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**Effectiveness of Trade Sanctions as an Enforcement Mechanism in  
Greenhouse Gas Mitigation Agreements in Agriculture and Forestry**

by

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# **Effectiveness of Trade Sanctions as an Enforcement Mechanism in Greenhouse Gas Mitigation Agreements in Agriculture and Forestry**

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## **Abstract**

This study explores the conditions under which a trade sanction can be an effective enforcement mechanism used by the US against China in global greenhouse (GHG) mitigation in agriculture and forestry. The problem has the structure of prisoner's dilemma and hence both the US and China have incentive to free-ride in GHG emissions abatement. It is found that if the US joined the rest of the world (ROW) in emissions abatement in agriculture and forestry, the US could also convince China to comply with abatement using trade sanctions. In this study, trade sanctions are considered as a deterrent to free-riding. For threats of trade sanctions to become a viable enforcement mechanism tariff rates have to achieve two conditions defined in this study: credibility and effectiveness. In a scenario where China is the only region refusing to implement an emissions tax on its GHG from agricultural and forestry sectors it is shown that there may be a window in which trade sanctions constitute a viable enforcement mechanism for the environmental agreement. This window is depicted by tariff rates below 9% (these rates achieve credibility) and above an increasing lower bound (denoting rates achieving effectiveness). The lower bound intersects 9% at a carbon tax of \$80/TCE implying that; 1) at carbon taxes above \$80/TCE trade sanctions are no longer a viable enforcement mechanism for the environmental agreement, and 2) the viability of trade sanctions as an enforcement mechanism may be limited to a certain level of targeted abatement.

## Introduction

The Emissions Gap Report (UNEP, 2010) by the United Nations Environment Programme shows that the 1997 Kyoto Protocol will not be as effective as expected in moderating climate change. This is an expected result considering the fact that the US and China, the two largest contributors to the global greenhouse gas (GHG) emissions<sup>1</sup>, are yet to take action aimed at curbing their emissions. China is not abating its emissions because the Kyoto protocol exempts China and other developing countries (called non-Annex 1 countries) from abatement responsibilities. The US, on the other hand, decided not to commit to the treaty because<sup>2</sup>; 1) it exempts the non-Annex 1 countries, including China<sup>3</sup> and 2) it lacks an enforcement mechanism that would be effective in guaranteeing compliance from developing countries once they are required to curb emissions themselves.

Barrett (2003) posited the lack of enforcement mechanism within the Kyoto protocol as a central reason of its ineffectiveness. Since GHG emissions amount to a global public good (bad) then the Kyoto protocol (or any other international environmental agreement designed to curb GHG emissions) has the structure of the well-known prisoner's dilemma: while the social optimum is achieved when all countries cooperate, all of them have individual incentives not to do so. If there is no enforcement mechanism that allows complying countries to effectively and credibly punish free riders then no cooperation can be sustained.

Barrett (1997) also demonstrates that trade sanctions may provide a viable enforcement mechanism. Indeed trade sanctions have been effectively used as an enforcement mechanism to control Ozone Depleting Substances (ODS). Countries signed the Montreal Protocol which employed trade restrictions and threats to ban trade in ODS and ODS-containing products with

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<sup>1</sup> See McKibbin (2008).

<sup>2</sup> There may be other reasons but these have, in general, been considered the most relevant ones in the literature.

<sup>3</sup> See Owen and Hanley (2004), pg: 67.

non-parties as an enforcement mechanisms. Although the two problems, i.e., control of the ODSs and the GHG mitigation, have fundamental differences<sup>4</sup>, herein it is hypothesized that trade sanctions may constitute an effective enforcement mechanism to sustain compliance in the context of agreements to curb global greenhouse gas (GHG) emissions. Like Barrett (1997), in this study, trade sanctions are considered as a deterrent to free-riding.

It has been estimated that over one third of global carbon emitted since 1850 is related with agricultural and deforestation activities (Houghton, 2003). Furthermore, approximately 50% of the global methane emissions (CH<sub>4</sub>) and 75% of the global nitrous oxide (N<sub>2</sub>O) emissions are coming from land-related agricultural activities (USEPA, 2006). Therefore, an attempt to tackle the problem of GHG emissions related to agricultural and forestry activities may provide a solution to a significant portion of the GHG problem. In addition trade sanctions may be especially effective when it comes to GHG mitigation in the agricultural and forestry sector as these products are highly traded in international markets.

