The Effects of Strategic Goods Control on Productivity: The Case of Korea

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This paper empirically examines how controlling strategic goods affects productivity by focusing on Korean industries from 2015 to 2019. We hypothesize that strategic goods control positively affects productivity because it promotes international trade by making up for market failures, building up national credibility, and stabilizing market environment; in turn, international trade contributes to productivity growth. The regression results are congruent with our hypothesis. The effects of strategic goods control on productivity were positive and statistically significant in general. These positive effects were more prominent in the group of industries that include strategic goods and, thus, are technologically intensive. The results also support that international trade is a key medium for the effects of strategic goods control on productivity. Consequently, our empirical results support government policy on strategic goods control, ensuring that strategic goods control can contribute to economic growth by reducing diplomatic friction and stabilizing the global market.

Keywords: Strategic Goods Control, Total Factor Productivity

JEL Classification: F13, F14

I. Introduction

Strategic goods refer to products, software, and technology that can be used for both civilian and military applications which can contribute to the proliferation of weapons of mass destruction, chemical, biological and nuclear weapons, and conventional military

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goods. To prevent their proliferation and guarantee national security, United Nations Security Council Resolution 1540 emphasizes that, based on effective legal basis, countries should implement strategic goods control and transparently release a list of strategic military and dual-use items. Also, the Wassenaar Arrangement has been established in order to contribute to security and stability, by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilizing accumulations.[1] Accordingly, nations of the world created a strategic goods control act that permits for imports, exports, and reexports of strategic goods: exports as well as imports of strategic goods requires a license from government. Korea also introduced a system for strategic goods control in 1987 and established the Korea Security Agency of Trade and Industry (KOSTI) by Article 29 of the Foreign Trade Act in 2007. Since then, KOSTI has officially managed strategic goods in business transactions in Korea and annually publishes their list by the 10-digit Harmonized System (HS) code, based on the international organization such as the Wassenaar arrangement and other countries. Figure 1 reports the annual number of strategic goods and their portion of total products in Korea during the 2015–2020 period. The number of strategic goods and their portion constantly increased in the mid and late 2010s. In particular, the year 2020 witnessed a sharp increase, implying that strategic goods control has become even more important for trade policies in Korea. Indeed, 17.16% of all processed goods are designated as strategic goods in 2020.[2]

Despite the growing importance of strategic goods control, few studies have examined strategic goods control (Jang and Song, 2021). In addition, previous studies have mainly focused on identifying the relationship between strategic goods control and international trade, rather than other economic performances. Considering that international trade is a key medium to affect policy goals such as economic growth and employment, it will be important to examine how strategic goods control ultimately affects these economic performances via international trade. The objective of this paper is to fill this seeming lacuna in the research. This paper empirically examines how strategic goods control affected productivity in Korea during the 2015–2019 period.

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[1] https://www.wassenaar.org
[2] Also see the webpage of KOSTI for other information such as a specific list of strategic goods and annual trend of strategic goods trade. (https://www.kosti.or.kr)

Figure 1. Annual Trend of Strategic Goods in Korea during the 2015-2020 Period

Source: Author's calculation using the data of KOSTI

With this new research topic, this paper also makes other contributions. Previous studies have only considered strategic goods control as an independent variable due to data limitation in the regressions, ignoring other factors that might affect a dependent variable, resulting in an endogeneity problem due to the omitted variables. Unlike previous studies, we built up a unique industry-level dataset classified using the 3- or 5-digit Korean Standard Industrial Classification (KSIC) code and considered various industrial characteristics as well as strategic goods control. To do this, we converted the 10-digit HS code in the original dataset of KOSTI to the 5-digit KSIC and combined it with other industrial variables provided by Statistics Korea. In addition, we considered two proxies, the frequency index and the coverage ratio, to measure the level of strategic goods control by industry. For this, previous studies have considered the total number of strategic goods at the industry level; however, this number is more likely to be higher if an industry contains greater sub-industries and, thus, seems not related to a greater level of strategic goods control. Based on previous studies on non-tariff barriers, we expect the frequency index and the coverage ratio to solve this disadvantage of considering total numbers of strategic goods control.

The rest of the paper is organized as follows. Section II summarizes previous studies and sets up the research hypothesis. Section III provides econometric specifications and data sources. Section IV reports the empirical results. Finally, Section V provides a conclusion and policy implications.

II. Literature Review and Research Hypothesis

1. Strategic Goods Control and International Trade

The previous studies addressed that strategic goods control can simultaneously have both positive and negative effects on international trade. Concerning the possibility of reexports to third countries, countries exporting dual-use items and strategic arms will restrict international trade if their partners have uncertain effects on national security. In response, trade partners will adopt a credible system for strategic goods control to enhance national security and restrict indiscriminate proliferation of dual-use items and strategic arms. With this legitimacy of strategic goods control, countries can reduce the possibility of war and terror attacks and avoid diplomatic friction. In addition, a system for strategic goods control can prevent exporting firms from engaging in illegal activities due to careless management of strategic goods and costs caused by economic sanctions. Hence, strategic goods control can resolve market failure by asymmetric information between trading countries, build national credibility, stabilize market environment, and, thus, facilitate international trade (Cupitt et al., 2001; Fuhrmann, 2008; Jones and Karreth, 2010; Jang and Song, 2021).

