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Assessing climate change mitigation proposals for Malaysia: Implications for emissions and abatement costs

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ABSTRACT

In accordance with the Paris Accord to cap global temperature rise to1.5°Celsius over the next 100 years, Malaysia submitted its Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) seeking to reduce emissions by 45% by 2030, which was changed to 2050 following the Marrakech Proclamation in 2016. This paper analyzes the implications of Malaysia's INDC and an additional proposal of continuing further climate control to cap temperature rise over the next century against the existing scenario in the country. The results show that the cumulative damage from climate change over the period 2010–2100 will amount to MYR2.1 billion under the present climatic regime. It will fall to MYR1.1 billion under scenario 2 and to MYR0.6 billion under scenario 3. Since the total abatement costs for scenario 2 (MYR14.3 billion) is close to that of scenario 3 (MYR14.6 billion) against the significant reduction in climate damage of the latter, the third proposal is the best alternative for Malaysia.

1. Introduction

Climate change was first scientifically investigated in the early 19th century when the melting of ice caps and other natural changes were first suspected to cause greenhouse gas (GHG) effect (Neumann, 1985; Fleming, 1990; Holli Riebeek, 2005). It was not until the late 19th century that scientists discovered that human emissions of greenhouse gases could adversely change the climate (Sawyer, 1972; Neville, 2007), which triggered a series of discussions on the dangers and mitigation measures to prevent them (Rhodes, 2016; Rajamani, 2016); Obergassel et al., 2016; Chaisson, 2008). However, mean temperatures over the globe reached a new peak in May 2016, which exceeded the highest 20th century peak by 0.87 °C (Brown et al., 2016; Rogelj et al., 2012; IPCC, 2013; Hansen et al., 2016; NOAA, 2016). Research shows that human activity is the prime cause of rising carbon concentration in the atmosphere (Den Elzen et al., 2016; Liu et al., 2015; Van Vuuren et al., 2016; Leygraf et al., 2016; Sigman et al., 2010), which is the main cause of global warming (McGrath, 2013; IPCC, 2013; NOAA, 2016; Kellstedt et al., 2008; Crutzen, 2006; Hautier et al., 2015; Rosenzweig et al., 2008; Foley et al., 2013; Beniston, 2016). Consequently, GHG emissions has been escalating (Reisinger et al., 2013; Romero-Lankao and Dodman, 2011; Tilman et al., 2011; Miles and Kapos, 2008). The WMO has confirmed that 2011–2015 was the hottest five-year period ever recorded in history, and expected 2016 to be hotter still with global average temperatures of 1.2 °C above the long-term average (Morena, 2016; COP 22; Frieler et al., 2013; Piao et al., 2010).

The UNFCCC has played a major role in sensitizing governments to formulate policies to reduce GHG emissions. Indeed, by 2016 it had organized 22 Conference of Parties (COP) by bringing together regional and world leaders to deliberate on capping temperature rise globally. It was at COP21 that the "Paris Accord" became a

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milestone in the history when 186 countries pledged to limit earth's temperature increase to 1.5^0 Celsius over the next century. This landmark agreement has provided a framework for meaningful progress towards climate mitigation (Farid et al., 2016; Burleson, 2016). These countries submitted emission reduction pledges, covering 96 percent of global emissions, and agreed on procedures for evaluating progress, and updating these pledges (Bodansky, 2016; Falkner, 2016; Le Quéré et al., 2016; Rogelj et al., 2016). Without mitigation of man-made climate change, global temperatures are projected to rise by about 3–4 °C over the pre-industrial levels by 2100 with risks of catastrophic warming (Christoff, 2016; Van Asselt, 2016). Many developing countries, (especially areas that are coastal or highly agriculture-dependent) are vulnerable to climate change impacts (Huq et al., 2015; Pettengell, 2010; Antwi-Agyei, Lahsen et al., 2010; Dulal et al., 2010; Khan et al., 2016). Hence, it is important to identify policies best suited for making progress on these man-made climate change mitigation pledges (Rajamani, 2016; Savaresi, 2016; Morgan et al., 2014; Clémençon, 2016). This exercise seeks to offer policy relevant findings to promote sustainable development.

Malaysia is an excellent laboratory to test proposals currently available to cap man-made carbon emissions as it has pledged to the UNFCCC to reduce GHG emissions intensity of GDP by 45% by 2050 relative to the emissions intensity of GDP in 2005, which consists of 35% on an unconditional basis and a further 10% on condition of obtaining climate finance from the developed countries to transfer technology and capacity building.[1] Quantitative targets are attractive, and their desirability in projecting emission prices is widely accepted, which is partly why the INDCs have a strong appeal as they state explicitly carbon pricing, and annual average emission targets even if actual emissions fluctuate to deviate from projected figures in reality. Potential revenues from carbon taxes also have an appeal on fiscal grounds. Therefore, the purpose of this paper is to analyze the climate change projections and abatement costs under two different scenarios against the no intervention scenario. The first scenario assumes that existing economic activities are continued unabated. The second scenario takes the revised INDC following the Marrakesh proclamation for Malaysia till 2050 and thereafter no new policies to reduce further carbon emissions. The third scenario takes on the full Paris Accord period to reduce carbon emissions so as to cap man-made temperature rise over the next century to 1.5 °C. The results will offer policymakers a useful set of results to formulate made-made climate change mitigation policies.

