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Sources of Trade Balance Dynamics in Korea*

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Jiwoon Kim
School of Economics, Hongik University, South Korea
Jongmin Yu†
School of Economics, Hongik University, South Korea

Abstract

Purpose – This study quantifies sources of trade balance dynamics over the business cycle in Korea. Specifically, we quantify the relative importance of domestic and foreign factors on trade balance dynamics using a small open economy real business cycle (SOE-RBC) model and provide policy implications for stabilization policies. Aggregate productivity and interest rate spreads are considered domestic factors affecting the trade balance. A world interest rate (the U.S. interest rate) is considered a foreign factor.

Design/methodology – Following Neumeyer and Perri (2005), we build the SOE-RBC model with three types of shocks: aggregate productivity, interest rate spread, and world interest shocks. The model is estimated by the generalized method of moments (GMM) using relevant business cycle statistics. The estimated model is used for quantifying the relative importance of domestic and foreign factors on trade balance dynamics in Korea.

Findings – Our main findings can be summarized as follows: 85.64% of the trade balance fluctuations in Korea are explained by domestic factors, the remaining 14.35% by foreign factors. Particularly, trade balance dynamics are mostly accounted for by the change in aggregate productivity shocks (85.58%). World interest rate shocks considerably explain trade balance (14.35%), whereas the role of interest rate spread shocks that represent domestic risks is limited (0.08%). Although aggregate productivity is key in explaining trade balance dynamics in Korea, interest rates still have an essential role. This is because aggregate productivity changes induce interest rate spread variations and, thus, the trade balance significantly. The results suggest that government policies mitigating fluctuations in aggregate productivity would be effective for stabilization policies in Korea by reducing the trade balance volatility.

Originality/value – Existing studies on the emerging market business cycle examine mostly Latin American countries, and the main object of the studies is the volatility of consumption rather than trade balance dynamics. Conversely, our study examines Korea rather than Latin American countries. Additionally, we examine sources of trade balance dynamics, which are relatively more important in Korea, rather than those of the volatility of consumption. Hence, we estimate the model to explicitly match moments related to trade balance in the data.

Keywords: Aggregate Productivity, Business Cycle, Korea, Real Interest Rate, Spread, Trade Balance Dynamics
JEL Classifications: E32, E43, F41, F44

1. Introduction

The share of exports, imports, and the trade balance—the difference between exports and imports—in Korea's national income is relatively high compared to that of other advanced countries (Kim and Kim, 2021). Furthermore, the volatility of the trade balance in Korea is

† **Corresponding author:** yucono@hongik.ac.kr

also high compared to that of those countries (Neumeyer and Perri, 2005[1]; Uribe and Schmitt-Grohe, 2017[2]). Hence, trade balance dynamics may be important in business cycles in Korea. Moreover, although the volatility of the real GDP in Korea has decreased[3] after the 2008 global financial crisis[4], the contribution of the trade balance volatility to the volatility of real GDP has instead increased (Lee et al., 2017). This suggests that the welfare cost of business cycles in Korea is more likely attributed to trade balance fluctuations than those in consumption and investment. Therefore, to lower the welfare cost of business cycles in Korea, reducing trade balance volatility may be relatively more effective than reducing consumption and investment volatility.

Hence, this study quantifies sources of trade balance dynamics over the business cycle in Korea. Several studies in international macroeconomics—Neumeyer and Perri (2005), Uribe and Yue (2006), Aguiar and Gopinath (2007), Garcia-Cicco et al. (2010), Chang and Fernandez (2013), and Miyamoto and Nguyen (2017)—examined trade balance dynamics over the business cycle in emerging countries. These studies are limited not only to the trade balance dynamics but also investigate international business cycles including dynamics of output, consumption, investment, and trade balance, which constitute national income. Most of these studies focus on consumption dynamics to identify sources of the difference in the volatility of consumption between emerging and developed countries. However, we focus on the source of trade balance dynamics rather than consumption dynamics as the former is relatively more important in Korea than in other countries.

In previous studies of the international business cycle, mentioned above, aggregate productivity and real interest rates are the main factors for economic fluctuations in small open economies. In national income identity, the trade balance is defined as output minus consumption and investment. This is equivalent to net exports. Fluctuations in domestic aggregate productivity can affect trade balance dynamics by changing relative sizes of output, consumption, and investment. Although they are increased by positive productivity shocks, the relative change in each factor is different, causing trade balance variations. If a positive aggregate productivity shock increases income more than consumption and investment, the trade balance will increase. On the other hand, real interest rate variations can also affect trade balance dynamics. An increase in real interest rate lowers consumption and investment given domestic production, leading to an increase in the trade balance. Additionally, an increase in real interest rates leads to higher borrowing costs abroad, reducing consumption and investment and further increasing trade balance.

Aguiar and Gopinath (2007) argue that the trend (or permanent) aggregate productivity is key in accounting for fluctuations in consumption and the countercyclical trade balance in Mexico. In contrast, Neumeyer and Perri (2005) and Uribe and Yue (2006) introduced the

[1] Table 1 of Neumeyer and Perri (2005) shows that among ten countries (Argentina, Australia, Brazil, Canada, Korea, Mexico, Netherlands, New Zealand, Philippines, Sweden), Korea has the highest standard deviation of the trade balance.

[2] Table 1.9 of Uribe and Schmitt-Grohe (2017) shows that the standard deviation of the trade balance in Korea is the 5th highest among the 28 countries.

[3] The phenomenon is called the Great Moderation in developed countries, which is characterized by the reduction in the volatility of business cycle fluctuations from the mid-1980s until 2007 compared with the decades before.

[4] The global financial crisis refers to a severe worldwide financial crisis occurring in the late 2000s, and it is called also called the subprime mortgage crisis. During this period, severe contraction of liquidity in global financial markets originating in the United States owing to the collapse of the US housing market.

notion that real interest rate fluctuations, which are amplified by financial frictions, significantly impact the emerging market business cycle.[5] Garcia-Cicco et al. (2010) and Chang and Fernandez (2013) confirm that real interest rate fluctuations, which are amplified by financial frictions, are the main driving forces for business cycles in emerging countries, whereas the role of permanent productivity shocks is limited.[6] Miyamoto and Nguyen (2017) quantify the relative importance of aggregate productivity and real interest rate fluctuations to output variations for seventeen countries.[7] Moreover, they find that relative contributions vary across countries. Their results show that real interest rate variations are key in explaining business cycles in Mexico and Argentina; however, aggregate productivity fluctuations are negligible for the output variations. Conversely, aggregate productivity variations explain a large fraction of output variations for India, Taiwan, Venezuela, Australia, and Portugal.

Based on previous studies' results on international business cycles, our study also considers aggregate productivity and real interest rate fluctuations as major sources of trade balance dynamics. The real interest rate is the sum of two independent components: interest rate spreads, which capture domestic risks, and a world interest rate, which is independent of domestic factors. Hence, aggregate productivity and interest rate spreads are considered domestic factors affecting trade balance, and a world interest rate (the U.S. interest rate) is considered a foreign factor.

Our study departs from previous works by quantifying the relative importance of domestic and foreign factors on trade balance dynamics, which can provide important and practical policy implications for stabilization policies. Depending on whether the sources of trade balance dynamics are domestic or foreign factors, the direction of government policies to mitigate fluctuations in trade balance may change. If the trade balance dynamic is mainly determined by domestic factors, government policies for reducing the trade balance volatility will be effective in mitigating domestic economic fluctuations. Additionally, specific policies that reduce the volatility of aggregate productivity or domestic interest rate spread can be considered for stabilization policies. In contrast, if most of the trade balance volatility originates from foreign factors, focusing on government policies that reduce the volatility of consumption or investment rather than that of the trade balance would be more effective for lowering the welfare costs of overall economic fluctuations.

