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An economic and environmental assessment of future electricity generation mixes in Japan – an assessment using the E3MG macro-econometric model

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HIGHLIGHTS

- We modelled 12 scenarios for Japan with different shares for nuclear power and different emission targets.
- The results showed that phasing out nuclear power would have at most a very small reduction in GDP.
- If a carbon tax with revenue recycling is applied, there could be an increase in GDP.
- But the carbon price required to meet Japan's 25% emission reduction target is very high if the share of nuclear power is reduced.

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ABSTRACT

In this paper we consider future options for Japanese energy and climate policy. We assess the economic and environmental impacts of changing the share of electricity generated by nuclear power and varying the mid-term GHG targets. The quantitative approach we use is based on the global macro-econometric E3MG model.

Our analysis reveals that the cost of denuclearisation to Japanese GDP is close to zero, and for employment the impact is slightly positive. Our results also show a double-dividend effect if (revenue-neutral) carbon taxes are levied in order to meet the GHG reduction targets, and this double-dividend effect is largest in the scenarios without nuclear power. However, our analysis suggests that a very high carbon tax rate would have to be imposed in order to achieve a 25% reduction in GHG emissions in 2020 (compared to 1990 levels) while simultaneously phasing out nuclear power.

1. Introduction

This paper uses the global macro-econometric model E3MG to analyse the economic and environmental impacts of the three options for the share of nuclear power in electricity generation in 2030 proposed in the report *Options for Energy and the Environment* (hereafter referred to as *Options*) published in June 2012. We consider the impacts of the three options in the context of three possible mid-term targets for reducing greenhouse-gas (GHG) emissions (0%, −15% and −25% by 2020 compared to the 1990 level); and we also analyse the contribution of Environmental Tax Reform (ETR) to achieving these targets. The main aim of the analysis is to determine the costs for the Japanese economy arising from denuclearisation, ETR or a combination of both.

The Fukushima–Daiichi Nuclear Power Accident (the Fukushima Accident) of March 2011 made Japanese citizens aware of the dangers of nuclear power plants (NPPs). The Democratic Party of Japan (DPJ), which was then in government, had to respond to the public demand for denuclearisation, and so it reviewed the *Basic Energy Plan*. The *Options* report published in June 2012 proposed three options for the share of NPP in power generation in 2030 (0%, 15%, and 20%–25%). All three options were lower than the 45% share of NPP in 2030[1] that was envisaged in the most recent (June 2010) version of the *Basic Energy Plan*. After public discussion based on the *Options* report the *Innovative Energy and Environment Policy*, which declares "to implement all conceivable policy resources to enable zero NPP in the 2030s", was published in September 2012. Nevertheless, nuclear policy was not seen as a priority in the Lower House Election in December 2012 and the Upper House Election in July 2013; and this election resulted in

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[1] See The Energy and Environment Council (2012b).

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victory for the Liberal Democratic Party (LDP), which had previously promoted Japanese nuclear power. There is still much discussion about the direction of future energy policy and nuclear power in Japan.

When it comes to assessing the effects of denuclearisation on the Japanese economy, there are two opposing views. The first is that reducing the share of NPP in the energy mix will lead to higher costs and be harmful to the economy, while the second emphasises the potential beneficial effects of the promotion of renewable energies and energy conservation. Four institutes have carried out model-based analyses of the three options for reducing the NPP share and have found that a lower NPP share leads to a slightly worse economic performance and a small increase in electricity prices. These results are discussed in Section 3.

At the same time it is recognised that policy measures will be required to reduce GHG emissions. On this subject, the existing research shows that ETR, a policy that recycles the revenue from additional carbon/energy taxation by reducing other taxes in a revenue-neutral way, could have favourable impacts on economic indicators such as employment (see Section 4). However, as energy use in Japan is already quite efficient, the scope for emission reductions outside the power sector may be quite limited (Akimoto et al., 2010).

This paper analyses the possible effects of denuclearisation and ETR on Japan's economy and GHG emissions levels, and the interaction between the two policies. We apply the global macro-econometric model E3MG (Energy–Environment–Economy Model at the Global level), which is quite different to the CGE models that were used for the previous analysis (see Section 5). We use the scenario assumptions of *Options* as reference data so that our results can be compared with previous analyses.

Section 2 discusses the policy context in which this study has been carried out. Section 3 describes the three options in further detail, including the findings from previous analyses. In Section 4 we discuss ETR and the concept of the double dividend, and we introduce the E3MG model in Section 5. Sections 6 and 7 describe the scenarios that we assessed and present the results from the modelling exercise. Section 8 presents our conclusions.

