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Effectiveness of greenhouse-gas Emission Trading Schemes implementation: a review on legislations

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ABSTRACT

Due to the severe problems caused by global warming, controlling greenhouse-gas emissions has become an emerging topic around the world. This situation has led to the implementation of legislations, forcing companies to implement innovations and strategies to prevent and reduce carbon emissions. Nevertheless, the effectiveness of implementing these strategies and the estimation to fulfill Kyoto Protocol's 2020 target Emission Trading Schemes needs to be further analysed and discussed. This paper reviews the existing greenhouse-gas-emission legislations, as well as carbon offset programs worldwide. A detailed analysis on carbon emissions trends related to emissions penalties is shown for six major countries. The optimal penalty for emissions trading schemes is also analyzed and discussed in this paper. Future changes that could be made to the existing programs for enhancing their effectiveness are also suggested. It was found that carbon emissions decreased around 1.58% per year since Emission Trading Schemes implementation. Around 23.43% of CO_2 reduction can be reached after 10 years of Emission Trading Schemes implementation, compared to the trend when Emission Trading Schemes was not implemented. Despite Emission Trading Schemes implementation is extremely recent, based on the existing data a first estimation of the optimal penalty in achieving the maximum carbon reduction it was found around US$90.22 per tonne. However, as the implementation period of Emission Trading Schemes is still limited for most countries, it is necessary to explore similar analysis as future work.

1. Introduction

Greenhouse-gas (GHG) emissions have become one of the most impacting environmental issues in today's society (Hedberg et al., 2010; Wang and Wang, 2015). According to United States Environmental Protection Agency, GHG can be defined as any gas that absorbs infrared radiation in the atmosphere (Environmental Protection Agency, 2015). In 2012, the most significant GHG emitted by human activities is carbon dioxide (CO_2) of about 82%, followed by methane (CH_4) of about 9%, nitrous oxide (N_2O) of about 6% and fluorinated gases (F–gases) – such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6) of about 3% (Environmental Protection Agency, 2014; Environmental Protection Agency, 2015).

A rapidly increasing trend in global CO_2 emissions –particularly since the early nineties (about 23.64% since 1990)–, has led to the generation of about 50,000 million tonnes of CO_2–equivalent (eq) worldwide in 2010 (Joint Research Center, 2012). However, after a 4.5% recovery in 2010 and a 3% increase in 2011, a slowdown in global CO_2 growth was observed in 2012, in which global CO_2 emissions increased only 1.1%, reaching 34.5 billion tonnes. For 2012, top three emitting countries/regions, which accounted for 55% of total global CO_2 emissions, were China with about 29%, United States with about 16% and European Union (EU) with about 11% (Steckel et al., 2011; Joint Research Centre, 2014).

Nevertheless, there are remarkable differences among countries. Data from EU indicate that the total carbon emissions from EU remained below United States's emission levels throughout the whole period analyzed (Joint Research Centre, 2014). However,

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EU-27's emission levels remained above China's and Russia's emissions until 2000. Furthermore, in 2012, China increased its CO_2 emissions by 3%, which is low compared to the annual increases of about 10% observed over the last decade due to the increased electricity consumption (Pew center on global climate change, 2007). In this sense, Chinese emissions have significantly fallen over the past few years due to the implementation of aggressive policies. Such trends are expected to continue as the International Energy Agency has estimated that about half of the growth in global energy-related carbon emissions from now until 2030 will come from China (Han et al., 2012). In the United States and the EU, CO_2 emissions decreased by 4% and 1.6% respectively. In addition, in India and Japan, emissions increased by 7% and 6% respectively, and the Russian Federation noted a 1% decrease. Also, Australian total GHG emissions have slightly increased in 2011 due to the strong international demand for Australian services consequence from global economic crisis recovery (Australian Government, 2012).

According to the main activities emitting CO_2 in the world, previous data shown in Table 1 highlight that energy, electricity and transport production are the main sectors generating CO_2. The second and third largest sectors are industry and agriculture, followed by waste and other sectors. Since the combustion of fossil fuel is the largest source of CO_2, changes in emissions from fossil fuel combustion have historically been the dominant factor affecting total emission trends. Although the data collected in Table 1 is based on available resources from different years, the information provided can be used as a guideline of the GHG emissions contributions among industries. Wu et al. (2015) conducted a review on the GHG related to ISO standards and their evolution and future trends.

