990-2014 | 0.59% |
| United States | Fertility Rate | 1990-2014 | -0.004 |

Source: Author's calculation

Table 3.2.3 : Counterfactual Shocks for Aging

| | | China | Japan |
|---|---|---|---|
| $\frac{\Delta C}{C}$ | $\hat{\alpha}_2 \frac{\Delta AgeDep}{AgeDep}$ | -0.016 | -0.034 |
| $\frac{\Delta I}{I}$ | $\hat{\beta}_4 \Delta Fertility$ | 0.007 | 0.001 |
| $\frac{\Delta E}{E}$ | $\hat{\gamma}_2 \frac{\Delta AgeDep}{AgeDep} + \hat{\gamma}_3 \frac{\Delta PopOld}{PopOld} + \hat{\gamma}_4 \Delta Fertility$ | -0.004 | -0.023 |
| | | Korea | United States |
| $\frac{\Delta C}{C}$ | $\hat{\alpha}_2 \frac{\Delta AgeDep}{AgeDep}$ | -0.033 | -0.005 |
| $\frac{\Delta I}{I}$ | $\hat{\beta}_4 \Delta Fertility$ | 0.003 | 0.001 |
| $\frac{\Delta E}{E}$ | $\hat{\gamma}_2 \frac{\Delta AgeDep}{AgeDep} + \hat{\gamma}_3 \frac{\Delta PopOld}{PopOld} + \hat{\gamma}_4 \Delta Fertility$ | -0.018 | -0.002 |

Source: Author's calculation

### 3.2.2. Rising Income Inequality

The overall procedure for constructing counterfactual scenarios for the analysis of rising inequality is similar to that of aging. The only difference is the proxies used. The proxies corresponding to inequality are income share held by the highest 10 percent ($top10$), the highest 5 percent ($top5$), the highest 1 percent ($top1$), the highest 0.1 percent ($top0.1$), and the inverted Pareto-Lorenz coefficient ($iPL$).[7] The source of the data is the World Wealth and Income Database (WID).

We relate these proxies with each country's consumption, investment,

[7]The inverted Pareto-Lorenz coefficient increases with rising income inequality. See Atkinson, Piketty and Saez (2011) for more details.

and employment as follows

$$\begin{aligned}
\log C_{n,t} &= \alpha_1 + \alpha_2 top10 + \alpha_3 top5 + \alpha_4 top1 + \alpha_5 top0.1 \\
&\quad + \alpha_6 \log iPL + \alpha_{7n} + \varepsilon_{n,t}, \qquad (3.2.4) \\
\log I_{n,t} &= \beta_1 + \beta_2 top10 + \beta_3 top5 + \beta_4 top1 + \beta_5 top0.1 \\
&\quad + \beta_6 \log iPL + \beta_{6n} + \varepsilon_{n,t}, \qquad (3.2.5) \\
\log E_{n,t} &= \gamma_1 + \gamma_2 top10 + \gamma_3 top1 + \gamma_4 top1 + \gamma_5 top0.1 \\
&\quad + \gamma_6 \log iPL + \gamma_{7n} + \varepsilon_{n,t}. \qquad (3.2.6)
\end{aligned}$$

We run the regression of the above equations in the same way as in eq.(3.2.1), (3.2.2), and (3.2.3).

Table 3.2.4 shows that there might be opposing forces at work in the effect of rising income inequality on consumption, investment, and employment. An increase in either income held by top 10 percent ($top10$) or 0.1 percent ($top0.1$) tends to have negative effects on consumption, investment, and employment. On the contrary, income share held by top 1 percent ($top1$) tends to have positive effects on consumption, investment, and employment. As a result, our predicted effect of an increase in top income shares, arising from rising inequality, on consumption, investment, and employment depends on the combination of the predicted path of top income shares weighted by the estimated coefficients. In addition, the inverted Pareto-Lorenz coefficient, which represents a country's degree of income inequality, does not have any significant effect.

Table 3.2.5 shows the average change in the proxies corresponding to rising inequality. Data period in the table varies across countries due to the differences in the availability of data. The table shows that all of top income shares tend to increase. As in the analysis of aging, we treat the historical average changes reported in the table as the predicted changes in top income

Table 3.2.4 : Inequality Regression

| | (1) $\log C$ | (2) $\log I$ | (3) $\log E$ |
|---|---|---|---|
| $top10$ | -0.039 | -0.142* | -0.042* |
| | (-1.19) | (-2.03) | (-1.92) |
| $top5$ | 0.060 | 0.148 | 0.039 |
| | (1.45) | (1.65) | (1.37) |
| $top1$ | 0.083* | 0.211* | 0.073** |
| | (1.80) | (1.93) | (2.28) |
| $top0.1$ | -0.146* | -0.356** | -0.104** |
| | (-2.01) | (-2.39) | (-2.08) |
| $\log iPL$ | -0.171 | -0.004 | -0.120 |
| | (-0.86) | (-0.01) | (-0.64) |
| Constant | 12.818*** | 12.602*** | 2.731*** |
| | (37.58) | (20.68) | (12.06) |
| Year Dummy | Y | Y | Y |
| Observations | 379 | 379 | 379 |
| Adjusted $R^2$ | 0.818 | 0.700 | 0.659 |

Note: (1) $t$ statistics in parentheses

(2) * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's estimation

Table 3.2.5 : Changes in Inequality Related Proxies

| Country | Variable | Period | Average Change |
|---|---|---|---|
| China | $top10$ | 1990-2003 | 0.66 |
| China | $top1$ | 1990-2003 | 0.20 |
| China | $top0.1$ | 1990-2003 | 0.05 |
| Japan | $top10$ | 1990-2010 | 0.34 |
| Japan | $top1$ | 1990-2010 | 0.07 |
| Japan | $top0.1$ | 1990-2010 | 0.02 |
| Korea | $top10$ | 1995-2012 | 0.92 |
| Korea | $top1$ | 1995-2012 | 0.31 |
| Korea | $top0.1$ | 1995-2012 | 0.14 |
| United States | $top10$ | 1990-2015 | 0.36 |
| United States | $top1$ | 1990-2015 | 0.22 |
| United States | $top0.1$ | 1990-2015 | 0.12 |

Source: Author's calculation

shares.

Table 3.2.6 : Counterfactual Shocks for Inequality

| | | China | Japan |
|---|---|---|---|
| $\frac{\Delta C}{C}$ | $\hat{\gamma}_3^C \Delta top0.1$ | -0.007 | -0.004 |
| $\frac{\Delta I}{I}$ | $\hat{\gamma}_3^I \Delta top1 + \hat{\gamma}_4^I \Delta top0.1$ | 0.024 | 0.007 |
| $\frac{\Delta E}{E}$ | $\hat{\gamma}_1^E \Delta top10 + \hat{\gamma}_2^E \Delta top1 + \hat{\gamma}_3^E \Delta top0.1$ | -0.019 | -0.011 |
| | | Korea | United States |
| $\frac{\Delta C}{C}$ | $\hat{\gamma}_3^C \Delta top0.1$ | -0.021 | -0.017 |
| $\frac{\Delta I}{I}$ | $\hat{\gamma}_3^I \Delta top1 + \hat{\gamma}_4^I \Delta top0.1$ | 0.016 | 0.004 |
| $\frac{\Delta E}{E}$ | $\hat{\gamma}_1^E \Delta top10 + \hat{\gamma}_2^E \Delta top1 + \hat{\gamma}_3^E \Delta top0.1$ | -0.030 | -0.012 |

Source: Author's estimation

In Table 3.2.6 , we apply the results in Table 3.2.4 and 3.2.5 to eq.(3.2.4), (3.2.5), and (3.2.6). As in the analysis of aging, Table 3.2.6 shows the predicted change in consumption, investment, and employment arising from rising inequality. Therefore, the results in Table 3.2.6 become our inputs into GMW for the analysis of rising inequality. The table shows that consumption and employment are predicted to decrease, while investment is predicted to increase. The increase in investment reflects that the positive effect through an increase in $top1$ is greater than the negative effect through increases in both $top0.1$ and $top10$.

