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Research Report

Impacts of climate policies on industrial competitiveness in Korea

KDI Policy Forum, No. 291

Provided in Cooperation with:

Korea Development Institute (KDI), Sejong

Suggested Citation: Kim, Hyunseok (2022) : Impacts of climate policies on industrial competitiveness in Korea, KDI Policy Forum, No. 291, Korea Development Institute (KDI), Sejong,
<https://doi.org/10.22740/kdi.forum.e.2022.291>

This Version is available at:

<https://hdl.handle.net/10419/279691>

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KDI

Policy Forum

KDI Policy Forum

October 13, 2022 (No. 291 (2022-06), eng.)

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Impacts of Climate Policies on Industrial Competitiveness in Korea

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* Summarized and adapted from Kim, Hyunseok, *Impacts of Climate Policies on Industrial Competitiveness in Korea*, KDI Policy Study 2021-13, Korea Development Institute, 2021 (in Korean).

Summary

- As carbon reduction targets are being strengthened globally, it is increasingly important in Korea to comprehend the impact of two major greenhouse gas (GHG) reduction policies, Target Management System (TMS) and Emissions Trading System (ETS), on industrial competitiveness.
 - ETS relies more on individual firms' economic incentives compared to TMS, which is a command-and-control regulation.
- While the transition from TMS to ETS in 2015 is found to have partially alleviated the burden for manufacturing firms, there is a need to enhance policy effectiveness by acknowledging their limited performance in reducing carbon emissions thus far.
 - While TMS was introduced in 2011 with the aim of enforcing emissions reduction and enhancing energy efficiency across different sectors, heavy emitters have been managed separately through ETS since 2015.
 - Knowing the low abatement performance in the manufacturing industry after mid-2010, the reduced burden can be attributed to two factors: i) improvement in efficiency resulting from the transition, and ii) alleviation of the burden through the provision of free allocations.
 - The policy efforts should aim for a greater reduction by strengthening the targets for the regulated firms, which is in line with the reinforced policy goals announced in October 2021.
- Stricter goals are inevitable in the future, and therefore, policymakers must endeavor to bolster the sustainability of the manufacturing sectors by developing a detailed roadmap based on multiple indicators.
 - Taking into account the varying impacts of GHG reduction policies on the competitiveness based on the energy intensity and emission intensity of each sector, the roadmap needs to be carefully crafted in order to impose a feasible burden on the regulated firms.

1.

Background

- Given that global efforts to mitigate climate change have significantly intensified, the transition for carbon neutrality has sparked concerns over industrial competitiveness.
 - Since the Paris Agreement in 2015, various climate summits have been actively urging the pursuit of carbon neutrality by 2050.
 - After declaring the pursuit of carbon neutrality, Korean government announced the 2050 Carbon Neutrality Scenario and the 2030 NDC Enhancement Plan in 2021.
 - Alongside the strengthening of greenhouse gas reduction targets, measures to prevent carbon leakage are also being considered in the EU and the United States.
 - The EC has announced the Fit for 55 legislative package aimed at reducing carbon emissions by 55% from 1990 levels by 2030, which includes the introduction of carbon border adjustment mechanisms (CBAM).
 - Energy-related non-profit entities have emphasized the necessity of measures to mitigate carbon leakage and enhance industrial competitiveness (Aldy, 2021, etc.).
- This study estimates the impact of two major greenhouse gas (GHG) reduction policies, Target Management System (TMS) and Emissions Trading System (ETS), on competitiveness in the manufacturing sectors during the period 2011-2019.

- TMS and ETS were respectively introduced in 2011 and in 2015, where the adoption of ETS signifies a shift towards policies based on market-friendly incentives from regulatory approaches.
 - Domestic GHG emissions in Korea have continued to increase during the 2000s and 2010s, where the manufacturing industry has been a major contributor.
 - * As of 2019, the domestic net emissions in Korea amounted to 660 Mt CO₂-eq, with emissions from the manufacturing industry constituting 380 Mt CO₂-eq (57.9% of the total).
- Since 2015, heavy emitters under TMS have been managed separately through ETS.
 - According to the data compiled by the author using NGMS, the numbers of manufacturing firms subject to TMS and ETS were respectively 333 and 0 in 2011, 209 and 373 in 2015, and 235 and 440 in 2019.
 - * As of 2019, emissions from subject entities (675 in total) were 320 Mt CO₂-eq, representing 86.5% of total emissions from the manufacturing industry.
- Given the necessity of strengthening ETS in the future, it is important to examine how the shift of the policy focus has impacted the competitiveness of the manufacturing industry.
 - There are not many domestic studies on the impact of GHG reduction policy on industrial competitiveness, where no statistically significant outcomes were obtained from the studies limited to firms subject to ETS post its introduction (Son, 2019).
 - This paper intends to empirically investigate the impacts of the two major policies on competitiveness of the manufacturing industry over their implementation period (2011-2019).