Government policies (e.g., fiscal, monetary, and trade policy) and the real exchange rate can also affect trade balance dynamics. In this study, government policies will be partially captured by domestic factors (aggregate productivity or interest rate spread variations). The real exchange rate is indirectly reflected in the model through the real interest rate, given the close inverse relationship between interest rates and the real exchange rate. The major factors considered in this study may not cover all factors affecting trade balance dynamics in Korea. However, if the model including the major factors describes business cycle patterns well in Korea, the problem related to the model specification will be limited.

This study primarily aims to quantify the relative importance of domestic and foreign factors on trade balance dynamics in Korea. To this end, we build a small open economy real

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[5] Neumeyer and Perri (2005) study Argentina and Uribe and Yue (2006) use averages of data for seven developing countries, Argentina, Brazil, Ecuador, Mexico, Peru, Philippine, and South Africa.

[6] Garcia-Cicco et al. (2010) examine Argentina and Mexico, and Chang and Fernandez (2013) study Mexico.

[7] Miyamoto and Nguyen (2017) study Argentina, Brazil, Chile, Colombia, India, Mexico, Peru, Taiwan, Turkey, Venezuela, Australia, Canada, Finland, Norway, Portugal, Spain, and Sweden.

business cycle (henceforth SOE-RBC) model with three shocks following Neumeyer and Perri (2005): aggregate productivity, interest rate spread, and world interest shocks. The model is estimated by the generalized method of moments (GMM) using relevant business cycle statistics. The estimated model is used to quantify the relative importance of domestic and foreign factors on trade balance dynamics in Korea. We then examine the role of aggregate productivity and real interest rates to investigate trade balance dynamics more extensively.

We need to identify three structural shocks that affect trade balance dynamics to perform variance decomposition using identified shocks to quantify the source of trade balance dynamics. Structural vector autoregressive (SVAR) and dynamic stochastic general equilibrium (DSGE) models are the most appropriate methodologies for this analysis. The SOE-RBC model is a popular DSGE model appropriated for a small open economy. The SVAR model has the advantage that it uses a minimum number of identifying assumptions or economic theories and it can be estimated relatively easily. However, it cannot provide the deep underlying economic mechanism for the causal relationship between variables in the model as it uses minimal economic theories. On the other hand, in the SOE-RBC model, the optimization problems of economic agents are explicitly defined based on specific economic theories or hypotheses. Moreover, the optimal choices of economic agents are aggregated to macroeconomic variables in equilibrium. Therefore, it can provide the detailed underlying economic mechanism for the causal relationship between macroeconomic variables in the model.

In the context of this study, the SVAR model can identify the main sources of trade balance dynamics but cannot provide a detailed economic explanation of how each structural shock affects trade balance dynamics. For example, explicitly distinguishing between direct channels wherein the aggregate productivity shock directly affects the trade balance through output, consumption, and investment and indirect channels wherein the aggregate productivity shock indirectly affects the interest rate spread and the trade balance is difficult. On the other hand, in the SOE-RBC model, the indirect channel that the aggregate productivity shock affects trade balance through the interest rate can be explicitly modeled through a spread equation as in Equation (7) based on existing economic theories and empirical evidence. Moreover, it can conduct counterfactual experiments by adjusting estimated parameter values in the model. For these reasons, most studies in the international business cycle literature mentioned above and our study utilize the SOE-RBC model rather than the SVAR model.

Previous studies using the SOE-RBC model determined the parameters of the main model using either Bayesian or GMM estimations. Aguiar and Gopinath (2007) used GMM estimation, whereas Chang and Fernandez (2013) and Miyamoto and Nguyen (2017) used the Bayesian estimation. Garcia-Cicco et al. (2010) estimated parameters using both the Bayesian and GMM estimation. Uribe and Yue (2006) estimated the parameters of the model so that impulse response functions (IRFs) in the SOE-RBC model are optimally close to IRFs in the SVAR model. This estimation method is called the indirect inference estimation and is significantly similar to the GMM estimation method. The difference from GMM is that in the indirect inference estimation, more various statistics (e.g., IRFs) can be used as moments. Additionally, simulated moments are used in the indirect inference estimation, whereas theoretical moments are used in the GMM estimation.

In studies using the SOE-RBC model, there seems to be no consensus on which of the

Bayesian and GMM estimation methods is better for determining parameter values. The estimation method is usually chosen according to the researcher's personal preference or need to emphasize specific moments in the estimation. The Bayesian estimation utilizes information on joint distributions of all variables including in the estimation.[8] Conversely, the GMM estimation selects moments directly related to parameters like calibration, and, if necessary, additional weight can be given to specific moments (Cochrane, 2001; Ruge-Murcia. 2013). In this study, the GMM estimation method was used to make moments related to trade balance dynamics in the model as close as possible to moments from the data. Furthermore, moments directly related to important parameters in the model were additionally used for estimation. Although the GMM estimation method is somewhat arbitrary in selecting moments, it can determine which moment information was used to estimate a specific parameter. However, in Bayesian estimation, identifying parameters is less transparent as parameters are estimated using complicated joint distributions of data. Hence, linking particular information of data with individual parameters is difficult (Ríos-Rull et al., 2012).

The main results of the study can be summarized as follows: 85.64% of the trade balance fluctuations in Korea are explained by domestic factors, and the remaining 14.35% by foreign factors. Particularly, trade balance dynamics are mostly accounted for by the change in aggregate productivity shocks (85.58%). Unlike other macroeconomic variables, foreign factors (world interest rate shocks) explain the trade balance considerably (14.35%). However, the role of interest rate spread shocks representing domestic risks is very limited (0.08%). Although aggregate productivity is key in explaining trade balance dynamics in Korea, the role of interest rates remains important. This is because aggregate productivity changes induce interest rate spread variations, which capture domestic risks and, thus, the trade balance significantly. Although making a direct comparison is difficult owing to the difference in the countries examined and the estimation method, our main results are similar to those of Chang and Fernandez (2013). In Chang and Fernandez (2013), the contribution of aggregate productivity shocks was 57.6%. The contribution of the world interest rate shocks was 41.2% in the variance decomposition of the trade balance in Mexico. However, the contribution of the aggregate productivity, domestic factors, is relatively larger in Korea.

This study primarily aims to identify sources of trade balance dynamics in Korea and derive policy implications for mitigating trade balance fluctuations. According to the main results of this study, most trade balance fluctuations in Korea are explained by domestic factors, especially aggregate productivity variations. Therefore, alleviating trade balance fluctuations by reducing fluctuations in aggregate productivity is possible.

Although few studies[9] on business cycles in Korea exist, they mainly focus on output, consumption, investment, and employment dynamics and do not focus only on trade balance dynamics. This study aims to fill the gap in business cycle literature by investigating sources of trade balance dynamics in Korea. Our study differs from those previous studies in main objective and methodology. Rhee (2017) studies Korea’s business cycle using the SOE-RBC model, including the trade balance. However, the study mainly aims to examine the high

[8] According to Guerron-Quintana (2010), even in the Bayesian estimation, estimated parameters are sensitive to the variables included in the estimation. However, since joint distributions of included variables are used, the problem of selecting specific moments of variables does not occur.

[9] For example, Han and Kim (2019), Jung (2019), and Lee (2014) study the business cycle in Korea, but trade balance dynamics are not the main object of the studies.

volatility of consumption. Therefore, moments related to the trade balance in the model are quite different from those in actual data as Bayesian estimation, the estimation used for the model, is not designed to match the trade balance dynamics in the data. Rhee (2017) finds that the simple RBC model with recursive utility can generate high volatility of consumption to output.

Kim (2011) studies international macroeconomic fluctuations in Korea, focusing on output, real exchange rate, and trade balance, using a SVAR model and shows that country-specific supply, demand, and nominal shocks all play a non-negligible role in explaining trade balance fluctuations. Buyangerel and Kim (2013) analyze the effects of macroeconomic shocks on the trade balance in Korea using a SVAR model. They find that interest rate shocks (contradictory monetary policy shocks) and output shocks worsen the trade balance, whereas money supply shocks improve the trade balance. I and Kim (2013) examine the dynamic relationship between country spread and macroeconomic variables in Korea, including trade balance, using a SVAR model. They conclude that country spread has a small but significant effect on output, investment, and trade balance in the short run. Unlike Kim (2011), Buyangerel and Kim (2013), and I and Kim (2013) and, our study examines sources of trade balance dynamics through the calibrated and estimated SOE-RBC model, and the types of shocks that affect the trade balance are also different.