In the case of Korea, Kim (2012) found that strategic goods control had positive effects on imports from developed countries during the 1988-2011 period. Jang and Song (2021) also found that strategic goods control positively affected international trade during the 2015–2019 period in Korea. In particular, they found that the effects on imports were greater than those on exports and the positive effects were more prominent in capital-intensive industries. All these studies addressed that the positive effects come from an increase in national security and market stability due to strategic goods control.

Meanwhile, it is very clear that strategic goods control can be barriers to international trade. In a system of strategic goods control, firms should obtain government permission to export or import strategic goods via complicated administrative procedures. These procedures cause compliance costs for administration, reduce production efficiency, and, thus, hamper international trade (Kowalczyk and Riezman, 2009). In particular, these costs are more prominent if a country uses strategic goods control as an instrument to gain economic benefits over its original legitimacy, such as preventing technology transfer and protecting domestic industries (Chellaney, 1994). A survey of 202 firms in the United States space industry estimated that the compliance cost for

strategic goods control averaged $50 million per year for the industry (Chao and Ben-Ari, 2008). Elwell (2000) also estimated the cost of strategic goods control to range from $500 million to $14 billion in the United States.

2. International Trade and Productivity Growth

Many studies have found that international trade induces an increase in productivity (De Hoyos and Iacovone, 2013; Jang et al., 2015). For exports, the learning-by-exporting theory emphasizes the export-led growth through tight competition and technology spillover. After entering export markets, exporters participate in tighter competition with local firms with a high level of quality and different technical standards led by foreign consumers' needs (Salomon and Shaver, 2005; De Loecker, 2013; Fernandes and Isgut, 2005). To survive this competition, exporting firms should be more efficient, develop new technologies, and improve productivity. In this process, there will be technology spillovers between firms and, thus, an increase in industry-level productivity in aggregate (Castellani, 2002; Westphal, 2002).

Several studies empirically support the learning-by-exporting theory. Salomon and Shaver (2005) found that Spanish exporting firms had significantly positive effects on product innovation and productivity during the 1990–1997 period. De Loecker (2013) also found that, in Slovenian manufacturing firms, exports positively affected productivity growth ranging from 1.08% to 7.38%. These phenomena were also found in other countries such as Colombia, Mexico, and Morocco (Fernandes and Isgut, 2005) as well as Italy (Castellani, 2002). For the case of Korea, Hahn (2004) and Ahn (2005) found that exports increased the total factor productivity by 1.4% to 2.7% during the 1990–1998 period. Lee and Choi (2009) found that the learning-by-exporting effects lasted about 4 years during the 1993–2003 period. Seo et al. (2017) showed that exports had positive effects on sales growth after the global financial crisis during the 1980–2012 period, and the learning effects were more pronounced in technology-intensive industries.

For imports, imported intermediate goods play an important role in productivity growth, especially when they are technologically advanced and have a wide range of varieties (Hasan, 2002; Goldberg et al., 2010; Amiti and Konings, 2007; Abreha, 2019; Camino-Mogro et al., 2020). Firms importing intermediate goods can reduce production costs and improve productivity via foreign technology transfer (Kasahasa and Rodrigue, 2008; Goldberg et al., 2010; Máñez Castillejo et al., 2020).

Several studies empirically support these phenomena. Lööf and Anderson (2010) found that imports from R&D-intensive countries had positive effects on the labor productivity of Sweden's manufacturing firms during the 1997–2004 period. Abreha (2019) estimated that, in Ethiopia, imports increased productivity by 3.5% to 4.9% during the 1996–2011 period. Camino-Mogro et al. (2020) showed that Ecuadorian manufacturing firms using foreign intermediate goods increased productivity by 7% during the 2007–2018 period. The same results were also found in other countries, such as China (Yu and Li, 2014), India (Hasan, 2002; Goldberg et al., 2010), Chile (Kasahara and Rodrigue, 2008), Hungary (Halpern et al., 2015), and Indonesia (Amiti and Konings, 2007). For the case of Korea, Kim et al. (2000) estimated that productivity in manufacturing industries increased by 0.19% when the import growth rate increased by 1% during the 1966–1999 period. Lee and Kim (2003) found the same results in 17 industries during the 1990–2001 period. Jang and Cho (2015) showed that the increase in imported intermediate goods caused by free trade agreements had positive effects on productivity during the 2002–2011 period.

3. Research Hypotheses

Based on our meticulous literature review, we speculate that strategic goods control will affect productivity indirectly through the channel of international trade. In fact, previous studies have addressed that the effects of strategic goods control on international trade are theoretically undetermined due to the trade-off relationship between an increase in credibility and compliance costs. This trade-off relationship varies depending on economic conditions by countries, periods, items, and industries. Meanwhile, for the case of Korea, previous studies have empirically found that strategic goods control generally had positive impacts on international trade during the 2010s (Kim, 2012; Jang and Song, 2021). In turn, international trade had positive impacts on productivity in Korea during the 2010s (Jang and Cho, 2015; Jang et al., 2015). In particular, given that, in Korea, strategic goods control promoted imports more prominently and imported strategic goods mostly come from developed countries with high technologies such as the United States, this increase in imports led by strategic goods control might induce greater technology transfer and spillover effects. Technology transfer and spillover effects by imports can be a major driving force of economic growth (Eaton and Kortum, 1996; Schneider, 2005). Consequently, we

hypothesize that Korea might benefit from productivity growth after applying strategic goods control (Jones and Karreth, 2010).