As two of the world's largest GHG emitters (in general and from agricultural sources), the US and China are critical players in this game and their actions so far are consistent with the result of a prisoner's dilemma game without an enforcement mechanism, i.e., they do not mitigate their emissions. Hence it seems relevant to assess the potential viability of trade sanctions as an enforcement mechanism capable of inducing, in particular, the US and China to cooperate in curbing emissions from agricultural and forestry. Trade sanctions are an effective enforcement tool as long as they fulfill two conditions: credibility and effectiveness of sanction threats. A threat is credible if and only if the punisher is better off applying the punishment to the

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<sup>4</sup> Barrett (2007) lists the differences between the two problems. One difference is that in depletion of the ozone layer problem, everyone on Earth is affected in same way, i.e., they all become worse off. In the global warming problem, on the other hand, different regions are affected by the problem in different ways, at least in the short term. For instance, while some regions become worse off because of sea level rise, some regions become better off with the help of agricultural activities becoming possible in those regions that used to be unqualified for such activities.

non-complying party. In addition, a threat is effective if the punished country is better off complying than free riding and receiving the punishment. The two conditions depend on different payoffs. The former condition depends on the payoff of the punisher while the latter depends on the payoff of the punished country. While a threat may be credible it may not be effective or vice versa.

In this study, the payoffs obtained by punisher and punished countries, and hence the credibility and the effectiveness of trade sanctions to mitigate global GHG emissions related with agricultural and forestry industries, are determined by using the GTAP-AEZ-GHG model (Golub et al., 2009). The abatement policy considered in this study is a carbon tax on output related emissions, intermediate input related emissions, and primary input related emissions in the agricultural sectors and a subsidy on forest carbon sequestration. Given the stated reasons put forth by the US for not subscribing to the protocol, we assume the US will join the agreement as long as an enforcement mechanism is in place. We then determine the effectiveness of trade sanctions as a mechanism through which the US may or may not be able to induce China to comply with a carbon tax.

Therefore the main structure of our model is as follows. A carbon tax is set by countries signing an international agreement including the US. The US uses threats of trade sanctions (import tariffs to products from China) to try to induce China to set the same carbon tax. If trade sanctions are both credible and effective then it is expected that a global environmental agreement will be signed and complied with by the US, China, and the rest of the world. As the main objective of this study is to assess the potential effectiveness of trade sanctions as enforcement mechanism we aim at answering the following question: under what conditions is a threat of tariff by the US against China both credible and effective?

## Literature Review

The existing studies of trade sanctions and international cooperation either utilize a static modeling framework (Barrett, 1997; Alpay, 2000) or Computable General Equilibrium (CGE) models (Kemfert, 2004). Barrett (1997) considers trade sanctions as a deterrent to free-riding and the author shows how trade sanctions in a multilateral environment agreement (MEA) such as the Montreal Protocol can work as a credible threat to deter free-riding and sustain cooperation. Alpay (2000) uses a general equilibrium model with a game theoretic component to show under which conditions international trade can stimulate GHG mitigation.

Kemfert (2004) investigates a mechanism which gives incentives to the biggest GHG emitter, the USA to reduce its GHG emissions. Kemfert, Lise and Tol (2004) study effects of international trade and carbon leakage<sup>5</sup> on countries' coordination in GHG emissions mitigation efforts. In the first part of the work, the authors build their model which assumes that there are three determinants of the GHG abatement cost of a country: (1) its own abatement efforts, (2) other countries' abatement efforts (because of carbon leakage), and (3) abatement costs of other countries (because of international trade). Since their analytical analyses give ambiguous results, the authors run simulations to estimate the effects of international trade and carbon leakage on carbon emissions efforts and cooperation between countries. To run the simulations, the authors use WAGEM (Kemfert, 2000) which is a static computable general equilibrium (CGE) model based on GTAP data of 1995. Among the 11 regions, it is assumed that only the US, EU, and Japan are involved with the GHG emissions mitigation problem and the rest of the regions which are dummy players do not abate their emissions. A total of 14 simulations are run which differ along two dimensions: number of participants (7 possibilities including full participation of all

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<sup>5</sup> See Elliott et al. (2010) for another recent study about carbon tax and leakage.

three regions, single region, and two regions out of three) and abatement target (reducing emissions by 10% or 20% in comparison to the base year emissions, 1990). The simulations, however, do not give crystal clear results because of limitations of the model like building a static model for a dynamic problem, or considering limited number of regions for a global problem. Nonetheless, the authors find that if spillover effects are driven by the abatement costs of other countries, then incentives to cooperate are as weak as if there were no spillovers at all. On the other hand, if spillover effects are driven by the abatement efforts of other countries, then incentives to cooperate are stronger than the case without spillovers.