Several studies in international macroeconomics, such as Neumeyer and Perri (2005), Uribe and Yue (2006), Aguiar and Gopinath (2007), Garcia-Cicco et al. (2010), and Chang and Fernandez (2013) and Miyamoto and Nguyen (2017), examine business cycles in emerging countries. The most distinguishing features in the emerging market business cycle are the high volatility of consumption and the strong negative correlation between output and trade balance. These studies analyze mostly Latin American countries such as Mexico and Argentina, and the primary variable of interest is consumption rather than trade balance. Although trade balance dynamics are partly dealt with by examining the high volatility of consumption and the negative correlation between the trade balance and output, the main objective of the studies is the volatility of consumption. Conversely, we analyze Korea rather than Latin American countries. Additionally, we estimate a model to explicitly match moments related to trade balance in the data to investigate sources of trade balance dynamics rather than those of the volatility of consumption. Therefore, we use GMM estimation to carefully match target moments related to trade balance in the actual data. Although our estimation focuses on the trade balance dynamics, moments related to consumption are also quite close to those in the data.

The remainder of the study is organized as follows. Section 2 documents the business cycle statistics related to the trade balance. Section 3 shows our baseline model. Section 4 discusses the calibration and estimation of the model. Section 5 represents the quantitative results. Section 6 examines the robustness of the baseline model. Finally, Section 7 concludes the study.

2. Trade Balance Dynamics in Korea

Table 1 shows business cycle statistics for trade balance in Korea. We used seasonally adjusted quarterly data during 1990: Q1-2019Q4. Y, C, I, TB, and e denote output, consumption, investment, trade balance, and employment, respectively. Trade balance (TB) is defined as net exports ($NX = Y - C - I$) divided by output (Y) following literature on the emerging market business cycle. Moreover, all variables except for trade balance are logged. They are then filtered by the HP (Hodrick-Prescott) filter or by the BK (Baxter-King) bandpass filter as the HP and BK bandpass filters are the most popular filters used in the business cycle literature. We used a smoothing parameter of 1,600 for the HP filter and a frequency range [6, 32] for the BK bandpass filter, which are appropriate for quarterly data.

Although autocorrelation coefficients of the variables are generally high when the BK bandpass filter was used, moments in Table 1 are qualitatively very similar regardless of filters. Therefore, in this study, we use HP-filtered data for the analysis. The relative standard deviation of the trade balance to output is 0.84, which is much lower than that of consumption and investment. The relative standard deviation of consumption to output (1.54) is much larger than one. This indicates the emerging market business cycle features. Moreover, the correlation between the trade balance and output (-0.82) is a big negative and a well-known feature of the emerging market business cycle. Higher volatility of consumption and the strong countercyclical trade balance suggest economic fluctuations in Korea need to be examined from the perspective of the emerging market business cycle. Finally, the autocorrelation of the trade balance is 0.73, which is slightly less than that of other variables.

Table 1. Business Cycle Statistics in Korea

Moment	Value	
	HP filter	**BK bandpass filter**
σ_{TB}/σ_Y	0.84	0.79
$\rho(TB,Y)$	-0.82	-0.86
$\rho(TB,TB_{-})$	0.73	0.92
σ_Y	1.96	1.94
σ_C/σ_Y	1.54	1.55
σ_I/σ_Y	2.59	2.58
σ_e/σ_Y	0.68	0.66
$\rho(C,Y)$	0.92	0.93
$\rho(I,Y)$	0.87	0.89
$\rho(e,Y)$	0.83	0.87
$\rho(Y,Y_{-})$	0.82	0.90
$\rho(C,C_{-})$	0.84	0.92
$\rho(I,I_{-})$	0.85	0.93
$\rho(e,e_{-})$	0.83	0.92

Note: $\sigma_X, \sigma_X/\sigma_Y$, $\rho(X,Y)$ and $\rho(X,X_{-})$ denote a standard deviation of the variable X, a relative standard deviation of the variable X to output (Y), the correlation between variable X and output, and autocorrelation of the variable X, respectively. The trade balance is normalized by output. All variables except for trade balance are logged. They are then filtered by the HP (Hodrick-Prescott) filter with a smoothing parameter of 1600 or by the BK (Baxter-King) bandpass filter with a frequency range [6, 32]. Data for 1990:Q1-2019:Q4 are used for the analysis.

The domestic and international macroeconomic environment may have structurally changed around the global financial crisis. To determine the possibility of the structural change, the business cycle statistics are calculated for two subperiods: 1990:Q1-2005:Q4 and

2006:Q1-2019:Q4. Table 2 shows business cycle statistics for each subperiod. The biggest change in business cycle statistics after 2005 is that the volatility of output, consumption, and employment has decreased significantly. This is similar to the phenomenon observed during the Great Moderation period in developed countries. However, unlike in advanced countries, trade balance volatility has increased significantly in Korea. This pattern suggests the possibility that trade balance dynamics in Korea have been determined by factors different from other developed countries since 2005.

Table 2. Business Cycle Statistics in Korea: 1990:Q1-2005:Q4 vs. 2006:Q1-2019:Q4

Moment	**Value (HP filter)**	
	1990:Q1-2005:Q4	**2006:Q1-2019:Q4**
σ_{TB}/σ_Y	0.78	1.10
$\rho(TB,Y)$	-0.88	-0.56
$\rho(TB,TB_-)$	0.81	0.51
σ_Y	2.51	1.06
σ_C/σ_Y	1.59	1.04
σ_I/σ_Y	2.56	2.75
σ_e/σ_Y	0.70	0.47
$\rho(C,Y)$	0.93	0.89
$\rho(I,Y)$	0.94	0.48
$\rho(e,Y)$	0.87	0.43
$\rho(Y,Y_-)$	0.84	0.73
$\rho(C,C_-)$	0.85	0.69
$\rho(I,I_-)$	0.88	0.76
$\rho(e,e_-)$	0.84	0.76

Note: $\sigma_X, \sigma_X/\sigma_Y$, $\rho(X,Y)$ and $\rho(X,X_-)$ denote a standard deviation of the variable X, a relative standard deviation of the variable X to output (Y), the correlation between the variable X and output, and autocorrelation of the variable X, respectively. The trade balance is normalized by output. All variables except for the trade balance are logged. They are then filtered by the HP (Hodrick-Prescott) filter with a smoothing parameter of 1600. Data for 1990:Q1-2019:Q4 are used for the analysis.

At the same time as the volatility of the trade balance increased significantly, the counter-cyclicality of the trade balance weakened, and the autocorrelation of the trade balance decreased considerably. Therefore, the relative importance of factors affecting trade balance dynamics may be changed. The fact that business cycle statistics related to the trade balance have changed significantly after 2005 suggests that the factors affecting the trade balance dynamics and the relative importance of those factors may have changed and that implications for stabilization policies can be different.

3. Model

The model is built upon Neumeyer and Perri (2005), the small open economy real business cycle (henceforth SOE-RBC) model incorporating financial frictions. The baseline model has three shocks that can become potential sources of the business cycle: aggregate productivity shocks and two types of interest rate shocks (domestic interest rate spread shocks and world interest rate shocks). The effect of these shocks on the business cycles depends on the degree of financial friction. Therefore, we include two types of financial frictions in the baseline model: a working capital requirement and a risk premium from the expected future productivity following Neumeyer and Perri (2005).