III. Econometric Specifications and Data

1. Econometric Specifications

Based on the literature review, we build up the following three equations to empirically examine the effect of strategic goods control on productivity considering international trade as a medium.

$$
\begin{aligned}
\ln TRADE_{it} = \beta_0 &+ \beta_1 EC_{it} + \beta_2 \ln CPI_{it} + \beta_3 \ln TAR_{it} + \beta_4 \ln HHI_{it} \\
&+ \delta_i + \tau_t + \varepsilon_{it}
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
\ln PRO_{it} = \beta_0 &+ \beta_1 \ln TRADE_{it} + \beta_2 \ln CPI_{it} + \beta_3 \ln TAR_{it} + \beta_4 \ln HHI_{it} \\
&+ \delta_i + \tau_t + \varepsilon_{it}
\end{aligned}
\tag{2}
$$

$$
\begin{aligned}
\ln PRO_{it} = \beta_0 &+ \beta_1 EC_{it} + \beta_2 \ln CPI_{it} + \beta_3 \ln TAR_{lt} + \beta_4 \ln HHI_{it} \\
&+ \delta_i + \tau_t + \varepsilon_{it}
\end{aligned}
\tag{3}
$$

where i and t refer to industries and years, respectively; 'ln' represents the natural logarithm of variables; δ_i and τ_t are dummies for industry and year, respectively; and ε_{it} is the error term.

Equation (1) represents the regression model for the effects of strategic goods control on international trade. Equation (2) represents the regression model for how international trade affects the productivity. Finally, Equation (3), the main regression model, presents the regression model for the effect of strategic goods controls on productivity.

The sample period covers the 2015–2019 period. For i, we considered all mining and manufacturing sectors being classified by the 3-digit KSIC on one hand; on the other hand, we specified the sample to the group of advanced technology products (ATP) because strategic goods control is concentrated in it (Table A2).

2. Dependent Variables

In (1) and (2), $TRADE_{it}$ represents the international trade which is considered as export (EXP_{it}) and import (IMP_{it}). In (2) and (3), PRO_{it} refers to productivity. The value of export and import was drawn from the United Nations Commodity Trade Statistics Database (UN COMTRADE). As its monetary unit is the US dollar, we transferred it into Korean won, based on the annual Korean won–US dollar exchange rate provided by the Bank of Korea (BOK).

We consider total factor productivity (TFP) and labor productivity as productivity indicators. We calculate the TFP index from a log form of the Cobb-Douglas production function as follows:

$$\ln TFP_{it} = \ln PRD_{it} - \hat{\phi}_1 \ln CPS_{it} - \hat{\phi}_2 \ln EMP_{it} - \hat{\phi}_3 \ln INP_{it} \qquad (4)$$

where PRD_{it} is total outputs, CPS_{it}, EMP_{it} and INP_{it} are capital stock, labor force and intermediate input, respectively. $\hat{\phi}_1$, $\hat{\phi}_2$ and $\hat{\phi}_3$ represent coefficient estimates from the regression analysis of $\ln CPS_{it}$, $\ln EMP_{it}$ and $\ln INP_{it}$ on $\ln PRD_{it}$, respectively.

We proxied capital stock by the annual balance of tangible assets that consist of land, buildings, and machineries and labor force by the total number of employees. Therefore, the TFP index is calculated by the difference between the actual total outputs and the predicted one. Also, we calculated labor productivity, $\ln LAP_{it}$, as value added divided by employment (i.e., per capita value added) to support the results using TFP. All data were extracted from the Korean Statistical Information Service (KOSIS) provided by Statistics Korea.[3] The monetary units of tangible assets and value added were a million Korean won. We transferred these values to real ones by applying the producer price index (PPI) provided by the Bank of Korea.

3. Independent Variables

We built a unique sector-level dataset by obtaining the annual list of strategic goods from KOSTI. As the original data were classified using the 10-digit HS code, we converted the data to the 3-digit KSIC with the correlation tables provided by Statistics

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[3] https://kosis.kr/eng

Korea. Based on it, we set up EC_{it} as a key independent variable, representing the level of strategic goods control. For this, we consider two proxies, FI_{it} and CR_{it}, which are commonly used to measure the level of non-tariff measures (Fugazza, 2013). FI_{it} is a frequency index. We calculated the FI index as follows:

$$FI_{it} = \frac{\sum D_{kt} N_{kt}}{\sum N_{kt}} \tag{5}$$

In the denominator, $\sum N_{kt}$ represents the total number of sub-industry k that belongs to industry i in t. In the numerator, D_{kt} is a dummy variable that is one if k includes strategic goods in t, and zero otherwise. $\sum D_{kt} N_{kt}$ refers to the number of k subject to strategic goods control in i in t. Accordingly, FI_{it} indicates the proportion of sub-industries subject to the control of strategic goods to the total number of sub-industries in i. However, a frequency index does not reflect the importance of international trade in its estimation. In practice, the impact of strategic goods control will be more prominent in an industry with active international trade. To supplement the shortcoming of a frequency index, we consider a coverage ratio, CR_{it}, as follows:

$$CR_{it} = \frac{\sum D_{kt} V_{kt}}{\sum V_{kt}} \tag{6}$$

where $\sum V_{kt}$ is the total value of imports of sub-industry k that belong to industry i in t. $\sum D_{kt} V_{kt}$ refers to the sum of import values of k subject to strategic goods control in i in t. Accordingly, CR_{it} indicates the proportion of import values of sub-industries that are subject to strategic goods control to the total value of imports of i. CR_{it} is a weighted average of the level of strategic goods control, considering the impact of international trade. Both FI_{it} and CR_{it} represent greater importance of strategic goods control, irrespective of how many sub-industries i includes.

