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Leakage Risks in South Korea: Potential Impacts on Global Emissions

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Abstract

South Korea will be launching its emission trading scheme (ETS) in January 2015. The Korean ETS draws inspiration from the European Union (EU) ETS, and is being launched with the expectation of significantly reducing the GHG emission within South Korea. In the process, however, there has been substantial apprehension about the risk of carbon leakage. It is important, therefore, to assess the risk of carbon leakage ex-ante so that appropriate policies can be designed to mitigate this risk. This policy brief is a an attempt to assess the risk of carbon leakage in South Korea following from implementation of the ETS, drawing on available data. The paper uses the methodology advocated by the EU ETS Directive, and is based on secondary data. The analysis is carried out at an aggregate level due to paucity of data. Still, it reveals that there are certain sectors within the South Korean economy which are indeed exposed to a moderate to high degree of risk of carbon leakage, due more to trade intensity than carbon intensity. Korea can borrow from the experiences made in other countries regarding policies to mitigate leakage risk, but further analysis with a more detailed data breakdown is needed for a refined assessment.

1. Introduction

In January 2015, the Republic of Korea (South Korea) is scheduled to launch the Korean emission trading scheme (KETS). Drawing inspiration from the European emission trading scheme (EU ETS), the KETS is envisaged to have three phases – the first two phases will each have 2 years of trading, and the third phase will see 5 years of trading. The KETS will cover all six Kyoto Protocol greenhouse gases (GHG) (Bloomberg and Ernst & Young, 2013). It is estimated that the KETS will cover 70% of the country's GHG emissions. As per the policy design, industrial units with annual GHG emissions of 25 KtCO_2e, and companies with multiple installations emitting, in agregate, 125 KtCO_2e/year, will be part of the KETS. Simultaneously, any industrial unit which wishes to join the KETS voluntarily is also able to join. In the first three phases, installations in the power and industry sector are slated to be the part of KETS (Bloomberg and Ernst & Young, 2013).

Still, a carbon pricing approach such as an ETS can give rise to concerns about the risk of carbon leakage (Bukowski, 2013). Carbon leakage is the displacement of emission from one region enforcing stringent climate policies, to another region with less restrictive carbon constraints. From the point of view of climate policy, the phenomenon of carbon leakage is undesirable (Droege, 2012). In the absence of a global carbon price, the risk of carbon leakage looms large. Therefore, it is essential that the sectors that are vulnerable to the risk of carbon leakage are identified at the earliest possible time, and protection mechanisms are designed to reduce stress on these sectors from the impact of carbon prices. Additionally, in a world with common but differentiated responsibilities for climate change mitigation, policies that promote clean technology transfer to the regions where emissions are displaced merit attention.

The issue of carbon leakage has attracted the interest of many researchers. For instance, the EU aims for a 30% GHG reduction by 2030, which is expected to result in higher carbon prices and hence may lead to reduced production in heavy industry, especially in the steel and cement sector; with border adjustment measures in place, for instance, such carbon leakage could be prevented (Droege, et al., 2012). In Japan, a move to a mandatory ETS is expected to lead to carbon leakage in the steel and cement sectors unless leakage prevention measures such as free allocation and border adjustments are taken (Droege, et al., 2012). China has announced its intention to introduce emissions trading in seven provinces starting in 2015. The effect of the CO_2 price will be much higher in China, as its industries are comparatively low in energy efficiency (Droege, et al., 2012).

In a study concerning the carbon leakage risk in the EU (Pollitt, et al., 2012), it has been shown that increases in consumer prices have been lower than the increase in carbon prices because the cost pass through is less than 100%. Also, the impact of border adjustments would be limited in sectors such as steel, cement and aluminium. This is because the EU imports very small amounts of these items from non-EU countries. While the results suggest that border adjustments, in the presence of revenue recycling, can boost EU output even within emissions constraints, the size of the impacts is quite small and the conclusion is that, for this scale of emission reduction, the effects are broadly neutral at the macroeconomic and 2-digit sectoral level.

A study on the Spanish economy (Linares & Santamaría, 2012)[1] shows that the cement sector in the country may face carbon leakage. However, the risk of leakage is not a concern in the immediate future, as the industry is already facing decreasing demand as a result of macroeconomic conditions. The most effective leakage prevention policy suggested is border tax adjustments. To compensate for the loss of competitiveness of the Spanish cement industry, a high level of taxation is recommended (a minimum of 30% on clinker imports). In the steel sector, the leakage risk may be completely eliminated by levying a border tax (5%) or by providing free allowances (50%). The oil refining industries in Spain face a significant risk of carbon leakage. To address this risk, imposition of an import tax is suggested.

This policy brief attempts to assess the carbon leakage risk in the KETS implementation phase. For the purpose of analysis, only industries in the manufacturing sector have been considered, as the KETS aims at covering the industrial and power sector emissions in the initial phase. The methodology deployed in the study is similar to that used in the EU Comitology process in 2009 (de Bruyn, et al., 2013). Deploying a similar methodology, researchers have assessed carbon leakage risks in various countries in the EU (Sartor and Spencer, 2013) (Sato, et al., 2013). The power sector is kept outside the purview of the analysis to avoid double counting, as indirect emissions by the sectors analysed have been considered.[2] Although most past studies in the EU use sectors disaggregated to the 3-4 digit level, with the constraints of data, the present brief analyses the risk of carbon leakage at an aggregated level, using the data available in the input-output table (IO Table) of South Korea in the World Input Output Database.[3] However, if disaggregated data become available at 3-4 digit level of disaggregation, the method can be rerun.

The subsequent section of this report discusses, in brief, the process leading to the KETS. The following sections present a snapshot of the economy and emissions of South Korea. A decomposition analysis of CO_2 emissions has been conducted – first, for the economy as a whole, and then, for the manufacturing sector. Subsequently, the results of the carbon leakage risk analysis are presented. The issues concerning policies are presented in the next section.

2. Brief Review of Climate Policies in South Korea and the Road to ETS

In recent years, while the GDP of South Korea has witnessed an average annual growth rate of 4.9% per annum (p.a.), the country has also become the world's seventh largest GHG emitter (EDF-IETA, 2013). South Korea is the fastest growing source of emissions among the 34 nations of the OECD (Sangim, 2012). However, it is one of the few OECD countries which has no binding emission reduction obligation under the Kyoto Protocol. The country has supported the continuation of the Protocol and has also accorded its support to the formalization of the Copenhagen pledge in the international climate negotiations. Further, in 2008, South Korea pledged an assistance of USD 200.00 million to projects targeted at climate change mitigation under the East Asia Climate Partnership.

However, the country has planned to reduce its GHG emissions by 30% of projected levels[4] by 2020 or equivalently to 4% reductions below 2005 levels (EDF-IETA, 2013). For achieving this goal, Korea passed the Framework Act on Low Carbon Green Growth on December 29, 2009, followed by the Enforcement Decree of the Framework Act on Low Carbon Green Growth of April 6, 2010. This act takes precedence over all other Acts concerning low carbon and green growth, and any amendments to other Acts must align with the Framework Act.