### 3.2.3. China's 13th Five-Year Plan

Our procedure for the analysis of China's Plan differs from that of aging population and rising income inequality. China's Plan consists of several tasks to

Table 3.2.7 : Counterfactual Shocks for China's Five-Year Plan

| | | |
|---|---|---|
| Assumptions | GDP annual growth rate | 6.5% |
| | Labor productivity annual growth rate | 6.6% |
| | Urbanization | 3.9%p ↑ |
| | Service share | 5.5%p ↑ |
| | R&D share of GDP | 0.4%p ↑ |
| | Disposable income growth rate | 6.5% |
| Period | 2016-2021 | |

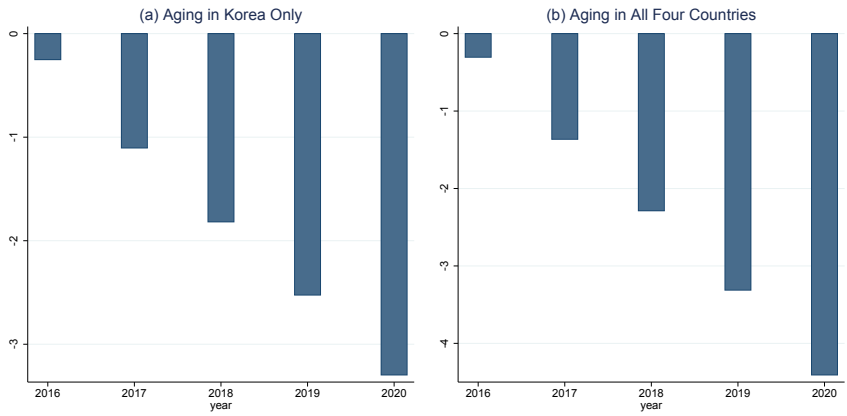
Source: Lim, Yang, Park, Kim and Cho (2016)

be accomplished within 5 years. In particular, the actual China's Plan contains detailed economic development guidelines for areas such as social security and pollution. Due to the variable restriction in GMW, however, we cannot address all these guidelines through GMW. Therefore, our analysis focus only on the implementation of parts of the guidelines in China's Plan, which we can perform using GMW. In addition, to construct counterfactual scenarios, we assume that China successfully carries out the tasks in China's Plan. Table 3.2.7 summarizes our assumptions for the analysis of China's Plan.

## 3.3. Results

In the following, we provide and discuss our counterfactual results on the effects of three structural changes on Korean economy.

Figure 3.3.1 : The Effect of Aging on Korea's GDP




Source: Author's calculation

### 3.3.1. Aging Population

Figure 3.3.1 shows the effect of aging population on Korea's GDP. The figure shows the percent changes relative to benchmark. Panel (a) and (b) illustrate the effect of aging only in Korea and in all four countries, China, Japan, the United States, and Korea, respectively. Table 3.2.3 has shown that aging tends to decrease consumption and employment while it tends to increase investment. Despite the opposing forces at work, Figure 3.3.1 shows that the negative effect of aging on consumption and employment outweighs its positive effect on investment and therefore the overall effect on Korea's GDP is negative.

Figure 3.3.1 also shows that even though aging in Korea itself is the main driver to decrease Korea's GDP, the effect from aging in the other three countries is significant as well. For example, the model predicts that Korea has 4.4 percent smaller GDP than benchmark in 2020 due to aging in all four coun-

tries. On the other hand, Korea is predicted to have 3.3 percent smaller GDP from aging only in Korea.

To further our understanding of the mechanism through which aging population affects GDP, we apply the following decomposition framework to our counterfactual results[8]:

$$\frac{\Delta Y}{Y} = \underbrace{\frac{\Delta(C+I)}{C+I}\frac{C+I}{Y}}_{\text{Private Domestic Demand}} + \underbrace{\frac{\Delta G}{G}\frac{G}{Y}}_{\text{Government Expenditure}} + \underbrace{\frac{\Delta Exp}{Exp}\frac{Exp}{Y}}_{\text{Export}} - \underbrace{\frac{\Delta Imp}{Imp}\frac{Imp}{Y}}_{\text{Import}} + \underbrace{\frac{\Delta \varepsilon}{\varepsilon}\frac{\varepsilon}{Y}}_{\text{Residual}}, \quad (3.3.1)$$

where $Y$, $G$, $Exp$, and $Imp$ denote GDP, government expenditure, export, and import respectively. $\varepsilon$ denotes residual which makes eq.(3.3.1) hold with equality. In eq.(3.3.1), percent change in each component is multiplied by its share of $Y$.

Table 3.3.1 summarizes the decomposition results when we apply eq.(3.3.1) to the effect of aging in all four countries on Korea's GDP. In the table, we normalize every component by dividing both sides of eq.(3.3.1) by $-\frac{\Delta Y}{Y}$.[9] Therefore, a negative sign for each component in the table implies that the contribution from the component is negative and the component moves in the same direction as $Y$ does. In addition, a contribution from each component is relative to a change in $Y$, which is the sum of all contribution.

We assume that government expenditure is constant in both benchmark and counterfactual analysis and is set to be zero. In the table we do not report a contribution from residual, which is neither substantional nor our focus of the analysis. In addition, a simple algebra shows that a contribution

[8] Whang, Moon, Ahn, Kim and Kim (2015) also use the similar demand side decomposition.

[9] Because Figure 3.3.1 shows that aging has a negative effect on $Y$, we put negative sign simply to avoid confusion when we interpret the results.

Table 3.3.1 : Decomposing the Effect of Aging on Korea's GDP

| Year | Private Domestic Demand (1) | Export (2) | Import (3) | Net Export (4) |
|---|---|---|---|---|
| 2016 | -1.221 | -0.225 | -0.446 | 0.221 |
| 2017 | -1.335 | -1.96E-01 | -0.686 | 0.490 |
| 2018 | -1.400 | -0.105 | -0.598 | 0.492 |
| 2019 | -1.364 | -0.096 | -0.526 | 0.430 |
| 2020 | -1.312 | -0.118 | -0.480 | 0.362 |

Source: Author's calculation

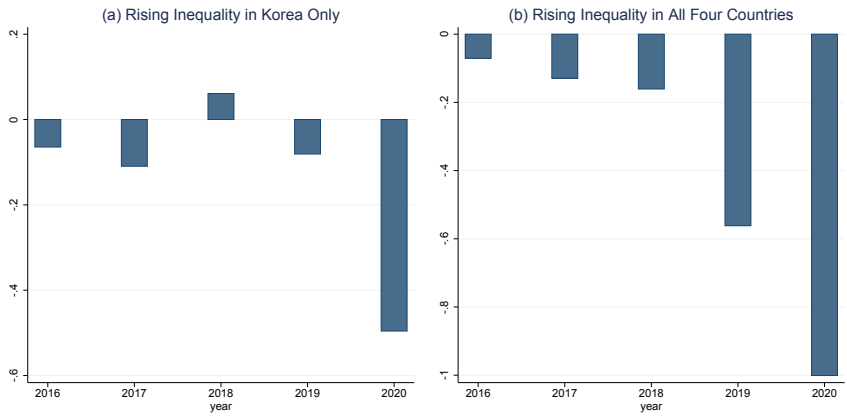
from net export in column (4) is the contribution from export net of that from import.

Two implications stand out in Table 3.3.1 . First, a negative sign for private domestic demand, export, and import in the table implies that as aging has a negative effect on $Y$, all these three variables also declines. On the other hand, a positive sign for net export implies that import delinces more than export.

Second, the primary channel through which aging affects Korea's GDP is Korea's private domestic demand. Table 3.3.1 shows that the magnitude of the contribution by private domestic demand is greater than unity, while that of the contribution by export and import is less than unity (both in an absolute term). Therefore, the response of private domestic demand to aging is greater than that of $Y$, while the response of export and import is smaller than that of $Y$.

### 3.3.2. Rising Income Inequality

Figure 3.3.2 : The Effect of Inequality on Korea's GDP




Source: Author's calculation

Figure 3.3.2 shows the effect of rising inequality on Korea's GDP in terms of the percent changes relative to benchmark. Panel (a) and (b) illustrate the effect of rising inequality only in Korea and in all four countries, China, Japan, the United States, and Korea, respectively. Despite the opposing forces at work between the negative effect on consumption and employment and the positive effect on investment in Table 3.2.6 , the figure shows that the negative effect of inequality on consumption and employment outweighs its positive effect on investment and therefore the overall effect on Korea's GDP is negative. The only exception is 2018 in panel (a), in which the positive effect of inequality on investment outweighs its negative effect on consumption and employment.

In addition, comparing Figure 3.3.2 with Figure 3.3.1 reveals two implications. First, the overall effect of rising income inequality is smaller than

that of aging. For example, aging in all four countries lowers Korea's GDP by 4.4 percent, while rising inequality in all four countries lowers it by 1.0 percent in 2020.