McKibbin et al. (2008) introduce a mechanism which is called the McKibbin-Wilcoxon Hybrid approach, to allow China both to grow and help prevent the tragedy of GHG commons, at the same time. Naghavi (2010) builds a model to investigate the effectiveness of trade sanctions in multilateral environmental agreements (MEAs) under the assumption that firms' decision on location and governments' environmental and trade policies are endogenous. The author finds that trade sanctions can be effective as long as the abatement requirement is not too stringent with respect to the marginal cost of emissions.

A very recent study by Devarajan, Go, Robinson, and Thierfelder (2011) compares three different tax instruments achieving reductions of CO<sub>2</sub> emissions by 15% in South Africa. The instruments are a direct tax on carbon emissions, a proxy tax on energy commodities (coal, petroleum, and electricity) and a proxy tax on emission-intensive commodities. Unlike Fullerton (2001) which is making the same comparison, Devarajan et al. (2011) include preexisting distortions in the labor market of South Africa in their analysis. The authors find the following three results: (1) a direct tax on emissions causes the least welfare losses. (2) Welfare losses are very sensitive to pre-existing factor market distortions. (3) Three tax instruments order in



different rank in terms of effects on equity from the rank they have in terms of welfare losses. Although, the proxy tax on energy commodities is the second best instrument in terms of the welfare loss effects, it is the least regressive one in terms of equity effects.

McEvoy et al. (2008) experimentally investigate problems in maintaining compliance in stable coalitions. The authors' theoretical model suggest that introducing a member-financed enforcement mechanism into a coalition may increase compliance and hence contribution to the public good. The authors test this hypothesis by running a series of experiments and they find that the experimental results reject the hypothesis that member-financed enforcement within a coalition increases contribution to the public good. Another result that the authors find is that increasing participation threshold decreases average contribution to the public good because of decrease in frequency of coalitions to occur. "Improving coalition formation and compliance within coalitions requires a higher participation threshold, perhaps full participation, and more stringent enforcement than suggested by theory."

In the climate change literature<sup>6</sup>, there are two distinct approaches commonly used to determine how much action is needed to price or to control GHGs in the short-term and longer term in a global level. The first approach is the welfare maximizing emissions pricing approach which weights benefits and costs of slowing global warming and determine the optimal climate policy by comparing their welfare effects. The most popular studies in this field are William D. Nordhaus' "DICE Model" (Nordhaus, 1994) Nicholas Stern's "Stern Review" (Stern, 2007). Unlike other studies in the literature<sup>7</sup> the DICE model and Stern Review consider damages from extreme warming scenarios.

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<sup>6</sup> See Aldy et al. (2010) for a literature review.

<sup>7</sup> Fankhauser (1995), Mendelsohn and Williams (2004, 2007), Tol (1995, 2002).

The second approach in climate change literature is the cost-effectiveness approach which looks for the climate policy that minimizes the cost of mitigating GHG emissions to an ultimate target. The “bottom-up”, the “top-down” approaches<sup>8</sup> and their hybrids are the approaches used in the cost-effectiveness analyses.

### **3. Simulations**

#### **3.1. The GTAP-AEZ-GHG Model**

The GTAP-AEZ-GHG model developed by Golub et al. (2009) is used to quantify welfare changes associated with different combinations of strategies considered in our model. The GTAP-AEZ-GHG model uses the cost-effectiveness approach and is built to analyze computable general equilibrium (CGE) estimates of global land-use and GHG abatement potential between 2000 and 2020. In the model, there are 24 sectors in three regions: USA, China, and the Rest of the World (ROW). The agricultural sectors in the model are Paddy Rice, Other Grains, Other Crops, Ruminants, and Non-Ruminant Livestock. The simulations are run in WinGEM and the equivalent variation (EV) is used to measure changes in the welfare of the regions.