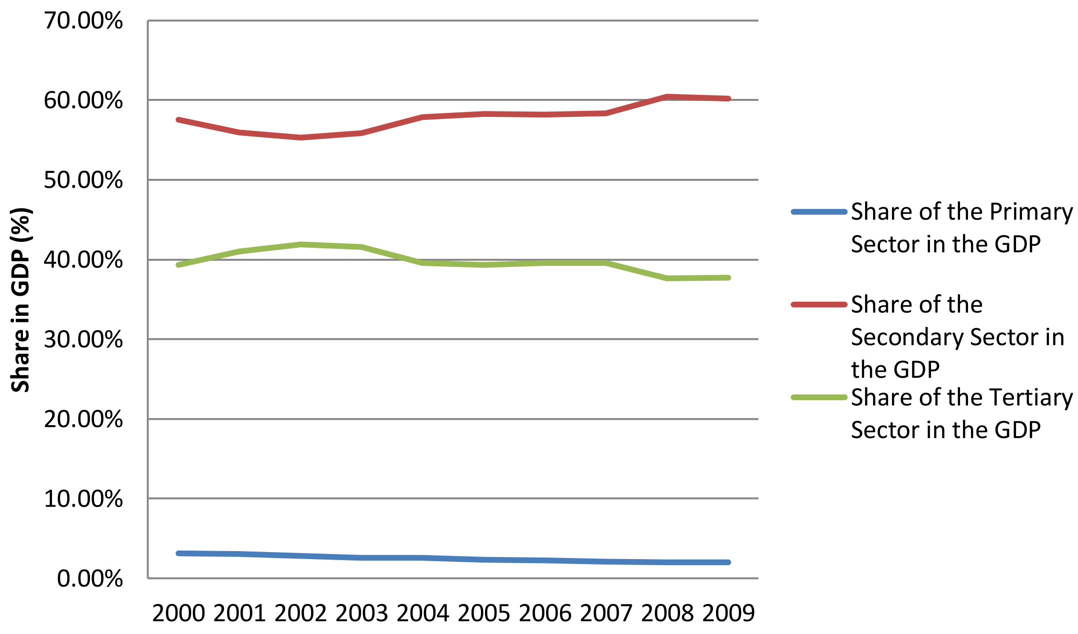
[1] The study considers 3 sectors: cement, iron and steel, and oil refinery.

[2] Another reason for excluding the power sector in the analysis is because there likely is no grid connection with other countries.

3 World Input Output Database (www.wiod.org) is a project funded by the European Commission, Research Directorate General, as part of the 7th Framework Programme, Theme 8: Socio-Economic Sciences and Humanities. Grant Agreement no: 225 281. The Korean IO-Table has been constructed with the inputs from the Bank of Korea.

[4] Projections are made considering the BAU scenario.

Figure 1. Different Sectors: Share in the Total GDP of South Korea (2000-2009)



The purposes of the Framework Act is to primarily provide an outline to guide emission targets, carbon disclosure, carbon taxation etc. as well as to provide a broad guideline for the carbon trading system. The Act specifies that the Korean government must support the establishment of an emissions trading scheme and gradually increase taxes on goods that have high emissions and low energy efficiency. The act is also expected to help the country mainstream the use of renewable energy.

South Korea, following Kazakhstan, is expected to become the second country in Asia to enact a nation-wide emissions trading scheme (EDF-IETA, 2013). On July 23, 2012, the Korean government released a draft executive policy directive called "Laws pertaining to the allowance and trading of greenhouse gas emission permits", facilitating the implementation of the Act by way of a Presidential Decree in November 2012. Before releasing the directive, the opinions of industry, non-governmental organizations, experts, other stakeholders and related ministries were considered. The national ETS, passed unanimously by Korea's national assembly, is a three phase programme with a very similar design to the European Union Emission Trading Scheme (EU ETS). The Korean ETS is expected to operate on and from January, 2015[5]. The government of Korea plans to use the ETS as a policy tool to promote green business and augment green jobs in the country (Cho, 2012). The ETS 'Master Plan' is expected to be released in December 2013 by the Ministry of Strategy and Finance (MoSF). This master plan will provide a 10 year plan for the market's operations, revisable every 5 years.

3. Economy of South Korea: Highlights

Starting in 1960, South Korea has transformed itself from an agricultural economy to an industrialized economy (Choi, 1986). Since 1970, South Korea has witnessed an appreciable growth in its Gross Domestic Product (GDP).[6] During 1970–2010, the

[5] Although the original plan was to commence the ETS from 2013, the commencement of the scheme has been delayed due to the intense opposition from the Federation of Korean Industries.

[6] The GDP here refers to the GDP at constant at constant prices and is calculated at 2005 prices. The source of the data is OECD Stat Extracts (http://stats.oecd.org/Index.aspx?DatasetCode=SNA_TABLE1).

Compound Annual Growth Rate (CAGR) of the GDP at constant prices is estimated at 7.05% p.a. The country experienced a comparatively higher growth rate during the two decades from 1970 to 1990. Thereafter, the growth rate declined (OECD, 2013). The decline in the "economic miracle" in South Korea in the 1990s can be traced back to 1987, when the country was plagued with intense labor unrest (Minns, 2001). Fast-paced industrialization, and increasing dependence on the capital/technology intensive processes in earlier years, had created an excess supply of labour and decline in wage rates that led to discontent among the wage earners and caused the unrest (Lee, et al., 2002). Thereafter, the country experienced a downturn in the GDP. The economy was also badly hit by the financial and economic crisis of 1997. In 1998, the annual growth of GDP was negative.[7]

However, interventions by the Korean government helped the economy overcome the turbulence temporarily, before being hit by the banking and currency crisis of the late 1990s. New policies helped the country access overseas funds and explore new markets. Between 1992 and 1996, foreign loans to South Korea rose by 158%. By 1997, South Korea had the highest proportion of short-term debt compared to any country in Asia, Latin America or Eastern Europe. In 1997-98, South Korea experienced an acute currency and banking crisis. The crisis lead to a reduction in economic growth and decline in investments; consequently, increasing the unemployment rate in the country (Barro, 2001). In response to this crisis, the government initiated one of the largest IMF bailout programmes in history, [8] helping South Korea overcome the crisis.

3.1 Contribution of Different Sectors to Korean GDP

South Korea is an industrialized economy. The economy of South Korea is characterized by the dominance (more than 60%) of the secondary sector in terms of contribution to the GDP (figure 1). The tertiary sector and the primary sector, respectively, follow the secondary sector. Another interesting point to note is that between 2000 and 2009, the contribution of both the primary sector and the tertiary sector has steadily decreased.