Second, the difference in the effect between rising inequality in Korea only and all four countries is larger than the difference in the effect between aging in Korea only and all four countries. For example, the effect of rising inequality only in Korea is a half of its effect in all four countries (0.5% vs 1.0%). On the other hand, Figure 3.3.1 shows that the effect of aging only in Korea is three fourths of the effect of aging in all four countries (3.3% vs 4.4%).

Table 3.3.2 : Decomposing the Effect of Inequality on Korea's GDP

| Year | Private Domestic Demand (1) | Export (2) | Import (3) | Net Export (4) |
|---|---|---|---|---|
| 2016 | -1.929 | 0.181 | -0.748 | 0.929 |
| 2017 | -5.008 | 2.447 | -1.718 | 4.164 |
| 2018 | -6.970 | 5.849 | -0.114 | 5.963 |
| 2019 | -2.763 | 2.212 | 0.328 | 1.884 |
| 2020 | -1.949 | 1.358 | 0.331 | 1.027 |

Source: Author's calculation

Table 3.3.2 summarizes the decomposition results when we apply eq.(3.3.1) to the effects of rising inequality in all four countries. Because rising inequality lowers Korea's GDP, as shown in the previous decomposition results on aging, we normalize and divide every component by $-\frac{\Delta Y}{Y}$. Therefore, all results in the table is relative to a change in $Y$.

Comparing Table 3.3.2 with Table 3.3.1 , we find several implications.

First, as in decomposition results on aging, the main driver of the negative effect of rising inequality on Korea's GDP is through private domestic demand. However, the magnitude of the contribution from private domestic demand in Table 3.3.2 is larger than in Table 3.3.1 . On the other hand, the opposing movement from net export is even larger than in Table 3.3.1 . As a result, the overall efffect of rising inequality on Korea's GDP is smaller than that of aging on Korea's GDP (Figure 3.3.1 vs 3.3.2 ).

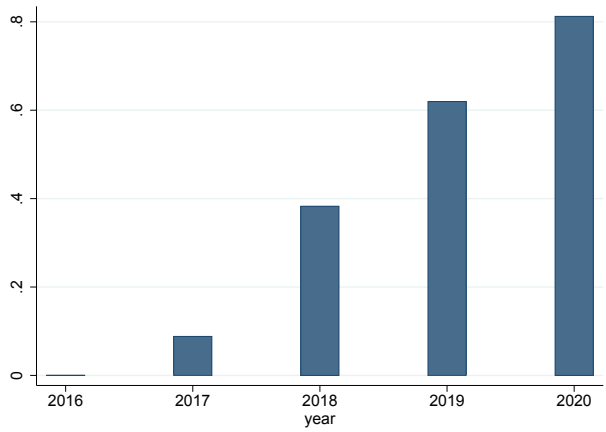
The proximate reason for the positive effect on net export differs between Table 3.3.1 and 3.3.2 . In contrast with the decomposition results on aging, the contribution from export is positive in Table 3.3.2 , while both contributions from export and import is negative in our decomposition results on aging in Table 3.3.1 . Given our exercises so far, we conjecture that the difference between the size of the positive shocks on investment would play a central role in our difference between Table 3.3.1 and 3.3.2 . In particular, a closer look at Table 3.2.3 and 3.2.6 reveals that the positive change in investment is larger in the analysis on rising inequality than on aging.

### 3.3.3. China's 13th Five-Year Plan

Figure 3.3.3 shows the effect of the implementation of China's Five-Year Plan on Korea's GDP in terms of the percent changes relative to benchmark. The figure shows that China's Plan have a positive effect on Korea's GDP. For example, the model predicts that Korea's GDP increases by 0.8% in 2020 relative to benchmark.

Table 3.3.3 summarizes the decomposition results when we apply eq.(3.3.1) to the effects of China's Plan. Because China's Plan raises Korea's GDP as in Figure 3.3.3 , we divide the contribution from each component by $\frac{\Delta Y}{Y}$ and report the results which are relative to a change in $Y$. Therefore, a positive sign for a component in the table implies that the contribution from the compo-

Figure 3.3.3 : The Effect of China's Five-Year Plan on Korea's GDP




Source: Author's calculation

Table 3.3.3 : Decomposing the Effect of China's Plan on Korea's GDP

| Year | Private Domestic Demand | Export | Import | Net Export |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| 2016 | 0.156 | 1.188 | 0.406 | 0.781 |
| 2017 | 0.398 | 0.983 | 0.520 | 0.464 |
| 2018 | 0.561 | 0.815 | 0.512 | 0.303 |
| 2019 | 0.722 | 0.774 | 0.590 | 0.184 |
| 2020 | 0.692 | 0.851 | 0.587 | 0.264 |

Source: Author's calculation

nent is positive and the component moves in the same direction as $Y$ does.

Table 3.3.3 shows that the effect of China's Plan is distinguished in two respects. First, as $Y$ increases with China's Plan, all components have a positive contribution to an increase in $Y$. Note that a contribution from export exceeds that from import and therefore a contribution from net export is also positive.

Second, a contribution from net export is more significant than that from private domestic demand initially in 2016, while a contribution from private domestic demand becomes more substantial later in 2020. For example, a contribution from private domestic demand in 2016 is 0.156 in column (1), which is smaller than that from net export, 0.781 in column(4), in 2016. In 2020, however, a contribution from private domestic demand increases from 0.156 in 2016 to 0.692 in 2020, while a contribution from net export declines from 0.781 in 2016 to 0.264 in 2020. A closer look at export and import separately reveals that a contribution from export declines from 1.188 to 0.851 while that from import increases from 0.406 to 0.587. Therefore, the results suggest that while the positive effect of China's Plan is conveyed through the net export channel in the beginning, private domestic demand plays a bigger role in Korea's GDP growth later.

# 4. Brexit

In this chapter we put numbers on the medium run and long run consequences of Brexit. Bilateral trade agreement is not easily incorporated in GMW. Therefore, we follow a different approach from the previous chapter. In particular, we rely on both reduced form and structural approach to quantify the effect of Brexit. At the heart of our structural approach is the model developed by Eaton, Kortum, Neiman and Romalis (2016, EKNR henceforth). The model is a multicountry neoclassical growth model with Eaton-Kortum style Ricardian bilateral trade.

Our analysis deviates from EKNR in two important ways. First, our goal is different. They apply the model to account for global trade collapse in 2008-2009. Instead, we evaluate the effect of Brexit. Second, EKNR interpret trade barriers as kinds of wedge which might potentially account for trade collapse. Because trade barriers in the model do not necessarily represent tariff, we use a reduced form approach and associate the time-varying shocks on trade barriers to tariff. To conduct a counterfactual exercise on Brexit, we change the shocks according to tariff changes from the effectively applied current tariff (AHS) to WTO tariff (MFN) .

To quantify the effect of Brexit, it is required to identify how much and in which direction Brexit affect the shocks on trade barriers. To do that, we need the shocks in level as well as data on tariff. To extract the shocks in level, we derive a simple formula from the model and extract the shocks from data constructed by EKNR. One method to extract the shocks slightly differs from EKNR because we use the shocks in level while EKNR recover the shocks in growth term. Then we assume a linear relationship and regress the extracted shocks on sector level weighted average of tariff. In this way, we estimate the relationship between the shocks on trade barriers and the currently applied tariff for each country pair. Applying the difference in tariff between AHS and MFN to the estimated relationship, we can construct a counterfactual time series of the shocks after Brexit.

Finally, we plug the counterfactual shocks into the model and solve the model. Then the solution of the model represents an economy undergoing Brexit. We compare this solution to the solution of benchmark, in which there is no change in the shocks on trade barriers. In this way, we quantify the effects of Brexit.

In the following we first introduce the EKNR model and show how the model is used to quantify the effect of Brexit.

## 4.1. Model

Time is discrete and continues forever, $t = 1, 2, \ldots$. There are $N$ number of countries, $n = 1, \ldots, N$. There are four sectors $j \in \Omega = \{C, D, N, S\}$, where construction ($C$), durable manufactures ($D$), nondurable manufactures ($N$), and services ($S$). A continuum of goods $z \in [0, 1]$ is a separate one for each sector. Total output in each sector is a CES aggregate of the ouputs of goods $z \in [0, 1]$ with a constant elasticity of substitution $\sigma$. Every sector's output can be used as intermediate inputs for the production in every sector.

There are two types of capital $k \in \Omega_K \equiv \{C, D\}$. Either households or firms consume services of these stocks of capital. Through investment, each type of capital is used to accumulate the stocks of capital. Households consume goods from either nondurable manufactures or services sector $j \in \Omega_K^* = \Omega \setminus \Omega_K = \{N, S\}$.