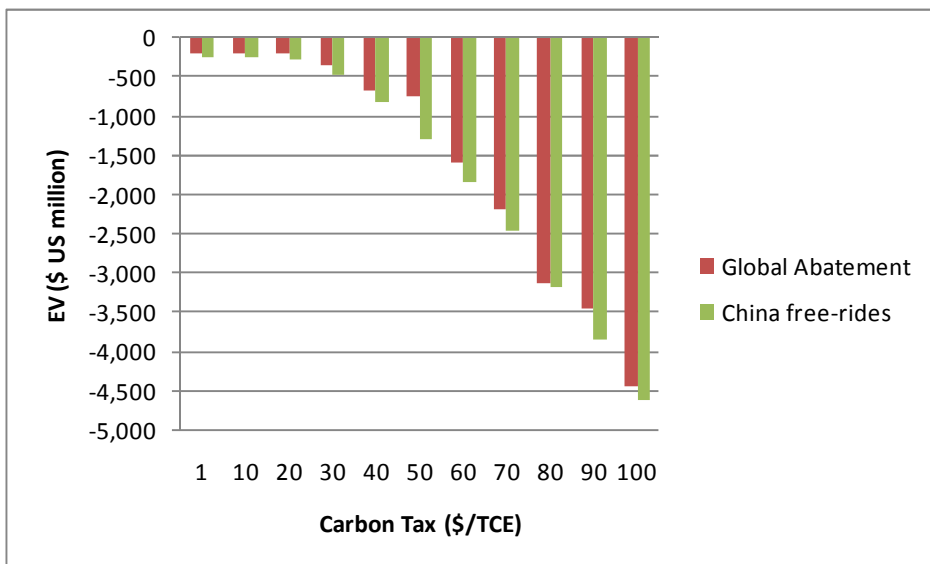
#### **3.2. Methodology and Results**

The cost of abating a given quantity of GHG emissions in this context is depicted by the welfare loss associated with the imposition of a carbon tax that achieves that abatement goal. Increasing abatement levels will require higher carbon tax rates. Figure 1 displays welfare losses incurred by the US under increasing carbon tax rates under compliance and free riding by China.

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<sup>8</sup> See Burniaux et al. (2002) for a comparison of the bottom-up and top-down approaches.

Results suggest that marginal abatement cost is increasing. They also seem to reveal that abatement costs incurred by the US are reduced by compliance on the part of China. The latter is due to the fact that emissions taxes on agriculture and forestry in China always favor the US economy because emissions intensities of the US are relatively lower than China's, especially in paddy rice and ruminant livestock production (Golub et al, 2009). Therefore, an emissions tax in those sectors in China reduces their supply increasing China's food imports from the US leading to a welfare gain in the US<sup>9</sup>.



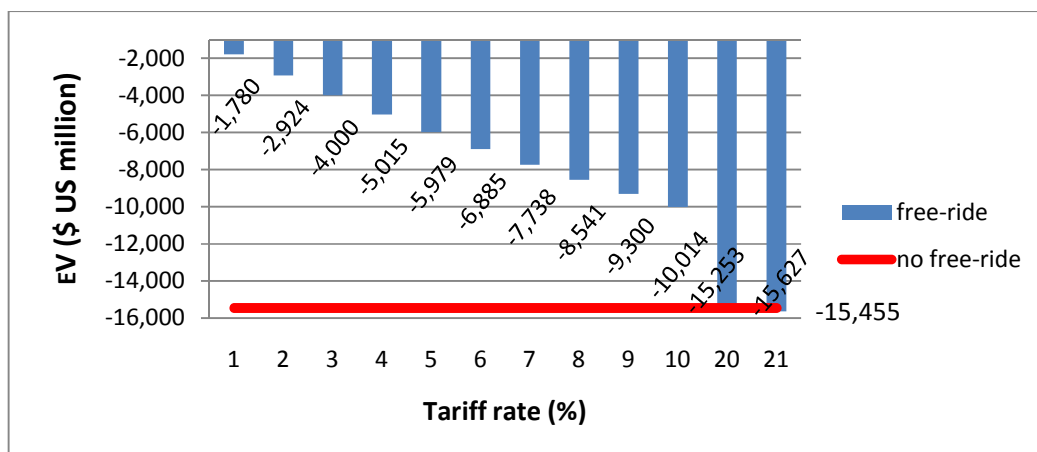
**Figure 1 – Equivalent Variation (EV) of the US over different carbon taxes when China free-rides and cooperates**

As denoted in Figure 1, free riding by China harms the US. Therefore the US will try to induce China to comply if it has an enforcement mechanism the implementation of which yields more benefits than costs. One such mechanism may be trade sanctions; i.e., the US declares that it is going to impose a certain rate of tariff rate on all tradable commodities imported from China.