Table 1 Growth Rate of GDP

Period	CAGR (% p.a.)	AAGR (% p.a.)
1970 – 2010	7.05%	7.12%
1970 – 1980	7.87%	7.94%
1980 – 1990	9.72%	8.68%
1990 – 2000	6.53%	6.87%
2000 - 2010	4.15%	4.59%

Within the secondary sector, manufacturing plays a dominant role, contributing to more than 80% of the output in the secondary sector. Industries like basic metals and fabricated metals, electrical and optical equipment, transport equipment, food and beverages are the most important manufacturing industries. In the non-manufacturing category, construction contributes appreciably to the output of the secondary sector.

3.2 Employment in South Korea

The employment rate of South Korea is close to 60%.[9] The labour participation rate in case of males is about 70%, and is considerably higher than that of females (close to 50%). Although the contribution of the tertiary sector to the national output is decreasing, this sector contributes significantly to the employment – generating a little less than 70% of the total employment. The CAGR of employment in the tertiary sector during 2000-2009 is close to 3% p.a. On the other hand, the contribution of the primary sector to total employment is less than 2%, and is marked by a gradually diminishing trend. The secondary sector absorbs about 27% of the workforce, with manufacturing contributing to about 25% of the employment.

[7] In 1998, the annual growth rate of GDP at constant prices was -5.71%.

[8] South Korea availed a loan from the IMF ammounting to USD 57.00 billion in December 1997.

[9] Population above 15 years has been considered as population eligible for employment (http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS/countries).

3.3. International Trade

Data during 2009-2011[10] shows that, during these three years, the South Korean economy was characterized by a positive balance of trade. The economy's main imports are from the People's Republic of China (PRC), Japan, EU27, USA and Saudi Arabia. In 2012, these countries accounted for about 55.7% of the total imports by South Korea. Major imports are fuel, mining products, manufactured goods and agricultural products.

On the export front, PRC, USA, EU27, Japan and Hong Kong account for about 59% of the exports from South Korea.

3.4 International Financial Crisis (2008) and Recovery

During the last decade, South Korea witnessed growth in GDP from 2000 to 2007. Since 2008, there is an evidence of decline. The decline is attributable to the international economic downturn that began in 2007. Following the global economic recession, the real economy of South Korea shrank due to reduced domestic and export demands (Chung, 2010). However, the effects of the recession are more prominent in the domestic sector than in exports (OECD, 2012) (Kim, 2012). Increasing oil prices and increasing imports of oil together resulted in a current account deficit of USD 14.0 billion in the first three quarters of 2008 — a huge difference compared to the USD 6.0 billion surplus of 2007. By September 2008, the Korean stock market collapsed, simultaneously with a weakening Korean Won.

As before (in the aftermath of the East Asian crisis of 1997), the government intervened. A portfolio of policy measures has been implemented since 2008 to stabilize the financial markets. However, the measures proved inadequate and the downturn of the Korean economy continued. In 2009 the Korean government started adopting expansionary monetary and fiscal policies. These measures contained the Korean economy's downturn, and by the second quarter of 2009, it had started recovering. Exports increased due to the depreciating Won and increasing imports by China. The falling prices of oil, also helped the Korean economy recover. Supported by the favourable government policies and a buoyant trade performance, the country is once again among the top 20 economies in the world (OECD, 2013).

[10] Source: DG Trade Statistics, European Union

4. Energy and Emission Profile

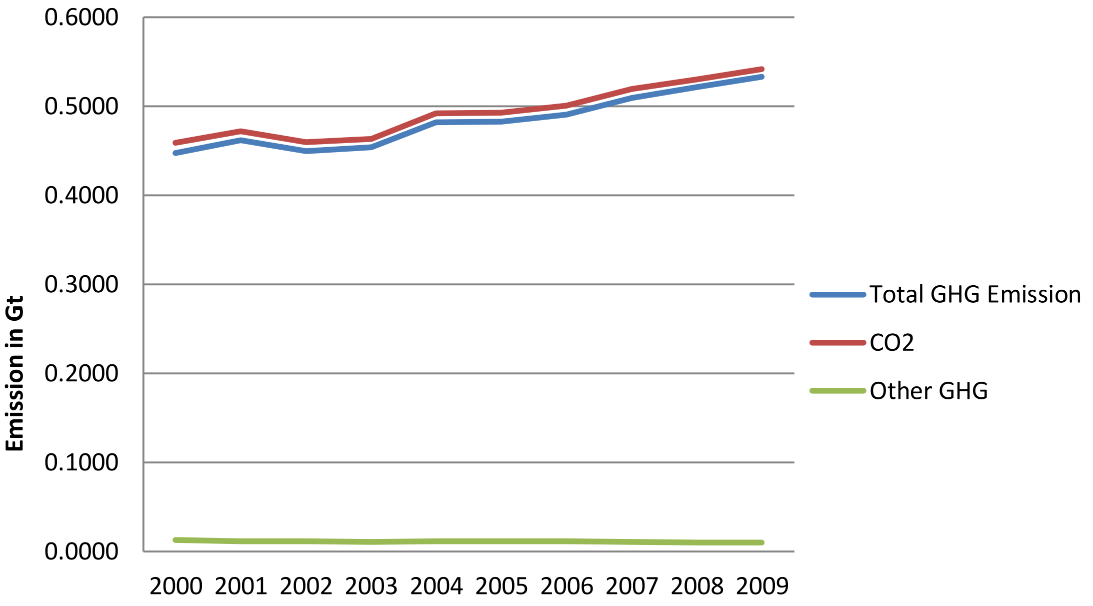
Literature posits that, in the context of emerging economies, energy consumption, CO_2 emission and GDP are highly correlated (The World Bank, 1992) (Choi and Ang, 2001). Since 1990, the economic growth of South Korea is also characterized by a heavy reliance on energy consumption, leading to a substantial increase in CO_2 (and overall GHG) emission (Oh et al., 2010).

4.1 Energy Consumption

In 2011, South Korea was reported as the tenth largest energy consumer in the world (USEIA, 2013). Since the country is deficient in domestic reserves, the economy has to rely heavily on energy imports. The country is the second largest importer of liquified natural gas, the third largest importer of coal, and the fifth largest importer of crude oil[11] (USEIA, 2013). Oil has been the largest source of primary consumption (42%), followed by coal (29%). It is also important to note that South Korea has a number of oil refineries which depend on imported crude oil. Since the mid-1990s, the country started exploring opportunities in energy from natural gas and nuclear sources. The share of these sources is steadily increasing. Renewables constitute less than 1% of the energy mix.

