



ASAN REPORT

A Quantitative Assessment of South Korea's Options for the INDC in 2030

CHOI HYEONJUNG, GALLO FEDERICO, KIM CHONG WOO

SEPTEMBER 2015

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The Asan Institute for Policy Studies

About

The Asan Institute for Policy Studies is an independent, non-partisan think tank that undertakes policy-relevant research to foster domestic, regional, and international environments that promote peace and prosperity on the Korean Peninsula, East Asia, and the world-at-large.

About the authors

Choi Hyeonjung

Dr. CHOI Hyeonjung is a Research Fellow in the Climate Change and Sustainable Development Program in the Center for Global Governance at the Asan Institute for Policy Studies. Previously, Dr. Choi was deputy secretary to the ROK President for green growth and assistant secretary for national agenda in the Blue House (the Presidential Office). Dr. Choi also worked as a policy research fellow in the 17th Presidential Transition Committee. Prior to the public service positions, he was a research scholar at the Institute of Social Science, the University of Tokyo, and full-time instructor at the Korean Air Force Academy. Dr. Choi's areas of research interest include climate change, green growth and sustainable development, new growth engines, East Asian developmental state model and industrial policy, and national future strategy. Dr. Choi received his B.A. and M.A. from Yonsei University and his Ph.D. in political science from Purdue University.

Gallo Federico¹

Dr. Federico Gallo has international expertise in quantitative environmental finance, and has advised top decision makers including aides to British Prime Minister Gordon Brown and Mexico's President Felipe Calderon. Since completing his Ph.D. in Applied Mathematics at the University of Cambridge in 2005, Federico has been applying advanced quantitative modeling skills to help solve today's environmental and social challenges, in particular by developing market based solutions. His early work at the RAND Corporation received international media coverage, including the Economist Magazine, the BBC, and the Guardian. In 2007, Federico joined the British Government, where he led the development of a set of innovative models to quantify and analyze renewable energy and carbon finance, including carbon markets. The models played a crucial role both nationally, for example in supporting the UK Climate Change Act of 2008, and internationally, for example supporting the Prime Minister on a number of occasions, such as in preparation for Gordon Brown's G8 meeting in Japan in 2008. Federico has also been very active on the international arena. In 2009, under the British Foreign Office, he led an international collaboration to support the development of the national carbon finance modeling capabilities in India, Brazil, Argentina, Colombia, Peru and Mexico. For example, in 2010 he led a team at the Mexican Finance Ministry to quantify its proposal for a Global Green Fund. Findings by Federico were formally endorsed by the United Nations Secretary-General (UN AGF Report), and paved the road for today's Green Climate Fund. Federico is also a regular adviser to international organizations, including the World Bank and the United Nations. Federico holds a BSc in Theoretical Physics from King's College London and a Ph.D. in Applied Mathematics from Cambridge University.

1. Contact email: federico@believegreen.org, Web address: www.believegreen.org.

Kim Chong Woo

Dr. KIM Chong Woo is a Senior Research Fellow and oversees the Quantitative Methods Program at the Asan Institute for Policy Studies. Previously, he was an analyst working on choice modelling and valuation at RAND Europe. He was also a Senior TCAD Engineer at the Samsung Semiconductor Research and Development Center and a Java Application Developer at PCMS-Datafit, UK. Dr. Kim’s research focuses on the estimation and application of Discrete Choice Modelling; Stated Preference Analysis, valuing public services and non-market goods; SP model development in transport, health, communication and utilities sector. He has published widely including “Security at What Cost? Quantifying Individuals’ Trade-offs between Privacy, Liberty and Security,” RAND Report (2010) and “Modelling Demand for Long-Distance Travellers in Great Britain: Stated preference surveys to support the modelling of demand for high speed rail,” RAND Report (2011). He received his B.Sc. in Mathematics from the University of London and his Ph.D. in Mathematical Physics from Imperial College of Science, Technology and Medicine, London. He also holds a post-graduate Diploma in Computer Science from the University of Cambridge.

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Background

In January 2015, South Korea launched its Emissions Trading System (SK ETS) modeled on the European Union Emissions Trading System (EU ETS). It has become the second largest ETS in operation after the EU ETS. In the Kyoto Protocol, “flexible mechanisms” were introduced to lower the overall costs of achieving its mitigation target. These mechanisms include Clean Development Mechanism (CDM), Joint Implementation (JI), and Emissions Trading.² At the Durban COP-17 in 2011, it was decided to establish a new international market mechanism (NMM) under the United Nations Framework Convention on Climate Change (UNFCCC) to complement the existing carbon market mechanism for years beyond 2020. Its details will be negotiated and worked out at upcoming meetings. We use the term “international carbon markets” collectively to refer to the existing mechanism such as ETS, voluntary markets as well as other mechanisms which are yet to take shape.

Against the backdrop of these developments, it is of paramount importance to see how South Korea can meet its mitigation target for 2030 on its own as well as working with another country with the information available. In this report, we examine the economic impacts of meeting South Korea’s mitigation target on

2. Clean Development Mechanism: It provides for emissions reduction projects which generate Certified Emission Reduction units which may be traded in emissions trading schemes.

Joint Implementation: It provides Annex-I countries with binding greenhouse gas emissions targets by enabling them to invest in an emission reduction project in any other Annex-I country as an alternative to reducing emissions alternatively.

Carbon Emissions Trading: A form of emissions trading that targets CO₂.

Wikipedia. https://en.wikipedia.org/wiki/Flexible_Mechanisms.

its own, via international carbon markets, or when linked to China, the EU and Mexico’s carbon markets.

Key findings: Linking South Korea’s carbon market to international carbon markets would lower mitigation costs

- Using the Capri (Carbon Pricing) model, we quantified and analyzed various scenarios to meet South Korea’s carbon mitigation targets.
- The results clearly show that linking South Korea’s carbon market to international carbon markets can significantly reduce the costs of mitigation (see Section 2).
- The actual market dynamics will depend on the country that South Korea links its market with. For example South Korea would be a net seller of carbon credits to the EU, but a net buyer of carbon credits from China (see Section 3).
- The benefits of linking the SK ETS to carbon markets in similar countries, such as Mexico, would be less significant. The reason is that similar circumstances mean that the opportunities for trade would be smaller, as both countries would likely find it cheaper to achieve their mitigations domestically.

Recommendations: Link South Korea's ETS to other carbon markets, beginning with low-risk pilots with voluntary carbon markets

- The results suggest that South Korea may benefit from linking its carbon market with those of other countries: this can lead to considerable cost reductions.
- However, experience shows that linking separate carbon markets is a complex challenge and may take several years to implement.
- A quick and low risk strategy to link South Korea's carbon market to international markets is to run pilots linking South Korea's carbon market with international voluntary markets. This could be a short/mid-term solution, a 'stepping stone' strategy that would offer learning opportunities. This could be complementary to the more complex process of linking the SK ETS with other major compliance markets.
- Also, linking South Korea's carbon market with voluntary markets in developing countries would have several economic and geopolitical advantages:
 - Create and enter new markets in fast growing developing countries.
 - Raise South Korea's standing, and gain concrete influence, in developing countries.

1. Introduction: South Korea's carbon reduction targets in 2030

1.1 Background: international climate change negotiations

In 1992, at the Conference on Environment and Development in Rio de Janeiro, the UNFCCC was formally established to set an overall framework to tackle a grave threat posed by global warming. Its 156 signatories declared their "concern that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases ... and may adversely affect natural ecosystems and humankind." Anthropogenic GHG (Greenhouse Gas) emissions have to be curbed before it is too late to limit the damage. In 1997, 193 countries signed a treaty in Japan, now known as the Kyoto Protocol, to reduce GHG emissions. However, only developed countries grouped under the Annex I had legal obligations to cut their GHG emissions to an average of 5% relative to 1990 levels during the first commitment period (2008~2012) and further to an average of 18% against 1990 levels during the second commitment period (2013-2020).

The Kyoto Protocol is the single international accord that governs the global mitigation efforts today and categorizes all states parties into Annex I and Non-Annex I Parties according to their GHG reduction obligations. The Protocol is characterized by a top-down approach that commits only Annex I Parties to take responsibility for the GHG emissions that they generated during the industrialization period.³ In short, the Protocol obligates past heavy emitters to reduce GHG emissions while exonerating current major emitters, namely develop-

3. The Kyoto Protocol stipulates that industrialized countries will reduce their collective emissions of greenhouse gases by at least 5.2 percent between 2008 and 2012 as compared to 1990.

ing nations like China and India. Further casting doubts over the utility and sustainability of the Kyoto Protocol, developed nations like the United States have refused to take part in this international regime.