2. Materials and methods

This study uses a multidisciplinary top-down dynamic model with ‘Climate and Ecology’ variables that combine economic and earth science concepts. The modelling starts with a detailed description of variables that are deemed responsible for climate change with a focus on backstop technologies, abatement costs, and carbon concentration (e.g. ppm[2] under 650) and temperature cap below 1.5 °C over the next 100 years to analyse the long-run climate damage effects.[3] The study model considers three scenarios. The first is the business as usual scenario with no efforts to reverse climate change. The second uses Malaysia's INDC submitted to UNFCCC following the Marrakesh Proclamation with carbon concentration to be lowered from under 900 ppm[2] in 2005 to under 650 ppm[2] in 2050 and no additional interventions to reduce carbon emissions further. The third scenario focuses on initiatives to continue temperature capping over the next century to 1.5 °C.

Thus, the essential variables, such as the rate of social time preference, initial growth rate of backstop technology, level of total factor productivity, marginal atmospheric retention rate, emissions-output ratio, and discount rates are used to project long-run effects (see Appendix 1). This non-linear model also considers population growth rate, capital stock, fossil fuel stock, and cumulative improvement in energy efficiency.

Two major decision variables are considered in the ‘Climate and the Economy’ model, namely, (a) rate of physical capital (*K(t)*) accumulation (equation (1)) as a function of investment (*I(t)*) with depreciation rate (δ_k) to be substituted with green growth in future, and (b) rate of emissions control in the production function, *Q(t)* (e.g. equation (2)) with factor productivity, *A(t)* for GHGs over time with a damage, $\Omega(t)$and abatement cost, $\Lambda(t)$functions:

$$K(t) = I(t) + (1-\delta_k)K(t-1) \tag{1}$$

$$Q(t) = \Omega(t)[1-\Lambda(t)]A(t)K(t)^{\gamma}L(t)^{1-\gamma} \tag{2}$$

The two decision variables are closely linked with temperature limit over time (equations (3) and (4)), carbon-saving and capital accumulation for green financing. Capital accumulation is endogenously determined by optimizing the flow of vulnerability over time, while carbon-saving is endogenously linked with the abatement through alternative green technology adoption, and is modelled to reduce the ratio of carbon emission in the production process. Production is determined using the cross elasticity substitution (CES) and cross elasticity transformation (CET) productivity functions, which takes the form of either carbon-based or non-carbon-based energy in output production ratios over the long run. However, technology substitution and abatement costs will fall over time as a consequence of the switch from carbon-based to non-carbon-based technologies as the conventional energy option would become expensive due to rigorous climate change mitigation policies.

$$\begin{aligned} T_{AT} = T_{AT}(t-1) + \zeta_1\{F(t) - \zeta_2 T_{AT}(t-1) \\ - \zeta_3 T_{AT}(t-1)T_{LO}(t-1)\} \end{aligned} \tag{3}$$

$$T_{LO}(t) = T_{LO}(t-1) + \zeta_4\{T_{AT}(t-1) - T_{LO}(t-1)\} \tag{4}$$

The model projects economic growth of Malaysia by considering national growth, investment in capital, marginal damage of climate change, marginal cost of controlling climate damage, and backstop technologies and abatement costs against related climate effects and vulnerabilities based on three scenarios, namely, (a) climate change with no abatement (b) climate change under Malaysia's INDC submitted to UNFCCC following the Marrakesh Proclamation but no further reduction in carbon emissions after 2050, and (c) carbon concentrations targeted at capping temperature rise to 1.5 °C over the next 100 years. The details of variables, parameter definitions, notations of mathematical equations and units used in the estimation are shown in Appendix 1. The General Algebraic Modelling System (GAMS) software (Konopt 4 version) was used to run all the projections.

The assumptions of Hick's neutral technical change, i.e. perfect substitution between capital and labour that is assumed when projecting from input-output tables, and the technical coefficients estimated without due consideration to both incremental and radical innovations (see Schumpeter, 1934, 1943) does constrain the

[1] The Marrakesh proclamation also called for an injection of USD50 million from the developed nations to support temperature capping initiatives in the developing countries.

[2] PPM stands for parts particulate matters.

[3] This model runs using mathematical optimization with geometric algebraic modelling system (GAMS) programming.