Through three regression models in (1)-(3), we can expect the effect of strategic goods control on productivity through international trade promotion. As the previous studies have generally shown that strategic goods control positively affects proposing countries' exports and imports. Therefore, we expect β_1 in (1) to be positive, implying that strategic goods control positively affects international trade with its legitimacy. In addition, the effect of international trade promotion on productivity is expected to be positive because of tight competition in export market and technology transfer through

trade. Therefore, we expect β_1 in (2) to be positive. Finally, we expect β_1 in (3) is positive, implying that strategic goods control positively affects productivity through international trade promotion. Especially, we expect that the positive value of β_1 will be more prominent when considering CR_{it} because it is a weighted average with international trade.

In (1)-(3), we additionally considered other control variables that could affect international trade and productivity, based on previous studies. CPI_{it}, TAR_{it}, and HHI_{it} represent capital intensity, import tariffs, and market concentration, respectively (Jang, 2021; Ahn and Kim, 2005). We calculated capital intensity (CPI) using the ratio of capital stock to labor force. We expect β_2 to be positive, implying that a capital intensity will have positive effects on trade and productivity. A capital intensity represents the levels of technology and R&D, which can positively affect trade and productivity in turn (Kogut and Chang, 1991; Heshmati and Rashidghalam, 2016; Kim and Lee, 2012; Seo et al., 2017).

However, the effects of market concentration on productivity are more complicated. The rise in market concentration induces large firms to perform more innovations with greater profits and contributes to booming productivity growth on the one hand (Klenow et al., 2019). On the other hand, Disney et al. (2000), Zitzewitz (2003), and Badinger (2007) found that intensified market competition (i.e., lower market concentration) has a positive effect on productivity because firms try to be more efficient to survive in fierce competition. Accordingly, the sign of β_4 will be ambiguous. We proxied market concentration by the Hirschman-Herfindahl index (HHI), which is a common measure of market concentration.[4] The data of HHI were drawn from the Korean Fair Trade Commission (KFTC).[5]

The same is true of TAR_{it}. On the one hand, trade liberalization drawn from lowering import tariffs has a positive effect on productivity through an increase in exports, intermediate imports, foreign direct investment, and market competition (Jang et al., 2015). In this case, the sign of β_3 will be negative. On the other hand, Hwang et al. (2017) and Jang (2021) showed that the change in import tariffs was stabilizing, and the policies of trade openness were becoming inefficient in Korea during the mid-

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[4] HHI is calculated by squaring the market share of each firm competing in an industry and summing them. It ranges from 0 to 10,000, with a higher (lower) value indicating a monopoly (perfect competition).

[5] https://ftc.go.kr/eng/index.do

to late 2010s. Accordingly, the sign of β_3 will be ambiguous. We proxied import tariff (*TAR*) by the simple average of applied tariff rates, which was obtained from the World Trade Organization Statistics (WTO Stats).[6] As some values of *TAR* are zero, we added one to the original values for considering the logarithm to avoid data omission.

4. Econometric Methodologies and Summary Statistics

To determine an economic method in (1)-(3), we performed the Davidson-Mackinnon test of exogeneity. Not all test results rejected the null hypothesis that independent variables are exogenous. In addition, we performed the Woodridge test for autocorrelation for the regressions in (1)-(3), which showed that all test results rejected the null hypothesis that there is no first-order autocorrelation. However, we were still concerned that there would be an endogeneity problem drawn from omitted variables and reverse causality despite the results of the Davidson-Mackinnon test.

Therefore, we performed the Arellano-Bond estimator with the two-step generalized method of moments (GMM), which can solve both endogeneity and autocorrelation problems for the regressions in (1)-(3) (Arellano and Bond, 1991). The two-step GMM is a dynamic panel regression using the lagged value of differential variable as an additional instrumental variable as well as lagged dependent variables. For estimating TFP in (4), we performed the two-way fixed effects models with robust standard errors adjusted for clusters in industries after performing the Hausman test (Moulton, 1990). Table A1 in the appendix reports the regression results.[7]

Tables 1 and Table 2 report the summary statistics of the variables and the coefficients of correlation between independent variables, respectively. As the coefficients of correlation were less than absolute value of 0.8, we concluded that there were no symptoms of multicollinearity.

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[6] https://stats.wto.org
[7] We also performed the Davidson-Mackinnon test of exogeneity for (4) and the result did not reject the null hypothesis that independent variables are exogenous.