[11] The positions reported are as of 2011

Figure 2. GHG Emission in South Korea: 2000 – 2009

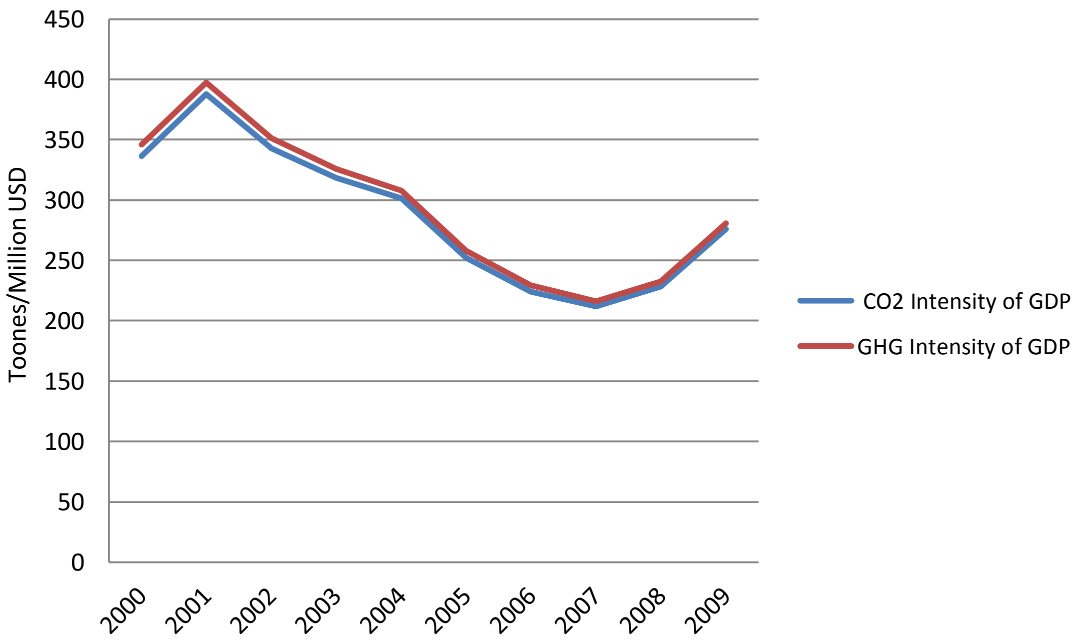


In the context of electricity generation, the country relies heavily on coal. Conventional thermal power accounts for more than two-thirds of the electricity generated. 30% of the electricity is generated from nuclear sources.

4.2 Emissions

Economic growth and heavy reliance on oil and coal have made South Korea a hotspot for GHG emissions. The GHG emissions in 2005 are double the emissions levels of 1990. The increase in GHG emissions in South Korea is the highest among all

Figure 3. GHG and CO_2 Emissions Intensity of GDP in South Korea: 2000 – 2009



the OECD countries (Norton Rose Group, 2011). In 2010, South Korea ranked 8th among the OECD countries in terms of per capita CO_2 emissions, with per capita CO_2 emission reaching 11.5 Mt. [12] Emissions have continued to steadily rise on a year-to-year basis during the 2000s (Ministry of the Environment, Korea, 2009). Between 2000-2009, the overall increase in GHG emissions was 18%, with a CAGR of 1.86% p.a. CO_2 emissions comprise more than 97% of GHG emissions in Korea, and closely reflect the trend of overall GHG emissions. During the foregoing period, the increase in CO_2 emissions was 19%, with a CAGR of 1.96% p.a. Emissions of other GHGs have decreased between 2000-2009.[13]

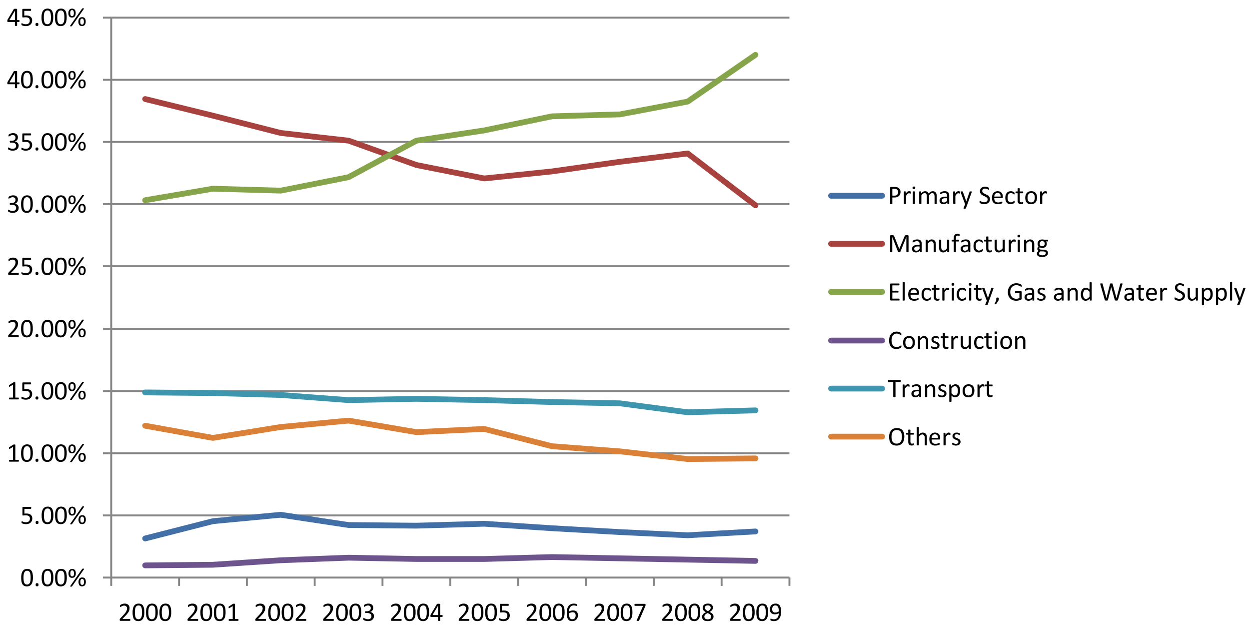
Manufacturing, electricity, gas and water supply are the main contributors to the GHG emissions in the country, followed by transport. Together, these sectors account for more than 80% of GHG emission. In recent years, the share of the manufacturing sector has decreased considerably due to measures such as improved energy management practices and modification of production processes. On the other hand, the emissions from electricity, gas and water supply reveal an increasing trend – mainly because of increased electricity demand for final use and a substantial shift from oil to coal (Oh et al., 2010).

The CO_2 emissions intensity of Korea's GDP shows a downward trend during 2000-2009. Following the 1997 financial crisis, the slow growth rate of GDP was accompanied by a slower growth rate of energy consumption and CO_2 emissions, leading to a downward trend of the CO_2 (and GHG) intensity of GDP (Oh et al., 2010). In 2005, the CO_2 emissions intensity was more or less, near the average of OECD countries (Oh et al., 2010).