3.1. Household

There is a continuum of identical and infinitely lived households of measure one. The household's problem is provided as follows:

$$\max_{\{C_t, I_t, e_t, K_{t+1}, D_{t+1}\}_{t=0}^{\infty}} E\left[\sum_{t=0}^{\infty} \beta^t U(C_t, e_t, \Gamma_{t-1})\right] \tag{1}$$

$s.t.$

$$C_t + I_t + D_t = W_t e_t + r_t K_t + q_t D_{t+1} \tag{2}$$

$$K_{t+1} = (1-\delta)K_t + I_t - \Phi(K_{t+1}, K_t) \tag{3}$$

$$1/q_t = R_t + \psi\left(exp\left(\widetilde{D}_{t+1}/\bar{Y} - \bar{d}\right) - 1\right) \tag{4}$$

$$R_t = R_t^* S_t \tag{5}$$

$$ln(R_t^*/\overline{R^*}) = \rho_{R^*} ln(R_{t-1}^*/\overline{R^*}) + \varepsilon_{R^*,t} \tag{6}$$

$$ln(S_t/\bar{S}) = -\eta ln(E(A_{t+1})) + \varepsilon_{s,t} \tag{7}$$

$$\Gamma_t = g\Gamma_{t-1}, \tag{8}$$

where $\beta, U(\cdot), E(\cdot)$ denote a time discount factor, a period utility function, and an expectation operator, respectively. Labor augmenting productivity (Γ_t) is included in the utility function to allow balanced growth in the model. $\bar{d}$ denotes the steady-state value of the normalized external debt ($\bar{D}/\bar{Y}$), debt-to-GDP ratio. η denotes a parameter governing risk premium from the expected productivity.

The household maximizes the utility by choosing the amount of consumption (C_t), investment (I_t), employment (e_t)[10], capital stock (K_{t+1}), and debt (D_{t+1}) given labor income ($W_t e_t$), capital rental income ($r_t K_t$), and newly issued debt ($q_t D_{t+1}$). $W_t, r_t,$ and q_t denote the wage rate per employment, the rental rate of capital, and the price at which the household issues net debts. Capital stocks evolve according to the standard law of motion of capital with capital adjustment costs ($\Phi(\cdot)$), and δ denotes the depreciation rate of capital stocks.

The inverse of the price of new debts ($1/q_t$) equals the sum of the gross domestic interest rate (R_t)[11] and a debt-elastic interest rate premium ($\psi\left(exp\left(\widetilde{D}_{t+1}/\bar{Y} - \bar{d}\right) - 1\right)$). $\widetilde{D}_{t+1}$

[10] Hours per worker (intensive margin) is assumed to be inelastic and is thus normalized to one. Therefore, total labor input (total hours) is measured in terms of employment (extensive margin) in this study.

[11] In this study, interest rates refer to gross interest rates unless otherwise stated.

denotes the country's aggregate debt, which is equal to the household debt (D_{t+1}) in equilibrium. The household takes it as exogeneous in the optimization problem. The debt-elastic interest rate premium is included in the model to ensure model stability when linearizing the model around the steady-state. Inclusion of the debt-elastic interest rate premium is one of the ways to guarantee that debt holdings do not exhibit unit root, as noted in Schmitt-Grohe and Uribe (2003).[12]

The domestic interest rate comprises two parts following the induced country risk model in Neumeyer and Perri (2005): a world interest rate (R_t^*) and an interest rate spread (S_t).[13] World interest rate captures foreign factors affecting domestic interest rates, and the interest rate spread reflects domestic risk premiums in the interest rate. The world interest rate is assumed to evolve according to the AR(1) process. ρ_{R^*} denotes the AR(1) coefficient for the world interest rate, and $\varepsilon_{R^*,t}$ is an independent and identically distributed process with a mean of zero and a standard deviation of σ_{R^*}.

The interest rate spread depends on the expected future productivity, which is approximated by future aggregate productivity ($E(A_{t+1})$) following Neumeyer and Perri (2005). This formulation implies that when future productivity is expected to be low, a country's default risk is high and, thus, the risk premium on domestic interest rates is high. Therefore, we expect a negative relationship between the spread and future aggregate productivity. η captures the degree of negative correlation between two variables. The spread equation in the model is a reduced form approach to endogenize a default problem. $\varepsilon_{s,t}$ denotes spread shocks that capture other domestic factors affecting domestic interest rate but are unrelated to expected future productivity. Spread shocks are assumed to be an independent and identically distributed process with a mean of zero and a standard deviation of σ_S.

3.2. Firm

One of the two financial frictions in the model is the working capital requirement. This is reflected in a firm's problem, as in Neumeyer and Perri (2005) and Uribe and Yue (2006). θ fraction of the total wage bill ($\theta W_t e_t$) should be paid to workers in advance at the beginning of each period before production occurs owing to working capital friction. A firm needs to borrow working capital ($\theta W_t e_t$) at the beginning of each period at the net interest rate ($R_{t-1} - 1$) as production becomes available only at the end of each period. The working capital requirement makes labor demand sensitive to the domestic interest rate as an increase in the interest rate makes firms' effective labor cost higher and decreases labor demand given real wage. As the capital stock is relatively stable over the business cycle, a decrease in labor demand would reduce output. Excluding the working capital friction, the firm's problem is standard as follows:

$$\max_{K_t, e_t} \; A_t F(K_t, \Gamma_t e_t) - W_t e_t - r_t K_t - \theta(R_{t-1} - 1) W_t e_t \tag{9}$$

$s.t.$

$$ln(A_t) = \rho_A ln(A_{t-1}) + \varepsilon_{A,t} \tag{10}$$

[12] Although Neumeyer and Perri (2005) call the debt-elastic interest rate premium the bond hold costs, they are essentially the same.

[13] It is also called a country-specific risk premium in the literature.

where $\theta(R_{t-1} - 1)W_t e_t$ denotes interest cost associated with the financing of the working capital. Interest rate dynamics affect the firm's optimal decision for labor and capital demand through the working capital requirement. Aggregate productivity is assumed to evolve according to the AR(1) process. ρ_A denotes the AR(1) coefficient for the aggregate productivity, and $\varepsilon_{A,t}$ is an independent and identically distributed process with a mean of zero and a standard deviation of σ_A.

3.3. Equilibrium

Given initial conditions (K_0,D_0), a sequence of productivity and interest rates $\{A_t, R_t\}_{t=0}^{\infty}$, a *competitive equilibrium* is defined as a sequence of quantities $\{C_t, I_t, e_t, K_{t+1}, D_{t+1}\}_{t=0}^{\infty}$ and of prices $\{W_t, r_t\}_{t=0}^{\infty}$ such that:

1) The quantities solve the household's and the firm's problems at the equilibrium prices.
2) Labor market and capital rental market clear.

A balanced growth path for the economy is an equilibrium wherein A_t and R_t are constant and all other variables, except for e_t and r_t, grow at a constant growth rate (g) of labor-augmenting productivity (Γ_t). The model is nonstationary as all other variables, except for e_t and r_t, grow over time. Therefore, we convert the nonstationary model to a stationary model by deflating all relevant nonstationary variables (X_t), which is defined as capital letters in the model, with Γ_{t-1}. In this way, we define stationary variables $x_t = X_t/\Gamma_{t-1}$ and rewrite the model with stationary variables x_t to solve it.

In the model, the trade balance is defined as net exports divided by output in the same way we compute moments from data. Goods are produced in the country but are not spent on consumption and investment are net exports (or trade balance). Trade balance can be positive or negative because we assume a small open economy and the goods market does not clear domestically.

4. Calibration and Estimation

We use the GHH (Greenwood–Hercowitz–Huffman) utility function, which is widely used in studies on the open economy business cycle:

$$U(C_t, e_t, \Gamma_{t-1}) = \frac{(C_t - \tau\Gamma_{t-1}e_t^{\omega})}{1-\sigma}. \tag{11}$$

The production function is assumed to be the Cobb-Douglas function:

$$F(K_t, \Gamma_t e_t) = K_t^{1-\alpha}(\Gamma_t e_t)^{\alpha}, \tag{12}$$

where α is the labor share of income. We also use a standard quadratic capital adjustment cost function as follows:

$$\Phi(K_{t+1}, K_t) = \frac{\phi}{2}K_t\left(\frac{K_{t+1}}{K_t} - g\right)^2. \tag{13}$$

The parameters in this study can be categorized into two groups. The first group is calibrated, which is predetermined and independent of the model, whereas the second group is estimated by using the two-step GMM using relevant target moments from the actual data in Korea.