<sup>9</sup> Figure 1 reveals that the US is better off not imposing a tax regardless of China's behavior. This is so because there are not benefits from abatement. By assuming the US is imposing a given tariff we are implicitly assuming that benefits always justify the costs.

However, while such a threat may benefit the US by enhancing terms of trade it may also reduce welfare by increasing the price paid by consumers for those commodities. The net effect on welfare will determine the credibility of this threat.

We verify the effectiveness of a carbon tax on agriculture and forestry by initially<sup>10</sup> assuming that the global carbon price is \$100 per ton of carbon equivalent (TCE)<sup>11</sup> and by varying the tariff rate, at 1% increments. Figure 2 illustrates China's EV for a range of tariff rates imposed by the US on the entire imports coming from China. As the US increases its tariff rate China's EV decreases. However, when the US sets its tariff rate at 21%, China's welfare loss due to abatement (\$15,455 US million) becomes less than the welfare loss due to US tariff (\$15,628 US million). In other words, under the assumption that both ROW and USA are implementing abatement, US has to impose a tax of 21% on tradable goods imported from China in order to convince China for abatement. Figure 2 suggests that, with a carbon tax of \$100 a ton, the tariff rate is not effective until it gets to 21%.

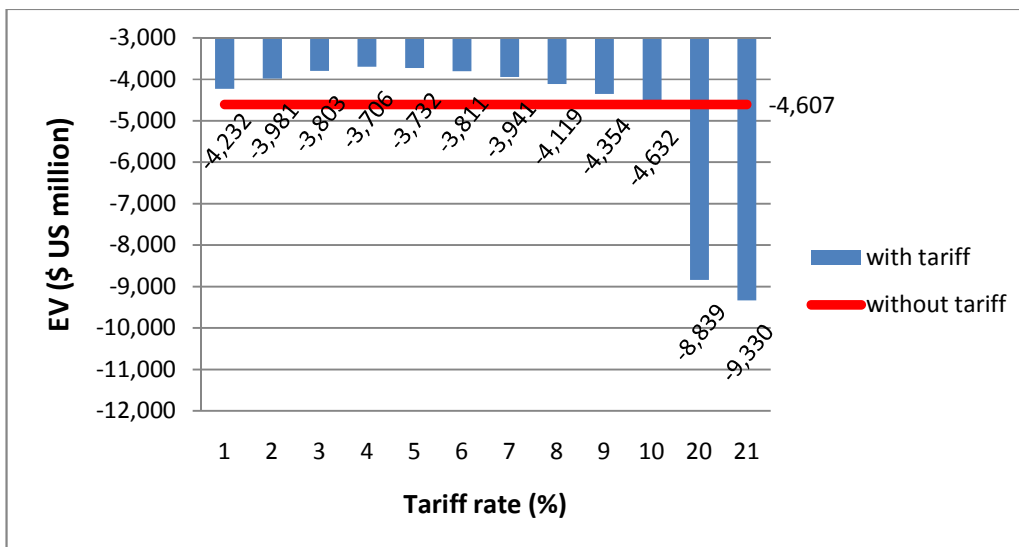


**Figure 2 - China's EV under USA tariff (\$ US million) and \$100/TCE carbon tax on agriculture and forestry**

<sup>10</sup> Since Golub et al. (2009) measure emissions mitigation potential of agricultural and forestry sectors for a carbon price equal to \$100/TCE, we also initially set the carbon price equal to \$100/TCE then look for a carbon price in which it is possible to find a tariff rate which is both credible and effective.