The productivity draws for each $j$, $z$, and $n$ are characterized by the following type II extreme value distribution:

$$F_{n,t}^j(a) = \Pr[a_{n,t}^j \leq a] = \exp\left[-\left(\frac{a}{\gamma A_{n,t}^j}\right)^{-\theta}\right]$$

where $A_n^j > 0$. Higher $A_n^j$ implies better productivity draws and higher $\theta$ implies lower variability in productivity draws.

Production function for good $z$ in each sector $j$ is:

$$a_{n,t}^{j}(z)\left(\frac{L_{n,t}^{j}(z)}{\beta_{n}^{L,j}}\right)^{\beta_{n}^{L,j}}\prod_{k\in\Omega_{K}}\left(\frac{K_{n,t}^{jk}(z)}{\beta_{n}^{K,jk}}\right)^{\beta_{n}^{K,jk}}\prod_{j'\in\Omega}\left(\frac{M_{n,t}^{jj'}(z)}{\beta_{n}^{M,jj'}}\right)^{\beta_{n}^{M,jj'}},$$

where $j, j' \in \Omega$, $k \in \Omega_K$. $a_{n,t}^{j}(z)$, $L_{n,t}^{j}(z)$, $K_{n,t}^{jk}(z)$, and $M_{n,t}^{jj'}(z)$ denote a country $n$'s efficiency at making good $z$ in sector $j$, labor used for production of each good $z$ in each sector $j$ in country $n$ at date $t$, capital of type $k$ used for production of each good $z$ in each sector $j$, and intermediates from sector $j'$ applied to produce each good $z$ in each sector $j$. We assume that production function is constant returns to scale.

Only the outputs from tradable sectors, nondurable and durable sectors, are traded across countries. Transportation costs are defined as iceberg trade costs. Therefore, we assume that one unit of good $z$ shipped from country $i$ to country $n$ results in $1/d_{ni,t}^{j} \leq 1$ units arriving in country $n$, with $d_{nn,t}^{j} = 1$ and $d_{ni,t}^{j} > 0$.

The law of motion for capital accumulation of type $k$ in country $n$ is:

$$K_{n,t+1}^{k} = (I_{n,t}^{k})^{\alpha^{k}}(K_{n,t}^{k})^{1-\alpha^{k}} + (1-\delta^{k})K_{n,t}^{k}$$

where $K_{n,t}^{k}$, $I_{n,t}^{k}$, $0 < \alpha^{k} \leq 1$, and $\delta^{k}$ denote capital endowment of type $k$, investment, adjustment costs, and the depreciation rate respectively.

Country $n$'s representative household's preference is:

$$U_{n} = \sum_{t=0}^{\infty}\rho^{t}\left(\sum_{j\in\Omega_{K}^{*}}\psi_{n}^{j}\ln C_{n,t}^{j} + \sum_{k\in\Omega_{K}}\psi^{k}\ln K_{n,t}^{H,k}\right)$$

where $\left\{C_{n,t}^{j}\right\}_{j\in\Omega_{K}^{*}}$ and $\left\{K_{n,t}^{H,k}\right\}_{k\in\Omega_{K}}$ denote consumption of the nondurables and services goods and consumption of the services of the stocks of capital in durables and structures sectors respectively. $\psi_{n}^{j}$ is sectoral composition

parameters with $\psi^C + \psi^D + \psi^N_n + \psi^S_n = 1$. We only allow for country specific shift between nondurable and service sectors.

A state of a country $n$ at date $t$ is summarized by $L_{n,t}$, $\left\{K^k_{n,t}\right\}$, $\left\{a^j_{n,t}(z)\right\}$, and $\left\{d^j_{ni,t}\right\}$, where $L_{n,t}$ denotes labor endowment. Following EKNR, we formulate the world planner's problem and solve for competitive equilibrium as the solution to the planner's problem. The planner's objective at date 0 is as follows:

$$W = \sum_{n=1}^{N} \omega_n U_n \tag{4.1.1}$$

where $\omega_n$ is the weight assigned to country $n$.

The formal definition of the world planner's allocation is as follows.

**Definition** The *world planner's allocation* in this economy consists of time paths $\left\{ \left\{C^j_{n,t}\right\}, \left\{K^{H,k}_{n,t}\right\}, \left\{L^j_{n,t}(z)\right\}, \left\{K^k_{n,t}\right\}, \left\{K^{jk}_{n,t}(z)\right\}, \left\{K^{H,k}_{n,t}\right\}, \left\{M^{jj'}_{n,t}(z)\right\}, \left\{y^j_{n,t}(z)\right\}, \left\{x^j_{mn,t}(z)\right\}, \left\{x^j_{n,t}(z)\right\}, \left\{x^j_{n,t}\right\}, \left\{I^k_{n,t}\right\} \right\}^{\infty}_{t=0}$ that maximizes utility in equation (4.1.1) given the initial endowments of capital in each country, $K^k_{n,0}$, and the following sets of constraints:

1. The labor endowment restricts the labor used for production.
2. Each type of capital stock restricts the amount of capital used for production.
3. The output of $z$ is bounded by production technology and inputs used for the production.
4. The amount of the output of $z$ produced by country $n$ restricts the world's use of $z$ from $n$.

5. The sum of $n$'s absorption of good $z$ from world restricts country $n$'s total absorption.
6. Country $n$'s aggregates across total aborption of good $z$ restricts $n$'s absorption either for final or for intermediate use.
7. The sum of country $n$'s consumption and use for intermediates is restricted by $n$'s absorption from sector $h \in \Omega_K^*$.
8. The sum of country $n$'s investment and use for intermediates is restricted by $n$'s absorption from sector $k \in \Omega_K$.
9. Each type of capital accumulates according to the law of motion for each type of capital.

Because the model does not allow for a closed form for an equilibrium, we compute approximate equilibrium. Our benchmark calibration is essentially EKNR with no changes in the shocks across time. Therefore, the benchmark economy converges to its steady state, if it does not start in its steady state. Both the computation procedure for solving the model and the parametrization of our benchmark calibration are the same as EKNR and therefore we do not repeat here. The same computation procedure is applied when we solve the model with different processes of shocks on trade barriers as in our counterfactual exercises on Brexit.

## 4.2. Constructing Counterfactual Scenarios

Table 4.2.1 summarizes our counterfactual scenarios for Brexit. Based on the UK-EU trade agreement, we treat Scenario 1 and 2 as Soft Brexit and Scenario 3 and 4 as Hard Brexit. In Scenario 1 and 2, the United Kingdom succeeds in retaining their trade agreement with non-EU countries. In Scenario 3 and 4, the United Kingdom and EU levy MFN against each other rather than the current zero level of FTA tariff. Then non-EU countries in-

Table 4.2.1 : Counterfactual Scenarios after Brexit

| Country Pair | UK-EU | UK-Non EU countries | UK-Korea |
|---|---|---|---|
| Scenario 1 | FTA | FTA | FTA |
| Scenario 2 | FTA | FTA | MFN |
| Scenario 3 | MFN | FTA | FTA |
| Scenario 4 | MFN | MFN | MFN |
| Date of Brexit | | 2018 Q4 | |

Source: Kim, Kim, Han, Kim, Cho and Lim (forthcoming)

cluding Korea choose whether to implement a new trade agreement with the United Kingdom. In all scenarios, we assume that EU and non-EU countries including Korea retain the current FTA.

We assume that the U.K. increases its tariffs in the fourth quarter of 2018 in our counterfactual for Brexit.[10] We also assume that every tariff change is bilateral. Therefore, if a country changes its tariff on goods from the the United Kingdom from FTA tariff to MFN tariff, the United Kingdom also changes its tariff on goods from the country in the same way.