■ The impact of GHG reduction policies—their intensities are varying over time and sectors—on industrial competitiveness can generally be stratified into three distinct orders.

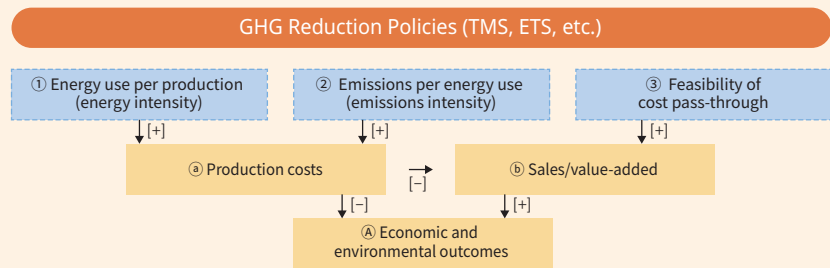
- Dechezlepretre and Sato (2017) categorize the ramifications on industrial competitiveness triggered by environmental policies into a triad of orders.
- The first-order effect pertains to changes in the cost of production activities that result in the emission of pollutants.
- The second-order effect entails the firms' response to changed costs through adjusting production volume, value-added, selling prices, and investment decision.
- The third-order effect denotes sequential changes in 'economic outcomes' such as spanning business performance (profitability, employment, market share), technological advancement (product and process innovation, TFP), international presence (trade volume, foreign direct investment), and also 'environmental outcomes' in terms of pollutants emission factors and amount.

2.

Factors Determining the Impact of GHG Reduction Policies on Industrial Competitiveness

- The short-term impact of GHG reduction policies on competitiveness hinges upon key factors, namely '① energy use per unit of production (energy intensity),' '② emissions per unit of energy use (emissions intensity),' and '③ feasibility of cost pass-through', where their relevance is amplified as policies become more stringent (Figure 1).
 - In the case where target industries are highly energy-intensive, the enforcement of GHG reduction policies will, ceteris paribus, escalate production costs (channel ①→③), inflicting negative ramifications on both economic and environmental outcomes.
 - In the case where target industries are highly emission-intensive, the enforcement of stringent GHG reduction policies will elevate production costs (channel ②→③), engendering adverse impacts on economic and environmental outcomes.
 - Conversely, if cost pass-through to subsequent producers or final consumers is facile (channel ③→②), the negative impact on sales or value-addition can be mitigated.

[Figure 1] The Factors Determining the Short-Term Impact of GHG Reduction Policies on Industrial Competitiveness



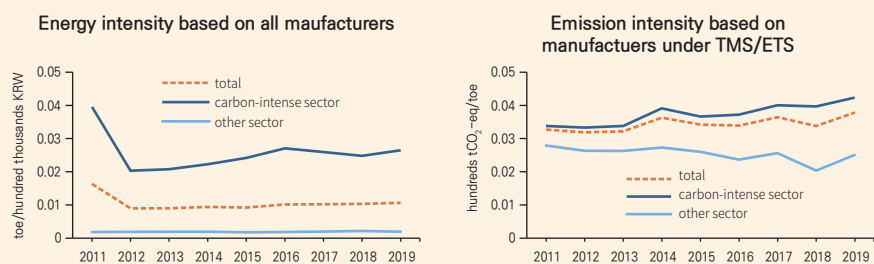
Note: The positive sign next to the arrow means a quantitative increase in the target of the arrow, while the negative sign means a quantitative decrease. The total effect of key factors (1, 2, ③) on industrial competitiveness (ⓐ, ⓑ, Ⓐ) can be understood as a result of multiplying the sign on each channel.

Source: Author's reconstruction based on Grubb (2004), pp.6-7 and Oberndorfer and Rennings (2007), p.3, Figure 1.

Recent trends in the manufacturing industry show that energy intensity experienced a sharp decrease in the early stages of goal management implementation, followed by maintaining a similar level, and emission intensity demonstrates a mild upward trend (Figure 2).