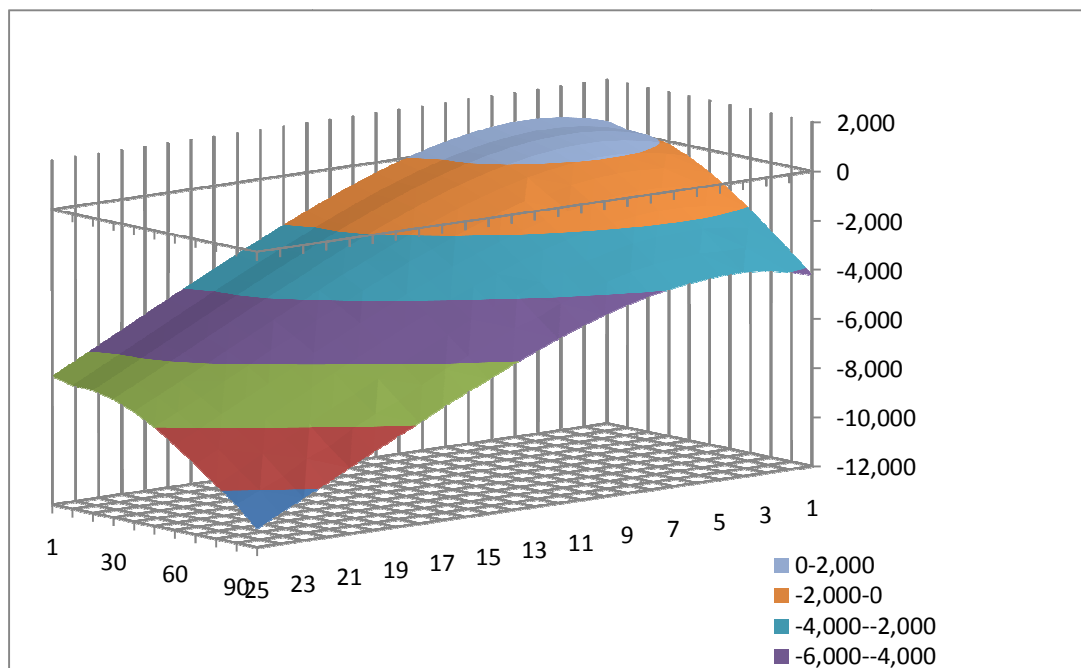
<sup>11</sup> To convert \$ per ton of carbon to \$ per ton of CO<sub>2</sub>, multiply by the ratio of molecular weights, 44/12=3.67, i.e., \$3.67/TCE = \$1/TCO<sub>2</sub>E.

Under a carbon tax of \$100 per ton, on the other hand, the 21% tariff is not a credible threat. This is illustrated by Figure 3. Figure 3 shows how USA's EV changes with the tariff rate imposed on goods imported from China. At a 10% tariff rate, the total welfare loss in the US (\$4,632 US million) exceeds the welfare loss under China non-compliance and no trade sanctions (\$4,607 US million). This means that, any tariff rate above 10% would reduce the US welfare to a level even lower than the scenario without the tariff. Therefore, at a carbon tax of \$100 per ton the set of tariffs that are both effective and credible is empty, meaning that trade sanctions do not constitute an effective enforcement mechanism. We illustrated this point with a carbon tax of \$100 per ton which was used in previous simulations by Golub et al. (2009). However a carbon tax is not likely to be that high so is the set of credible and effective tariff rates also empty at lower tax levels? Changes in US welfare for different combinations of tariff rates and carbon taxes are depicted in Figure 4.



**Figure 3 - USA's EV (\$ US million) under \$100/TCE carbon tax on agriculture and forestry**

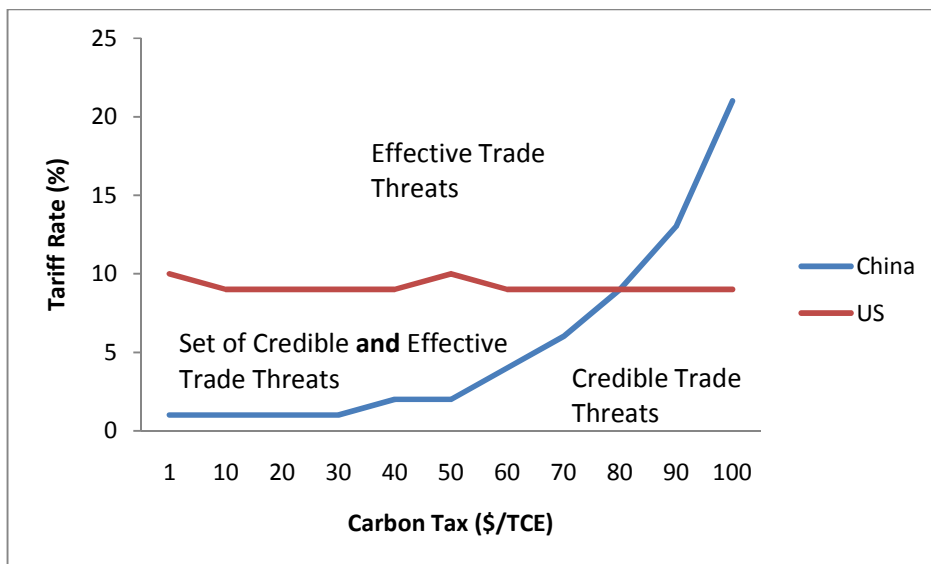
Figure 4 reveals that initial increases in tariffs for a given carbon tax increase EV up to a point. After a certain level, however, additional increases in the tariff rate start to reduce EV. In addition increases in the level of the carbon tax decrease EV at an increasing rate which is consistent with increasing marginal abatement cost depicted by Figure 1. The welfare surface depicted by Figure 4 needs to be compared with the EV in the US associated with different carbon tax levels, a zero tariff rate, and non-compliance by China.