We now illustrate how the model can be used to construct each counterfactual scenario after Brexit. First, we need to extract time series of the shocks on trade barriers. EKNR only extract the changes in the shocks. Instead, we extract the shocks on trade barriers in levels for our analysis. From Eaton and Kortum (2002)'s familiar share of the absorption shipped from

[10]Our conjecture is that the timing of tariff changes does not matter if it is far away from the fourth quarter of 2011, which is the late time of our data and after which we assume that there is no change in all our shocks except for the counterfactual shock.

country $i$ to $n$ in sector $j$:

$$\pi^j_{ni,t} = \left( \frac{c^j_{i,t} d^j_{ni,t}}{A^j_{i,t} p^j_{n,t}} \right)^{-\theta}, \quad \text{for } j \in \{D, N\}, \tag{4.2.1}$$

where

$$c^j_{n,t} = \left(w_{n,t}\right)^{\beta^{L,j}_n} \Pi_{k \in \Omega_K} \left(r^k_{n,t}\right)^{\beta^{K,jk}_n} \Pi_{j' \in \Omega} \left(p^{j'}_{n,t}\right)^{\beta^{K,jj'}_n}$$

Dividing $\pi^j_{ni,t}$ by $\pi^j_{ii,t}$ and reformulating, we have the shocks on trade barriers $d^j_{ni,t}$ in level in terms of trade shares and prices:

$$d^j_{ni,t} = \left( \frac{\pi^j_{ni,t}}{\pi^j_{ii,t}} \right)^{-\frac{1}{\theta}} \frac{p^j_{n,t}}{p^j_{i,t}} \tag{4.2.2}$$

Applying data on trade share and price index, both of which are constructed by EKNR, to eq.(4.2.2), we extract the shocks on trade barriers in level.

Once the shocks on trade barriers are extracted, we construct the association between the shocks on trade barriers and the currently applied tariff for each country pair. The previous gravity literature, Eaton and Kortum (2002) for instance, relate the shocks on trade barriers to proximity and language. Because we are interested in tariff changes from the implementation of FTA, we add tariff to the standard regression of the gravity equation. Therefore, we relate the barriers in moving goods from country $i$ to $n$ to proximity, language, and tariff. In particular, we have, for all $i \neq n$ and $j \in \{D, N\}$:

$$\begin{aligned} \log d^j_{ni,t} \;=\; & \alpha + comlang_{ni} + \beta \log(dist_{ni}) + landborder_{ni} + tariff^j_{ni,t} \\ & + \alpha_n + \alpha_i + \varepsilon_{ni,t}, \end{aligned} \tag{4.2.3}$$

where $\beta$ is the coefficient for log of geographic distance between $n$ and $i$, $dist_{ni}$, and the dummy variables associated with each effect has been sup-

pressed for notational simplicity. Here $comlang_{ni}$ is the effect of $n$ and $i$ speaking a common language, $landborder_{ni}$ is the effect of $n$ and $i$ being neighboring countries, and $tariff_{ni}$ is the effect of tariff levied by $n$ on $i$'s goods. $\alpha$, $\alpha_n$, and $\alpha_i$ are constant term and country fixed effects for $n$ and $i$. $\varepsilon^j_{ni}$ is the error term which captures trade impediments arising from all other factors.

To estimate (4.2.3), we need data on $comlang_{ni}$, $dist_{ni}$, $landborder_{ni}$ and $tariff_{ni}$ for each country pair. $comlang_{ni}$ and $dist_{ni}$ are from CEPII. We manually construct $landborder_{ni}$ for each country pair. The source of $tariff^j_{ni}$ is the World Bank's World Integrated Trade Solution (WITS) website. To construct $tariff^j_{ni}$ for durable and nondurable sectors, first we start with with the relevant 2-digit International Standard Industrial Classification (ISIC Rev. 3) data on tariff and imports value for each country pair. Applying the import share as a weight to the effectively applied (AHS) weighted average tariff, we calculate each year's weighted average tariff for durable and nondurable sectors for each country pair.

Table 4.2.2 shows the regression results of eq.(4.2.3) for durable and nondurable sectors. In both regressions, speaking common language and sharing a border tend to reduce trade frictions. On the other hand, distance between a pair of countries tends to increase the trade frictions. These estimated coefficients are in line with the previous gravity literature.

All three proxies for geographic barriers on trade do not change by the implementation of policies. To study the counterfactual effect of Brexit, therefore, our focus should be the effect of tariff on the shocks on trade barriers. Column (2) and (4) show that tariff only tends to significantly increase trade frictions in the durable sector when we control for geographic factors. In the following counterfactual exercise, therefore, we assume that tariff change from Brexit will change trade frictions only in durable sectors. Among others, we use the result in column (2) in Table 4.2.2 as our estimated association between tariff and the shocks on trade barriers.

Table 4.2.2 : Trade Friction Regression

| | (1) $\log d_{ni}^{D}$ | (2) $\log d_{ni}^{D}$ | (3) $\log d_{ni}^{S}$ | (4) $\log d_{ni}^{S}$ |
|---|---|---|---|---|
| tariff_durable$_{ni}$ | 0.039*** | 0.005*** | | |
| | (6.87) | (3.29) | | |
| tariff_nondurable$_{ni}$ | | | 0.024*** | 0.001 |
| | | | (5.32) | (0.64) |
| common language$_{ni}$ | | -0.235*** | | -0.269*** |
| | | (-38.18) | | (-30.22) |
| log of distance$_{ni}$ | | 0.578*** | | 0.624*** |
| | | (62.45) | | (41.17) |
| land border$_{ni}$ | | -0.157*** | | -0.161*** |
| | | (-28.22) | | (-7.33) |
| Constant | 1.617*** | -2.198*** | 2.168*** | -2.000*** |
| | (57.52) | (-27.49) | (27.22) | (-16.92) |
| Observations | 16156 | 11586 | 12412 | 9870 |
| Adjusted $R^2$ | 0.744 | 0.901 | 0.737 | 0.915 |

Note: (1) $t$ statistics in parentheses

(2) $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Source: Author's estimation

Table 4.2.3 : Tariff Changes and Changes in Trade Barriers 2-1

| Importer | Exporter | Year | Tariff Change (%) | Trade Barriers |
|---|---|---|---|---|
| United Kingdom | Austria | 2006 | 7.565 | 1.034 |
| United Kingdom | Canada | 2006 | 0 | 1 |
| United Kingdom | China | 2006 | 0.303 | 1.001 |
| United Kingdom | Czeck Republic | 2006 | 8.479 | 1.038 |
| United Kingdom | Denmark | 2006 | 5.600 | 1.025 |
| United Kingdom | Finland | 2006 | 2.448 | 1.011 |
| United Kingdom | France | 2006 | 7.968 | 1.036 |
| United Kingdom | Germany | 2006 | 8.327 | 1.038 |
| United Kingdom | Greece | 2006 | 9.858 | 1.045 |
| United Kingdom | India | 2006 | 0.087 | 1.000 |
| United Kingdom | Italy | 2006 | 8.122 | 1.037 |
| United Kingdom | Japan | 2006 | 0 | 1 |
| United Kingdom | Mexico | 2006 | 0.139 | 1.001 |
| United Kingdom | Poland | 2006 | 10.284 | 1.047 |
| United Kingdom | Romania | 2006 | 9.229 | 1.042 |
| United Kingdom | Korea | 2006 | 6.245 | 1.028 |
| United Kingdom | Spain | 2006 | 11.529 | 1.052 |
| United Kingdom | Sweden | 2006 | 8.598 | 1.039 |
| United Kingdom | United States | 2006 | 0 | 1 |
| United Kingdom | Rest of World | - | 5.552 | 1.025 |

Note: (1) Tariff change = weight average MFN−weighted average AHS.

(2) Trade Barriers= $d^j_{ni,t+1}/d^j_{ni,t} = 0.00454\times$tariff change$+1$.

(3) ROW's tariff change is the average of all other tariff changes.

Source: Author's calculation

Table 4.2.4 : Tariff Changes and Changes in Trade Barriers 2-2

| Importer | Exporter | Year | Tariff Change (%) | Trade Barriers |
|---|---|---|---|---|
| Austria | United Kingdom | 2006 | 8.358 | 1.038 |
| Canada | United Kingdom | 2015 | 0 | 1 |
| China | United Kingdom | 2015 | 0 | 1 |
| Czech Republic | United Kingdom | 2006 | 8.358 | 1.038 |
| Denmark | United Kingdom | 2006 | 8.358 | 1.038 |
| Finland | United Kingdom | 2006 | 8.358 | 1.038 |
| France | United Kingdom | 2006 | 8.358 | 1.038 |
| Germany | United Kingdom | 2006 | 8.358 | 1.038 |
| Greece | United Kingdom | 2006 | 8.358 | 1.038 |
| India | United Kingdom | 2013 | 0 | 1 |
| Italy | United Kingdom | 2006 | 8.358 | 1.038 |
| Japan | United Kingdom | 2015 | 0 | 1 |
| Mexico | United Kingdom | 2014 | 5.675 | 1.026 |
| Poland | United Kingdom | 2006 | 8.358 | 1.038 |
| Romania | United Kingdom | 2006 | 8.358 | 1.038 |
| Korea | United Kingdom | 2015 | 5.531 | 1.025 |
| Spain | United Kingdom | 2006 | 8.358 | 1.038 |
| Sweden | United Kingdom | 2006 | 8.358 | 1.038 |
| United States | United Kingdom | 2015 | 0 | 1 |
| Rest of World | United Kingdom | - | 5.868 | 1.027 |

Note: (1) Tariff change = weight average MFN−weighted average AHS.

