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Energy and economic impacts of the global climate change policy on Southeast Asian countries: A general equilibrium analysis

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ABSTRACT

The universal climate agreement is expected to be concluded in 2015 at 21st Conference of the Parties of the United Nations Framework Convention on Climate Change in Paris. Importantly, developing countries, who were not part of Kyoto Mechanisms, are expected to be part of new global regime in some meaningful ways. The move comes as countries all over the world are just starting to put together their national pledges, either voluntary activities of emissions mitigation or legally-binding reduction targets, in 2015 for implementation by 2020. Moreover, past assessments of mitigation costs, that all Southeast Asian countries representing in a disaggregated way would face under a global climate change regime, are rare. In this context, a dynamic computable general equilibrium model of the global economy is developed in this study and extended with a bottom-up representation of electricity generation technologies to analyze the energy and economic consequences in Southeast Asian countries under the uncertain global climate constraints. The results highlight the impacts of Southeast Asian nations when non-Annex I countries play a gap-filling role to achieve the long-term 2°C goal in the global climate agreements. We find that clean electricity generation technologies play a key role in emissions reductions, as well as provide positive impacts to economy under the stringent emissions caps. Thailand and Vietnam will have the most severe impacts in Southeast Asia across the climate policy scenarios. Lastly, negotiations for pushing very stringent pledged targets on Annex I countries does not guarantee benefits for Southeast Asia due to the increasing decline in export revenues under more stringent mitigation targets in Annex I nations.

1. Introduction

In recent years, international climate policy has increasingly focused on limiting temperature rise. The level of ambition for reductions by developed countries (or Annex I Parties to the UN Climate Change Convention) and non-Annex I parties is one very important element in the current climate negotiations. In 2007, the Ad-Hoc Working Group on further commitments for Annex I countries under the Kyoto Protocol (AWG-KP) recognized that, in order to reach the lowest stabilization levels assessed by the IPCC, developed countries would need to reduce emissions within a range of 80–95% below 1990 levels by 2050, if all non-Annex I regions managed to "substantially deviate" their emissions below a business-as-usual baseline [19]. Many Annex I parties has then made an important first step by setting a post-2020 target. Moreover, some Annex I countries, especially EU member states, offer to increase the pledged reduction targets if other major countries agree to undertake fair burden shares of a global emissions reduction effort [17]. In contrast, because individual Annex I commitments are pledge-based negotiations, some Annex I countries can withdraw as desired since they argued that greenhouse gas emissions would continue to rise as other largest polluters are not covered by the climate mitigation agreement [31]. Until this time, uncertainty remains about future emissions reduction levels of Annex I countries, especially in the light of the global climate change negotiations. Under an expected 2015 climate deal covering all countries, we assume that Annex I countries as a group commit to the three variants of the IPCC range and use the bottom of the range, 80% below 1990 levels in 2050, as a central case.

Depending also on the cumulative emissions accumulated in the atmosphere, the long-term global temperature stabilization level can be translated into a range of emissions levels by year with different chances of reaching the 2°C target in the next century.

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When comparing the global emissions reductions in 2050 from various studies, we find that different studies use different targets such as 50% below 2005 levels (about 38% below 1990 levels) in Refs. [27,40]; 57% below 2005 levels (about 46% below 1990 levels) in Ref. [1]; 66% below 2005 levels (about 57% below 1990 levels) in Ref. [46]. In summary, Ref. [37] evaluating 193 published emissions scenarios from different models concludes that to maintain at least a likely chance (>66%) of reaching the 2°C target in 2100, total anthropogenic CO_2 emissions should be limited in a range of 415–460 ppm in 2100 or 35–55% below 1990 levels in 2050. Recently, over 900 published mitigation scenarios using integrated models have been collected in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5). This report classifies the development of modeling scenarios to explore different plausible futures by agreed RCPs (representative concentration pathways). RCPs are based on the long-term target levels of radiative forcing, the additional energy taken up by the earth system reported in watts per square meter (W/m^2) due to the enhanced greenhouse effect. Clearly, the lower the radiative forcing level, the better chance of avoiding worse impacts of climate change. As shown in Table SPM.1 in the IPCC WGIII AR5, within the four selected RCPs, RCP2.6 with 2.6 W/m^2 by 2100 represents the lowest mitigation scenario which is likely to limit global temperature change to less than 2°C relative to pre-industrial levels. The range spans atmospheric concentration levels in 2100 from 430 to 480 ppm, which is comparable to the reduction of GHG emissions in 2050 to 41–72% below 2010 levels (about 22–63% below 1990 levels) [14]. In this study, we assume that non-Annex I countries commit to fulfill the three variants of the global emissions reduction targets in a range of 35–55% below 1990 levels in 2050.