The appendices contain further information about the assumptions that were used in forming the scenarios and about the E3MG model.

2. Review of energy policy after the Fukushima accident

The Fukushima Accident not only heightened concerns about the safety of NPP, but also raised doubts about its economic benefits. After Fukushima it became widely understood that NPP is not necessarily cheap if the risk of catastrophic accidents and its associated costs are taken into account. The report of the governmental Cost Estimation and Review Committee, published in December 2011, showed the generation cost of NPP to be at least 8.9 yen/kWh (taking into account the assumed costs of damage caused by a nuclear accident), compared to 9.5 yen/kWh for coal or 10.7 yen/kWh for gas (Cost Estimation and Review Committee, 2011; Matsuo, 2012). The report provides very important background material for this paper.

It is important to note that the marginal generation cost of existing NPP is very low, because the generation cost of NPP consists mainly of construction cost (sunk cost), while the risk of accidents or the associated costs of the policy are externalised[2]. This largely explains the considerable concern that, if generation were switched from NPP to combustion power plants, the costs of imported fuels would reduce the profits of power companies; and if the government were to permit the power companies to raise prices, this would impose additional burdens on companies and households, and perhaps lead to an economic downturn.

The former Prime Minister Kan Naoto, who was in charge of the response to the Fukushima Accident, announced that Japan would "break away from dependence on nuclear power"; and Parliament passed the Feed-in Tariff Law for Renewable Electric Energy in summer 2011. After the resignation of Kan Naoto, Noda Yoshihiko, who became Prime Minister in September 2011, set up the Energy and Environment Council in October 2011, under the National Policy Unit, which is chaired by the Prime Minister. The Council started the discussion of Japan's future energy policy, with a view to bring about substantial reductions in nuclear generation by 2030.

In June 2012 the Energy and Environment Council published its conclusions *Options for Energy and the Environment* (*Options*)[3]. This proposed for public discussion three options for the share of NPP in electricity generation in 2030 (0%, 15%, and 20%–25%). As background information, *Options* includes estimates of the potential impacts on electricity prices, real GDP and GHG emissions, as well as estimates of investment costs for renewable energies and energy conservation. These estimates were based on a modelling exercise, discussed in Section 3.

In July and August 2012 the Energy and Environment Council canvassed public opinion by holding public hearings, inviting public comments, and conducting a deliberative poll. The conclusion of the public discussions was that the zero-NPP scenario had the strongest support. Therefore, a policy plan based on the zero-NPP scenario was drawn up and published in September 2012 as the *Innovative Strategy for Energy and the Environment* (the *Strategy*)[4]. The *Strategy* sets out three principles for achieving the goal of zero NPP by 2030:

(1) The 40 years lifetime rule will be stringently applied.
(2) Only those nuclear power plants whose safety has been verified by the Nuclear Regulation Authority will be permitted to operate.
(3) No construction of new nuclear power plants will be permitted.

Faced by strong opposition to the zero-NPP policy from business groups, including Nihon Keidanren, the former government did not adopt the *Strategy* in Cabinet meeting.

Another consequence of the Fukushima Accident is that it has now become very difficult, or so it is widely believed, to achieve the de-facto official target of reducing GHG emissions by 25% of their 1990 level by 2020. The policies to achieve this target, set out in 2009 by the former Prime Minister Hatoyama Yukio, depended heavily on nuclear generation. The *Strategy* recognises this in the statement, "although the uncertainty of NPP operation means that we can only provide a range-estimate, under certain assumptions GHG emissions in 2020 will be between 5% and 9% below the 1990 level", instead of 25%. Duscha et al. (2013) suggests that Japan's emission reduction costs would increase by more than any other country's if nuclear power was phased out and, in November 2013, the Japanese government announced that it was effectively replacing the 25% GHG reduction target with a 3.1% increase target for 2020, based on a nuclear power share of zero (although this could be revised again).

[2] After deduction of capital cost the unit cost of NPP is 6.4 yen/kWh (Energy and Environment Council (2012b, p. 14). Fuel costs of Japanese NPP are about 1.0 yen/kWh including back-end costs for the direct disposal of spent nuclear fuels (Cost Estimation and Review Committee, 2011, p. 39).

[3] See Energy and Environment Council (2012a, 2012b).

[4] See Energy and Environment Council (2012c).

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