- Energy intensity is measured based on aggregate data for all manufacturing firms due to limitation in data availability, while emissions intensity is based on manufacturers that are subject to policies.
- The trajectory over the past nine years suggests that energy intensity is higher in the carbon-intensive manufacturing sectors relative to other sectors, with a significant decrease in 2012 followed by a period of stagnation.
- The emissions intensity remains high in the carbon-intensive industry with a weak upward trend, which contrasts with other industries.
 - The surge in emissions intensity in carbon-intensive industries post-2015 can be primarily ascribed to the rise in emissions intensity of the metal and non-ferrous metal industries, which collectively accounted for 39.3% of total manufacturing emissions as of 2020.

[Figure 2] Changes in Energy and Emissions Intensities in Domestic Manufacturing Industry (2011-2019)



Note: Carbon-intensive sectors in the manufacturing industry consist of petroleum, metal and nonferrous metals, chemicals, and non-metallic industries.

Source: Calculated by the author, using "Mining : Manufacturing Survey," "Economic Census," the National Energy Total Information System, and the National GHG Emission Total Information System.

This study examines whether the changes in key intensity indicators between 2011 and 2019 have had a significant influence on domestic manufacturing sectors in terms of production costs, value-added, and production output.

- For nine manufacturing sectors* spanning from 2011 to 2019, the author constructed industry/region-specific competitiveness variables (production costs, value-added, production output), intensity variables, and control variables**.

* Manufacturing sectors (per UNFCCC CRF data): 'Petroleum refining,' 'steel and non-ferrous metals,' 'chemicals,' 'pulp, paper and printing,' 'food processing and tobacco manufacturing,' 'non-metals,' 'metal parts,' 'trees and timber,' 'textiles and leather.'

** Control variables: Renewable power generation ratio, physical capital, number of employed workers, R&D expenditure, ratio of large enterprises, GRDP change, net trade income, etc.

- Intensity variables, constructed by industries without regional distinction due to data constraints, are normalized using min-max normalization per industry referring previous studies (Ouyang *et al.*, 2020, etc.).

○ The author estimated the impact of the preceding year's (t-1) intensity level on 1) primary production cost per unit of output (= primary production cost ÷ output), 2) value-added per unit of output (= value-added ÷ output), 3) output quantity (= production cost + value-added).

- For primary production cost and value-added, the dynamic adjustment process is considered by including the preceding year's (t-1) level as an explanatory variable (Wang, Sun, and Guo, 2019, etc.), and the estimation is conducted using the system GMM to mitigate the endogeneity problem.

3.

Analysis of the Impact of GHG Reduction Policies on Industrial Competitiveness

■ It was found that in manufacturing sectors, a higher emissions intensity of the regulated firms led to greater negative impacts on the production cost and value-added, with a particularly noticeable effect on carbon-intensive sectors (Table 1).

○ Channels of energy intensity (①→**a**) and ①→**a**→**b**) in Figure 1 were found to be insignificant, but those of emissions intensity (②→**a**) and ②→**a**→**b**) were significant.

- When the preceding year's emissions intensity of regulated firms escalated by 1 (the minimum value → the maximum value, in terms of the normalized value), the proportion of primary production costs (average 67.5%) per unit of output for all industries in that year augmented by 1.68%p.

- According to the sample data, the average emissions intensity of regulated firms rose from 0.41 to 0.56 from 2015 to 2019, equating to a 0.25%p increase in the primary production cost per unit of output of all industries in that period.

○ Furthermore, despite the impact on costs and value-added, the absence of a significant impact of production output suggests that price pass-through has not been active in domestic manufacturing sectors (channel ③→**a**).

○ In another analysis confined to the carbon-intensive sectors, the magnitude of the negative impact was found to be greater for the emissions intensity factor.

- When the emissions intensity of regulated firms increased by 1 in the preceding year, the proportion of the primary production cost per unit of output (72.3% on average) increased by 2.0%p, which suggests that given the increment (0.31→0.64) in emissions intensity during that period, the primary production cost per unit of output in the entire manufacturing sectors increased by 0.67%p in 2019 compared to 2015.

<Table 1> Effects of GHG Reduction Policies on Manufacturing Competitiveness: Basic Results

	All sectors: dependent variables			Carbon-intensive sectors: dependent variables		
	Main production cost per production	Value- added per production	Output	Main production cost per production	Value- added per production	Output
Energy intensity of all firms in 2011-2019 (t-1)	-0.0083 (0.0476)	-0.0022 (0.0500)	0.0327 (0.0244)	0.0394 (0.0344)	-0.0246 (0.0339)	-0.0016 (0.0190)
Energy intensity of regulated firms in 2011-2019 (t-1)	0.0168*** (0.0060)	-0.0150** (0.0074)	-0.0061 (0.0050)	0.0203*** (0.0076)	-0.0186** (0.0078)	-0.0030 (0.0028)
Inclusion of control variables and year dummies	Y	Y	Y	Y	Y	Y
Nob.	1,080	1,080	1,080	480	480	480

Note: 1) Carbon-intensive sectors in the manufacturing industry consist of petroleum, metal and nonferrous metals, chemicals, and non-metallic industries.