The Copenhagen COP15 (the 15th Conference of the Parties) in 2009, which discussed a new climate system to succeed the Kyoto Protocol, failed due to inadequate preparations and a lack of prior consultations among member states. Determined not to repeat this failure, the COP17 in 2011 adopted the “Durban Platform for Enhanced Action” forming an ad hoc working group to lay the groundwork for a post-Kyoto Protocol era.⁴ At the COP19 held in Warsaw in 2013, member states decided to finish by 2015 all negotiations on post-2020 global environmental governance in the context of creating “another legal instrument or agreed outcome with legal force ... applicable to all Parties.”⁵ This principle was reaffirmed by the “Lima Call for Climate Change” at the Lima COP20 in 2014.⁶

With COP21 set to open in Paris in December 2015, all states parties have taken steps to submit their Intended Nationally Determined Contributions (INDC) and are gearing up to launch a new climate mechanism that can more effectively respond to the existing global climate regime. GHG emission reductions determined by each states party’s INDC is a concept that emerged at COP19, and it implies that bottom-up reduction goals—not top-down—will form the basis of the new climate system. Unlike the Kyoto Protocol, which set GHG emission reduction targets for its states parties, the new climate system allows both developed and developing countries to determine their own GHG emission reduction

goals based on their INDC submissions.

At the forthcoming international climate conference in Paris, December 2015, all the countries will strive to adopt the new agreement. Its objective is to achieve a “protocol, another legal instrument or an agreed outcome with legal force”⁷ with the aim of keeping global warming below 2°C.⁸ While the total emissions from the Annex I countries bound by the Protocol’s targets have been decreasing, emissions from developing countries listed on the Non-Annex I with no obligation have increased sharply. Man-made carbon dioxide (CO₂) has been accumulating since the industrial revolution and reached 402.8 PPM (parts per million)⁹ in June 2015. This has already surpassed 350 PPM, which is broadly accepted by the scientific community to be the safe level to avoid dangerous climate change. In the latest IPCC (Intergovernmental Panel on Climate Change) fifth Assessment Report on Mitigation of Climate Change, it says “The scenarios centered on 450 PPM CO₂e are likely (> 66% chance) to avoid a rise in temperature that exceeds 2 degrees above pre-industrial levels. Scenarios reaching 550 PPM CO₂e have less than a 50% chance of avoiding warming more than 2 degrees, and the probability of limiting warming to 2 degrees further declines if there is significant overshoot of the 550 PPM CO₂e concentration.”¹⁰

4. United Nations. Decision 1/CP.17. FCCC/CP/2011/9/Add.1. March 15, 2012.

5. United Nations. Decision 1/CP.19. FCCC/CP/2013/10/Add.1. January 31, 2014.

6. United Nations. Decision 1/CP.20. FCCC/CP/2014/10/Add.1. February 2, 2015.

7. <http://unfccc.int/bodies/body/6645.php>

8. Clark, Duncan. “Has the Kyoto Protocol Made Any Difference to Carbon Emissions?” *The Guardian*, November 26, 2012. <http://www.theguardian.com/environment/blog/2012/nov/26/kyoto-protocol-carbon-emissions>.

9. CO2Now.org. *Atmospheric CO₂*. <http://co2now.org/>.

10. Edenhofer, Ottmar et al. *Climate Change 2014, Mitigation of Climate Change, Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 2014.

1.2 South Korea's contribution (INDC)

The South Korean government set its post-2020 GHG emission reduction goal by submitting an INDC on June 30, 2015. South Korea's INDC stipulates that it will cut back emissions by 37.0 percent (314.7 MtCO₂e) compared to its 2030 BAU baseline (850.6 MtCO₂e). Worth noting is that, of the pledged 37-percent reductions, 11.3 percent will derive from international carbon markets. South Korea's INDC has been subject to much debate both at home and abroad. The general sentiment is one of disappointment with the conspicuous decline in South Korea's will to partake in the international community's efforts to reduce GHG emissions. Furthermore, there are questions about the validity of South Korea's plan to fulfill part of its GHG emission reduction target through international carbon markets.

The goal of this report is to facilitate South Korea's strategic considerations on how it might maximize the use of global carbon markets by presenting several scenarios that show the possible outcomes of linking the country's GHG emission reduction efforts to international carbon markets. This report analyzes what strategic positions South Korea may be able to take in connection with global carbon markets purely based on the potential *economic costs* of the dozen scenarios that are open to South Korea as it seeks to meet its INDC target. It excludes the *political and diplomatic* benefits and losses that South Korea may experience on the international stage to reduce GHG emissions. Furthermore, this report leaves out the cost-benefit analysis of *national-capacity building* that may result during the GHG emission reduction process, but some benefits were mentioned in the Issue Brief by Gallo and Kim recently.¹¹

11. Gallo, F. and Kim C. W., "Climate and Carbon Markets: Options for South Korea,"

The Asan Issue Brief, 2015-06, April 17, 2015.

1.3 Quantifying and analyzing the INDC using the Capri Model

The impact of the 2030 target on South Korea's economy is intrinsically uncertain for several reasons and unknowns, which can be classified into two groups:

- **Economic uncertainty.** This arises from the uncertainties intrinsic in making projections fifteen years into the future: for example, unforeseen crises or disruptive technologies could affect South Korea's economic growth or the forecasted carbon emission projections.
- **International policy uncertainty.** This uncertainty arises from the complexity of the international negotiations on climate change. The international financial flows and the national mitigations costs will be determined by the interactions between the contributions made by all countries. For example, in the case of carbon markets, especially if they are linked internationally, the financial flows will be determined by the national mitigation targets, as well as by the design of the mechanisms, such as restrictions to trade. Since the negotiations for these parameters are ongoing, the proposals made by negotiators and policy makers are subject to significant levels of uncertainty and risk.

This report focuses on the second group of uncertainties to help policy makers manage the risks associated with international policy uncertainty.

Using the Capri model¹², we are able to quantify, analyze and compare the mitigation costs under a wide range of scenarios. This includes scenarios for South

12. See Appendix I for more details on the Capri model.

Korea’s proposed INDC as well as the proposed contributions made by other countries.

The rest of the document explores the costs of achieving South Korea’s proposed INDC under several scenarios: some involve South Korea meeting its targets domestically, while others include interactions with key countries and regions, specifically the EU, China and Mexico.

2. South Korea’s Intended Nationally Determined Contribution: A quantitative analysis

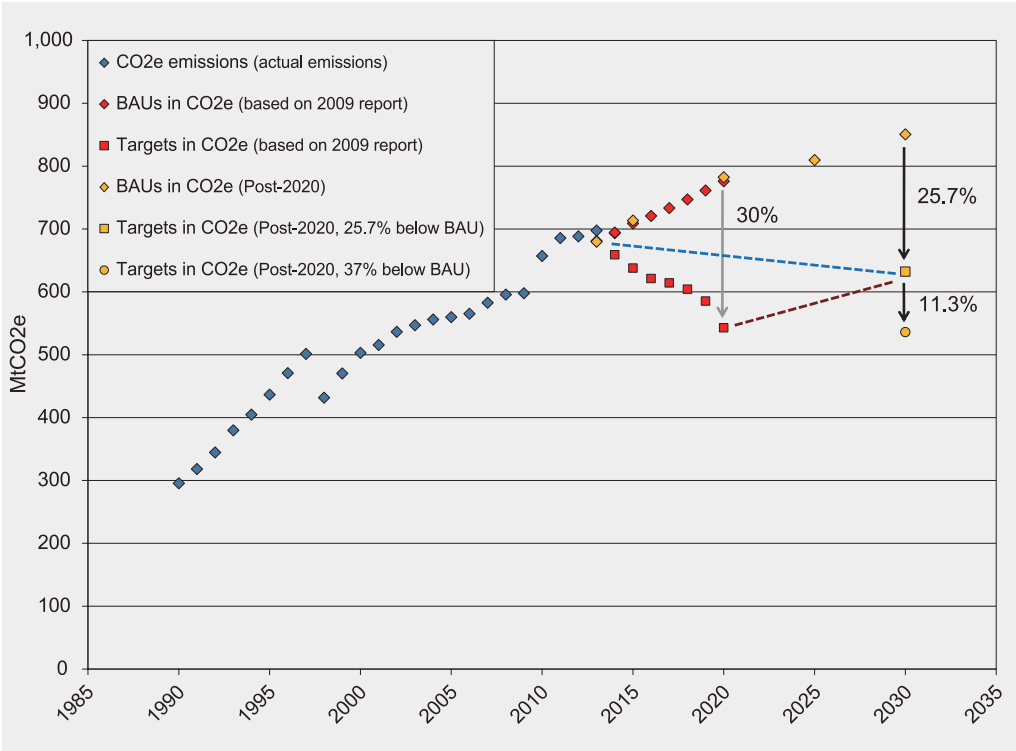
In this section we use the Capri model to quantify and analyze the economic impacts of South Korea’s carbon target for the year 2030.

The target was submitted formally to the UNFCCC in South Korea’s official INDC document. Subsequently, the Government, in an internal document¹³, further specified how its carbon reduction target should be split between domestic reductions and the purchase of carbon credits from the international markets.