**Figure 4 – Carbon Tax, Tariff Rates, and US Equivalent Variation (EV)**

After finding that there is no credible **and** effective tariff rate at \$100/TCE carbon price, other carbon prices are studied and it is found that the set of tariff rates that are both credible and effective becomes non-empty at carbon taxes at or below \$80/TCE. In other words, it is always possible to find a credible and effective tariff rate as long as carbon taxes do not exceed \$80/TCE. It is found that an \$80/TCE carbon price causes USA and China to lose \$2.809B USD and \$8.308B USD, respectively. If China rejects abatement and chooses to free-ride, China's

welfare loss is only \$336M USD but USA's welfare loss will be \$3.175B USD. It is found that to convince China to implement abatement, at \$80/TCE carbon price level, the US would have to impose a 9% tariff rate on all China's tradable goods. Under such a trade sanction, even though China is free-riding, its welfare loss reaches \$8.310B USD (higher than \$8.308B USD which is the cost of compliance) while USA's welfare loss becomes \$2.692B USD (lower than \$3.175B USD which is the cost of not implementing the trade sanction). Therefore, while a 9% tariff rate makes China worse off than complying with abatement (making it an effective threat), its cost to USA is not as high as letting China free-ride (making it a credible threat).



**Figure 5 – Credible and Effective Tariff Rates**

In figure 5, the combinations of tax and tariff rates above the blue line achieve effectiveness; i.e. China is better off complying and avoiding the trade sanction than free riding and being punished. Combinations below the red line achieve credibility; the US is better off implementing the trade sanction than not implementing it when China is free riding. Therefore the area below the red line and above the blue line constitutes the set of carbon tax-tariff rate

combinations that achieve both credibility and effectiveness at the same time. The blue line intersects the red line at the point where carbon tax is \$80/TCE and tariff rate is 9% meaning that tariff rates of up to 9% will be credible and effective threats when carbon price is less than or equal to \$80/TCE. Note however that as the price of carbon increases the set of credible and effective threats becomes smaller until the price of carbon reaches \$80/TCE at which point the set becomes empty. Therefore our results suggest that there might be a trade-off between abatement level targeted and self-enforcement of an international environmental agreement. As the abatement target increases an increasingly smaller set of tariff rates achieve both credibility and effectiveness.

## **5. Conclusion**

As the two largest GHG emitters, the US and China are two major players in the game of GHG mitigation. The game of GHG mitigation between the US and China is a standard prisoner's dilemma with the current situation being the expected one: neither region abates its emissions. In this study, under the assumption that the US abates its emissions along with ROW (the rest of the world but China), it is investigated under what conditions trade sanctions become an effective tool to deter China from free-riding, i.e. to have China agree to abatement.

For threats of trade sanctions to become a viable enforcement mechanism tariff rates have to achieve two conditions defined in this study: credibility and effectiveness. In a scenario where China is the only region refusing to implement an emissions tax on its GHG from agricultural and forestry sectors it is shown that there may be a window in which trade sanctions constitute a viable enforcement mechanism for the environmental agreement. This window is depicted by tariff rates below 9% (these rates achieve credibility) and above an increasing lower bound



(denoting rates achieving effectiveness). The lower bound intersects 9% at a carbon tax of \$80/TCE implying that; 1) at carbon taxes above \$80/TCE trade sanctions are no longer a viable enforcement mechanism for the environmental agreement, and 2) the viability of trade sanctions as an enforcement mechanism may be limited to a certain level of targeted abatement.

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