Founded in 1967 the ASEAN (Association of Southeast Asian Nations) recently has ten member states, namely Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei Darussalam, VietNam, Lao PDR, Myanmar and Cambodia. The ASEAN countries are all classified as non-Annex I countries in the United Nations Framework Convention on Climate Change. With a shared vision of ASEAN member states, on 12th ASEAN Summit in January 2007, the association has issued "Cebu Declaration on the Acceleration of the Establishment of an ASEAN Community by 2015" to accelerate a plan to establish a closer economic integration within the region by 2015 instead of by 2020 as mentioned earlier in "ASEAN Vision 2020" published in Ref. [2]. As proclaimed in "Declaration of ASEAN Concord II" in Ref. [3]; ASEAN Community consists of three major pillars; the ASEAN Political-Security Community, ASEAN Economic Community and ASEAN Socio-Cultural Community. Importantly the AEC (ASEAN Economic Community) pillar aims to transform ten ASEAN economies into an integrated and highly competitive economic region with equitable development that is fully integrated into the global economy in creating a viable single market and production base. ASEAN leaders adopted the "AEC Blueprint" in Refs. [4,5] to serve as a master plan to establish the AEC in 2015. The key achievements of the single market and production base include five core elements: free movement of goods, free movement of services, free movement of investment, free movement of skilled labor, and free flow of capital. Our study includes some of these elements into all scenarios to represent important changes in the regional economic system over time.

In particular, this paper addresses the energy and economic impacts of the possible range of carbon constraints in Southeast Asian countries by addressing two dimensions of the uncertainty of carbon reduction targets: Annex I reduction targets and required global CO_2 levels to stabilize 2°C goal. The gaps between Annex I contribution and global limits are fulfilled by accessions of non-Annex I countries in 2020 with differentiated responsibilities between LDCs and non-LDCs. In addition to this introduction, this paper is organized as follows. Section 2 presents a brief description of the modeling framework. Following in Section 3 are details of the reference and policy scenarios. Finally, Section 4 discusses the main results and their interpretation and Section 5 concludes.

2. Model description

Modeling non-Annex I participation in the global climate agreement with regionally focused on Southeast Asia, we develop a global CGE (computable general equilibrium) model incorporating a bottom-up module for power generation sector, allowing us to better represent the structural shifts of the energy sector toward 2050. The CGE model used in this study is extended from the core versions of GTAP-EG Ref. [38] and GTAP7inGAMS [39] models. The model is developed in the framework of a hierarchical structure of interconnected modules at the international, regional and national levels. The structures of production and consumption functions are multi-level constant CES (elasticity of substitution) cost functions using primary factors and intermediate goods. The nesting structures and values for elasticities of substitutions differ across sectors, and are mainly separated into 4 groups based on the EPPA 4 model [34]. The first structure designed for non-energy sectors (AGR (Agriculture & Food), COM (Commercial & Services), EIS (Energy Intensive), OIN (Other Industry), LTR (Land Transportation) and OTR (Other Transportation)) is similar to the nesting structure shown in Fig. 3a of Ref. [34]. Second, the structure of primary energy sectors (CEX, OEX and GEX) is the same as Fig. 3d of Ref. [34]. The third structure used for energy sectors (OIL and GAS) is identical to Fig. 3e of Ref. [34]. Fourth, for final consumption demand of a single representative agent, a transport composite is combined at the upper level nest with a composite of other consumptions, in which an energy composite is traded off with a material composite at the second level nest. The transport service composite is simply provided using inputs from LTR and OTR. The economic agents optimize their objective functions (utility for households and cost for firms) and separately determine the supply or demand of capital, energy, emissions, labor and other goods. The model is a dynamic, recursive over time, computable general equilibrium model of the global interactions between the economy and the energy system in which the aggregated geographical regions are linked through endogenous bilateral trade flows. The model is solved until 2050 with one year time step. For each time step, the evolution of the economy is driven by capital accumulation, GDP growth and population growth [23,45,48]. The accumulation of capital in the next period is made up of the investment plus the stock of capital remaining after depreciation. The investment is equal to the saving, an exogenously fixed fraction of the household income distributed from the government. The government, who collects taxes and provides public services which are fixed at the benchmark level, distributes the net revenue to the representative household in a lump sum manner. The fixed foreign saving and endogenous exchange rate is an assumption used for macroeconomic closure.

The social accounting matrix and emissions database of the model are based on the GTAP version 8.1 database, with 2007 as the base year, the most recent base year provided by the GTAP dataset [29]. Also, the GTAP dataset incorporates various existing taxes and distortions including output taxes, taxes on intermediate inputs, taxes on final demands, factor taxes, export taxes and tariffs. The dataset breaks down the world into 12 regions, of which 9 correspond to ASEAN countries and 3 correspond to country aggregates, and 12 production sectors (Table 1). It is assumed that each production sector produces one unique commodity, except in the bottom-up power generation module that different electricity generation technologies produce electricity. As one of the most CO_2 polluting sector in ASEAN countries, we disaggregate the model

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