4.1. Calibrated Parameters

The period in the model is assumed to be a quarter. The 13 parameters are calibrated outside the model and are listed in Table 3. The data for 1990:Q1-2019:Q4 are used for the calibration unless otherwise stated. The quarterly time discount factor (β) is assumed to be 0.98, wherein the value is used in Aguiar and Gopinath (2007). Although various values are used in the literature, they are not much different from 0.98. Meanwhile, the growth rate of the labor-augmenting productivity (g) is set to 1.0123 using the average growth rate of the real GDP in Korea. The parameter for relative risk aversion (σ) is set to two, which are commonly used in related literature.

Table 3. Calibrated Parameters

Parameter	Description	Value	Remark
β	Time discount factor	0.9800	Aguiar and Gopinath (2007)
g	The growth rate of labor-augmenting productivity	1.0123	Data (real GDP growth rate)
σ	Relative risk aversion	2.0000	Literature
ω	Labor supply elasticity	1.6000	Literature
τ	Labor parameter in the GHH utility function	1.7168	Total hours: 1/3
α	Labor exponent in the CD production function	0.6041	Data (labor share of income)
δ	The depreciation rate of capital	0.0099	Data (see the text)
ψ	Parameter for the debt-elastic int. rate premium	0.0010	Literature
$\bar{d}$	Debt-to-GDP ratio in the steady-state	0.1000	Literature
ρ_A	AR(1) coef. for the productivity process	0.9958	Data (Solow residual)
σ_A	Std. for the productivity process	0.0085	Data (Solow residual)
ρ_{R^*}	AR(1) coef. for a world interest rate process	0.9607	Data (U.S. real interest rates)
σ_{R^*}	Std. for a world interest rate process	0.0009	Data (U.S. real interest rates)

Note: Data for 1990:Q1-2019:Q4 are used for the calibration.

The parameter related to labor supply elasticity ω is set to 1.6, a widely used value in the literature, such as Mendoza (1991), Schmitt-Grohe and Uribe (2003), and Garcia-Cicco et al. (2010). The labor parameter (τ) that governs the steady-state value of the total hours ($\bar{e} = 1/3$) is set to 1.7168, which follows Chang and Fernandez (2013). The parameter for the labor exponent in the Cobb–Douglas production function (α) is set to 0.6041, considering the average labor share of income in Korea during 1990:Q1-2019:Q4.[14]

Although the Bank of Korea provides quarterly investment data, capital stock data are provided annually. Therefore, given the initial level of the capital stock (k_{1989}) and a series of quarterly investment data, we construct quarterly capital stock data by using the perpetual

[14] The exact formulation of labor share of income in this model is given as $\alpha/(1+(R-1)\theta)$ due to the working capital requirement. Given the steady-state value of R and the calibration of θ, the error resulting from approximating the labor share of income to α would be small.

inventory method. The quarterly depreciation rate of capital is calibrated to match the level of the capital stock in 2019 in the constructed series of capital stocks with the actual level of the capital stock in 2019 in the annual data for capital stocks. Thus, the depreciation rate of capital is calibrated to be 0. 99%.

The parameter for the debt-elastic interest rate premium (ψ) is set to 0.001, which guarantees the equilibrium solution to be stationary following Schmitt-Grohe and Uribe (2003) and Aguiar and Gopinath (2007). The steady-state value of the debt-to-GDP ratio ($\bar{d}$) is set at 10%, which is used in Aguiar and Gopinath (2007), Uribe and Yue (2006), and Chang and Fernandez (2013). As already noted in Aguiar and Gopinath (2007), the simulation results in this model are not sensitive to other values of the debt-to-GDP ratio.

The shock process for the aggregate productivity is estimated using the detrended Solow residual in Korea. In constructing the measured Solow residual, we use an average value of labor share of income during 1990:Q1-2019:Q4. The estimated AR(1) coefficient (ρ_A) and standard deviation (σ_A) of the aggregate productivity are 0.9958 and 0.0085, respectively. The shock process for the world interest rate is estimated using the detrended U.S. real interest rates. We construct the U.S real interest rate using the U.S. 3-month T-bill rate deflated by the expected GDP deflator inflation. Following Neumeyer and Perri (2005) and Uribe and Yue (2006), the expected inflation is computed as an average of GDP deflator inflation rates in the current period and the three preceding periods. The estimated AR(1) coefficient (ρ_{R^*}) and standard deviation (σ_{R^*}) of the world interest rate are 0.9607 and 0.0009, respectively.

4.2. Estimated Parameters

The four parameters ($\text{i.e.}, \phi, \theta, \eta, \sigma_S$) are jointly estimated using the two-step GMM estimator with the optimal weighting matrix. Following Ruge-Murcia (2013), the optimal weighting matrix is constructed using the Newey–West estimator with a Bartlett kernel and bandwidth given by $4(T/100)^{2/9}$. Eight moments are used in the estimation for the model: σ_I/σ_Y, σ_e/σ_Y, σ_R/σ_Y, $,\rho(R,R_{-})$, $\rho(I,R)$, σ_{TB}/σ_Y, $\rho(TB,Y)$, $\rho(TB,TB_{-})$ where σ_X denotes the standard deviation of a variable X and $\rho(X,Y)$ denotes the correlation between variables X and Y. All moments are computed using HP-filtered variables with a smoothing parameter of 1600.

Although the eight moments used for the estimation provide comprehensive information for identifying the four parameters, the moments that contain essential information for each parameter are worth discussing. The relative standard deviation of investment to output is included to identify the parameter for the capital adjustment cost (ϕ). The relative standard deviation of employment to output is used to identify the parameter for the working capital requirement (θ). This is because employment dynamics in response to the productivity and interest shocks are amplified through the working capital frictions governed by parameter θ.

The relative standard deviation of the domestic real interest rate to output is included to identify the parameter for the risk premium from the expected future productivity (η) considering the spread equation in Equation (7). Two moments related to the domestic real interest rates are used to identify the standard deviation of the spread shocks (σ_S). Finally, three moments related to the trade balance are used to fit the trade balance dynamics in the model with those in the data because the moments are the main interest in this study.

Table 4 shows the GMM estimates. All parameters, except for the parameter for the working capital requirement, are statistically significantly estimated. The parameter for the capital adjustment cost is estimated to be 45.9497. Although it is not statistically significant, the parameter for the working capital requirement is estimated to be 1, which is the same value assumed by Neumeyer and Perri (2005).[15] The estimate for the parameter for the risk premium from the expected future productivity is 0.1412. Finally, the standard deviation of spread shocks is estimated to be 0.0012.

Table 4. Estimated Parameters

Parameter	Description	Estimates (standard errors)
ϕ	Parameter for the capital adjustment cost	45.9497 (3.3127)
θ	Parameter for the working capital requirement	1.0000 (0.8770)
η	Parameter for the risk premium from the expected productivity	0.1412 (0.0091)
σ_S	Std. for the spread shocks	0.0012 (0.0004)

Note: Data for the period 1990:Q1-2019:Q4 are used for the estimation.

4.3. Model Evaluations

Table 5 shows the moments that are used in the estimation. Most of the moments in the data and the model are similar, except for the moments related to the real interest rate. In particular, the three moments related to the trade balance (i.e., σ_{TB}/σ_Y, $\rho(TB,Y)$, $\rho(TB,TB_{-})$) are quite well reproduced by the model, given that the model is relatively simple and parsimonious. They are essential moments because the primary purpose of this study is to quantify the relative importance of domestic and foreign factors on trade balance dynamics.