Figure 1 shows three separate datasets together. The dotted dark blue curve traces out the actual CO₂e emissions between 1990 and 2012. For 2013 and 2014, the data are not from the official source. In 2008, former South Korean President Lee Myung-Bak declared “low carbon, green growth” as a new national strategy to fuel future economic growth and embarked on an aggressive action plan

13. Ministry of Environment, South Korea, June 30, 2015. <http://www.me.go.kr/home/web/board/read.do?menuId=284&boardMasterId=108&boardId=534140>.

Figure 1. South Korea’s greenhouse gas emissions



Note: The graph includes historical and projected emissions (BAU), as well as the proposed targets for 2020 and 2030 (INDC)

to cut carbon emissions. The red curves are showing projected carbon emissions under BAU scenario (i.e., red diamonds) and projected carbon emissions reductions (i.e., red squares) under this former action plan for the period 2013~2020. It would have drastically cut South Korea’s emissions by 30% below the BAU level by 2020 from 776.1MtCO₂e to 543.0MtCO₂e mitigating 233.1MtCO₂e. This cap on CO₂ emissions now appears to be difficult to meet in light of the recently released INDC target of 37.0% below the BAU level by 2030 shown with a yellow circle.

As mentioned above, mitigation actions will involve two different routes. First, domestic mitigation of a 25.7% below the BAU level would bring down the total emissions to 632 MtCO₂e shown with a yellow square in Figure 1. It is likely that domestic mitigation will more or less follow the dotted light-blue line rather than the red squares of the earlier action plan. Then, a further reduction of 11.3% will be achieved by purchasing carbon credits from abroad. This will reduce the total emissions to 535.9 MtCO₂e¹⁴ from the BAU level of 850.6 MtCO₂e mitigating 314.7 MtCO₂e by 2030. This is only a 1.3% improvement over the period of 10 years when compared to the earlier 2020 target. In real terms, it represents a reduction of a meager 7.1MtCO₂e. When considering domestic reductions alone, South Korea is slipping back considerably from the 2020 target as marked out by the dotted brown line.

At present, there is no detailed roadmap available showing how South Korea is going to reduce its carbon emissions in stages for the period 2020~2030, and also no mention of how the existing plan leading up to the year 2020 will be affected by its INDC pledges.

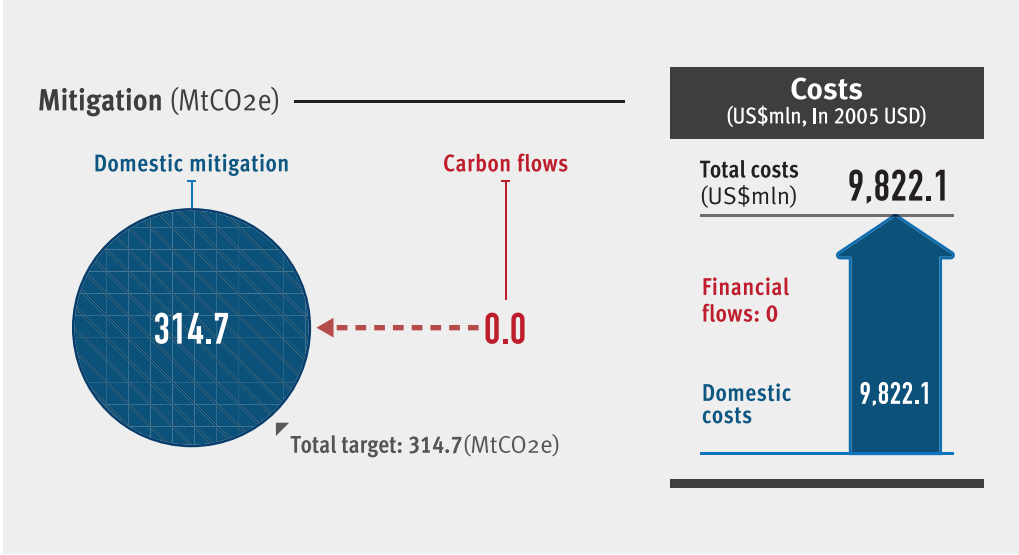
In this section we quantify and study the economic costs of two separate scenarios based on South Korea’s INDC.

2.1 South Korea’s INDC: 37.0% relative to BAU

In its INDC, South Korea offered to cut its carbon dioxide emissions by 37.0% from the expected BAU level by 2030, but it did so without clearly specifying how the 2030 target will be met. However, in January 2015 South Korea launched

14. South Korea Herald. <http://www.koreaherald.com/view.php?ud=20150630001172>

Figure 2. South Korea’s INDC (37% relative to BAU)



Note: Costs for South Korea meeting its INDC contribution domestically, i.e. using its carbon market but excluding the purchase of carbon credits from the international markets.

its national carbon market, which should play a crucial role in 2030. In this first scenario, we use the Capri model to require that South Korea meets its target domestically, using its carbon market.

Figure 2 shows the model results. On the left, it shows the mitigations. In this case we required that the total target be met domestically, and hence the carbon flows are zero (i.e. the number of carbon credits purchased from international markets).

The mitigation cost chart on the right shows the costs involved. Since the carbon flows are zero, the total cost of meeting the 2030 target coincides with the cost of implementing all the required domestic mitigation actions. In this case, the total cost is US\$9,822.1mln.

2.2 South Korea’s Government target: 25.7% internally, 11.3% via international carbon markets

Although the INDC states that ‘South Korea will partly use carbon credits from international market mechanisms to achieve its 2030 mitigation target’, it does not specify how or what share of the target.

However, in an internal document, the Government of South Korea specified that the 37% target will be met as follows:

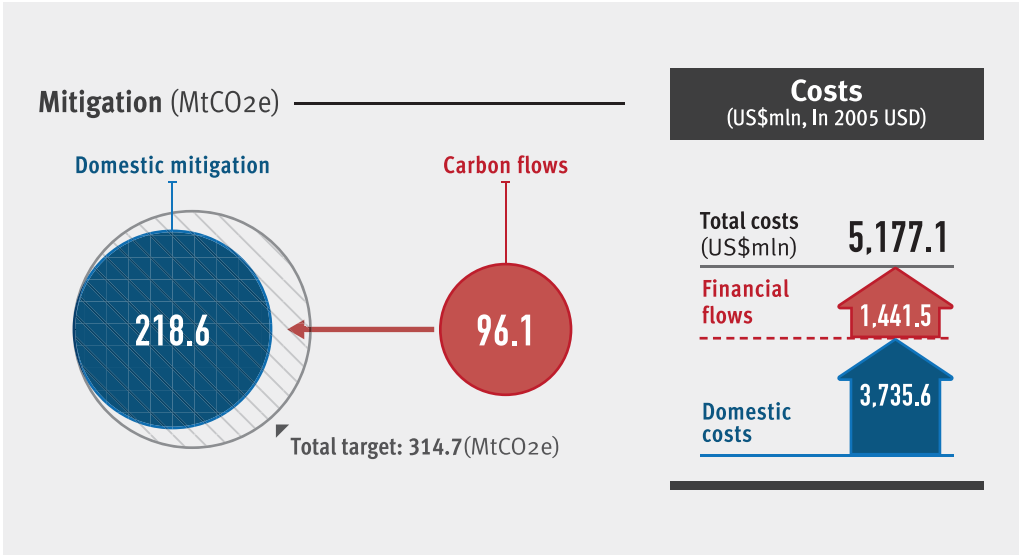
- 25.7% of BAU will be reduced domestically (i.e. through mitigation projects in South Korea)
- The remaining 11.3% of BAU will be met through the purchase of carbon credits from international markets.

At this stage it is not clear what the Korean Government means by ‘international carbon markets’, so we had to make some assumptions (described below). Figure 3 shows the model results.

In this scenario, we require South Korea to reduce domestically only 218.6 MtCO₂e (corresponding to 25.7% of BAU). In this case the domestic costs are much lower, totaling US\$3,735.6mln.

The remainder of the target (11.3% of BAU) is met by purchasing carbon credits from international carbon markets. Since at this stage it is not clear where these carbon credits will come from, we assumed a carbon price of US\$15/tCO₂e. This results in an additional cost of US\$1,441.5mln which, added to the domestic costs, leads to a total mitigation cost of US\$5,177.1mln. This is almost half of the cost of achieving the same goal entirely domestically.

Figure 3. South Korea government commitment (25.7% + 11.3%)



Note: Costs for South Korea meeting its INDC target using a mixture of domestic emission reductions and international carbon credits.

The preliminary conclusion is that allowing for the purchase of international carbon credits would enable South Korea to access cheap abatement options from around the world, thus avoiding the need to implement the more expensive domestic mitigation actions. This will reduce the overall mitigation cost. This result is also consistent with economic theory.

However, one weakness of the result shown in Figure 3 is that we had to make an assumption about the carbon price in 2030, and that we do not know where the carbon credits will be coming from.

To address this issue, the rest of this report explores a number of alternative scenarios where we use the Capri model to explicitly link South Korea’s ETS with the carbon markets of other countries and regions from around the world. In

these cases, the carbon prices will not be assumed, but will result naturally from the demand and supply dynamics arising from the linking of the carbon markets.

