# The Relationship between Exports and Carbon Emissions Using VDC and IRF *

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# 분산분해와 충격반응을 이용한 수출과 탄소배출량의 관계

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abstract

This paper empirically examines the nexus between carbon (CO2) emissions and maritime freight volume over the period of 1990-2019 in Korea. We analyze 2-digit HS codes of 40, 72, 27 & 39 and their disaggregated poducts further broken out into 4-digit HS codes. We aim to elucidate the relationship between CO2 emission and Korea's principal export products using the variance decomposition analysis and the impulse response function analysis. This paper shows that except for HS4011 and HS7208, the export volumes of HS40 and HS72 are exogenous to CO2 emission, so a policy to curb the increase in carbon emission can be effective without significant cost increase. On the other hand, the export volume of HS27 and HS39, except for HS2707, is endogenous to carbon emission, indicating it is hard to control the carbon increase because suppressing the increase in carbon emission leads to an export decrease.

## 1. Introduction

Since the late 1970s, issues related to the environment have become very prominent, and literature regarding the effects of increased international trade on the environment is vast. Some have argued that expansion of international trade leads to increased competition among countries and an improvement in the efficient use of scarce resources, while some oppose the expansion of global trade because it could lead to the depletion of natural resources, increased pollution, and degradation of environmental quality (Ronaghi et al., 2020).

International trade forms an essential tool to promote the increase in economic growth, but at the same time has the potential to lead to a lot of CO2 emissions. The low-carbon economy has been an important and hot topic for nearly two decades as it has played an essential role in the green economy and sustainable development. Copeland and Taylor (2004) investigated the relationship between trade and CO2 emissions. Al-mulali and Ting (2014) investigated the bi-directional long-run relationship between exports/imports and CO2 emission for 189 countries from different regions. Kasman and Duman (2015) examined the relationship between carbon dioxide emissions and trade openness for new EU member and candidate countries. Destek et al. (2016) investigated the relationship between CO2 emission and trade openness for 10 selected Central and Eastern European Countries (CEECs). Unlike previous studies, this paper aims to elucidate the relationship between CO2 and Korea's principal export products using VAR.

## 2. Variance Decomposition Analysis

The variance decompositions reveal the percentage of forecast error variance for each variable that is attributed to its own innovations and to shocks to the other system variables (Narayan, 2006). The variance decompositions for the HS27 export are presented in Table 1.

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[Table 1] Variance decomposition of HS27 and HS39 export(8 steps)

| code | ex | $CO_2$ emission | xrate | code | ex | $CO_2$ emission | xrate |
|---|---|---|---|---|---|---|---|
| HS2710 | 46.11 | 48.50 | 5.37 | HS3907 | 51.27 | 25.73 | 22.99 |
| HS2707 | 94.77 | 3.20 | 2.01 | HS3901 | 37.63 | 49.01 | 13.35 |
| HS2713 | 54.93 | 20.52 | 24.54 | HS3902 | 34.06 | 49.02 | 16.91 |
| HS2711 | 58.03 | 26.90 | 15.05 | HS3920 | 58.58 | 40.44 | 0.970 |

After 8 years only 46 percent, 55 percent and 58 percent of the variation in the export value of HS2710, 2713, and 2711 are explained by shocks in export itself; the remaining 54 percent, 45 percent, and 42 percent of the variation in export are explained by the combined impact of CO2 emission and exchange rate. These results generally point to the fact that a large proportion of the variation in the export of HS2710, 2713, and 2711, in the long run, is explained by the combined impact of variables including CO2 emission. However, the export of HS2707 is extremely exogenous to CO2 emission. Table 1 also presents the variance decompositions for the HS39 export value. After 8 years only 51 percent, 38 percent, 34 percent and 58 percent of the variation in the export of HS3907, 3901, 3902, and 3920 are explained by shocks in export itself; the remaining 49 percent, 62 percent, 66 percent and 42 percent of the variation in export are explained by the combined impact of CO2 emission and exchange rate. These results generally point to the fact that a large proportion of the variation in the export value of HS3907, 3901, 3902, and 3920, in the long run, is explained by the combined impact of variables including CO2 emission. However, HS3903 export is exogenous to CO2 emission.