4.3 CO_2 Emissions in South Korea: A Decomposition Analysis

What drives change in the energy consumption and CO_2 emission of an economy? The literature on energy and economic development posits that the change in specific energy consumption is not the

Figure 4. Share of Different Sectors in GHG Emission of South Korea



[12] The countries which recorded higher per capita CO2 emission than South Korea are Luxembung, US, Australia, Canada, Estonia, Norway and Finland (World Bank, 2013)

[13] In the class called other GHGs, the following gases have been considered: Methane (CH4), Nitrous Oxide (N2O), and following UNFCCC guidelines, the indirect GHGs - Suplhur Oxides (Sox), Nirogen Oxides (NOx), Carbon Monoxide (CO) and Non-Methan volatile organic compounds (NMVOC).

sole determinant of the change in energy consumption and emission. There are various other drivers, such as changes in the level of overall activity and the activity mix, as well as the fuel mix, all of which play critical roles in changing the pattern of energy consumption and CO_2 emissions (Roy, 2000; Ang, 2004).

Decomposition analysis is a 'simple, flexible methodology widely used since the 1980s in energy use pattern analysis and energy-related gas emissions analysis' (Oh et al., 2010). The decomposition method uses the Kaya Identity (Kaya, 1990; Kaya and Yokobori, 1993) to decompose the energy use of and/or emission from a sector over a period of time. It is acknowledged in literature that the decomposition based on basic Kaya type identity helps in identifying the contribution of activity/output effect, structural effect and technological/energy intensity effect drivers in emissions. In the preceding section, it was shown that CO_2 is the main component of the GHG emissions in South Korea. Further, for the purpose of this paper, the focus is on the manufacturing sector. Hence, in this paper, we deploy decomposition of CO_2 emissions in South Korea to understand, retrospectively, the relative contribution of different drivers to changes in emissions (Ang and Lee, 1996).

In additive form, changes in emissions can be expressed as

$$E_t - E_0 = \Delta E_{TOT} = \Delta E_{OE} + \Delta E_{SE} + \Delta E_{IE}$$

In multiplicative form, the same could be expressed as

$$\frac{E_t}{E_0} = D_{TOT} = D_{OE} * D_{SE} * D_{IE}$$

Here,

ΔE_{TOT} = Magnitude of change in emission in an additive framework

D_{TOT} = Proportional change in emission in a multiplicative framework

Defining,

E_t = total CO_2 emissions at period t
$E_{i,t}$ = CO_2 emissions in sector i at period t
Y_t = total output of the economy at period t
$Y_{i,t}$ = production of sector i at period t

changing the pattern of energy consumption and CO_2 emission (Roy, 2000; Ang, 2004).

$S_{i,t} = Y_{i,t} / Y_t$ = production share of sector i at period t
$I_t = E_t / Y_t$ = aggregate energy intensity at period t
$I_{i,t} = E_{i,t} / Y_{i,t}$ = energy intensity for sector i at period t

Assuming the number of sectors = n, the total CO_2 emission at period 't' can be expressed as:

$$E_t = \sum_{i=1}^{n} E_{i,t} = \sum_{i=1}^{n} Y_t \frac{Y_{i,t}}{Y_t} \frac{E_{i,t}}{Y_{i,t}} = \sum_{i=1}^{n} Y_t * S_{i,t} * I_{i,t}$$

This equation shows that, at any point in time, CO2 emission can be explained in terms of three drivers (level of output, sectoral/structural composition of the economy (or the manufacturing) sector represented by relative output shares of energy intensive and non-intensive industries, and energy intensity of different sectors). Using these three drivers as explanatory effects, the change in emission can be theoretically decomposed using additive and/or multiplicative methods (Ang, 2004).

ΔE_{OE} and D_{OE} = Output Effect in additive and multiplicative framework respectively = Change in emission due to the change in production and activity

ΔE_{SE} and D_{SE} = Structural Effect in additive and multiplicative framework respectively = Change in emission as a result of the relative change in output/activity growth in the energy intensive industries as compared to less energy intensive industries

ΔE_{IE} and D_{IE} = Intensity Effect in additive and multiplicative framework respectively = Change in emission as a result of the change in energy intensity of the production process

Following (Ang & Choi, 1997), the present paper deploys a Log-Mean Divisia Index (LMDI), as this method gives perfect decomposition since it satisfies the factor reversal test and results do not contain any residual term and areconsistent in aggregation (Su and Ang, 2012). The change in CO_2 emission is calculated as:

$$\Delta E_{OE} = \sum_{i=1}^{n} w_i \ln(\frac{Y_t}{Y_0})$$

$$\Delta E_{SE} = \sum_{i=1}^{n} w_i \ln(\frac{S_{i,t}}{S_{i,0}})$$

$$\Delta E_{IE} = \sum_{i=1}^{n} w_i \ln(\frac{I_{i,t}}{I_{i,0}})$$

and,

$$w_i = \frac{E_{i,t} - E_{i,0}}{ln(E_{i,t}) - ln(E_{i,0})}$$

First, the decomposition is carried out for the CO_2 emission of the South Korean economy as a whole, taking into account all the sectors (primary, secondary and tertiary) and the subsectors of the economy. Then, the decomposition is carried out for the CO_2 emissions from the manufacturing sector. The dataset used in the analysis is the input-output table for the South Korean economy published by the World Input-Output database; the period of analysis is 2000 to 2009. The results are presented in figures 5 and 6.

The analysis reveals certain important characteristics of the CO_2 emission profile of South Korea. For the entire economy, the structural effect is marginal, suggesting that the structure of the economy (in terms of CO_2 intensive and CO_2 non-intensive sectors) has more or less stabilized. Given the growth in the economy of South Korea, the output effect acts as a major driver for increases in CO_2 emissions. However, the output effect is partially offset by the negative intensity effect achieved through better energy management practices and the deployment of clean technologies across sectors and subsectors of the economy. Shift from coal and oil to natural gas and nuclear sources for energy production has played a role in reducing indirect emissions. Earlier research also suggests that stringent pollution regulations in the country have also contributed to the adoption of fuel switching and deployment of green technologies (Oh et al., 2010).

In contrast, the decomposition analysis of CO_2 emission in the manufacturing sector reveals that the structural effect is pronounced and has pushed up CO_2 emissions. The structure of the manufacturing sector is changing in favour of production units that are leading to higher CO_2 emissions. Immediately after the financial crisis of 1997, there was a structural shift within the manufacturing sector of the Korean economy and the relative contribution of the relatively less energy intensive industries (automobiles, electronics and semi conductors) to the national GDP increased. Simultaneously, the relative share of industries like cement, iron and steel, etc. stagnated. However, with the economy turning around since the middle of the last decade, these emission intensive industries (cement, iron and steel, etc.) have recovered significantly. Consequent to this recovery, it can be observed that the economic structure of South Korea has again become slightly biased towards these emissions-intensive industries.