Table 5. Moments That Are Used in the Estimation: Data vs. Model

Moments	Data	Model
σ_I/σ_Y	2.59	2.75
σ_e/σ_Y	0.68	0.67
σ_R/σ_Y	0.18	0.12
$\rho(R,R_{-})$	0.62	0.52
$\rho(I,R)$	-0.24	-0.81
σ_{TB}/σ_Y	0.84	0.89
$\rho(TB,Y)$	-0.82	-0.89
$\rho(TB,TB_{-})$	0.73	0.72

Although it successfully reproduces the moments related to the trade balance, matching the correlation between investment and real interest rate is difficult. The moment in the model (-0.81) is significantly larger than that in the data (-0.24). We attempted to fit the moment by adding or removing some moments, but fitting it closer was challenging. We

[15] As discussed later in the robustness check, the main results of this study are robust for alternative values of θ.

guess that additional ingredients should be reflected in the model, which should be examined in future research.

Table 6 shows the moments that are not used in the estimation. Considering that we do not intend to fit the moments presented in Table 6, the moment in the model does not exhibit much difference from those in the data. The volatility of output in the model (1.85) is slightly lower than that in the data (1.96). The relative volatility of consumption to output (1.69) is slightly higher than that in the data (1.54). Correlations with the output are generally higher than the data in the model, and autocorrelations are slightly lower than the data in the model. Although fitting all the moments very closely was not possible owing to the parsimoniousness of the model, the model overall fits the data well, especially the dynamics of the trade balance, which is the main interest of this study.

Table 6. Moments That Are Not Used in the Estimation: Data vs. Model

Moments	Data	Model
σ_Y	1.96	1.85
σ_C/σ_Y	1.54	1.69
$\rho(C,Y)$	0.92	0.98
$\rho(I,Y)$	0.87	0.96
$\rho(e,Y)$	0.83	1.00
$\rho(Y,Y_{-})$	0.82	0.75
$\rho(C,C_{-})$	0.84	0.74
$\rho(I,I_{-})$	0.85	0.72
$\rho(e,e_{-})$	0.83	0.77

5. Quantitative Results

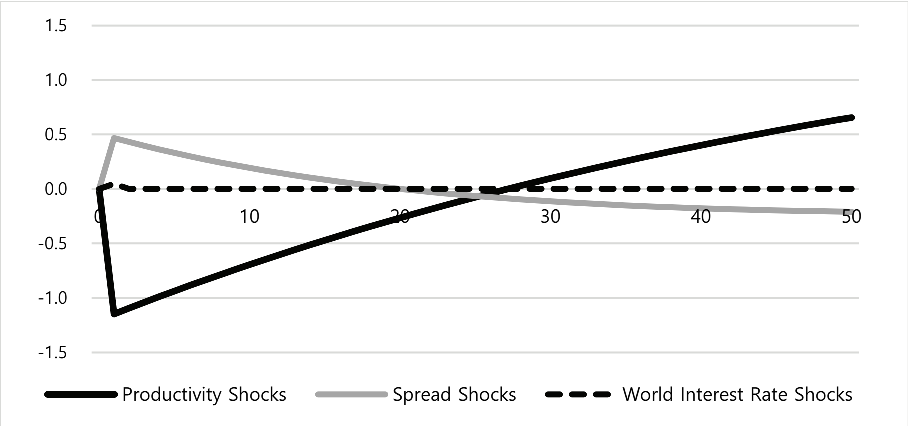
5.1. Domestic vs. Foreign Factors

This study mainly aims to quantify the relative importance of domestic and foreign factors on trade balance dynamics. Domestic factors are captured by aggregate productivity and interest rate spread shocks in the model. The aggregate productivity shocks can affect the trade balance by directly impacting the relative size of income, consumption, and investment. The aggregate productivity shocks can also affect interest rate spreads, indirectly affecting the trade balance through fluctuations in domestic interest rates. In this model, the latter channel is reflected in Equation (7). An increase in the expected future aggregate productivity is assumed to reduce the interest rate spreads following Neumeyer and Perri (2005). Meanwhile, spread shocks capture the domestic risks associated with fluctuations in the interest rate spread independent of the aggregate productivity. On the other hand, foreign factors are reflected by the world interest rate shocks in the model.

Fig. 1 shows the impulse response functions of the trade balance to shocks of aggregate productivity, interest rate spreads, and the world interest rate. A positive aggregate productivity shock makes the trade balance significantly lower to negative but gradually switches to positive over time. The trade balance decreases significantly, in the beginning, because the positive aggregate productivity shock reduces the interest rates which are borrowing costs abroad, through Equation (7), and increases consumption and investment. This results in a relatively large indirect effect of reducing the trade balance. However, this indirect effect gradually disappears over time, leaving only the direct effect of the aggregate productivity shock that increases the output relatively more than consumption and investment. This direct effect gradually improves the trade balance. The positive interest rate spread and world interest rate shocks raise the domestic real interest rates and reduce consumption and investment, which improves the trade balance. The impact of the world interest rate shock, which captures foreign factors that affect the interest rate, is much greater than that of the interest rate spread shock, which captures domestic factors that affect the interest rate. Regarding the impacts of the same size of shocks, one standard deviation of shocks, the degree to which the trade balance is influenced by each shock is large in the order of aggregate productivity, world interest, and international rate spread shocks.

Fig. 1. Impulse Response Functions of the Trade Balance

(Unit: % deviations from the steady-state)



Note: The X-axis denotes quarters after each shock, while the Y-axis denotes % deviations from the steady-state.

Source: Impulse response functions from the model.

Table 7 presents the variance decomposition of the model. The variance decomposition reveals the relative importance of each shock for the volatility of variables in the model. According to the variance decomposition, changes in macroeconomic variables, excluding real interest rates, are explained mainly by productivity shocks, one of the domestic factors. Particularly, most of the changes in production, consumption, investment, and employment are attributed to the changes in aggregate productivity. The role of interest rates is minimal, except for investment. Although spread shocks capture domestic risks that affect the domestic real interest rates, almost no role in explaining the variation of main macroeconomic variables emerges, except for real interest rates. Productivity, interest rate spread, and world interest rate shocks account for 45.74%, 25.40%, and 28.86% of real interest rate fluctuations, respectively. This result suggests that domestic factors account for 71.14% of real interest rate fluctuations in Korea.

Table 7. Variance Decomposition

(Unit: %)

Variables	Domestic factors		Foreign factors
	Productivity shocks (ε_A)	**Spread shocks (ε_S)**	**World interest rate shocks (ε_{R^*})**
Y	99.47	0.15	0.38
C	96.94	0.08	2.98
I	91.92	0.05	8.03
TB	85.58	0.08	14.35
e	97.84	0.88	1.27
R	45.74	25.40	28.86

Note: Data for 1990:Q1-2019:Q4 are used for the analysis.

Variations in the trade balance, our main interest, are also significantly accounted for by the change in productivity shocks (85.58%). Unlike other macroeconomic variables, foreign factors (e.g., world interest rate shocks) considerably explain the trade balance (14.35%). Again, the role of spread shocks is limited (0.08%). Overall, 85.64% of the trade balance fluctuations in Korea are explained by domestic factors, and the remaining 14.35% by foreign factors. The results of the variance decomposition suggest that government policies that mitigate fluctuations in aggregate productivity would be effective for stabilization policies in Korea by reducing the trade balance volatility.

Although making a direct comparison owing to the difference in the countries analyzed and the estimation method is difficult, the variance decomposition results of our study are similar to those of Chang and Fernandez (2013). In Chang and Fernandez (2013), the contribution of aggregate productivity was 57.6%, and the contribution of the US interest rate was 41.2% in the variance decomposition results for the trade balance in Mexico. The contribution of domestic factors that affect trade balance dynamics, especially aggregate productivity, is relatively larger than that of foreign factors. However, a difference exists in that the contribution of the aggregate productivity (85.58%), domestic factors, is significantly larger in Korea.