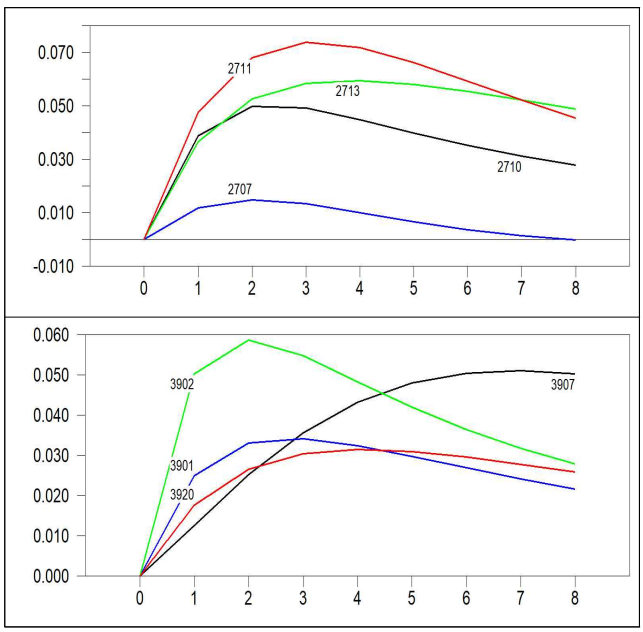
[Table 2] Variance decomposition of HS40 and HS72 export(8 steps)

| code | ex | $CO_2$ emission | xrate | code | ex | $CO_2$ emission | xrate |
|---|---|---|---|---|---|---|---|
| HS4002 | 70.73 | 29.20 | 0.060 | HS7210 | 77.05 | 18.53 | 4.412 |
| HS4011 | 65.82 | 26.96 | 7.206 | HS7208 | 48.02 | 37.37 | 14.59 |
| HS4016 | 83.07 | 9.948 | 6.973 | HS7209 | 70.54 | 27.27 | 2.178 |
| HS4009 | 71.54 | 19.89 | 8.561 | HS7219 | 77.48 | 8.138 | 14.37 |

The variance decompositions for the HS40 export are presented in Table 2. However, after 8 years only 71 percent, 66 percent 72 percent of the variation in the export of HS4002, 4011 and 4009 are explained by shocks in export itself; the remaining 39 percent, 34 percent and 28 percent of the variation in export are explained by the combined impact of CO2 emission and exchange rate. These results generally point to the fact that a large proportion of the variation in the export of HS4002, 4011 and 4009 in the long run, is explained by the combined impact of variables including CO2 emission. However, HS4016 export is exogenous to CO2 emission. The variance decompositions for the HS72 export volumes are presented in Table 2. After 8 years only 48 percent and 71 percent of the variation in the export of HS7208 and 7209 are explained by shocks in export itself; the remaining 56 percent, 29 percent and 37 percent of the variation in export are explained by the combined impact of CO2 emission and exchange rate. These results generally point to the fact that a large proportion of the variation in the export of HS7208 and HS7209 in the long run, is explained by the combined impact of variables including CO2 emission. However, HS7210 and 7219 are exogenous to CO2 emission.

## 3. Impulse Response Function Analysis

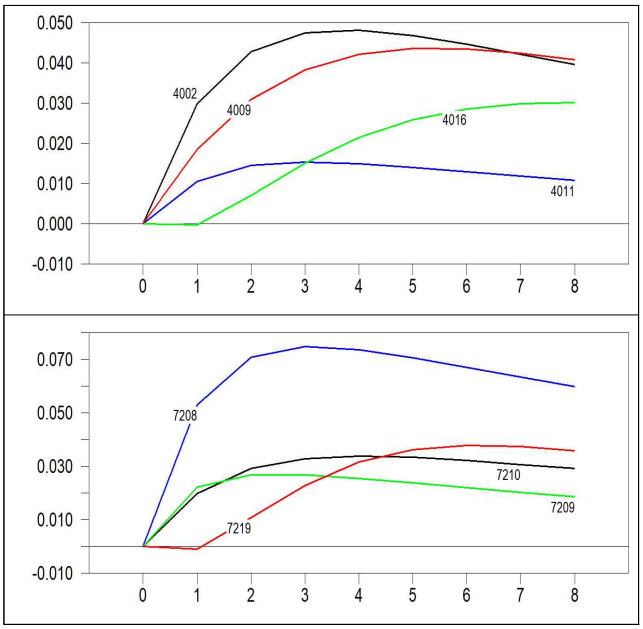
Another way of illustrating the dynamic behavior of the model is through impulse response functions. An impulse response function is the response of an endogenous variable to one of the innovations (Brahmasrene et al., 2014). It traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables(Dey & Tareque, 2020; Blazsek et al., 2021).