3. Alternative model scenarios

The government of South Korea has not yet specified where or how it intends to purchase the global carbon credits. In this section, we analyze hypothetical scenarios assuming links with existing or planned regional carbon markets. Specifically, we consider the EU, China and Mexico.

Part of the reason for choosing these countries is that they have already submitted their formal emission reduction targets, i.e. INDCs, to the UNFCCC. Furthermore, these countries either have implemented national carbon markets, or are in the process of doing so. The EU represents developed economies, while China and Mexico exemplifies developing economies. Due to the size of their carbon markets, the EU and China have long been studied and perceived as potential carbon credits trading partners by South Korea. The EU's 28 countries have been implementing the ETS covering around 45% of the EU's greenhouse gas emissions since 2005. On the other hand, China has been experimenting with seven regional carbon markets over the last three years, and will launch its world's biggest national carbon market in 2016. Similar to South Korea, Mexico has clarified in its INDC that it will utilize international market mechanisms to meet its emission reduction target. So far, four countries—South Korea, Mexico, Canada and Switzerland—have included in their pledges to use international carbon markets. Among the four countries, Mexico represents one of the middle power countries along with South Korea, and it has regarded South Korea as an important potential partner to develop a functioning international carbon market.

Also, we have chosen these countries because they offer a general overview of the range of scenarios that may occur. For example, South Korea could be a net seller of carbon credits to China, but a net buyer from the EU.

The sections below present the Capri model results and analyze the costs for South Korea meeting its target under the various scenarios. As a point to note, for each country we consider two scenarios:

- We allow South Korea to purchase only up to 11.3% of BAU, as indicated by the Government,
- We allow South Korea to trade freely with the other countries, allowing the markets to determine the optimal (i.e. cheapest) ratio of domestic abatement versus purchase of carbon credits.

3.1 Mitigation scenario 1: South Korea and China

In this first alternative model scenario, we link South Korea's ETS with China's carbon market.

At the time of writing, China is running seven separate regional pilot carbon markets. The plan is to launch its national carbon market in 2016. Given this trend we assume that by 2030 China will have a carbon market covering its entire economy.

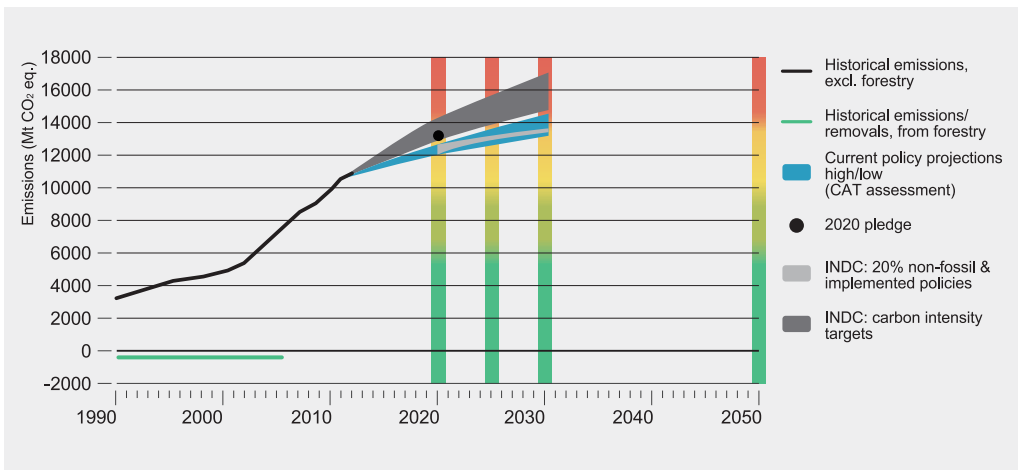
To run the Capri model, we need a mitigation target for China. In its INDC submission¹⁵, China did not specify an explicit abatement target. Instead, it submit-

15. The United Nations Framework Convention on Climate Change. China's INDC: <http://www4.unfccc.int/submissions/INDC/Published%20Documents/China/1/China's%20INDC%20-%20on%2030%20June%202015.pdf>.

ted a number of policies, goals and actions, including cutting levels of carbon emissions per unit of GDP 60-65% on 2005 levels by 2030.

There is significant uncertainty on what the actual overall target will be, since these depend on the BAU, GDP growth and other uncertain values. Figure 4 shows an analysis¹⁶ of what the emissions would be if China’s various proposals are implemented. A number of independent analyses¹⁷ confirm that China’s target is quite close to its BAU. Considering these facts and uncertainties, here we assume that in 2030 China’s mitigation target will be a cut of 5% relative to BAU.

Figure 4. China’s historical carbon emissions and projections¹⁸



Note: Historical carbon emissions and projections based on its portfolio of measures to tackle climate change.

16. Climate Action Tracker, <http://climateactiontracker.org/countries/china.html>.
17. The Institute for 21st Century Energy, an affiliate of the U.S. Chamber of Commerce “China’s INDC: Significant Effort or Business as Usual?” <http://www.energyxxi.org/china%E2%80%99s-indc-significant-effort-or-business-usual>.
18. Climate Action Tracker, China <http://climateactiontracker.org/countries/China.html>.

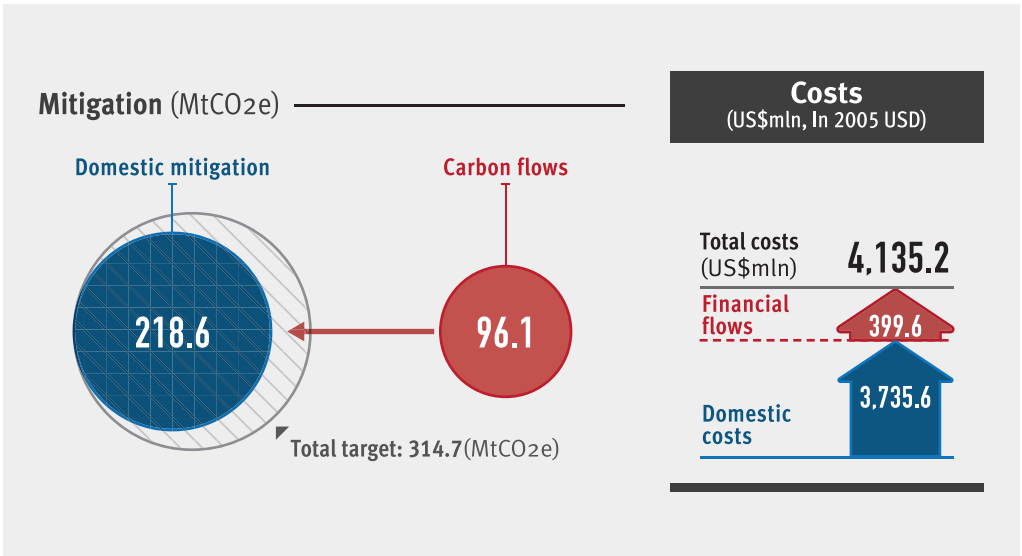
As mentioned earlier, we will use the Capri model to link China’s and South Korea’s carbon markets in two scenarios:

- Restricting the purchase of carbon credits by South Korea to 11.3% of its BAU, in accordance with the Government’s internal proposal.
- Allow for carbon credits to be traded freely.

3.1.1 Restrict carbon purchases to 11.3% of BAU

Figure 5 shows the model results for the scenario in which China’s and South Korea’s carbon markets are linked, but subject to restrictions to trade: South Korea is allowed to purchase carbon credits up to 11.3% of its BAU.

Figure 5. South Korea and China – Restricted trade (11.3% of BAU)



Note: Costs and financial flows for South Korea when its carbon market is linked to China’s carbon market, assuming restricted trade.

The mitigation cost chart on the right shows the costs. As expected, since the carbon flows are restricted by policy constraints, the domestic costs are identical to the case presented in Figure 3.

The key difference is in the financial flows, which in this case are much lower, at US\$399.6mln, leading to total costs of US\$4,135.2mln.

The diagram on the left on mitigation is determined by the restriction to trade. Since China has a low target and significant low-cost mitigation potential, it means that it can supply a large volume of cheap carbon credits to South Korea. In this case, the restriction to trade means that the total mitigation costs for South Korea are artificially high.

Economic theory suggests that by removing this restriction and allowing for free trade the mitigation costs for South Korea should go down. Indeed, the next model scenario explores and confirms this prediction.