Table 1. Descriptive Statistics

Variable		Obs.	Mean	Std. Dev.	Min.	Max.
PRO_{it}	TFP_{it}	436	1.171	0.201	1.000	2.894
	LAP_{it}	433	187.14	229.17	5.98	2,199.84
EC_{it}	FI_{it}	430	0.37	0.386	0	1
	CR_{it}	430	0.262	0.33	0	1
$TRADE_{it}$	EXP_{it}	430	7,097,895	14,200,000	8.83	127,000,000
	IMP_{it}	430	5,983,718	11,800,000	21,223.12	113,000,000
CPI_{it}		436	200.42	269.41	18.16	2,462.54
TAR_{it}		435	10.79	28.66	0	266.14
HHI_{it}		440	1,403.92	1,162.87	0	6,947

Table 2. Coefficient of Correlation between Independent Variables

	FI_{it}	CR_{it}	$\ln EXP_{it}$	$\ln IMP_{it}$	$\ln CPI_{it}$	$\ln TAR_{it}$	$\ln HHI_{it}$
FI_{it}	1						
CR_{it}	0.768	1					
$\ln EXP_{it}$	0.385	0.289	1				
$\ln IMP_{it}$	0.550	0.458	0.769	1			
$\ln CPI_{it}$	0.188	0.143	0.255	0.323	1		
$\ln TAR_{it}$	-0.305	-0.361	0.041	-0.075	-0.017	1	
$\ln HHI_{it}$	0.282	0.307	0.016	0.107	0.283	-0.171	1

IV. Empirical Results

1. Mining and Manufacturing

For the sample group of all mining and manufacturing sectors, Tables 3-5 shows the regression results of the Arellano-Bond estimator for (1)-(3), respectively. Table 3 reports the regression results for the effect of strategic goods control on international trade in (1). Columns (1) and (2) are the regression results for $\ln EXP_{it}$, while columns (3) and (4) are those for $\ln IMP_{it}$. Columns (1) and (3) report the regression results for FI_{it}, while columns (2) and (4) are those for CR_{it}. In all columns, AR tests and Sargan

tests show that the regression models are correctly specified, implying that instruments starting with two-year lag are jointly valid. International trade in previous year also positively affected the same in the current year, showing autocorrelation.

The coefficient estimates of $\ln CPI_{it}$ in all columns are positive and statistically significant, implying that capital intensity positively affects both for export and import via improving quality and price competitiveness. These results are consistent with Kim and Lee (2012). The coefficient estimates of $\ln TAR_{it}$ in all columns are negative and statistically significant, implying that tariff reduction promotes imports as well as exports, and so processing trade, which is consistent with Jang and Cho (2015) and Jang et al. (2015). However, the coefficient of $\ln HHI_{it}$ in all columns are statistically insignificant, implying that market concentration did not affect international trade.

Table 3. Regression Results for the Effect of Strategic Goods Controls on International Trade for Mining and Manufacturing Sectors

Dependent Variable	$\ln EXP_{it}$		$\ln IMP_{it}$	
	FI_{it}	CR_{it}	FI_{it}	CR_{it}
	(1)	(2)	(3)	(4)
$\ln TRADE_{it-1}$	0.893***	0.891***	0.958***	0.937***
	(0.021)	(0.018)	(0.012)	(0.018)
EC_{it}	0.354***	0.295***	0.158***	0.171***
	(0.102)	(0.102)	(0.032)	(0.056)
$\ln CPI_{it}$	0.192***	0.201***	0.095***	0.136***
	(0.039)	(0.037)	(0.027)	(0.042)
$\ln TAR_{it}$	-0.020***	-0.083***	-0.054***	-0.071*
	(0.081)	(0.099)	(0.030)	(0.040)
$\ln HHI_{it}$	0.067	0.075	0.027	0.029
	(0.011)	(0.011)	(0.007)	(0.007)
AB test for AR (1)	-2.054**	-1.941*	-1.979**	-2.013**
AB test for AR (2)	-0.985	-0.846	0.624	0.604
Sargan Test	24.435	25.804	28.664	26.702
# of Groups	83	83	83	83
# of Instruments	37	37	37	37
# of Observations	248	248	248	248

Notes: Figures in parentheses are standard errors. All regressions control for year fixed effects. *, **, and *** represent significance at the 1%, 5%, and 10% levels, respectively.

All columns in Table 3 show that the coefficient estimates of EC_{it} are positive and statistically significant, implying that strategic goods control positively affects international trade in Korea during the 2015–2019 period when considering mining and manufacturing industries as a scope of the analyses. The results of strategic goods control are consistent with Kim (2012) and Jang and Song (2021), which showed the strategic goods control has the positive effect on trade via building national security and market stability. In addition, Table 3 shows that the coefficient estimates of EC_{it} in columns (1) and (2) are greater than those in columns (3) and (4), implying that the positive effects of strategic goods control on international trade were more prominent in export than in import.

Table 4 reports the regression results for the effect of international trade on productivity in (2). Columns (1) and (2) are the regression results for TFP, while columns (3) and (4) are those for labor productivity. Columns (1) and (3) report the regression results for $\ln EXP_{it}$, while columns (2) and (4) are those for $\ln IMP_{it}$. In all columns, AR tests and Sargan tests show that the regression models are correctly specified. TFP and labor productivity in previous year also positively affected the same in the current year, showing autocorrelation.

The coefficient estimates of $\ln CPI_{it}$ are positive and statistically significant in all columns, implying that capital intensity positively affects both of TFP and labor productivity. These results are consistent with those of Kogut and Chang (1991) and Seo et al. (2017). Based on these studies, we speculate that capital intensity promoted productivity via an increase in technology and R&D in Korea during the 2015–2019 period. Meanwhile, the coefficient estimates of $\ln TAR_{it}$ are statistically insignificant in all columns, implying that tariffs did not affect productivity. Based on the previous studies, we speculate that policies of trade openness were becoming ineffective in Korea during the 2015–2019 period, which is consistent with the results of Hwang et al. (2017) and Jang (2021). The coefficient estimates of $\ln HHI_{it}$ in columns (1)-(3) are positive and statistically significant. For market concentration, we speculate that in general its rise contributed to increasing productivity via more innovations with greater profits of large firms in Korea during the 2015–2019 period, which is consistent with the results of Klenow et al. (2019).