(2) Trade Barriers= $d^j_{ni,t+1}/d^j_{ni,t} = 0.00454\times$tariff change$+1$.

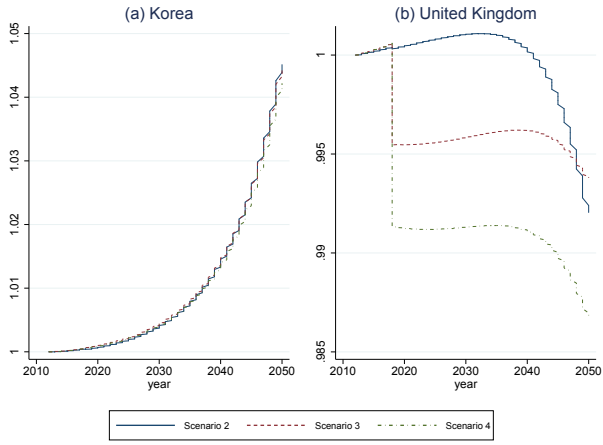
(3) ROW's tariff change is the average of all other tariff changes.

Source: Author's calculation

Given the association between the shocks on trade barriers and tariff, we now predict changes in tariff from Brexit. We assume that tariff increases from the current AHS tariff to the MFN tariff for each country pair. Table 4.2.3 and 4.2.4 show those tariff changes for each country pair. We attempt to use the most recent data on both tariffs from the World Bank's World Integrated Trade Solution (WITS) website. Tariff changes are the weighted average MFN net of the weighted average AHS for each country pair. Tariff changes with the rest of the world are the average of all other tariff changes.

We apply tariff changes to the estimated relationship between tariff and the shocks on trade barriers (column (2) in Table 4.2.2 ). Thereby we calculate the counterfactual changes in the shocks on trade barriers arising from Brexit.[11] The last column in Table 4.2.3 and 4.2.4 show these counterfactual changes in the shocks on trade barriers corresponding to tariff changes for each country pair. Depending on the scenarios on Brexit, we determine the country pairs of which the shocks on trade barriers should be changed according to Table 4.2.3 and 4.2.4 . For example, if every country retains FTA and only the United Kingdom and Korea levy MFN against each other as in Scenario 2, we only need to implement the changes in trade barriers between Korea and the United Kingdom from Table 4.2.3 and 4.2.4 . Finally, we solve the model with the newly implemented conterfactual shocks on trade barriers.

Figure 4.3.1 : The Effect of Brexit on Korea and the United Kingdom's GDP




Source: Author's calculation

## 4.3. Results

Figure 4.3.1 shows the model's predicted time series of GDP of Korea and the United Kingdom in every scenario. Because Scenario 1 is our benchmark, GDPs in Scenario 1 take a value of unity and GDPs in the other scenarios are relative to that of benchmark. In the Appendix , we also illustrate the time series of other eighteen countries' relative GDP in every scenario.

In panel (a), the model predicts that Korea either gains or loses from an FTA with the United Kingdom. In particular, when the United Kingdom remains an EU member state, Korea loses from an FTA with the United Kingdom. When the United Kingdom exits from an EU, however, Korea gains

[11] From our regression,

$$\frac{\partial d^j_{ni,t}}{d^j_{ni,t}} = \hat{\beta} \times \partial tariff^j_{ni} = 0.0045 \times \partial tariff^j_{ni}$$

from an FTA with the United Kingdom. On the other hand, panel (b) shows that the United Kingdom gains from an FTA with Korea in the long run, regardless of whether or not the United Kingdom remains in the EU. For example, the United Kingdom as an EU member state loses from an FTA with Korea from the beginning through 2040, while it starts to gain from an FTA with Korea after 2040. When the United Kingdom exits from the EU, the United Kingdom consistently gains from an FTA with Korea during the whole period.

In a static model such as Eaton and Kortum (2002), trade liberalization is as if a country has access to better technology. As a result, trading gives the country better distribution of prices of intermediate goods and therefore the country must gain from a reduction in trade barriers. Our dynamic model's prediction is somewhat different in that Korea sometimes loses from an FTA with the United Kingdom. Alothough we are not able to prove it analytically, we conjecture that our seemingly counterfactual results arise from the interaction between capital accumulation and market access versus the substitution effect. In particular, Korea loses its market share by ending its FTA with the United Kingdom. On the other hand, the other countries which trade with Korea gain from Korea's ending the FTA because Korea substitutes its import from the United Kingdom to these other countries. Through the input-output linkage, the growth pick up in these other countries in turn would benefit Korea especially if these other countries are fast growing economies through capital accumulation.

The previous Figure 4.3.1 shows that some countries such as Korea might lose from trade liberalization with the United Kingdom. The loss from trade liberalization might seem to be not consistent with the other standard theories and empirical evidences on trade liberalization. We want to know whether our model predicts a loss from trade liberalization in general. Table 4.3.1 provides the answer to the question. The table shows the ordering of Sce-

Table 4.3.1 : Country's Preference for Scenarios in 2050

| | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|---|---|---|---|---|
| Austria | 1 | 2 | 3 | 4 |
| Canada | 1 | 2 | 3 | 1 |
| China | 4 | 2 | 1 | 2 |
| Czech Republic | 1 | 2 | 3 | 3 |
| Denmark | 1 | 2 | 3 | 4 |
| Finland | 4 | 1 | 3 | 2 |
| France | 1 | 2 | 4 | 3 |
| Germany | 1 | 2 | 3 | 4 |
| Greece | 4 | 3 | 2 | 1 |
| India | 1 | 2 | 4 | 3 |
| Italy | 1 | 2 | 4 | 3 |
| Japan | 1 | 3 | 2 | 4 |
| Mexico | 4 | 3 | 1 | 2 |
| Poland | 1 | 3 | 2 | 4 |
| Romania | 1 | 3 | 4 | 2 |
| Korea | 4 | 1 | 2 | 3 |
| Spain | 1 | 4 | 3 | 2 |
| Sweden | 1 | 2 | 4 | 3 |
| United Kingdom | 1 | 3 | 2 | 4 |
| United States | 1 | 3 | 4 | 2 |
| Number of 1 | 15 | 2 | 2 | 2 |
| Number of 2 | 0 | 10 | 5 | 6 |
| Number of 3 | 0 | 7 | 7 | 6 |
| Number of 4 | 5 | 1 | 6 | 6 |

Note: The number is the ordering of our four scenarios based on GDP in 2050, e.g. Italy's highest and lowest GDP's in 2050 are in Scenario 1 and 3.

narios for each country based on GDP in 2050. For example, Korea's GDP in Scenario 2 is the highest among the four scenarios, GDP's in Scenario 3 and 4 are the second and the third highest, and GDP in Scenario 1 is the lowest. We use Figure 4.4.1 -4.4.3 in the Appendix and construct the table.