[Fig. 1] Impulse Response Function Graphs of HS27 and HS39

Fig. 1 depicts the responses of HS27 and HS39 export to

shocks arising from CO2 emission variable over a time horizon of 8 periods. It is observed that one SD shock of CO2 emission initially increases in periods 2 for HS2707 and HS2710, 3 for HS2711 and HS4 for HS2713 and decreases slightly and then becomes stable, meaning that shocks to CO2 emission has noticeable impact on HS2711 and HS2713, but meager effect on HS2707. It is also observed that one standard deviation own shock initially increases in period 2 for HS3902, period 3 for HS3903, period 4 for HS3920, and period 7 for HS3907 and decreases slightly, meaning that shocks to CO2 emission has strong impact on HS3902 and HS3907.




[Fig. 2] Impulse Response Function Graphs of HS40 and HS72

The IRF graphs in Fig. 2 show the positive responses of HS40 export volumes to a unit shock from CO2 emissions. It reveals that a unit shock from CO2 emissions leads to a rise in HS4011 export volume within 3 periods, in HS4002 export volume within 4 periods, in HS4009 export volume within 5 periods, and in HS4016 export volume within 8 periods. All the responses dwindles and then restores equilibrium, meaning that shocks to CO2 emission has strong impact on HS4002 and HS4009, but weak effect on HS4016 and HS4011. Fig. 2 displays the impulse response of the HS72 to CO2 emission shock under VAR. An CO2 emission shock has a positive impact on HS72 export volumes from the first month to the eighth month, and decays slowly. It is observed that one standard deviation shock of CO2 emission initially increases in period 2 for HS7209, period 3 for HS7208, period 4 for HS7210, and period 6 for HS7219 and decreases slightly, meaning that shocks to CO2 emission has strong impact on HS7208, but weak effect on HS7210, HS7219 and HS7209.

## 4. Conclusion

This paper empirically examines the nexus between carbon (CO2) emissions and maritime freight volume for HS40, 72, 27 and 39 over the period of 1990-2019 in Korea. This paper aims to elucidate the relationship between CO2 emission and Korea's principal export products using VAR such as the variance decomposition analysis and the impulse response function analysis, which are commonly used for analyzing the dynamic impact of random disturbances on a system of variables. Our major findings are summarized as follows. First, the proposition of the export volume that can be attributed to innovations in CO2 emission and exchange rate ranges from 35 percent to 66 percent for HS2710, 2713, 2711, 3907, 3901, 3902, 3920, 4011 and 7208. This indicates that a large fraction of the export volume is attributed to shocks originating from the other variables including CO2 emission. Second, the CO2 emission explains 20 percent to 40 percent of the variance forecast errors of export volume at the 8-step horizon. This finding supports the view that CO2 emission is relatively the leading variable and does affect export volume. Third, the IRFs experiment reveals that the shocks to CO2 emission has noticeable impact on HS2711 and HS2713 for HS27, HS3902 and HS3907 for HS39, HS4002 and HS4009 for HS40, and HS7208 for HS72, while CO2 emission shock has weak effect on HS2707, 4016, 4011, 7210, 7219 and 7209. This paper shows that except for HS4011 and HS7208, the export volumes of HS40 and HS72 are exogenous to CO2 emission, so a policy to curb the increase in carbon emission can be effective without significant cost increase. On the other hand, the export volume of HS27 and HS39 is endogenous to carbon emission, indicating it is hard to control the carbon increase because suppressing the increase in carbon emission leads to an export decrease.

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