2) () are standard errors, and *, **, and *** mean significance at the levels of 10%, 5%, and 1%, respectively.

Source: Calculated by the author, using Mining · Manufacturing Survey, Economic Census, National Energy Total Information System, National GHG Emission Total Information System, National Science and Technology Information Service, ISTANS, and e-Regional Indicators.

■ Upon subdividing the sample period, the influence of the emissions intensity channels on manufacturing competitiveness has been observed to diminish after the establishment of the ETA (Table 2).

- Given that the ETS was launched in 2015, additional analyses were conducted by dividing two intensity variables based on two periods, pre-ETS (2011-2014) and post-ETS (2015-2019).

- It was found that intensity variables exhibited the most distinct explanatory power when the period is divided into before 2014 and after 2015.

- That the influence of the emissions intensity channels was found to weaken in the later period can be explained by three reasons: 1) in contrast to the TMS with command-and-control elements, the adoption of the economic intensive-based ETS provided regulated firms with a greater ability to take strategic actions, thereby reducing the burden of emissions reduction; 2) during the early stages of ETS implementation, the abatement burden was intentionally reduced through free allocations to ensure a robust launch of the system; 3) the ongoing abatement efforts to this point have enhanced firms' adaptive capacities, thereby diluting the channels' effects.

- As depicted in the right panel of Figure 2, the emissions intensity across all sectors and carbon-intensive sectors both showed a slight increase in the later period. This can be attributed not only to the increased efficiency resulting from the transition to market-oriented system but also to the practical alleviation of regulatory burdens in the operational dimension.

- * Throughout the Phase 1 of the ETS (2015-2017), all permits were allocated free under the goal of 'experience accumulation and system stability,' and in the Phase 2 (2018-2020), 3% of total permits should be paid for selected sectors.

- Given the clear differences in the analysis results between the periods before and after the base year (2015), one could infer that the gradual diminution of the channels' role attributed to firms' overhauling may have been limited.

4.

Policy Implications

<Table 2> Effects of GHG Reduction Policies on Manufacturing Competitiveness: Energy Intensity by Separate Periods

	All sectors: dependent variables		Carbon-intensive sectors: dependent variables	
	Main production cost per production	Value-added per production	Main production cost per production	Value-added per production
Energy intensity of all firms in 2011-2014 (t-1)	0.0078 (0.0338)	-0.0150 (0.0244)	0.0246 (0.0374)	-0.0032 (0.0334)
Energy intensity of all firms in 2015-2019 (t-1)	0.0431* (0.0249)	-0.0477** (0.0197)	0.0383 (0.0368)	-0.0186 (0.0297)
Emissions intensity of regulated firms in 2011-2014 (t-1)	0.0447* (0.0254)	-0.0284 (0.0235)	0.0488*** (0.0174)	-0.0370** (0.0162)
Emissions intensity of regulated firms in 2015-2019 (t-1)	0.0145** (0.0061)	-0.0159** (0.0065)	0.0189* (0.0099)	-0.0181* (0.0093)
Inclusion of control variables and year dummies	Y	Y	Y	Y
Nob.	1,080	1,080	480	480

Note: The same as in Table 1.

- The impact through energy intensity showed a significant increase after the introduction of ETS, indicating that some burden became more evident in the latter half of the analysis period because significant efforts had already been made to improve energy efficiency within the manufacturing sectors.

- From 2005 to 2019, energy use per unit of production output in Korea's steel industry sector remained comparable to that of Japan, significantly higher than in other major economies (Oda, 2022).

- Considering the limited performance of the transition to ETS, there is a need to enhance its effectiveness to achieve future policy goals such as carbon neutrality.

- Prior studies have shown that the adoption and implementation of the ETS had only a negligible impact on the overall emissions in the manufacturing industry (Gil, Lee, and Im, 2021)

- Preceding studies (Jeong *et al.*, 2016; Son, 2019), which assessed the impacts of GHG reduction policies on manufacturing competitiveness and the burden on regulated firms, reported insignificant or inconsistent effects across sectors and firms' size.

- According to a survey by KDI (2021), regulated firms, particularly the larger ones with capabilities, have managed to mitigate the burden gradually by implementing various reduction measures and adopting sustainability-oriented management strategies.

- The analysis of this paper shows that the burden on the competitiveness of carbon-intensive manufacturing sectors in Korea somewhat eased following the ETS adoption.