The pull effect of output and structural effects are offset by downward push of the intensity effect.[14] The large intensity effect is the result of factors like fuel switching and energy efficiency improvements. The drivers for fuel switching have been identified, in earlier research, as increases in oil prices compared to natural gas and electricity, expanded natural gas distribution infrastructure, and stringent air quality management norms (Han et al., 2006). Energy efficiency measures are being adopted by most industries, including energy intensive sectors such as iron and steel (replacing blast furnaces with more efficient electric furnaces), cement (using tyre waste as a substitute for coal), etc. (Han et al., 2006). The government has also supported this technology deployment through schemes that have promoted the association between production units and technology consulting companies, and increased capital allowances for energy saving investments. However, some researchers have argued that the relatively low energy prices for industries have hindered the adoption of energy efficiency measures at a larger scale than what has been achieved (Han et al., 2006).

5. Impact Assessment: Carbon Leakage Risks from the Korean ETS

The Korean ETS follows the European ETS (EU ETS) in its basic design. Although the economic, social, cultural and geo-political situation of South Korea is markedly different from the European Union, lessons learnt from EU ETS can, therefore, be used as a reference point for anticipating the possible shocks that the Korean economy might face following implementation of the KETS. In the context of the EU ETS, an issue that has been repeatedly debated is the issue of carbon leakage. The EU ETS Directive defines carbon leakage as "an increase in greenhouse gas emissions in third countries where industry would not be subject to comparable carbon constraints". [15] The Intergovernmental Panel on Climate Change (IPCC) has also deliberated on the

[14] The only exception being in 2008.

[15] Recital 24 of the Directive 2003/87/EC as amended in 2009.

issue of carbon leakage. Its view on carbon leakage is that: "carbon leakage is defined as the increase in CO_2 emissions outside the countries taking domestic mitigation action divided by the reduction in the emissions of these countries. It has been demonstrated that an increase in local fossil fuel prices resulting, for example, from mitigation policies may lead to the re-allocation of production to regions with less stringent mitigation rules (or with no rules at all), leading to higher emissions in those regions and therefore to carbon leakage. Furthermore, a decrease in global fossil fuel demand and resulting lower fossil fuel prices may lead to increased fossil fuel consumption in non-mitigating countries and therefore to carbon leakage as well. However, the investment climate in many developing countries may be such that they are not ready yet to take advantage of such leakage. Different emission constraints in different regions may also affect the technology choice and emission profiles in regions with fewer or no constraints because of the spillover of learning" (Barker, et al., 2007). Risks of carbon leakage therefore depends on a set of economic and socio-technical factors.

With regard to the EU ETS, the third phase is currently in operation (2013-2020) and covers more than 11000 installations in 31 countries (de Bruyn, et al., 2013). According to the guidelines published by the European Commission, sectors exposed to risk of carbon leakage have been identified as "those sectors that may suffer a material competitive disadvantage against competitors located in areas outside the EU which do not have similar emission reduction commitments, which could in turn lead to an increase in green house gas emissions". The EU ETS directive also lays down the rules and procedures to decide whether a sector is exposed to the risk of carbon leakage. Two quantitative indicators are mentioned: (i) additional production costs and (ii) trade intensity. A sector is deemed to be exposed to the risk of carbon leakage if at least one of the following criteria is satisfied:

- Criterion I: additional production cost greater than 5% and trade intensity greater than 10%;
- Criterion II: additional production cost greater than 30%;
- Criterion III: trade intensity greater than 30%.

In addition, the directive also allows for qualitative assessment of a sector to evaluate the presence of risk of carbon leakage.

A number of studies have been carried out in the context of EU countries, addressing the issue of carbon leakage (see, e.g., Sijm et al., 2004; Summerton, 2010; Monjon and Quirion, 2011; Monjon, 2011; de Bruyn et al., 2013; Sato et al., 2013; Sartor and Spencer, 2013). In this short paper we deploy the quantitative indicators and criteria, as suggested by the EU directive, in order to assess the sectors exposed to the risk of carbon leakage in South Korea.

Figure 5. CO_2 Emission in South Korea: Results of the Decomposition Analysis

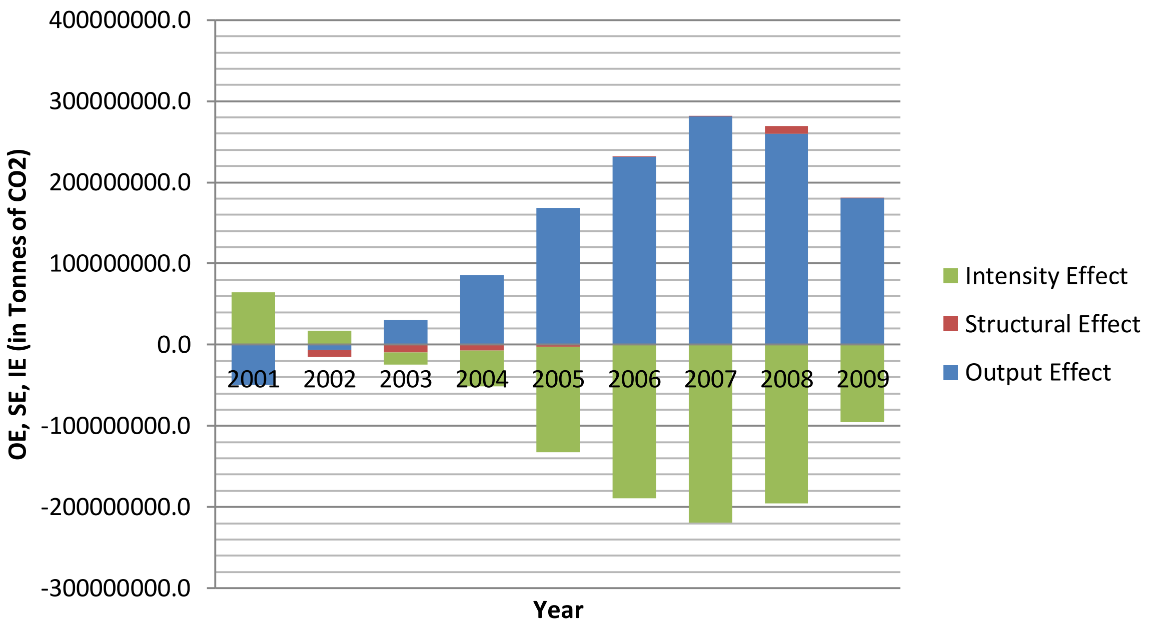
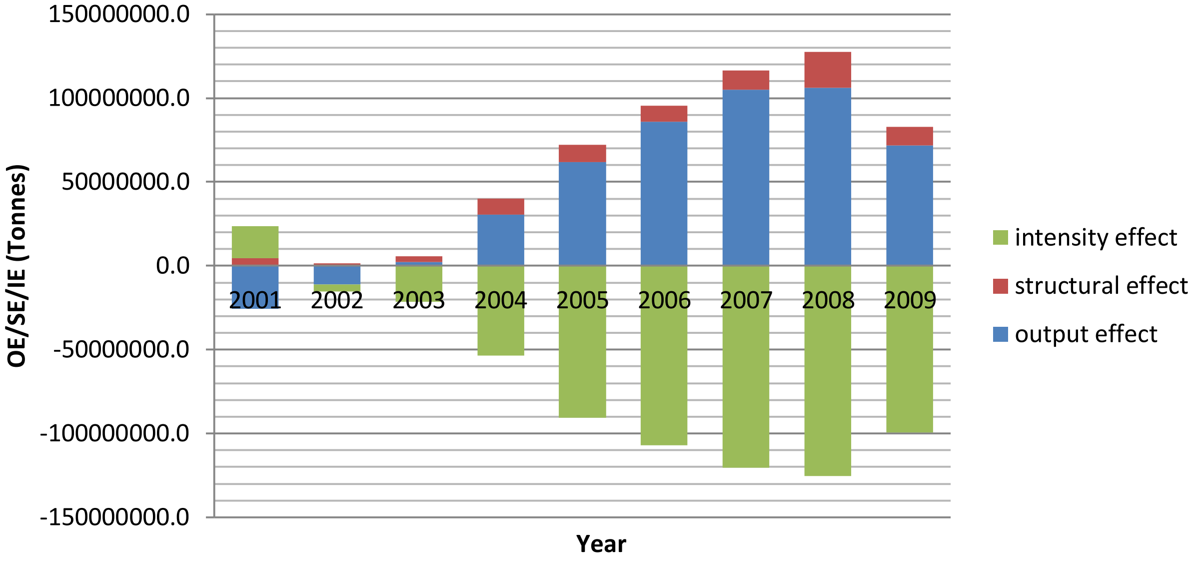