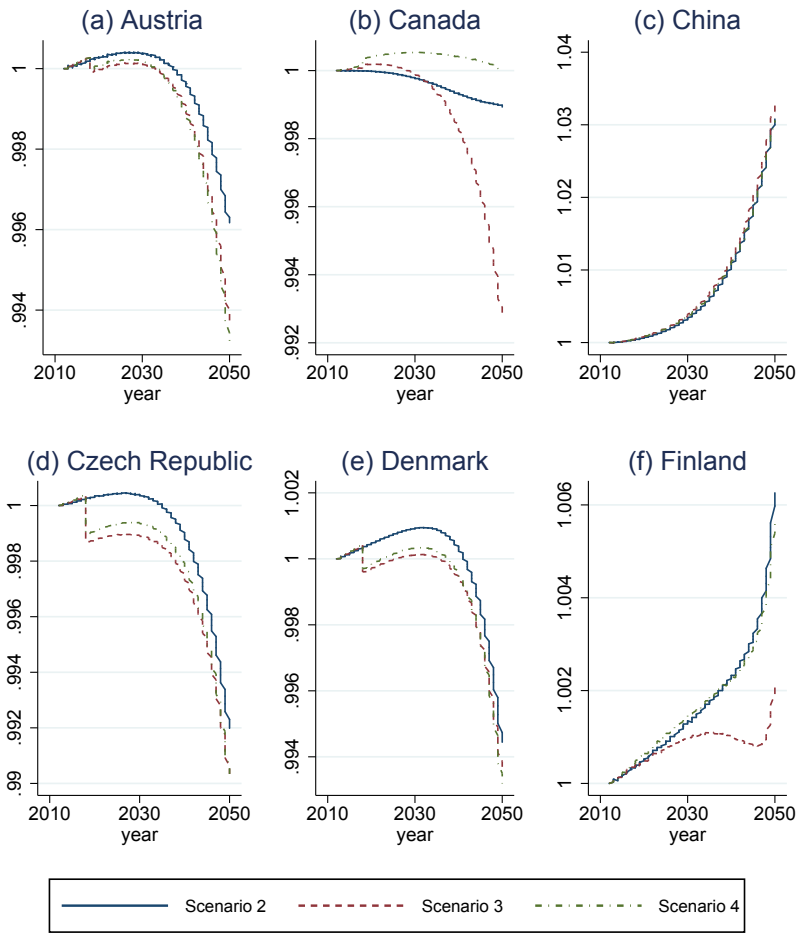
In Table 4.3.1 , we observe the overall gain from trade liberalization. In particular, we count the number of 1's in each scenario. Most countries, especially in Europe, gain the most in Scenario 1. The United Kingdom is one of them. At a first glance, Korea seems to be exceptional. However, its GDP is the highest in Scenario 2, in which Korea agrees on FTA's with all other countries except for the United Kingdom. Among the five countries, China, Finland, Greece, Mexico, and Korea, of which GDP is the lowest in Scenario 1, only Greece is exceptional in that its GDP is the highest in a world without FTA.

Therefore, we do not think that our results are against the general trend in gain from trade liberalization. Instead, we argue that our results confirm the overall trend in gains from trade liberalization again. Depending on factors such as a country's input-output linkages with other countries, moving up and down in global value chains, and whether a country and its trading partners are growing, a country could either gain or lose from an FTA with a specific country.

## 4.4. Appendix: Additional Figures

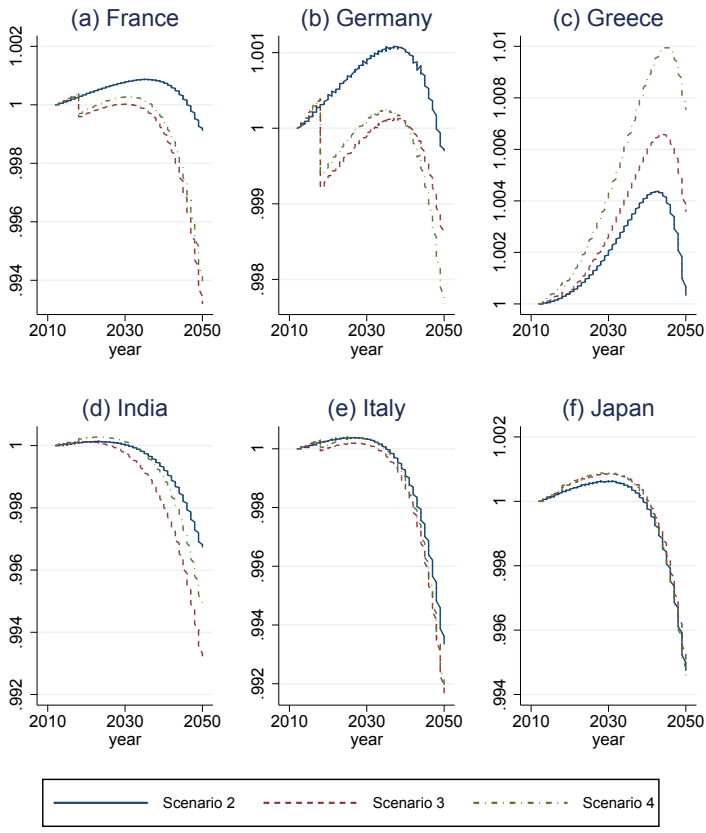
This appendix provides additioanl figures. Figure 4.4.1 -4.4.3 shows the time series of eighteen countries' GDP in Scenario 2, 3, and 4 relative to that in Scenario 1. These eighteen countries include Austria, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, India, Italy, Japan, Mexico, Poland, Romania, Spain, Sweden, and the United States. The following figures are also used to construct the previous Table 4.3.1 .

Figure 4.4.1 : The Effect of Brexit 3-1



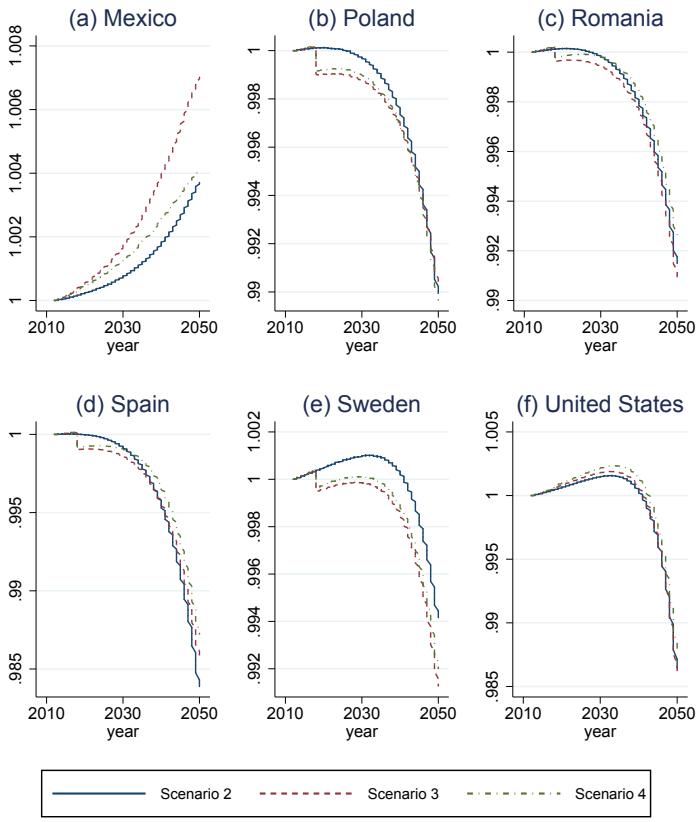

Source: Author's calculation

Figure 4.4.2 : The Effect of Brexit 3-2




Source: Author's calculation

Figure 4.4.3 : The Effect of Brexit 3-3




Source: Author's calculation

# 5. Summary and Policy Implications

## 5.1. Summary

The global economy still remains on a slow growth path. With an incipient, short recovery right after the end of the 2009 recession, the global economy has exhibited slow growth since 2015. Among the other final demand components of GDP, the global economy especially sees weak investment growth and trade slowdown.

Korea still faces severe headwinds from the weak growth recovery. Since Korea's growth path has tended to converge to that of the global economy since 2003, Korea's recent growth moderation partly reflects a still-weak global economy. A closer look at Korea's final demand components suggests that a recovery in the domestic investment is offset by a weak growth in consumption and a notable slowdown in trade. Therefore, the proximate cause of growth slowdown in Korea differs from that of global growth slowdown. Without the boost by the external demand for Korea's products, the Korean economy would lose its momentum in robust growth. Along with a weak growth in domestic consumption, Korea's substantial export disruption might lead to a further slowdown in the Korean economy in the future.

We suspect that there are common and structural global factors behind the convergence of Korean economy to the slow growth path of the global economy. Motivated by the recent policy-oriented works, we have analyzed the four structural changes of aging population, rising income inequality, the implementation of China's 13$^{th}$ Five-Year Plan, and Brexit. In particular, we have quantified their effects on the Korean economy and analyze the mechanism through which the structural changes affect the Korean economy.

Chapter 3 addresses the issues of aging population and rising income inequality in China, Japan, and the United States, and the implementation of China's 13$^{th}$ Five-Year Plan. The first finding in this chapter is that aging pop-

ulation has negative consequences on the Korean economy. Equally importantly, even though aging population in our neighboring countries has a significant effect on Korean economy, aging in Korea itself plays a major role in reducing Korea's GDP.

To further our understanding about the mechanism through which the aging population affects Korea's GDP, we apply a decomposition framework to the demand side of Korea. We find that aging tends to reduce all three aggregate demand components, private domestic demand, export, and import. Among them, the effect through private domestic demand is the most important channel. Because import tends to decline more than export, net export somewhat offsets the negative effects of aging through private domestic demand channel.

