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A methodology to estimate national REDD+ reference levels using the Zero-Sum-Gains DEA approach

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ABSTRACT

REDD+ reference levels directly impact the benefits which a country may receive. However, the existing "Compensation Reduction" (CR) and "Compensated Successful Efforts" (CSE) are only considered from a unilateral perspective of outputs or inputs. The combination of these two approaches is considered to estimate the REDD+ reference levels through the Zero-Sum-Gains Data Envelopment Analysis in this paper. The agricultural labor force and agricultural land area are used as input variables, and the gross agricultural production and carbon emissions from deforestation are considered as output variables. The REDD+ reference levels of 89 countries are calculated and classified through the Zero-Sum-Gains DEA model. The results demonstrate that the REDD+ reference levels are estimated efficiently through the Zero-Sum-Gains DEA model, and all countries with deforestation are in the Zero-Sum-Gains DEA frontier, indicating the overall Pareto optimality has been achieved. The empirical results also indicate that the use of Zero-Sum-Gains DEA model is more beneficial for Latin American and the Caribbean, while the countries that may see a revenue drop in REDD+ are in Africa, Asia and Oceania. Consequently, the final REDD+ reference levels should take into account both efficiency and fairness by selecting the appropriate fairness-efficiency weighting factor.

1. Introduction

1.1. Evolution of reducing emissions from deforestation and degradation-plus (REDD+)

Tropical forests account for approximately 15 percent of the planet's land surface (FAO, 2010), yet absorb roughly 25 percent of the terrestrial biosphere carbon (Bonan, 2008). A decrease in this forest area has become one of the major culprits of global warming. For instance, greenhouse gas emissions caused by deforestation and forest degradation have accounted for 12–20 percent of the total carbon emissions caused by anthropogenic factors (Sala et al., 2000; Houghton, 2008). Because this forest area is decreasing at an annual rate of 13 million hectares in tropical forest countries (FAO, 2010), the United Nations Framework Convention on Climate Change (UNFCCC) introduced a low-cost mitigation mechanism to assist developing countries in reducing deforestation and forest degradation in 2007. This program is called "REDD" and although it was introduced in 2007, it was first proposed much earlier in 2005. It was further expanded upon in REDD+, which was defined by the Bali roadmap, adapted at the United Nations Climate Change Conference in 2007. REDD+ involves implementation of a variety of policy approaches and incentive plans to help developing (Non-Annex I) countries reduce deforestation and forest degradation, as well as forest conservation, sustainable management of forests and the enhancement of forest carbon stocks (UNFCCC, 2010). REDD+ signifies a stronger commitment to protecting common interests of biodiversity, equitable treatment of carbon storage and human livelihoods (Rosendal and Andresen, 2011). In addition, to further support national REDD+ strategies, the FCPF (World Bank Forest Carbon Partnership Facility) and UN-REDD have been established in July 2008 and September 2008 respectively.

1.2. Existing solutions and unsolved issues

REDD+ aims to provide assistance to those countries, which are willing and able, in reducing the emissions caused by deforestation, and also provide the necessary financial means (Scholz

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and Schmidt, 2008). Consequently, more and more developing countries are interested in participating in REDD+. In the past, a variety of methods that was proposed to curb the loss of forest area failed to achieve the expected effect. However, REDD+, is changing this by providing a new framework to reduce deforestation. As the opportunity cost of REDD+ arises mostly from the investment income of land development (Ghazoul et al., 2010), previous research has mainly focused on REDD+ investment incentives to enable developing countries to protect forests and reduce deforestation and degradation (Busch et al., 2009; Olander et al., 2008). Emission reductions from deforestation under REDD+ should be compensated through results-based payments (UNFCCC, 2011). Therefore, developing (Non-Annex I) countries have to determine a national reference level (RL) as the benchmark. No standardized method for RL determination has been developed at present, and every country has some flexibility in the calculation of reference (Hargita et al., 2015). The flexible rules should consider the different economical and technical capacity of on-Annex I countries (Bucki et al., 2012, Romijn et al., 2012). Ryan et al. (2014) believe that the reference levels including national circumstances allow a more realistic assessment of the effectiveness of REDD+ than simple extrapolation from historical patterns, however, there is no guidance at present on how it should be done. Due to the lack of a standardized methodology, any individual choice of reference level may lead to opportunistic behavior of a single country, thereby reducing the effectiveness of REDD+ (Köthke et al., 2014).