Figure 6. CO_2 Emission in the Manufacturing Sector of South Korea: Results of the Decomposition Analysis



With regard to the methodology, the EU ETS directive advises that the analysis of risk of carbon leakage be carried out at a disaggregated level (3-digit industrial classification or more). This would ensure that the results would help in identifying the exact sectors, and further help in formulating appropriate policies to minimize leakage risk. However, such a detailed analysis is only possible when adequate data, time and resources are available. In this short paper, within the constraints regarding availability of disaggregated data, the analysis is carried out at an aggregated level (2-digit). Further, the analysis is carried out only for the manufacturing sector – since it is anticipated that a majority of the participants in KETS will be from the manufacturing sector (Bloomberg and Ernst & Young, 2013). Data from the Korean input output table has been used. Since the additional production costs take into account indirect emissions, the electricity, gas and water supply sectors have been kept out of the analysis to avoid double counting. The following fourteen sectors are considered for analysis: (a) basic metal and fabricated metal, (b) other non metallic mineral, (c) coke, refined petroleum and nuclear fuel, (d) chemicals and chemical products, (e) textile and textile products, (f) pulp and paper, (g) transport equipment, (h) food, beverages and tobacco, (i) electrical and optical equipment, (j) machinery, (k) manufacturing (not elsewhere classified) and recycling, (l) wood products, (m) leather and footwear, (n) rubber and plastic.

5.1. Additional Production Cost

Following the EU ETS directive, the additional production cost for a sector i is defined as:

$$APC_i = \frac{(DCO_{2i} * AF + ICO_{2i}) * EA}{GVA_i}$$

where,

APC_i = Additional Production Cost of sector i

DCO_{2i} = Direct emissions of CO2 of sector i

ICO_{2i} = Indirect emissions of CO2 of sector i[16]

AF = Amount of emission that fall under auctioning

EA = Expected Price of Allowance in 2015

GVA_i = Gross Value Added in the ith sector

To our knowledge, the results of the prediction of carbon prices under KETS are still outstanding. In the absence of authoritative estimates, this paper assumes that the participants in the Korean ETS

[16] Emissions from the electricty, gas and water supply sector have been apportioned to each sector under analysis, depending on their share of electricity, gas and water suplly as inputs.

will, at least in the initial years, form price expectations following the price of allowances prevailing in the EU ETS in 2015. Therefore, this analysis assumes that the expected price of allowance under the EU ETS (in EUR), converted to USD, as the expected price of allowances in South Korea. The price of allowances in 2015 under the EU ETS has been assumed at EUR 18.00 [17]. The expected exchange rate of EUR to USD in 2015 is assumed to be 1 EUR = USD 1.35[18] (CNBC, 2013).

Other assumptions made for calculations in past research (de Bruyn et al., 2013) have been retained. The additional production costs have been calculated under two scenarios of carbon leakage exposure factor (CLEF):[19] (a) 1.0, and (b) 0.90.[20] To our knowledge, the South Korean authorities have yet to publish an official list of values of CLEF by sectors. In this situation, the two scenarios have been constructed. [21] The costs for activity levels corresponding to each of the ten years between 2000 and 2009 have been calculated, and the maximum value has been assumed as a representative. The results are presented in table 2. Industries such as basic metals and fabricated metals, other non-metallic minerals, coke, refined petroleum and nuclear fuels exhibit a proximity to the benchmark value of the additional production cost.

5.2 Trade Intensity

The theoretical explanation of trade intensity is that an increase, however small, in production costs (and, perhaps, the cost of compliance) can adversely affect the comparative advantage of a sector (Sartor and Spencer, 2013). In such a situation, there is an adequate incentive for the domestic producers to import the goods where the comparative advantage has diminished. In a world characterized by integration of international trade, the risk of carbon leakage can best be countered by the ability of industries to abstain from passing on to the customer (domestic and abroad) the additional production costs (Droege, 2012). Hence, trade intensity assumes a substantial significance in the analysis of risks of carbon leakage.

The trade intensity of sector i is calculated as follows:

$$TI_i = \frac{M_i + X_i}{Y_i + M_i}$$

Where,

TI_i = Trade Intensity of sector i

M_i = Imports in sector i

X_i = Exports in sector i

Y_i = Domestic Output in sector i.

The trade intensity for each sector is calculated individually for the years 2000 to 2009, and the average is represented in table 3.[22]

5.3. Sectors Exposed to Risk of Carbon Leakage

Combining the results obtained in sub-sections 5.1 and 5.2, the sub-sectors exposed to the risk of carbon leakage in South Korea have been identified and listed in table 4.

For each criterion, those sub-sectors which satisfy the criteria stipulated by the EU ETS Directive have been considered at “high” risk. In case the values do not satisfy the benchmark values, but are close to the benchmark value (for at least one parameter), the risk has been termed “moderate”.

[17] See Thomson Reuters, 2012.

[18] Since the GCA data is in USD, hence, the need for conversion.

[19] CLEF represents free allowances in calculating the Auction Factor.

[20] For EU-ETS, the CLEF ranges from 0.8 to 1, see de Bruyn et al, 2013.

[21] For a detailed discussion of CLEF and calculation of CLEF, see de Bruyn et al., 2013.

[22] In this case we do not use the maximum values, since trade intesity depends not only on economic conditions of two countries, but is also affected by political factors.