5.2. Role of Aggregate Productivity

The variance decomposition result shows the dominant impact of domestic aggregate productivity shocks on trade balance dynamics. That is, in terms of sources of shocks, productivity shocks play a more critical role, compared to interest rate-related shocks, in explaining the variation of the trade balance. However, Equation (7) shows that aggregate productivity directly affects the interest rate spread. Therefore, the finding that productivity shocks are critical to explaining trade balance dynamics does not imply the unimportance of the interest rate channel.

In this model, aggregate productivity affects the trade balance through two different channels. Changes in aggregate productivity can affect the trade balance by affecting the relative sizes of income, consumption, and investment. However, the current productivity affects the expected future productivity and thus affects the trade balance through changes in domestic interest rate spreads, as expressed in Equation (7).

Table 8. Moments Related to the Trade Balance: No Induced Country Risk

Moments	Data	Baseline ($\eta = 0.1412$)	No induced country risk ($\eta = 0$)
σ_{TB}/σ_Y	0.84	0.89	0.37
$\rho(TB, Y)$	-0.82	-0.89	-0.28
$\rho(TB, TB_{-})$	0.73	0.72	0.71

Note: All variables, except for the trade balance, are logged and HP-filtered with a smoothing parameter of 1600. The trade balance is normalized by output and HP-filtered with a smoothing parameter of 1600.

We performed a model simulation with η set to 0 in Equation (7) to understand the importance of the interest rate channel where aggregate productivity directly affects the domestic interest rate through interest rate spreads. When η is set to 0, the effect of productivity shocks on the interest rate spread is removed, whereas the effect of aggregate productivity on the trade balance through changes in the interest rate can be identified.

Table 8 shows the trade balance-related business cycle statistics when η is set to 0 (no induced country risk). When the interest rate channel, wherein the expected future productivity negatively affects interest rate spreads, is removed from the model, the volatility of trade balance and the negative correlation between and output are significantly lower than those in the baseline model. That is, sufficiently explaining the trade balance dynamics in the data is difficult without changes in the spread induced by productivity changes. In Korea, trade balance dynamics are greatly affected by aggregate productivity, one of the domestic factors. However, much of this effect is from the relationship between productivity and interest rate spreads.

5.3. Role of Interest Rate Spreads

We now consider different assumptions on the dynamics of interest rate spreads in the model to examine the role of the interest rate spread channel. Hence, we replace the equation for the interest rate spread (Equation (7)) with Equations (14) and (15) following Neumeyer and Perri (2005):

$$ln(S_t/\bar{S}) = \rho_S ln(S_{t-1}/\bar{S}) + \varepsilon_{S,t} \quad (independent\ country\ risk\ model) \tag{14}$$

or

$$ln(S_t) = \bar{S} \qquad (no\ country\ risk\ model) \tag{15}$$

The model with Equation (14) is called the independent country risk model because the interest rate spreads fluctuate independent of the aggregate productivity. The parameters related to the spread process in Equation (14) can be exogenously estimated from Korea's interest rate spread data. The estimates for ρ_S and σ_S are 0.7039 and 0.0030, respectively. Meanwhile, the model with Equation (15) is called the no country risk model because the interest rate spreads, which reflect domestic risks on the interest rate, remain constant at the steady-state level ($\bar{S}$). Both models are re-estimated using the same target moments in the baseline model. Detailed information on the estimated parameters and moments of each model are presented in the Appendix.

Table 9 shows the trade balance-related business cycle statistics for the independent country risk and no country risk models. The volatility of trade balance and the negative correlation between outputs are significantly lower than those in the baseline model, similar to the result in Table 8 (no induced country risk). The model cannot easily adequately match the trade balance dynamics in the data without assuming that interest rate spreads move inversely to the aggregate productivity.

Table 9. Moments Related to the Trade Balance: Different Assumption for Spreads

Moments	Data	Baseline	Independent country risk	No country risk
σ_{TB}/σ_Y	0.84	0.89	0.54	0.55
$\rho(TB,Y)$	-0.82	-0.89	-0.32	-0.44
$\rho(TB,TB_{-})$	0.73	0.72	0.67	0.72

Note: All variables, except for the trade balance, are logged and HP-filtered with a smoothing parameter of 1600. The trade balance is normalized by output and HP-filtered with a smoothing parameter of 1600.

These results suggest that the variation of interest rate spreads induced by changes in aggregate productivity plays an essential role in explaining the trade balance dynamics in Korea. Theoretically, positive current and expected future aggregate productivity reduces domestic interest rates and thus increases consumption and investment, thereby increasing the trade balance deficit.

5.4. Subperiod Analysis

As presented in Table 2, the domestic and international macroeconomic environment may have structurally changed around the global financial crisis. In this case, the relative importance of factors that affect trade balance dynamics may be changed. To check the change in the relative importance of these factors, variance decomposition was performed by dividing the period into two subperiods: 1990:Q1-2005:Q4 and 2006:Q1-2019:Q4.

Table 10 presents the variance decomposition results for the subperiod. The results for the two sub-periods are quite different. Specifically, 81.16% of the trade balance fluctuations for the period 1990:Q1-2005:Q4 in Korea are explained by domestic factors, mostly the aggregate productivity, and the remaining 19.84% by foreign factors. Conversely, 16.30% of the trade balance fluctuations for the period 2006:Q1-2019:Q4 in Korea are explained by domestic factors, and the remaining 83.70% by foreign factors. The subperiod analysis results suggest that major structural changes exist in the factors that affect the trade balance dynamics in Korea around 2005. Since 2005, the trade balance dynamics have been mainly explained by the changes in world interest rates (i.e., foreign factors), rather than aggregate productivity (i.e., domestic factors). This result suggests that the effectiveness of government policies to reduce trade balance volatility after 2005 may be limited.

Table 10. Variance Decomposition: 1990:Q1-2005:Q4 vs. 2006:Q1-2019:Q4

(Unit: %)

Variables	1990:Q1-2005:Q4			2006:Q1-2019:Q4		
	Domestic factors		Foreign factors	Domestic factors		Foreign factors
	ε_A	ε_S	ε_{R^*}	ε_A	ε_S	ε_{R^*}
Y	99.52	0.09	0.39	99.92	0.00	0.08
C	96.47	0.07	3.46	95.59	0.00	4.41
I	92.69	0.04	7.26	84.67	0.00	15.33
TB	80.07	0.09	19.84	16.28	0.02	83.70
e	98.73	0.43	0.84	99.92	0.00	0.08
R	91.20	3.70	5.10	85.46	0.37	14.17

Note: Data for 1990:Q1-2019:Q4 are used for the analysis.

6. Robustness

In this section, we conduct robustness checks for the calibration of parameters: the parameter for the working capital requirement (θ) and the debt-to-GDP ratio ($\bar{d}$).

6.1. Working Capital Requirement

The working capital requirement makes the labor demand sensitive to the domestic interest rate because an increase in the interest rate makes firms' effective labor costs higher and decreases labor demand and output. Therefore, there is a possibility that the greater the degree of the working capital requirement, the greater the effect of interest rate spread fluctuations on trade balance dynamics.

In the baseline model, the parameter for the working capital is estimated to be one, although it is not statistically significant. Table 11 present the moments related to the trade balance dynamics when using different values for the parameter for the working capital requirement, while other parameters remain unchanged in the baseline model. No significant difference exists in moments related to the trade balance, despite the difference in the degree of the working capital requirement. Additionally, as presented in Table 12, the variance decomposition results are almost similar. This result suggests that the parameters for the working capital requirement are not quantitatively relevant to this study's main results.

Table 11. Moments Related to the Trade Balance: Different Values for θ

Moments	Baseline ($\theta = 1$)	$\theta = 0.5$	$\theta = 0$
σ_{TB}/σ_Y	0.89	0.89	0.89
$\rho(TB, Y)$	-0.89	-0.88	-0.88
$\rho(TB, TB_{-})$	0.72	0.72	0.72

Note: All variables, except for the trade balance, are logged and HP-filtered with a smoothing parameter of 1600. The trade balance is normalized by output and HP-filtered with a smoothing parameter of 1600.