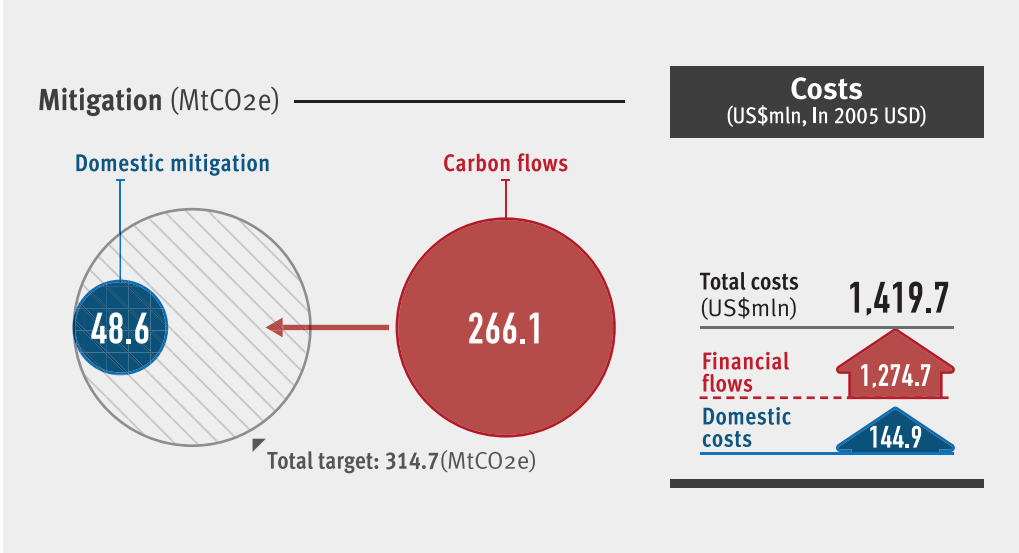
3.1.2 Free trade

In this section we analyze a scenario identical to the one above, except that here we allow for free trade. This means that the demand and supply dynamics are allowed to run and find an economically optimal (minimum cost) solution.

In practice this means that South Korea exerts considerably more demand for carbon credits from China: 266.2 MtCO₂e, compared to only 96.1 MtCO₂e under the restricted scenario, see Figure 6.

In this free trade case the carbon finance flows are considerably higher than in the restricted trade: US\$1,274.7mln compared to only US\$399.6mln. However,

Figure 6. China and South Korea under free trade



since South Korea now has to mitigate only 48.6 MtCO₂e internally, the domestic mitigation costs are only US\$144.9mln, leading to total costs of US\$1,419.7, compared to US\$4,135.2 in the restricted trade scenario.

In summary, if South Korea were to link its carbon market with China's, eliminating the restrictions to trade would lower costs by over 65%. However, economic costs represent only one dimension in the strategic decision making process. Another consideration is the outflow of finance from South Korea to China, which under free trade is much higher.

3.2 Mitigation scenario 2: South Korea and the EU

As a second alternative scenario, here we consider a link between the South Korean Emissions Trading System and the EU ETS. Here we assume that by 2030 both of these carbon markets would be covering their respective entire economies.

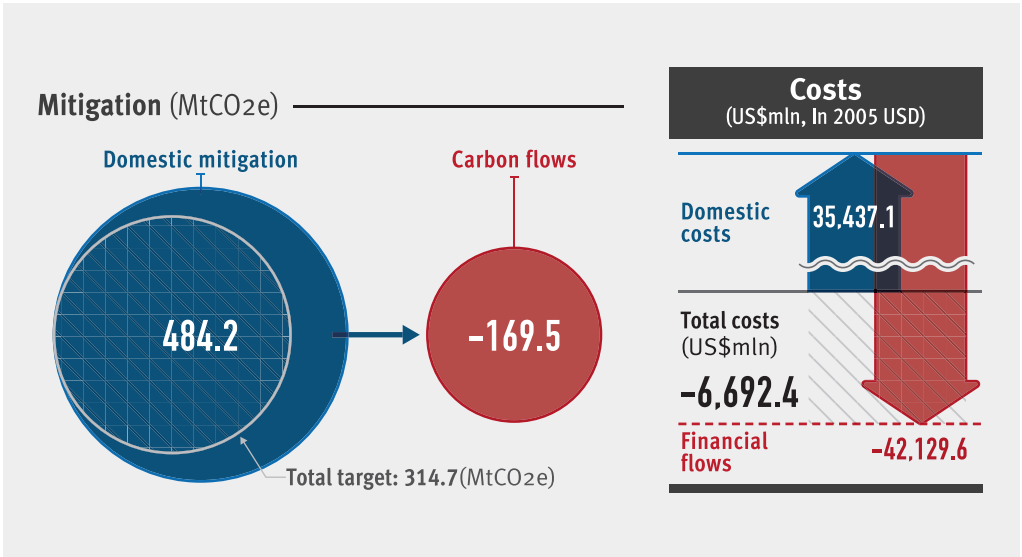
Unlike in the Chinese case, the European Union has proposed a very clear mitigation target: in its INDC¹⁹ it commits itself to reducing its emission by 40% relative to 1990 in 2030.

As before, here we also consider two cases: one for restricted trade and one for free trade.

3.2.1 Restrict carbon purchases to 11.3% of BAU

Figure 7 shows the model results for the scenario linking the EU’s and South Korean carbon markets, under restricted trade.

Figure 7. South Korea and the EU – Restricted trade (11.3% of BAU)



Note: Costs and financial flows for South Korea when its carbon market is linked to the EU’s carbon market, assuming restricted trade. Since South Korea is here a net buyer of carbon credits, the 11.3% restriction does not impact the carbon flows, so these results also coincide with the free trade scenario.

The negative carbon and financial flows immediately show that the dynamics here are very different from the cases studied thus far. Negative flows indicate outflows: here South Korea is selling carbon credits to the EU and receiving an income for it.

In other words, here South Korea is a net seller of carbon credits to the EU: it is able to meet its internal target and then mitigate a further 169.5 MtCO₂e to sell to the EU. The domestic costs are very high for South Korea, but it more than makes up for these additional costs through the sale of carbon credits: instead of a net cost, South Korea experiences a total net gain of US\$6,692.4mIn. In practice this may probably be an over estimate because if the EU is willing to link with the South Korean ETS, it would probably do the same with other markets, which would result in a reduced demand for South Korean credits.

3.2.2 Free trade

In this case the free trade case is identical to the restricted trade scenario. The reason is that the South Korean Government has put a limit to how many credits South Korea is able to buy, but not to sell.

In other words, the results for free trade between the EU and South Korea coincide with the results shown in Figure 7.

In summary, if South Korea linked its carbon market to that of the EU it would have considerable opportunities to sell carbon credits, including to the point of covering all its mitigation costs and making a net gain. These dynamics

19. The United Nations Framework Convention on Climate Change. The EU’s INDC: <http://www4.unfccc.int/submissions/INDC/Published%20Documents/Latvia/1/LV-03-06-EU%20INDC.pdf>.

should be the same with other major developed countries, such as Japan and the USA, which should have high mitigation targets relative to their abatement costs.

3.3 Mitigation scenario 3: South Korea and Mexico

The previous sections explored scenarios where South Korea is linking its carbon market with much larger countries, which represent two opposite ends of the spectrum: a more developed country (the EU) and a less developed one (China). This led to two opposite sets of results, where South Korea was a net seller and a net buyer of carbon credits, with significant carbon flows in both cases.

Here we explore a scenario where South Korea’s carbon market is linked to that of Mexico. In many ways these countries are very similar: they are both middle income countries as well as members of the OECD. Also, they are both at the interface of advanced nations and emerging markets.

Mexico was one of the first developing countries to pass national climate legislation²⁰ and the first one to submit its INDC²¹. Also, in its national climate law it requires the creation of a carbon market, which should come into being in the next couple of years: based on this, it is reasonable to assume that by 2030 Mexico will also have a national carbon market.

As far as its 2030 mitigation target is concerned, in its INDC, Mexico proposes a

20. Ley General de Cambio Climatico, 2012. http://www.inecc.gob.mx/descargas/2012_lgcc.pdf.
21. The United Nations Framework Convention on Climate Change. Mexico’s INDC: <http://www4.unfccc.int/submissions/INDC/Published%20Documents/Mexico/1/MEXICO%20INDC%2003.30.2015.pdf>.

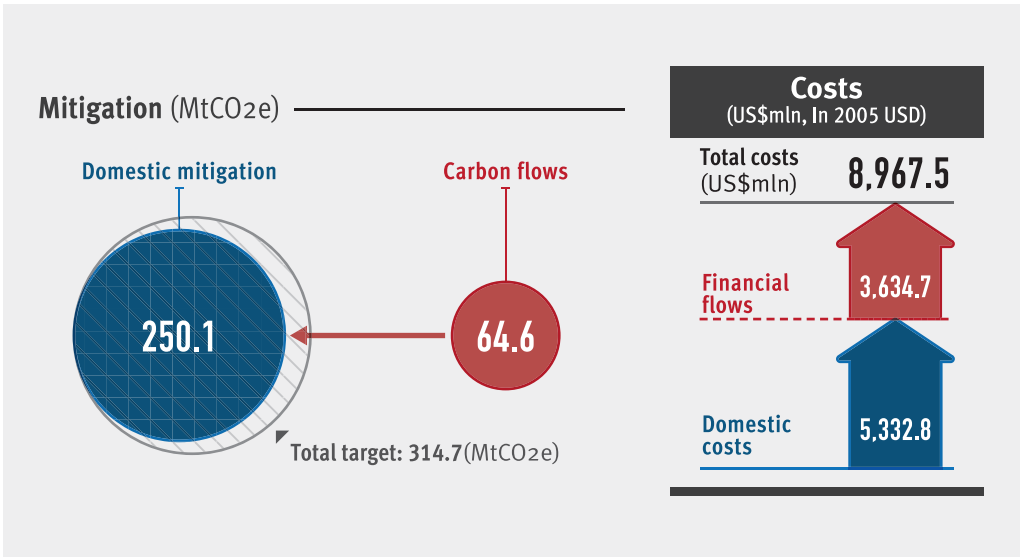
target of 25% relative to BAU, which could grow to 40%, conditional on ambitious commitments by the international community. This fluctuating, conditional target is an example of the types of policy uncertainties discussed in the introduction.