Table 2 Additional Production Cost in the Manufacturing Sector (2000-09)

Sector	APC (CLEF = 1.00)	APC (CLEF = 0.90)
Basic metals and fabricated metal	8.26%	8.68%
Other non-metallic mineral	10.58%	11.17%
Coke, refined petroleum and nuclear fuel	11.35%	11.92%
Chemicals and chemical products	3.74%	3.87%
Textile and textile products	1.94%	2.00%
Pulp and paper	1.83%	1.90%
Transport equipment	0.73%	0.75%
Food, beverages and tobacco	1.12%	1.16%
Electrical and optical equipment	0.50%	0.51%
Rubber and plastics	1.22%	1.26%
Machinery	0.56%	0.57%
Manufacturing (not elsewhere classified) and recycling	0.85%	0.88%
Wood and wood products	1.45%	1.49%
Leather and footwear	0.98%	1.03%

Table 3 Trade Intensity in the Manufacturing Sector (2000-09)

Sector	Trade Intensity
Basic metals and fabricated metal	28.80%
Other non-metallic mineral	13.50%
Coke, refined petroleum and nuclear fuel	57.91%
Chemicals and chemical products	37.72%
Textile and textile products	46.19%
Pulp and paper	16.41%
Transport equipment	47.71%
Food, beverages and tobacco	13.60%
Electrical and optical equipment	59.65%
Rubber and plastics	26.88%
Machinery	36.09%
Manufacturing (not elsewhere classified) and recycling	26.28%
Wood and wood products	17.29%
Leather and footwear	36.93%

Table 4 Carbon Leakage Risk Assessment for Manufacturing Industries

Sector	Criterion: I	Criterion: II	Criterion: III
Basic metals and fabricated metal	Moderate Risk	NA	Moderate Risk
Other non-metallic mineral	High Risk	NA	High Risk
Coke, refined petroleum and nuclear fuel	High Risk	NA	High Risk
Chemicals and chemical products	Moderate Risk	NA	High Risk
Textile and textile products	NA	NA	High Risk
Pulp and paper	NA	NA	NA
Transport equipment	NA	NA	High Risk
Food, beverages and tobacco	NA	NA	NA
Electrical and optical equipment	NA	NA	High Risk
Rubber and plastics	NA	NA	Moderate Risk
Machinery	NA	NA	High Risk
Manufacturing and recycling	NA	NA	Moderate Risk
Wood and wood products	NA	NA	Moderate Risk
Leather and footwear	NA	NA	High Risk

Note: NA = Not Applicable: The values against each criterion are less than the bechmark values.

It is important to note that the price of allowances and free allocation of allowances play a major role in determining the values of the additional production cost. Issuance of free allowances is a policy decision and to date, from the literature on the KETS available to us, the policy regarding free allowances is not clear. Reduction of free allowances in a subsector increases the additional production cost. While the policies are evolving, analysis of risk of carbon leakage at a disaggregated level needs to be updated and decision such as on allocation of allowances have to be taken carefully so that the risk of carbon leakage is minimized.

6. Policy Implications and Concluding Remarks

In the presence of a risk of carbon leakage, the domestic policy on emissions mitigation transcends national boundaries. Simultaneously, the presence of risk implies that there is potential for altering the trade and investment patterns in a carbon constrained world. The foregoing analysis suggests that, after the launch of the KETS, the manufacturing sector in South Korea is potentially exposed to the risk of carbon leakage. The analysis suggests that, although risks arising out of additional production costs are not substantial, South Korea's high trade intensity with its trading partners is a significant contributor to this risk. The trade intensity criterion alone contributes to eight sectors in manufacturing having potentially high risk of carbon leakage. Therefore, the challenge is to formulate appropriate policies to mitigate the potential displacement of emission to other countries - particularly those where no or only a nominal carbon price exists. However, whether a high trade intensity in a sector is due to the dominance of exports or imports needs further research at a disaggregated level.

To minimize the risk of carbon leakage, different countries have reacted differently. Two prominent measures have been used – free allowances and border adjustments. However, border adjustment measures have been viewed by some researchers with skepticism as such measures may face retaliatory measures from trading partners (Grubb & Counsell, 2010). Some of the alternative measures suggested by researchers in policy for mitigating risks of carbon leakage are: output based export rebates, allowance purchase requirements for importers, free allocation of allowances to energy intensive industries, etc. (Grubb & Counsell, 2010).

An option suggested by many researchers working on the issue of carbon leakage is to levy import taxes for the international trade of CO_2-intensive products with non-abating countries. Additionally, sectors (and sub-sectors) may be classified into those exposed to the risk of carbon leakage and those which are 'sheltered' from such risks. Then, policies that would shift a part of the reduction burden to the 'sheltered' sectors may reduce the risk of carbon leakage (Sijm, et al., 2004). A rational decision on the free allowance for each of the sectors and sub-sectors is crucial in this context. Simultaneously, provision of subsidies to energy intensive sectors has been advised to "soften the blow of ETS" and reduce the risk of carbon leakage (Reinaud, 2008). These issues merit the attention of the South Korean Government.

In the context of the EU ETS, the Member States of the EU have applied free allocation of allowances, and considered border adjustments (Droege, et al., 2012). In the US, a border adjustment was at one point considered for imports from countries that do not have comparable GHG reduction measures (Grubb & Counsell, 2010). More or less similar measures have been found in the context of Australia and New Zealand (Grubb & Counsell, 2010) (Reinaud, 2008). On the other extreme, the Japanese government has not taken significant steps to prevent carbon leakage. In Japan, although border adjustment measures were discussed, such plans were shelved because the risk of an increase in additional carbon costs was minimal as Japanese industries are highly efficient (Grubb & Counsell, 2010). However, following the Fukushima incident, as Japan reduces using nuclear power, it is expected that its additional carbon costs will rise along with the risk of carbon leakage. It remains to be seen what measures the government will now take to prevent carbon leakage.

Some researchers identify a dominant trend for the South Korean economy - the use of state policies to control patterns and distribution of technology transfer (Hahm & Plein, 1997). Probably, in the years following the KETS, the Korean Government has to actively support a flow of technologies to South Korea for reducing GHG emission and enhancing energy efficiency, particularly within the energy intensive sectors and subsectors. This issue may require interactions at the bilateral and multi-lateral levels.

The South Korean economy needs to plan for the road ahead based on other country experiences and detailed assessments at the subsector level. However, before converging on a portfolio of policies, the carbon leakage risk assessment may be used as an effective tool to decide on policy choices. But such analysis needs to be carried out at a disaggregated level. Identification of specific subsectors (within each sector) exposed to the risk of carbon leakage is important to design policies specific to the subsectors. Analysis of the trade performance of subsectors is also important, as it can help in designing targeted policies for these sub-sectors. Therefore, greater focus needs to be accorded to further research based on more detailed and disaggregated data.

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