Table 12. Variance Decomposition: Different Values for θ

(Unit: %)

Variable	Domestic factors						Foreign factors		
	Productivity shocks (ε_A)			Spread shocks (ε_S)			World interest rate shocks (ε_{R^*})		
	θ = 1	θ = 0.5	θ = 0	θ = 1	θ = 0.5	θ = 0	θ = 1	θ = 0.5	θ = 0
Y	99.47	99.73	99.84	0.15	0.04	0.00	0.38	0.23	0.16
C	96.94	97.40	97.83	0.08	0.03	0.01	2.98	2.57	2.16
I	91.92	92.04	92.17	0.05	0.05	0.05	8.03	7.91	7.78
TB	85.58	85.65	85.73	0.08	0.08	0.08	14.35	14.28	14.19
e	97.84	99.22	99.84	0.88	0.26	0.00	1.27	0.52	0.16
R	45.74	45.74	45.74	25.40	25.40	25.40	28.86	28.86	28.86

Note: Data for 1990:Q1-2019:Q4 are used for the analysis.

6.2. Debt-to-GDP Ratio

In the baseline model, the debt-to-GDP ratio is set to 0.1 following Aguiar and Gopinath (2007), Uribe and Yue (2006), etc. According to Aguiar and Gopinath (2007), the simulation results are not sensitive to other values of the debt-to-GDP ratio. We conducted a robustness check to determine whether the main results of this study hold for different values of the debt-to-GDP ratio. Thus, we used different values for the debt-to-GDP ratio, while other parameters remain unchanged in the baseline model.

Table 13 shows the moments related to the trade balance dynamics when using different values for the debt-to-GDP ratio. No significant difference exists in moments related to trade balance when we use different values of the debt-to-GDP ratio. Despite the small difference, the relative volatility of trade balance to output slightly increases when we use the higher value of the debt-to-GDP ratio. Table 14 presents the variance decomposition for different values of the debt-to-GDP ratio. The results are virtually the same regardless of the value of the debt-to-GDP ratio. The results in Table 13 and Table 14 confirm that the values for the debt-to-GDP ratio do not alter the study's main results.

Table 13. Moments Related to the Trade Balance: Different Values for $\bar{d}$

Moments	Baseline ($\bar{d} = 0.1$)	$\bar{d} = 0.01$	$\bar{d} = 1$
σ_{TB}/σ_Y	0.89	0.89	0.95
$\rho(TB, Y)$	-0.89	-0.89	-0.90
$\rho(TB, TB_{-})$	0.72	0.72	0.72

Note: All variables, except for the trade balance, are logged and HP-filtered with a smoothing parameter of 1600. The trade balance is normalized by output and HP-filtered with a smoothing parameter of 1600.

Table 14. Variance Decomposition: Different Values for $\bar{d}$

(Unit: %)

Variable	Domestic factors						Foreign factors		
	Productivity shocks (ε_A)			Spread shocks (ε_S)			World interest rate shocks (ε_{R^*})		
	$\bar{d}$ = 0.1	$\bar{d}$ = 0.01	$\bar{d}$ = 1	$\bar{d}$ = 0.1	$\bar{d}$ = 0.01	$\bar{d}$ = 1	$\bar{d}$ = 0.1	$\bar{d}$ = 0.01	$\bar{d}$ = 1
Y	99.47	99.47	99.47	0.15	0.15	0.15	0.38	0.38	0.39
C	96.94	96.96	96.72	0.08	0.08	0.08	2.98	2.96	3.20
I	91.92	91.93	91.82	0.05	0.05	0.05	8.03	8.02	8.12
TB	85.58	85.51	86.15	0.08	0.08	0.07	14.35	14.41	13.78
e	97.84	97.84	97.84	0.88	0.88	0.88	1.27	1.27	1.28
R	45.74	45.74	45.74	25.40	25.40	25.40	28.86	28.86	28.86

Note: Data for the period 1990:Q1-2019:Q4 are used for the analysis.

7. Conclusion

This study investigated the sources of trade balance dynamics over the business cycle in Korea. We quantified the relative importance of domestic and foreign factors on trade balance dynamics using the SOE-RBC model. Aggregate productivity and interest rate spreads were considered domestic factors that affect the trade balance. Further, a world interest rate (the U.S. interest rate) is considered a foreign factor. We developed the SOE-RBC model with three shocks following Neumeyer and Perri (2005): aggregate productivity, interest rate spread, and world interest rate shocks. The model was estimated by the GMM using business cycle statistics related to the trade balance dynamics. The estimated model was used to quantify the relative importance of domestic and foreign factors on trade balance dynamics in Korea.

Our main findings can be summarized as follows: domestic factors account for 85.64% of the trade balance fluctuations in Korea, and foreign factors explain the remaining 14.35% of them. Particularly, the trade balance dynamics are mostly accounted for by the change in aggregate productivity shocks (85.58%). Although the foreign factors (i.e., world interest rate shocks) explain the trade balance considerably (14.35%), the role of interest rate spread shocks that represent domestic risks is small (0.08%). Despite the critical role of aggregate productivity in explaining the trade balance dynamics in Korea, fluctuations in interest rates remain substantial because the change in aggregate productivity significantly induces the trade balance dynamics through the changes in interest rate spreads.

The results of the variance decomposition suggest that government policies that affect aggregate productivity can reduce the trade balance volatility for lowering welfare costs of the overall economic fluctuations in Korea. However, subperiod analysis suggests that the effects of domestic government policies to reduce trade balance volatility may be limited as world interest rate fluctuations explain most of the trade balance dynamics after 2005. In this study, various foreign factors that affect the trade balance dynamics in Korea are indirectly reflected in the world interest rate. However, the world interest rate is unlikely to include all foreign factors, and we do not see clearly which foreign factors are reflected in the world interest rate. Therefore, a more detailed analysis of foreign factors that affect trade balance dynamics after 2005 is left for future research.

Appendices

Table A1. Estimated Parameters: Alternative Models

Parameter	Description	Estimates (standard errors) Independent country risk	No country risk
ϕ	Parameter for the capital adjustment cost	25.9534 (2.9333)	19.0247 (1.6066)
θ	Parameter for the working capital requirement	0.0639 (5.3560)	1.0000 (5.1216)

Note: Data for 1990:Q1-2019:Q4 are used for the estimation.

Table A2. Moments That Are Used in the Estimation: Alternative Models

Moments	Data	Independent country risk	No country risk
σ_I/σ_Y	2.59	2.35	2.73
σ_e/σ_Y	0.68	0.63	0.63
σ_R/σ_Y	0.18	0.21	0.07
$\rho(R, R_{-})$	0.62	0.57	0.72
$\rho(I, R)$	-0.24	-0.58	-0.63
σ_{TB}/σ_Y	0.84	0.54	0.55
$\rho(TB, Y)$	-0.82	-0.32	-0.44
$\rho(TB, TB_{-})$	0.73	0.67	0.72

Note: All variables, except for the trade balance, are logged and HP-filtered with a smoothing parameter of 1600. The trade balance is a normalized one by output and HP-filtered with a smoothing parameter of 1600.

Table A3. Moments That Are Not Used in the Estimation: Alternative Models

Moments	Data	Independent country risk	No country risk
σ_Y	1.96	1.77	1.78
σ_C/σ_Y	1.54	1.12	1.11
$\rho(C, Y)$	0.92	0.96	0.97
$\rho(I, Y)$	0.87	0.72	0.78
$\rho(e, Y)$	0.83	1.00	1.00
$\rho(Y, Y_{-})$	0.82	0.73	0.73
$\rho(C, C_{-})$	0.84	0.72	0.73
$\rho(I, I_{-})$	0.85	0.69	0.72
$\rho(e, e_{-})$	0.83	0.73	0.73

Note: All variables are logged and HP-filtered with a smoothing parameter of 1600.

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