We also analyze the effects of rising income inequality in China, Japan, and the United States. Even though the overall effect of inequality is smaller than that of aging, inequality also tends to reduce Korea's GDP. As similar to the accounting results on aging, the same decomposition framework reveals that private domestic demand is the main driver of reducing Korea's GDP and net export partly offsets the negative consequences from inequality. Deviating from the accounting results on aging, export tends to increase and partly offset the overall negative effects of inequality. We conjecture that bigger increase in investment might cause the growth pick up through an increase in export because an increase in top 1% income shares tends to increase investment.

In the last part of Chapter 3, we analyze the effects of the implementation of China's 13$^{th}$ Five-Year Plan. We find that China's Plan tends to increase Korea's GDP. The same accounting framework reveals that China's implementation has positive consequences through all demand components. Notably, in the beginning positive effects from China's Plan go through external channel such as net export, while over time the contribution of private domestic

demand continues to increase while that of external demand declines.

We devote Chapter 4 to the quantitative analysis of Brexit. At first glance, our results do not seem to be consistent with the standard gain from trade liberalization. For example, Korea can sometimes lose from an FTA with the United Kingdom. Instead, raising trade barriers against the United Kingdom sometimes benefit Korea's growth. Although we are not able to prove it analytically, we conjecture that our seemingly counterfactual results arise from the interaction between capital accumulation and market access versus the substitution effect. In particular, ending an FTA with a certain country might benefit our other trading partners if we import goods from them instead of the original exporter. Such substitution effect might be large enough to give us back the benefit especially if the other new trading partners are fast growing economies.

Equally importantly, however, we do not argue that our results are against the general trend in gain from trade liberalization. Instead, we argue that our results confirm the overall gains from trade liberalization again. Depending on factors such as a country's input-output linkages with other countries, moving up and down in global value chains, and whether a country and its trading partners are growing, a country could either gain or lose from an FTA with a specific country.

## 5.2. Policy Implications

Based on our quantitative results, we propose the following policy recommendations. First, all our results in Chapter 3 support the important role played by domestic demand. Both rising inequality and aging population affect Korea's GDP primarily through the private domestic demand channel. In the beginning of the implementation of China's Five Year Plan, the external sector is the main driver of boosting an economy. Over time, however,

the channel through which domestic demand affects Korea's GDP outweighs external channels such as net export. Therefore, we should treat domestic issues of aging and rising inequality as important. Furthermore, our results in Chapter 3 show that implementing policies, of which target is the domestic variables, can sometimes be more effective.

Second, the policy to address aging population through raising the fertility rate should take into account trade-off between current employment and investment and the number of future working aged population. Chapter 3 shows that an increase in fertility rate has negative consequences in employment and investment. The result is consistent with our intuition that if women have more children, they are less inclined to supply labor. Therefore employment would decline. At the same time, because production factors, labor and capital, are complementary in general, a decrease in emploment would lead to investment slowdown. On the other hand, raising the fertility rate implies an increase in the future working aged population. Again due to complementarity between production factors, this can boost investment and pick up growth in the future. Therefore, implementation of the policy to address aging should be based on the optimal growth of population and take into account trade off between its short run and long run effects.

Third, we need to deeply look into the whole income distribution to address rising income inequality. Chapter 3 shows that looking at one single index of inequality might be insufficient to analyze the consequences of inequality. Population within the different income groups might play a different role and the aggregate consequences might depend on the whole income distribution. For example, one of our results illustrate that the population within the top 1 percent income group tends to have positive consequences on employment and investment. In the absence of detailed data, however, we cannot tell what kinds of people among them would benefit domestic demand. Instead of targeting a single index for inequality, there-

fore, policy tools to address rising inequality should be grounded by more sophisticated analysis.

Finally, after Brexit and more recently the presidential election in the United States, trade protectionism, which is partly fueled by rising income inequality, has been one of the recent incipient trends. Our results in Chapter 4 show that trade protectionism should have negative consequences on the global economy. However, equally importantly, depending on factors such as a country's input-output linkages with other countries, moving up and down in global value chains, and whether a country and its trading partners are growing, a country could either gain or lose from an FTA with a specific country. Given that the gain from trade liberalization may not be bilateral in practice, a careful approach to quantify the effect of trade liberalization should be necessary before the implementation of an FTA with a certain country.

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# Executive Summary

The Korean economy still faces severe headwinds from the weak growth recovery. Since Korea's growth path has tended to converge to that of the global economy since 2003, Korea's recent growth moderation partly reflects a still-weak global economy. Along with a weak growth in domestic consumption, Korea's substantial export disruption might lead to a further slowdown in the Korean economy in the future.

In this monograph, we suspect that there are common and structural global factors behind the convergence of Korean economy to the slow growth path of the global economy. Motivated by the recent policy-oriented works, we have analyzed the four structural, external changes of aging population, rising income inequality, the implementation of China's 13th Five-Year Plan, and Brexit. In particular, we have quantified their effects on the Korean economy and analyzed the mechanism through which the structural changes affect the Korean economy.

Our first finding exhibits the important role played by private domestic demand. Both rising inequality and aging population affect Korea's GDP primarily through the private domestic demand channel. In the beginning of the implementation of China's 13th Five-Year Plan, the external sector is the main driver of affecting Korea's GDP. Over time, however, the channel through which private domestic demand affects Korea's GDP outweighs external channels such as net export. Therefore, our results in

Chapter 3 show that implementing policies, of which target is the domestic variables, can be more effective.

Second, the policy to address aging population through raising the fertility rate should take into account trade-off between current employment and investment and the number of future working aged population. Our results show that an increase in fertility rate has negative consequences in current employment and investment. The result is consistent with our intuition that if women have more children, they are less inclined to supply labor. Therefore employment would decline. At the same time, because production factors, labor and capital, are complementary, a decrease in employment would lead to investment slowdown. On the other hand, raising the fertility rate implies an increase in the future working aged population. Again due to complementarity between production factors, this can boost investment and pick up growth in the future. Therefore, implementation of the policy to address aging should be based on the optimal growth of population and take into account trade-off between its short run and long run effects.

Third, we need to deeply look into the whole income distribution to address rising income inequality. Our results show that looking at one single index of inequality might be insufficient to analyze the consequences of inequality. Population within the different income groups might play a different role and the aggregate consequences might depend on the whole income distribution. For example, one of our results illustrate that the population within the top one percent income group tends to have positive consequences on employment and investment. In the absence of detailed data, however, we cannot tell what kinds of people among them would benefit domestic demand. Instead of targeting a single index for inequality, therefore, policy tools to address rising inequality should be grounded by further information on the whole income distribution.

Finally, we devote Chapter 4 to the quantitative analysis of Brexit. At first glance, our results do not seem to be consistent with the standard gain from trade liberalization. For example, Korea can sometimes lose from an FTA with the United Kingdom. Instead, raising trade barriers against the United Kingdom sometimes benefit Korea's growth. Our seemingly counterfactual results would arise from the interaction between capital accumulation and market access versus the substitution effect. In particular, ending an FTA with a certain country might benefit our other trading partners if we import goods from them instead of the original exporter. Such substitution effect might be large enough to give us back the benefit especially if the other new trading partners are fast growing economies.

Equally importantly, however, we do not argue that our results are against the general gain from trade liberalization. Instead, we argue that our results confirm the overall gains from trade liberalization again. Depending on factors such as a country's input-output linkages with other countries, moving up and down in global value chains, and whether a country and its trading partners are growing, a country could either gain or lose from an FTA with a specific country. Given that the gain from trade liberalization may not be bilateral in practice, a careful approach to quantify the effect of trade liberalization should be necessary before the implementation of an FTA with a certain country.

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Policy Analysis 16-02

# Implications of Global Recession and Structural Changes for Korean Economy

Minsoo Han, Soobin Kim, and Jinhee Lee

The main contributions of this monograph are to quantitatively analyze the effects of aging population, rising income inequality, China's 13th Five-Year Plan, and Brexit. To do that, we use the Oxford Economics Global Model Workstation and the model developed by Eaton, Kortum, Neiman, and Romalis (2016). Our quantitative results suggest four primary lessons. First, the domestic demand channel is as important as net export channels. Second, the policy to address aging through raising the fertility rate should take into account trade-off between current employment and investment and the number of future working-aged population. Third, the policy to address inequality should be grounded by further information on the whole income distribution, instead of targeting a single index for inequality. Finally, even though trade protectionism has negative consequences on the global economy, the gain from trade liberalization may not be bilateral between trading countries, depending on various characteristics of the countries.

94320
9 788932 216683
ISBN 978–89–322–1668–3
978–89–322–1088–9(Set)
Price USD 5

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