For this, the Kyoto Protocol sets compulsory targets for protocol's participants to reduce GHG emissions to an average of 5% against 1990 levels over a five-year period: 2008–2012 (United Nations Framework Convention on Climate Change, 1998). This Protocol places serious limitations on developed nations, as it is considered that developed countries are mainly responsible for the high levels of GHG emissions to the atmosphere. A total of 192 parties have signed and ratified the Kyoto Protocol and have set several GHG emission limitations or reductions targets for 2020. Table 2 shows the current status Kyoto Protocol's ratification and emission's targets for major countries.

In order to achieve these targets, most of the parties have made important changes to their national policies between 2004 and 2014. The Kyoto Protocol offers additional means of achieving their targets for parties using the following mechanisms (United Nations Framework Convention on Climate Change, 1998):

- Joint implementation (Art. 6).
- Clean development mechanism (Art. 12).
- Emission Trading Schemes (ETS) (Art. 17).

While actual emissions units can be sold under the Kyoto Protocol's ETS, other units which may be transferred under the scheme are (each unit is equal to one tonne of CO_2): (i) a removal unit on the basis of land use, land-use change and forestry activities such as reforestation; (ii) an emission reduction unit generated by a joint implementation project; and (iii) a certified emission reduction generated from a clean development mechanism project activity. At the end of each year, companies must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed (United Nations Framework Convention on Climate Change, 2008). Another mechanism to control GHG is carbon taxation. While ETS permits are initially auctioned by the government and subsequently traded by the market participants –allowing the cost of emissions to be determined by market forces–, carbon taxation is a fixed price method set by the government as a direct taxation (Goldblatt, 2010).

In resume, many emission reduction strategies have been recently implemented worldwide aiming a reduction of GHG emissions (Lincoln, 2012). Nevertheless, the effectiveness of implementing these strategies and the estimation to fulfill Kyoto Protocol's 2020 targets needs to be further analysed and discussed.

Therefore, this paper, draws an overview of the current situation towards Kyoto Protocol targets achievement for the major regions emitting GHG, compares the existing emission reduction strategies and finally analyzes the carbon emissions trend after the ETS implementation. Lastly, the ETS penalty's efficiency to achieve carbon reductions is also explored. The results of this paper can help to inform national policy makers on the development of new emission regulations or reviewing the current legislations.

2. Methods

For the analysis of the major countries emitting GHG and implementing emission reduction strategies, a five-phase methodology has been followed: (i) to examine the existing situation towards Kyoto Protocol targets achievement; (ii) to identify and compare the regions/countries currently implementing emission reduction strategies; (iii) to analyze carbon emissions after the ETS implementation; (iv) to calculate carbon reduction based on the implementation period of ETS; and (v) to relate ETS penalty and carbon reduction.

For this, a total of six major regions were identified and analyzed in this paper, as they are the major regions currently implementing ETS or carbon taxations for reducing their GHG emissions: (1) European Union, (2) Australia, (3) New Zealand, (4) Japan, (5) United States of America; and (6) Canada (Huisingh et al., 2015).

Data on carbon emission targets and actual carbon emissions were collected from United Nations Framework Convention on Climate Change (United Nations Framework Convention on Climate Change, 2014) and the Joint Research Centre of the Environmental Assessment Agency (Joint Research Centre, 2014).

Table 1
Percentage of total GHG emissions by sector.

Country	Year	Energy, electricity and transport	Industry and industrial processes	Agriculture	Waste	Other sectors	Source
European Union	2012	79.9%	6.9%	10%	3%	0.2%	(Eurostat, 2014)
Australia	2012	68%	6%	16%	3%	6%	(Australian Government, 2012)
China	2005	56%	21%	20%	3%	–	(Pew center on global climate change, 2007)
Japan	2010	58%	32%	–	2%	8%	(Japanese Government, 2012)
United States of America	2012	60%	20%	10%	–	10%	(Environmental Protection Agency, 2011)
New Zealand	2010	43.4%	6.7%	47.1%	2.8%	0.04%	(Government of New Zealand, 2012)
Canada	2010	60%	23%	10%	7%		(Government of Canada, 2011)
World	2010	46%	29%	7%	3%	15%	(Ecofys Consultancy, 2013)