All columns in Table 4 show that the coefficient estimates of $\ln TRADE_{it}$ are positive and statistically significant, implying that both exports and imports positively affected productivity in Korea during the 2015–2019 period. In particular, the estimate coefficients of $\ln TRADE_{it}$ in columns (2) and (4) are greater than those in columns

(1) and (3), implying that the positive effects of imports on productivity were more prominent than those of exports. The results are consistent with Jang and Cho (2015) which show that about 80% of total imports consists of intermediate inputs in processing trade and their imports contribute economic growth through the increase in the number of firms and productivity in Korea.

Table 4. Regression Results for the Effect of International Trade on Productivity for Mining and Manufacturing Sectors

Dependent Variable	TFP		Labor Productivity	
	$\ln EXP_{it}$	$\ln IMP_{it}$	$\ln EXP_{it}$	$\ln IMP_{it}$
	(1)	(2)	(3)	(4)
$\ln PRO_{it-1}$	0.720*** (0.041)	0.896*** (0.024)	0.158*** (0.045)	0.260*** (0.046)
$\ln TRADE_{it}$	0.007*** (0.003)	0.011*** (0.003)	0.018*** (0.017)	0.034*** (0.019)
$\ln CPI_{it}$	0.015*** (0.007)	0.008*** (0.004)	0.058*** (0.039)	0.042*** (0.038)
$\ln TAR_{it}$	0.012 (0.008)	0.004 (0.006)	0.019 (0.041)	-0.046 (0.024)
$\ln HHI_{it}$	0.010*** (0.003)	0.008*** (0.003)	0.023*** (0.008)	0.003 (0.006)
AB test for AR (1)	-2.932***	-2.818***	-2.389***	-2.759***
AB test for AR (2)	-0.572	-0.591	-0.622	-0.395
Sargan Test	31.099	36.747	30.391	25.092
# of Groups	83	83	83	83
# of Instruments	37	37	37	37
# of Observations	248	248	248	248

Notes: Figures in parentheses are standard errors. All regressions control for year fixed effects. *, **, and *** represent significance at the 1%, 5%, and 10% levels, respectively.

Table 5 reports the regression results for (3), which represents the effect of strategic goods control on productivity. Columns (1) and (2) are the regression results for TFP, while columns (3) and (4) are those for labor productivity. Columns (1) and (3) are the regression results for FI_{it}, while columns (2) and (4) are those for CR_{it}. Through the AR test and the Sargan test, we confirmed that the regression models are correctly

specified in all columns. Similar to the results in Table 4, TFP and labor productivity in previous year also positively affected the same in the current year, showing autocorrelation.

The estimate coefficients of $\ln CPI_{it}$, $\ln TAR_{it}$ and $\ln HHI_{it}$ are very similar to those in Table 4, showing that capital intensity and market concentration positively affects productivity, while tariff reduction does not. The estimate coefficients of EC_{it} in all columns are positive and statistically significant. The results imply that strategic goods control positively affected productivity. Regression results in Tables 3-5 ensure that strategic goods control enhanced productivity through international trade promotion. In addition, the estimate coefficients of EC_{it} in columns (2) and (4) are greater than those columns (1) and (3) in Table 5, implying that the positive effects of

Table 5. Regression Results for the Effect of Strategic Goods Control on Productivity for Mining and Manufacturing Sectors

Dependent Variable	TFP		Labor Productivity	
	FI_{it}	CR_{it}	FI_{it}	CR_{it}
	(1)	(2)	(3)	(4)
$\ln PRO_{it-1}$	0.497*** (0.039)	0.464*** (0.040)	0.289*** (0.040)	0.266*** (0.035)
EC_{it}	0.040** (0.022)	0.052*** (0.021)	0.029** (0.077)	0.187** (0.082)
$\ln CPI_{it}$	0.012*** (0.005)	0.016*** (0.005)	0.066*** (0.028)	0.065*** (0.029)
$\ln TAR_{it}$	0.017 (0.017)	0.026 (0.016)	-0.037 (0.032)	0.043 (0.034)
$\ln HHI_{it}$	0.006*** (0.001)	0.010*** (0.002)	0.050*** (0.008)	0.044*** (0.009)
AB test for AR (1)	-2.788***	-2.900***	-2.405**	-2.375**
AB test for AR (2)	-0.595	-0.560	-0.396	-0.389
Sargan Test	41.247	42.375	33.327	31.468
# of Groups	83	83	83	83
# of Instruments	37	37	37	37
# of Observations	248	248	248	248

Notes: Figures in parentheses are standard errors. All regressions control for year fixed effects. *, **, and *** represent significance at the 1%, 5%, and 10% levels, respectively.

strategic goods control on productivity were more prominent in the coverage ratio than in the frequency index. In other words, the effects of strategic goods control on productivity were more prominent in industries with active international trade. These results emphasize that a measurement of strategic goods control should reflect the importance of international trade as a medium for the effects on productivity.