In the scenarios presented below, we assume the target of 25% relative to BAU.

3.3.1 Restrict carbon purchases to 11.3% of BAU

Figure 8 shows the results for this scenario.

Figure 8. South Korea and Mexico – Restricted trade (11.3% of BAU)



Note: Costs and financial flows for South Korea when its carbon market is linked to Mexico’s carbon market, assuming restricted trade. In this case, the results also coincide with the free trade scenario.

The novelty in these results is that, although South Korea is allowed to purchase 11.3% of its BAU, which corresponds to 96.1 MtCO₂e, it is economically conven-

ient to purchase only 64.6 MtCO₂e, or only 7.6% of BAU. This means that in this scenario, in the absence of other sources of international carbon credits, it would be economically optimal for South Korea to mitigate 250.1 MtCO₂e domestically.

The total mitigation costs under this scenario are US\$8,967.5, which is still cheaper for South Korea than meeting its target entirely domestically.

3.3.2 Free trade

In this case the free trade scenario is identical to the restricted trade scenario. The reason is that the ceiling of 96.1 MtCO₂e (i.e. 11.3% of BAU) is higher than the optimal demand of 64.6 MtCO₂e, so in practice it does not restrict free trade.

In other words, the results for the free trade scenario are identical to those shown in Figure 8.

In summary, the results show that linking South Korea’s carbon market with those of similar middle income countries may not lead to major carbon flows (inflows or outflows) resulting in major cost reductions. Part of the reason is that these countries may have similar mitigation options and targets, thus limiting the opportunity to trade in carbon credits.

In this particular case, South Korea is a buyer of carbon credits from Mexico. However, if Mexico were to raise its target to 40% relative to BAU (as suggested in its INDC), then South Korea would become a net seller of credits to Mexico (this is confirmed by Capri results, although this specific scenario is not presented in this report). In other words, the balance of carbon finance trade is directly dependent on the targets of the countries involved, in particular on their relative level of ambition.

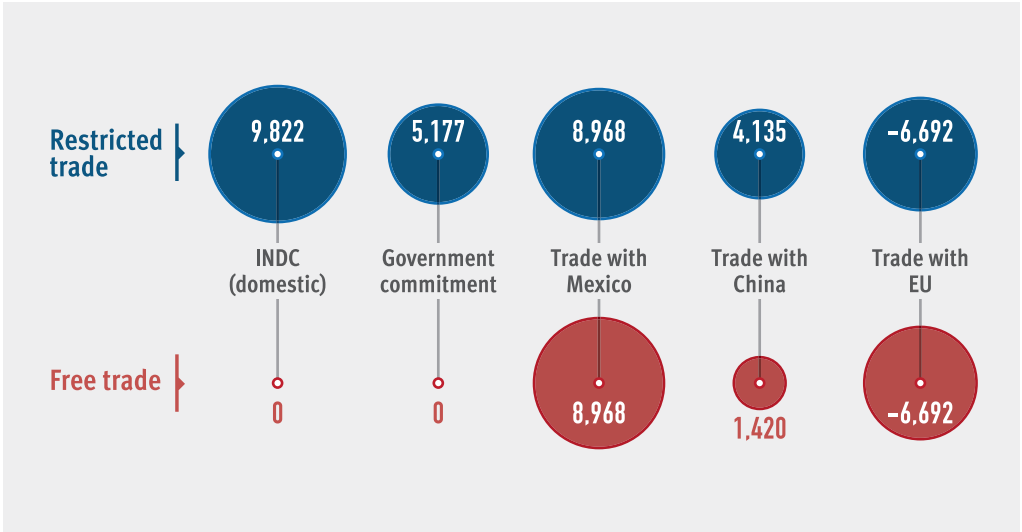
4. Conclusion

In this article we studied South Korea’s INDC contribution and its proposed carbon mitigation target for the year 2030.

We used the Capri model to quantify and analyze a number of scenarios. These included quantifying the specific targets proposed by the South Korean Government. Since at this early stage several details are still missing, we also quantified and analyzed a number of alternative scenarios to support policy makers and negotiators.

The outcome was that the Capri model produced a number of interesting results. As a summary, the table below compares the net costs to meet the 2030

Figure 9. 2030 scenario comparison – total cost (US \$mln, in 2005 USD)



Note: Comparison of the net costs in all the scenarios quantified.

target under all the scenarios analyzed.

A key general result is that South Korea would reduce mitigation costs by linking its ETS with other carbon markets. This is confirmed by economic theory.

How cost savings occur, however, varies greatly depending on what international carbon markets are linked to the SK ETS, as well as the structure of the linkage. In this section, we looked at free trade and restrictions to trade.

Specifically, the results show that from a purely financial perspective, linking South Korea's carbon market with the EU ETS would be the best scenario: as a net seller of carbon credits to a vast carbon market, South Korea could actually meet its mitigation target while earning significant revenues. However, it is likely that the EU could also link its market with other carbon markets, thus lowering the demand for carbon credits from South Korea. In other words, the net gains from linking the EU ETS and SK ETS are probably an upper bound estimate. To answer this question, we should use the Capri model to explore the dynamics when several countries are linked into a single carbon market.

South Korea would also benefit enormously from linking its ETS to China's upcoming national carbon market. The reason is that China has significant low-cost mitigation options that South Korea could use to reduce its costs. Under restricted trade with China, South Korea would more than halve its mitigation costs (compared to the cost of meeting its entire target domestically). If we allow for free trade, the costs go down sevenfold.

We also explored the dynamics of linking to countries similar to South Korea. Specifically, we analyzed the case of Mexico. We found that given the similar circumstances and targets, in these cases the carbon flows would be lower, as

would be the cost saving opportunities. The carbon flows would be small also because Mexico's carbon emissions are small compared to China or the EU.

4.1 Recommendations

Based on the above results, the overall recommendation is that South Korea should explore options to link its national Emissions Trading System with other carbon markets: this would reduce costs under all circumstances.

However, linking international carbon markets is a very complex challenge that can take several years to implement.

A low-risk strategy to accelerate the process of linking the SK ETS to international carbon markets is to purchase carbon credits from the voluntary markets. The key advantage compared to linking to another national compliance market is that it would be a unilateral decision by the South Korean Government, as opposed to a much more complex bilateral or multilateral negotiation with other governments. It would also be a one-way flow: carbon emission reductions would only be bought (by South Korea), rather than bought and sold. Furthermore, the voluntary nature of the strategy means that South Korea could more easily make changes or undo it if things go wrong.

This strategy (i.e. purchasing certified voluntary carbon emission reductions) would not exclude linking to other national compliance carbon markets: it would complement it. It could be carried out while negotiations with other countries are taking place, and informing the negotiations, for example by testing the market dynamics in the real world.

This could be a pragmatic, 'stepping stone' strategy to learn important lessons

and test the market dynamics on smaller scales. For example, the eligibility of projects could be limited to specific standards, countries, economic sectors or even project typologies.

Other benefits include immediate access to voluntary markets, and this strategy could be treated as a low-risk, modular pilot. Furthermore, it may have broader benefits for the Korean economy, as it would open the opportunity to enter new markets and raise the visibility and influence of South Korea, especially in fast growing emerging markets.

Finally, it is important to remember that relying too heavily on buying carbon credits from abroad will seriously undermine South Korea's own capacity to reduce carbon emissions and to develop the green technology sector which can become a real engine of growth. Both short and long-term economic benefits should be assessed when making policy decisions.

4.2 Suggestions for further research

As mentioned in the introduction, policy uncertainty arises from the wide range of national strategies and their interactions in the context of the forthcoming international agreement on climate change. The impact of tackling climate change on the South Korean economy would depend on its national policies but also on the policies of foreign governments, with which it would interact.

In this study we only touched the surface of this complex issue. We tried to identify some general dynamics but were unable to delve into the details due to space constraints.