In order to develop effective and reasonable incentives, it is necessary to review and assess the results of REDD+ implementation. There are two methods that are commonly being used in assessing results of REDD+: an output-oriented approach and an input-oriented approach. With the output-oriented approach, if a country's reduced carbon emissions from deforestation and degradation is less than the REDD+ reference levels in a referential period, then she benefits from economic benefits in accordance with the market mechanism. The revenue obtained equals the reduced carbon emissions multiplied by the carbon price. This method is similar to a "Compensated Reductions" approach where the country is compensated for the revenue foregone due to REDD+ implementation (Mollicone et al., 2007; Santilli et al., 2005; Virah-Sawmy et al., 2015). With the input-oriented approach, countries are rewarded for their "successful efforts" of REDD+ policy, which is also referred to as "Compensated Successful Efforts". Motel et al. (2009) states that deforestation is caused by structural factors that are at times beyond a country's control, therefore, developing countries should be offered appropriate compensation based on the degree of success of their national REDD+ policies.

Although success of REDD+ implementation may be rewarded using one of the two approaches explained above, both of them have certain limitations. In the "Compensated Reductions" approach, the assessment of REDD+ policy is based on the estimated difference between the actual emissions from deforestation and REDD+ reference levels. With the advancement of technology, the measurement of realized emissions will become more feasible (DeFries et al., 2007), however, the real difficulty lies in identifying the baseline forecast for carbon emissions due to deforestation. There are three methods that are practiced in predicting baseline emissions: (i) predictions developed using sophisticated models, (ii) based on historical trends with or without adjustment factors, or (iii) negotiated values based on existing carbon stocks at the start of the crediting period (Pirard and Karsenty, 2009). Due to existence of unpredictable factors or drivers of complexity of deforestation, the predictions are less reliable with the first two methods. The third method is often influenced by political factors inherent in a negotiation process, which makes the predictive value unreliable. Even though the "Compensated Successful Efforts" approach avoids setting REDD+ reference levels, the structural variables, such as population, economy, etc., possess large uncertainties. Consequently, there is not enough information available to determine how structural variables may impact REDD+ policies. In addition, "Compensated Successful Efforts" approach does not explicitly explain how to distribute the economic gains in developing countries.

1.3. A new approach to estimate REDD+ reference levels

As there are advantages and disadvantages for both the input-oriented "Compensated Successful Efforts" approach and the output-oriented "Compensated Reductions" approach, it may be appropriate to use a combination of the two methods in estimating REDD+ reference levels for the REDD+ mechanism. From the input point of view, the most important factors that lead to deforestation are high economic value of forest products in developing countries as well as over-expansion in agricultural cultivating and animal husbandry that requires land use (Culas, 2012). For instance, Culas (2009) found that a large number of forests are converted to pastures in Latin America, and to plantations in Asia and Africa. From the input perspective, agricultural production is one of the most important causes of deforestation occurring in developing countries. This is evident from the conversion of a large number of forests to agricultural land. From the output perspective, the expansion of agriculture can not only bring the agricultural economic growth, but also lead to an increase in emissions due to deforestation and degradation.

The land cleared with deforestation is mainly used for agriculture in countries with deforestation problems. However, this is not necessarily an efficient use of resources. For instance, in some countries, large-scale deforestation did not result in an increase in agricultural output (Marchand, 2012). Therefore, developing countries do not necessarily benefit from clearing forest land for purposes of agricultural production. On the contrary, the rational behavior in these cases should dictate reduction of deforestation. If the actual emissions from deforestation are lower than the REDD+ reference levels, the respective countries with high technical efficiency can exchange excess carbon emissions with carbon credits. This can benefit the country through trading in the international market or the country can obtain funds from developed countries.

Each country will be competitive in the distribution of carbon emissions provided that the annual figure of global carbon emissions does not change. Therefore, in this paper, the Zero-Sum-Gains DEA (Zero-Sum-Gains Data Envelopment Analysis) model will be used to estimate the national REDD+ reference levels. In the second section we introduce a Zero-Sum-Gains DEA model and related issues. Then, we apply it using the input-output data for 89 countries with deforestation in 2010 to estimate national REDD+ reference levels. Finally, we discuss the results of the model, and conclusions are drawn in the last section.

2. Data and methodology

2.1. Efficiency distribution model based on Zero-Sum-Gains DEA

In this paper, we focus on the optimal distribution of carbon emissions from deforestation in a given year, which will be used as national REDD+ reference levels. The optimal distribution will be constrained by the total carbon emissions from deforestation in all countries with deforestation. Therefore, as an undesirable output variable (Leleu, 2013), total carbon emissions from deforestation needs to be limited and shared by all countries. The invariance of undesirable total outputs will be reflected in this situation, namely a Zero-Sum Game (i.e. Zero-Sum-Gains). The DEA model which makes use of the theory of Zero-Sum Game is called a