2. Advanced Technology Products

Table A2 shows that strategic goods are centralized in specific industries with advanced technology products (ATP), such as general, electrical, and precision machineries and chemical products, rather than the entire industry. This fact may distort the empirical results of EC_{it} and, thus, we rechecked the results by reconsidering the scope of the analyses to the ATP group which are relevant with the dual-use items.[8] Accordingly, following previous studies with investigating the effect of the strategic goods control, we consider the ATP group as scope of analysis (Jones and Karreth, 2010; Kim, 2012; Jang and Song, 2021). In this case, the reference group will be industries with advanced technology but no strategic goods over the period.

Table 6 reports the regression for (1) for the ATP group. The estimate coefficients of $\ln CPI_{it}$ in Table 6 are very similar to those in Table 3, implying that capital intensity promoted international trade. The coefficient estimates of $\ln TAR_{it}$ are negative and statistically significant only in columns (3) and (4) in Table 6, implying that tariff reduction promoted only imports in the ATP group. International trade in previous year positively affected the same in the current year, showing autocorrelation.

The estimate coefficients of EC_{it} are positive and statistically significant in columns. These empirical results imply that strategic goods control still positively affected international trade in Korea during the 2015–2019 period when considering the ATP group as a scope of the analyses. When comparing the coefficient estimates in Table 6 and those in Table 3, we confirm that strategic goods control in the ATP group had greater positive effects on international trade than all mining and manufacturing sectors.

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[8] ATP is a classification method developed by the U.S. National Statistical Office in the late 1980s to aggregate high-technology trade. (https://www.census.gov/foreign-trade/reference/codes/index.html)

Table 6. Regression Results of the Effect of Strategic Goods Control on International Trade for the ATP Group

Dependent Variable	$\ln EXP_{it}$		$\ln IMP_{it}$	
	FI_{it}	CR_{it}	FI_{it}	CR_{it}
	(1)	(2)	(3)	(4)
$\ln TRADE_{it-1}$	0.884***	0.946***	0.963***	0.949***
	(0.012)	(0.005)	(0.009)	(0.011)
EC_{it}	0.579***	0.323***	0.181***	0.173***
	(0.026)	(0.065)	(0.031)	(0.059)
$\ln CPI_{it}$	0.191***	0.087***	0.082***	0.138***
	(0.026)	(0.016)	(0.020)	(0.025)
$\ln TAR_{it}$	0.091	0.103	-0.034*	-0.035***
	(0.095)	(0.052)	(0.018)	(0.024)
$\ln HHI_{it}$	-0.001	0.002	0.015	0.014
	(0.011)	(0.007)	(0.006)	(0.003)
AB test for AR (1)	-1.589*	-1.469**	-1.708***	-1.714**
AB test for AR (2)	-1.067	-0.731	0.740	0.728
Sargan Test	24.378	27.808	31.269	30.068
# of Groups	54	54	54	54
# of Instruments	37	37	37	37
# of Observations	161	161	161	161

Notes: Figures in parentheses are standard errors. All regressions control for year fixed effects. *, **, and *** represent significance at the 1%, 5%, and 10% levels, respectively.

Table 7 reports the regression results of the effects of international trade on productivity for the ATP group. The coefficient estimates of total productivity and labor productivity in previous years are positive and statistically significant, showing autocorrelation. As in Table 4, the estimate coefficients of $\ln TAR_{it}$ are statistically insignificant, implying that tariff did not affect productivity, irrespective of sectors. The coefficient estimates of $\ln HHI_{it}$ are also statistically insignificant, implying that market concentration did not affect productivity in the ATP group. As in Table 4, the coefficient estimates of $\ln TRADE_{it}$ and $\ln CPI_{it}$ are positive and statistically significant in Table 7, implying that capital intensity and international trade positively affected productivity, irrespective of sectors.

Table 7. Regression Results of the Effect of International Trade on Productivity for the ATP Group

Dependent Variable	TFP		Labor Productivity	
	$\ln EXP_{it}$	$\ln IMP_{it}$	$\ln EXP_{it}$	$\ln IMP_{it}$
	(1)	(2)	(3)	(4)
$\ln PRO_{it-1}$	**0.897*****	**0.901*****	**0.397*****	**0.149*****
	(0.023)	**(0.020)**	**(0.041)**	**(0.039)**
$\ln TRADE_{it}$	**0.009*****	**0.012*****	**0.061*****	**0.150*****
	(0.002)	**(0.002)**	**(0.019)**	**(0.044)**
$\ln CPI_{it}$	**0.016*****	**0.015*****	**0.373*****	**0.331*****
	(0.004)	**(0.004)**	**(0.030)**	**(0.055)**
$\ln TAR_{it}$	-0.003	-0.002	-0.097	-0.042
	(0.007)	(0.005)	(0.033)	(0.039)
$\ln HHI_{it}$	-0.001	0.000	0.010	0.009
	(0.002)	(0.002)	(0.006)	(0.006)
AB test for AR (1)	-3.238***	-3.368***	-1.960*	-1.776***
AB test for AR (2)	-1.111	-1.071	-0.602	-0.274
Sargan Test	42.408	36.250	27.002	22.445
# of Groups	54	54	54	54
#of Instruments	37	37	37	37
# of Observations	161	161	161	161

Notes: Figures in parentheses are standard errors. All regressions control for year fixed effects. *, **, and *** represent significance at the 1%, 5%, and 10% levels, respectively.