Much work remains to be done to inform South Korea's climate strategy for

2030. Below we suggest some areas of research that should be pursued to fill this knowledge gap:

- **More scenarios with other key countries.** Because of space constraints we were not able to explore the implications of linking the SK ETS to other major countries. Examples include the United States, Japan as well as India and Brazil. The Capri model covers the entire world, so it would be able to quantify and analyze such scenarios.
- **Multi-country markets.** It is possible that by 2030 the process of joining and integrating national emissions trading systems into larger international markets will be more advanced. Therefore, another area that deserves more detailed analysis is the quantification and study of multi-country carbon markets. The Capri model can handle the interactions of several countries in a single market. In fact, it is capable of modeling a global carbon market that includes all countries in the world.
- **Sectoral details.** In this study we looked only at the national level. Future studies should delve into the details of specific economic sectors such as industry, transport and agriculture. The Capri model can disaggregate each country/region into 22 economic sectors, assign individual targets to each of them and estimate the internal costs, financial flows and other economic variables of interest.
- **Other carbon finance mechanisms.** Carbon markets are only one finance mechanism used to incentivize carbon reduction projects. Other mechanisms include, for example, carbon taxes and carbon funds. For example, South Korea is the host of the UN's Green Climate Fund. The Capri model can describe many such mechanisms. In fact, it was used to support the Mexican proposal for a global green fund, which was eventually endorsed the UNFCCC and became today's Green Climate Fund.

- **Explore the idea of linking the SK ETS to voluntary markets.** This idea was suggested in the Conclusion and Recommendations section. However, if there is interest, more analysis would be required to explore its implications in more detail.

Appendix 1 – The Capri (Carbon Pricing) Model

1.1 Credentials of the Capri Model

Believe Green’s Carbon Pricing model is a quantitative tool to analyze a broad range of carbon finance policies and scenarios. It has been extensively used by several national governments to support both their national policies and international negotiation strategies. Initially developed in 2006 in the UK (under the name Glocaf), it was then formally shared with countries such as India, Brazil, Argentina and Mexico (where it was further developed under the name of Mexcaf).

Notable successes include: playing a crucial role in supporting the 2008 Mexican proposal to the UN for a global climate fund, which resulted today’s Green Climate Fund; providing hard evidence in support of the UK’s Climate Change Act of 2008, the first of its kind in the world; informing the design of Mexico’s Climate Change Law of 2012.

Over the years, the Capri model was improved and strengthened by collaborations and projects with several institutions from around the world. The diagram below shows some of them, including the University of Cambridge in the UK, the Indian Institute of Management, as well as international institutions like the United Nations and the World Bank, and also national governments.



Source: Believe Green LLC

1.2 Overview of the Capri Model

This section provides a brief overview of the model capabilities.

1.2.1 Inputs

The inputs to the Capri model can be divided into two distinct groups: data inputs and policy inputs.

- **Data inputs.** These are the data required to run the model, and include: Marginal Abatement Costs (MAC) curves, BAU emissions as well as oth-

er standard economic data such as GDP and population. These are required at regional and economic sector levels. The Capri model was designed for flexibility, so it can use MAC and BAU data from various sources. Here, we use MAC and BAU data from the same sources for all countries to ensure consistency between emission projections and mitigation targets. Specifically, the scenarios presented used three sources of data:

- **Energy CO₂.** This includes all emissions arising from the production and use of energy. The scenarios presented in this report use data from the POLES model²², an econometric, partial-equilibrium model describing energy demand and supply for the entire world.
- **Forestry CO₂.** This includes all emissions related to land use change, which includes both afforestation and deforestation. Here we used the Global Forests Model (G4M, and formerly known as DIMA) from the Austrian Institute for Applied Systems Analysis (IIASA)²³. G4M is a dynamic forestry and land use model.
- **Non CO₂.** This includes greenhouse gas emissions from gases other than CO₂, such as methane. MAC and BAU data for these gases was obtained from the FAIR model²⁴, run by the Netherlands Environmental Assessment Agency.

- **Policy inputs.** These are the inputs required to specify various policy scenarios, such as:

22. This link provides a layman overview of the POLES model, and includes links to technical documents: https://en.wikipedia.org/wiki/Prospective_Outlook_on_Long-term_Energy_Systems.

23. International Institute for Applied Systems Analysis. <http://www.iiasa.ac.at/web/home/research/modelsData/G4M.en.html>.

24. PBL Netherlands Environmental Assessment Agency. http://themasites.pbl.nl/tridion/en/themasites/_disabled_fair/overview/index-2.html.

- What is the carbon reduction target for a given year?
- Are the reductions achieved through a carbon market?
- Is the carbon market linked to other carbon markets?
- In a carbon market, what percentage of the target can be met by purchasing carbon credits from other regions, and what percentage should be met internally?
- Are the reductions achieved through a carbon tax? A carbon fund? A mixture of the above?

1.2.2 Outputs

The Capri model is a very powerful and flexible tool capable of producing a broad range of outputs. These include:

- carbon prices (both regional and global),
- marginal abatement costs,
- financial flows,
- net costs,
- domestic abatement,
- carbon flows, etc.

All costs are presented in 2005 US\$.

For more details, the article ‘Achieving increased ambition through targeted mitigation actions in the global power sector’²⁵, which was accepted by the United

25. Gallo, Federico and Worthington, Bryony. “Achieving Increased Ambition Through Targeted Actions in the Global Power Sector,” February 24, 2014. <http://unfccc.int/resource/docs/2012/smsn/ngo/144.pdf>.

Nations, illustrates some concrete examples of output types, including interactions of a global carbon market for the power sector with a carbon fund (such as the Green Climate Fund) for all other economic sectors.

1.2.3 Carbon finance mechanisms

The model can describe and quantify all the major carbon finance mechanisms, including carbon markets, carbon funds such as the Green Climate Fund, carbon taxes as well as their complex interactions, including secondary mechanisms such as raising public funds from the carbon market.

1.2.4 Geographic, sectoral and temporal disaggregation

The level of disaggregation that can be achieved depends on the underlying data. Currently, the model has the following level of detail:

- 20 geographical regions covering the entire world, including major individual countries such as the USA, China, Brazil, as well as economic blocks, such as Europe.
- 24 economic sectors covering the entire global economy, including industry, transport, energy, forestry etc.
- Years: scenarios run from 2010 to 2050.

1.3 How the Capri Model works

This section provides a brief overview of how the model works.

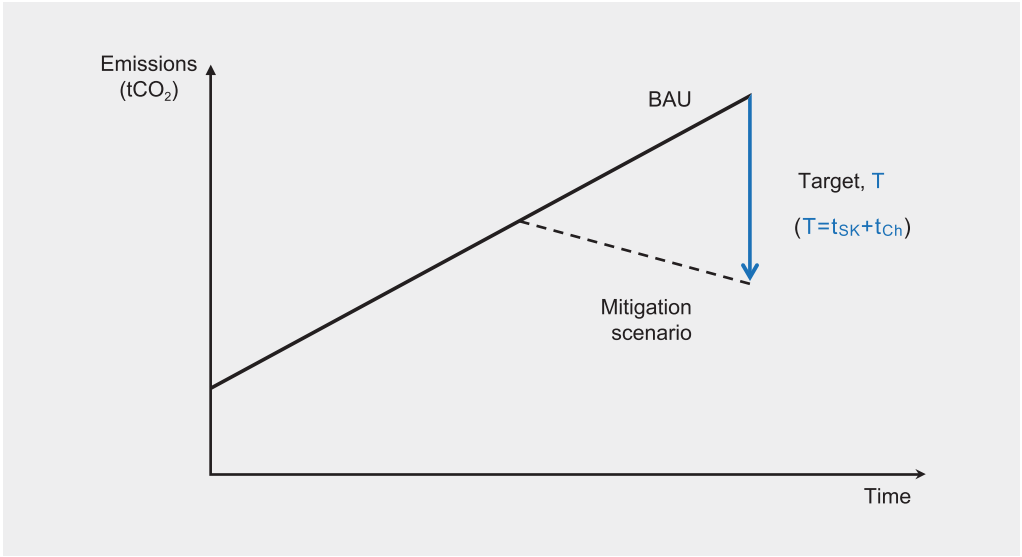
In practice, the Capri model is coded in C++. However, given the large number of countries, sectors, policy inputs, and potential scenarios, several user inter-

faces in Excel are used to manage the flow of inputs and outputs.

The underlying theory²⁶ and principles are based on microeconomic theory. The rest of this appendix describes these principles.

The first step in the Capri model is to obtain the BAU projections, see Figure 10. Next, we define the mitigation scenario. This allows us to calculate the ‘global’²⁷

Figure 10. Carbon emission projections



Note: Schematic BAU emissions, mitigation scenario and mitigation target.