- The manufacturing industry displayed a slight deterioration in GHG reduction performance, which may be attributed to efficiency gains inherent in the system's design and the practical mitigation of operational regulatory burdens.

- The imperative to actualize considerable emissions reduction in the manufacturing industry calls for augmenting the efficacy of the ETS, currently in its formative phase.

- The Ministry of Environment's timetable (2020) directs the extant enforcement of the ETS' Phase 3 Allocation Plan (2021-2025), yet it falls short of fully integrating the strengthened NDC goal announced in October 2021, where industry-specific allocation standards persist at levels fixed at 2020's end.

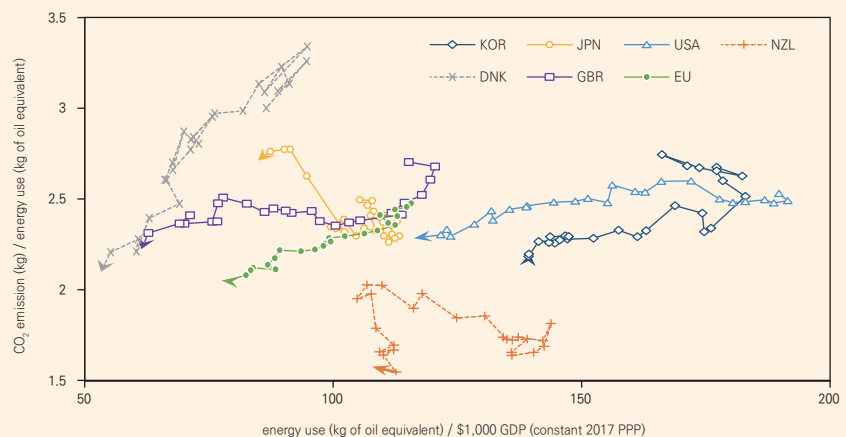
- Although Phase 3 expanded the deployment of the Benchmark (BM)-based allocation approach, utilizing emission efficiency metrics in lieu of past emission data to determine industry-specific free allocation, however, the retention of the 'average' level, akin to Phase 2, alludes to the potential underemployment of the Best Available Technology (BAT) (Kang and Oh, 2022).

- There is a pressing need to revise the allocation plan, enhancing allocation standards of each company within Phase 3 and propelling ETS-subjected firms to intensify their GHG emission reduction efforts through wider incorporation of the BM coefficient setting method that incorporates the BAT pertinent to each industry.
- Considering the analysis results of this study, which indicate that the GHG reduction policies affects the overall competitiveness of the manufacturing industry, it is important to carefully identify the portion where the abatement burden of regulated firms is shifted to low-emitting entities outside the system to ensure appropriate adherence to the polluter-pays principle.

■ The future demands more active reduction incentives and detailed guidelines on reduction targets and emissions allocations, informed by multiple indicators, including energy and emissions intensities.

- While Korea experienced a ‘reverse C’ trajectory in the 1990s, energy and emissions intensities have been on a declining trajectory since the 2000s, albeit at a pace that falls behind the more advanced nations (Figure 3).
- As confirmed earlier, energy and emissions intensities during the 2010s exhibited contrasting trajectories, each exerting distinct influences on the competitiveness of the domestic manufacturing industry.
- In the upcoming transition towards a decarbonized economy, with the strengthening of GHG reduction policies, it is crucial to enhance the sustainability of the manufacturing industry by considering a diversified and refined BAT based on various indicators related to energy usage and emissions during the process of setting targets and allocating emission allowances.
 - The government has expressed intent to incorporate BAT in calculating the BM coefficient for Phase 4, emulating the EU’s practices (Ministry of Environment, 2020).
 - Policy makers should contemplate expediting the BAT implementation originally scheduled for Phase 3, strengthening the reduction targets, while concurrently addressing equitable allocation of the resultant additional burden.
 - Considering that at present, the EU ETS mandates a variable annual reduction (0.2-1.6%) in the BM coefficient, reflecting the level of industrial innovation during Phase 4 (2021-2030) (EC, 2021), it is crucial that the Korean government integrates sector-specific characteristics as part of a transitional approach.
 - For instance, industries with significant direct emissions, such as fuel combustion, can lower their emission intensity through self-strategies such as transitioning to environmentally friendly fuels; on the other hand, industries with substantial indirect emissions may find it more effective to adjust energy intensity rather than emission intensity.

[Figure 3] Changes in Energy and Emissions Intensities in Major Countries (1990-2015)



Note: Symbols denote each year, and the last year (2015) of each country is displayed in an arrow.
Source: Recited from Kim (2021).

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