Finally, Table 8 reports the regression results of the effects of strategic goods control on productivity for the ATP group. The coefficient estimates of $\ln CPI_{it}$ are positive and statistically significant in all columns, implying that capital intensity positively affected both TFP and labor productivity. These estimates in Table 8 are greater than those in Table 5, implying that positive effects of capital intensity on productivity in the ATP group were greater than in the entire industries. Hence, we confirm that capital accumulation and R&D activity are more important in the ATP group for enhancing productivity. TFP and labor productivity in previous years also positively affected the same in the current year, showing autocorrelation. The coefficient estimates of $\ln HHI_{it}$ in columns (3) and (4) are positive and statistically significant, implying that market concentration positively affected labor productivity. However, tariff did not affect productivity in general.

The coefficient estimates of EC_{it} in all columns are positive and statistically significant, implying that strategic goods control promoted productivity in the ATP

group. It is noted that the coefficient estimates of EC_{it} in Table 8 are greater than those in Table 5, implying that positive effects of strategic goods control on productivity in the ATP group were more prominent than in the entire industry. In addition, the coefficient estimates of EC_{it} in columns (2) and (4) are greater than those columns (1) and (3) in Table 8, showing that positive effects of strategic goods control on productivity were more prominent in the coverage ratio than in the frequency index. As in Table 5, we confirm that positive effects of strategic goods control on productivity were more prominent in industries with active international trade in the ATP group.

Table 8. The Regression Results of the Effect of the Strategic Goods Control on Productivity for the ATP Group

Dependent Variable	TFP		Labor Productivity	
	FI_{it}	CR_{it}	FI_{it}	CR_{it}
	(1)	(2)	(3)	(4)
$\ln PRO_{it-1}$	0.670*** (0.025)	0.651*** (0.046)	0.423*** (0.031)	0.381*** (0.040)
EC_{it}	0.052*** (0.013)	0.071*** (0.026)	0.269*** (0.064)	0.363** (0.145)
$\ln CPI_{it}$	0.065*** (0.004)	0.065*** (0.012)	0.301*** (0.027)	0.368*** (0.029)
$\ln TAR_{it}$	-0.018** (0.007)	-0.012 (0.015)	0.014 (0.023)	0.163 (0.047)
$\ln HHI_{it}$	-0.002 (0.002)	-0.004 (0.006)	0.012** (0.006)	0.005*** (0.008)
AB test for AR (1)	-3.15***	-3.00***	-2.287**	-2.024**
AB test for AR (2)	-0.993	-1.122	-0.279	-0.207
Sargan Test	41.079	40.565	31.736	32.686
# of Groups	54	54	54	54
# of Instruments	37	37	37	37
# of Observations	161	161	161	161

Notes: Figures in parentheses are standard errors. All regressions control for year fixed effects. *, **, and *** represent significance at the 1%, 5%, and 10% levels, respectively.

V. Conclusion

National security has become important in international trade and, in response, countries have set up systems for strategic goods control. Previous studies have focused on the effects of strategic goods control on international trade, but no research has ever empirically addressed how it in turn affects productivity. To fill this seeming lacuna in the research, this paper empirically examined how strategic goods control affects productivity, focusing on Korean industries from 2015 to 2019. We hypothesized that strategic goods control will positively affect productivity because it promotes international trade by making up for market failures, building up national credibility, and stabilizing the market environment; in turn, international trade contributes to productivity growth. The regression results are congruent with our hypothesis. The effects of strategic goods control on productivity were positive and statistically significant in general. These positive effects were more prominent in the group of industries that include strategic goods and ATP and, thus, are more likely to be technologically intensive. Considering various proxies for the level of strategic goods control, the positive effects of the coverage ratio were greater than those of the frequency index, emphasizing international trade as a medium for the effects of strategic goods control on productivity. Considering various proxies for productivity, the positive effects on labor productivity were greater than those on total factor productivity.

This paper provides several implications for government policy related to strategic goods control. Contrary to the general perception of the negative economic effects, this paper ensures that strategic goods control can contribute to economic growth by reducing diplomatic friction and stabilizing the global market. Korea, a resource-scarce open economy, should consider the more effective utilization of strategic goods control, minimizing its administrative costs with related measures such as the compliance program of strategic trade management and international standardization (Kim, 2017). In addition, considering that the effects of strategic goods control on productivity vary depending on industry characteristics, the government should pursue a tailor-made policy for national security that takes full account of industrial heterogeneity and support exporters' own establishment of compliance program (Lee et al., 2007).

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APPENDIX

Table A1. Regression Results for Estimating TFP

Variables	Coefficients
$lnCPS_{it}$	**0.082*** (0.027)**
$lnEMP_{it}$	**0.216*** (0.028)**
$lnINP_{it}$	**0.693*** (0.019)**
R^2	99.00
Number of Observations	436
F-value ($u_i = 0$)	108.62***
Hausman Test	27.00***

Notes: Figures in parentheses are standard errors adjusted for clusters in industries. All regressions control for year fixed effects. *, **, and *** represent significance at the 1%, 5%, and 10% levels, respectively.

Table A2. Number of Strategic Products by Industries

HS	Description	Number of Items
84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	464
85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles	428
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and accessories thereof	146
28	Inorganic chemicals; organic or inorganic compounds of precious metals, of rare-earth metals, of radioactive elements or of isotope	130
29	Organic chemicals	125
72	Iron and steel	96
39	Plastics and articles thereof	81
38	Miscellaneous chemical products	72
73	Articles of iron or steel	70
81	Other base metals; cermets; articles thereof	56

Source: Author's calculation using the data of KOSTI.