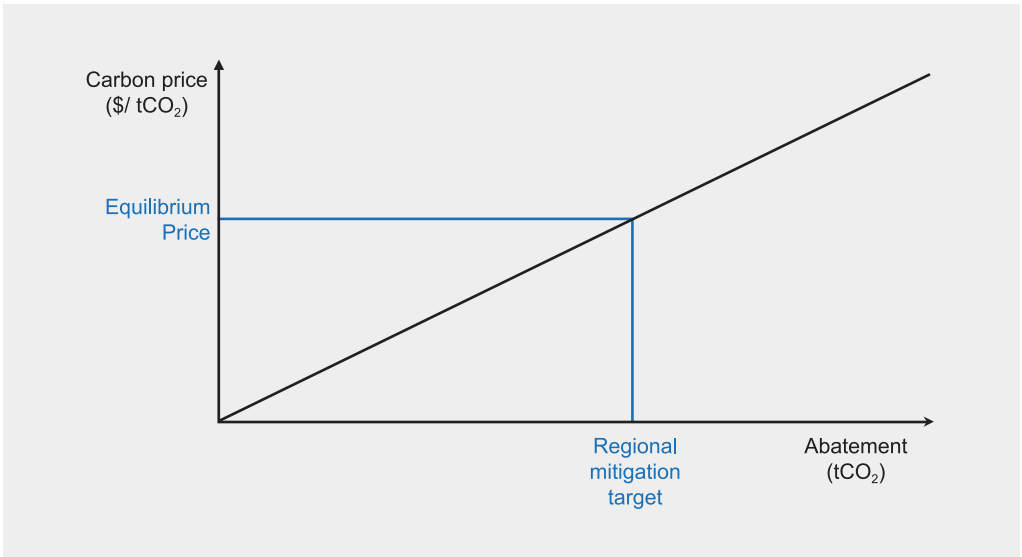
26. Ellerman, D. and Decaux, A. Analysis of Post-Kyoto CO₂ Emissions Trading Using Marginal Abatement Curves, *MIT EPPR*, report number 40, 1998.

27. By ‘global’ here we mean the sum of all the regions included in the scenario. It could be the entire world or, like in the example presented here, the sum of the emissions from China and South Korea.

target T for a given year (defined as BAU minus mitigation scenario). The target T is the sum of regional (national) targets. For example, if we consider a case that includes only China and South Korea, with respective targets t_{Ch} and t_{SK} , the total target is $T=t_{SK}+t_{Ch}$.

To calculate the costs and other economic and financial quantities, the Capri model uses Marginal Abatement Cost curves, see Figure 11. The Marginal abatement cost curve represents the costs of reducing carbon emissions by one more unit, in this case one ton of CO₂ equivalent (tCO₂e).

Figure 11. Marginal abatement cost curves



Note: Schematic marginal abatement costs (MAC) curves. In practice, MAC curves are very nonlinear.

The economically optimal solution to the problem is to use all the cheapest mitigation options to meet the regional mitigation target.

This naturally leads to the Equilibrium Carbon Price: if we stop implementing measures at a lower price, the mitigation target is not met; conversely, if we use more expensive mitigation options, the mitigation costs would be unnecessarily high.

1.3.1 Linking carbon markets

Up to this point we considered only one single region, but it is possible to link two or more regions or carbon markets.

As an example, Figure 12 illustrates a scenario where South Korea’s and China’s carbon markets are linked to create a larger, single carbon market.

By linking the markets, we are creating opportunities to reduce costs. For example, South Korea could buy cheap carbon credits from China to meet some of its target. This would make sense when the carbon credits from China are cheaper than implementing emission reductions measures domestically in Korea.

More specifically, the blue lines in Figure 12 show the case when the markets are separate. Each country has its own target: t_{SK} for South Korea and t_{Ch} for China.

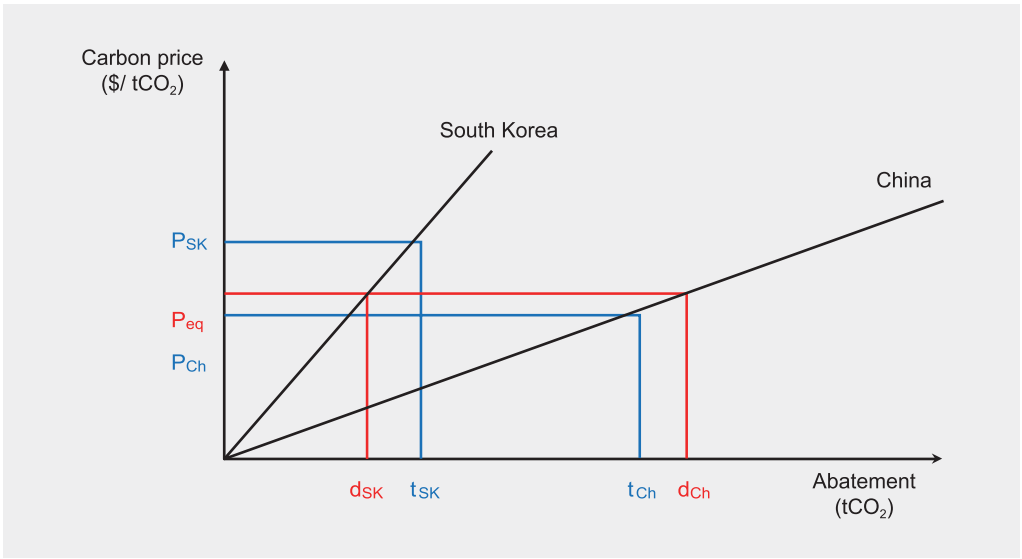
Following the reasoning explained above, this would lead to two separate equilibrium prices, one for the Chinese market (P_{Ch}) and one for South Korea’s ETS (P_{SK}). Generally, these would be different: ($P_{SK} \neq P_{Ch}$). In this example, $P_{SK} > P_{Ch}$ holds.

By linking the two carbon markets we are unleashing market dynamics driven by demand and supply. More specifically, South Korea, which in this example is experiencing a higher internal carbon price, would have an incentive to purchase

cheaper carbon credits from China. Similarly, China has an incentive to reduce emissions beyond its national target to sell the difference to South Korea at a profit (because the price at which it is selling the credits is higher than its mitigation costs to produce them).

These demand and supply dynamics will lead to a conversion of the separate market prices (i.e. P_{SK} and P_{Ch}) into a new equilibrium market price, P_{eq} .

Figure 12. Carbon trading



Note: MAC curves can be used to simulate carbon trading between two regions.

1.3.2 Calculating the equilibrium carbon price

At this point we have a number of unknowns that we are looking to calculate:

- The equilibrium carbon price, P_{eq} ,

- The mitigation achieved internally by South Korea and China, d_{SK} and d_{Ch} . This would be the economically optimal distribution of mitigation between the two regions.

To calculate P_{eq} , d_{SK} and d_{Ch} , we carry out a global optimization problem:

- Minimize the sum of regional incremental costs, defined as the integral of the Marginal Abatement Curve up to the internal abatement, e.g. d_{SK} and d_{Ch}
- Ensure that the global carbon target T is met.

To calculate the regional incremental costs we need to specify the Marginal Abatement Costs curves. These are usually produced by complex models, such as Computable General Equilibrium model (GCE), Partial Equilibrium models, and other methodologies.

Referring to the above diagrams, we can describe the marginal cost curves as linear functions:

- $p = \rho_{SK} q$, for South Korea, and
- $p = \rho_{Ch} q$, for China
- Where p is the marginal abatement cost as well as the carbon price (measured in $\$/tCO_2$), and q is the carbon abatement (measured in tCO_2), while ρ_{SK} and ρ_{Ch} are region specific empirical parameters.

Having identified the marginal abatement cost curve, we can define the regional incremental costs as their integral. We are now in a position to solve the constrained cost minimization problem using standard microeconomic theory and the method of Lagrangians.

Solving the problem we find

that the equilibrium carbon price is given by: $p_{eq} = \frac{t_{SK}+t_{Ch}}{\left(\frac{1}{\rho_{SK}}+\frac{1}{\rho_{Ch}}\right)}$.

While the economically

optimal regional mitigations are: $d_{SK} = \frac{p_{eq}}{\rho_{SK}}$ and $d_{Ch} = \frac{p_{eq}}{\rho_{Ch}}$.

Once we have these variables, we can use them to calculate other quantities of interest. For example, the carbon flows for China are defined as $C_{Ch} = t_{Ch} - d_{Ch}$.

To obtain the financial flows, we multiply the carbon flows by the carbon price:

$$F_{Ch} = C_{Ch} * P_{eq}.$$

In practice, the above linearized model is too simplistic and more realistic marginal abatement cost curves are used. However, these cost curved are very non-linear, and a numerical solution needs to be calculated via a dedicated computer program. Also, real-world scenarios are much more complex than the above illustration. They tend to include several countries, which themselves are composed of many economic sectors. Also, the policy specifications are limited only by the imagination of policy makers: this requires considerable flexibility and creativity to quantify and solve. The Capri model was designed to optimize these calculations, and has been tested in a wide range of contexts in numerous countries: this makes the Capri model a powerful, robust and reliable tool to support national policies and international negotiations to combat climate change.



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by **Choi Hyeonjung, Gallo Federico, Kim Chong Woo**

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Address 11, Gyeonghuigung 1ga-gil, Jongno-gu, Seoul 110-062, Korea

Telephone +82-2-730-5842

Fax +82-2-730-5876

Website www.asaninst.org

E-mail info@asaninst.org

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