Energy, and Environmental and Economic Sustainability in East Asia – Policies and Institutional Reforms for a Sustainable Use of Energy, Water, and Other Resources

Introduction

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Overview

If the world is to move towards a sustainable future, developments in the East Asian region are crucial. The region currently accounts for about 35% of global CO_2 emissions and includes three of the top ten global emitter countries, including the one with the highest emissions levels, China. The region accounts for a substantial and, in many cases, growing share of global material consumption; for example, China, Japan and South Korea(Korea, hereafter) remain as four of the world's top five producers of steel. Pressures on freshwater resources have been illustrated by the South-North Water Transfer Project in China. Air pollution in China is estimated to kill up to more than one million people per year[1].

The aim of this book is to demonstrate the necessary direction of an institutional reform for the use of energy and resources towards a sustainable future in East Asia. We consider four countries in the region (China, Japan, Korea and Taiwan)[2], each of which sets its own national policy. However, all of them also show a growing degree of mutual reliance in both economic terms and environmental sustainability.

In this book, we analyze the impact of different policies that can be used to address climate change and sustainability in East Asia. Through theoretical and empirical modelling, we estimate quantitatively the environmental and economic impacts from the introduction of such policies. In the field of climate policy, we consider a range of policies – including carbon taxes, energy efficiency-related mandates, measures to promote renewable energy forms and many more – with

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[1] https://www.scmp.com/news/china/science/article/2166542/air-pollution-killing-1-million-people-and-costing-chinese

[2] For convenience, we regard Taiwan as country in this book but do not make a judgment on its political status.

the aim of achieving long-term targets of emission reduction in East Asia that are consistent with the global target of a less than 2°C rise in temperature.

We then consider how climate policy might interact with other areas of sustainability in East Asia, including impacts on air quality, material and fresh water consumption. We show that interactions are complex and there might be a need for further policies to alleviate different environmental pressures.

Throughout this book we also evaluate the ripple effects of environmental and resource policies on each East Asian country's economy. We conclude with a set of recommendations on the direction of institutional reforms regarding energy systems and natural resource management in East Asia, and a desirable policy cooperation for a sustainable future.

The main analytical tool used in our analysis is the state-of-the-art E3ME-FTT model (see Chapter 1). The E3ME model is one of the largest macroeconomic models in the world that is able to divide each East Asian economy into 43 sectors. It integrates the economy, labor market and different aspects of sustainability – e.g. energy and material consumption. E3ME is well-established in the analysis of climate policy and resource efficiency, and is used frequently by the European Commission for its 'Impact Assessment' of new policy measures. The model is also used by national governments to assess proposed new policies. As described in Chapter 1, E3ME is highly empirical and based on theory that is different to that in the standard Computable General Equilibrium (CGE) model typically used for environmental policy analysis.

The E3ME model is linked to four bottom-up models of technology diffusion (Future Technology Transformation, FTT) for power generation, steel industry, road transport and heating. These models, which were originally developed by Jean-Francois Mercure (Exeter and Cambridge University, UK), simulate the diffusion of technology, which is crucial in any ambitious climate scenario. They are linked to E3ME to provide a micro-level technology representation.
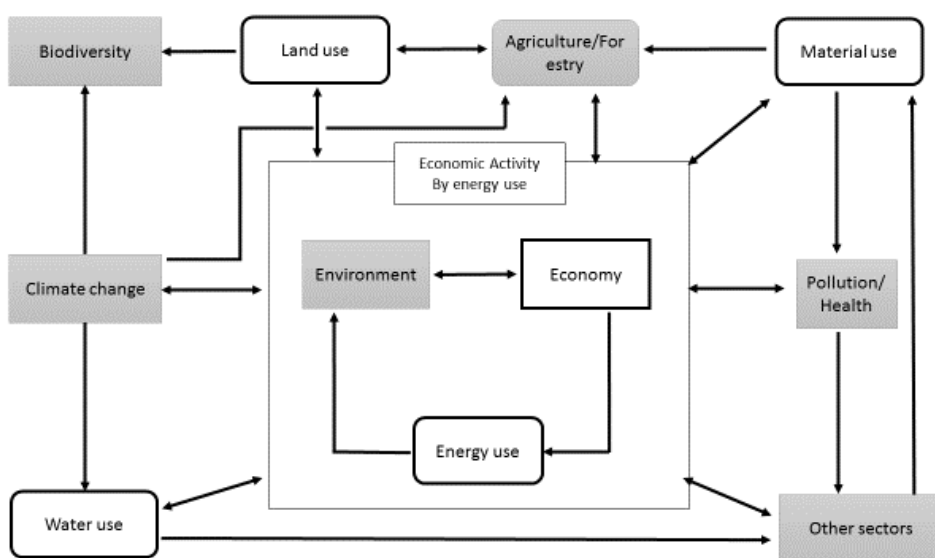
The complete integrated modeling framework is able to provide a wide range of policy analyses that are potentially of high interest to other researchers as well as policy makers. Throughout this book we also refer frequently to the underlying post-Keynesian and Schumpeterian theory that underpins the modelling, which is designed to provide educational value.

Background and aim of the book

This book builds on previous work by the same team, also published as a book (Lee, Pollitt and Park (2015). *Low-carbon, Sustainable Future in East Asia: Improving energy systems, taxation and policy cooperation*). The previous book assessed how mid-term CO_2 emissions targets in 2030 could be met in East Asia through reform of the power generation sector and taxation systems. The current book assesses how, in light of the acceptance of the long-term emissions targets by 2050 under the Paris climate agreement, East Asia can develop in a way, such that emissions are reduced without putting pressure on other environmental resources such as mineral resources and water, while at the same time promoting economic prosperity. It therefore adds a long-term perspective to the previous analysis and also considers use of energy and material resources in the context of a broader sustainable development strategy.

As noted above, it is recognized that environmental problems are already emerging in the East Asia region. These are due to mass consumption, rising energy demand, resource depletion, and uneven allocation of water usage (including virtual water transfers in trade) – major threats to sustainability in East Asia and that could give rise to resource nationalism. Addressing them at a cross-border regional level is, therefore, an urgent matter. Furthermore, greenhouse gases, and pollutants generated through energy, water, mineral resource and land use are having harmful impacts on the climate, agricultural output and health. The effects extend to biodiversity, society and culture (Figure 1).

Figure 1: Nexus between economy, Energy, resources and pollution

These issues are closely interwoven; for example, there is reciprocity among energy, water and resource consumption, and competition between agricultural production and biomass resources.

It is essential to understand problems relating to all these resources from a comprehensive perspective. A great deal of previous research has tackled these individual issues at the country level. However, there are few examples of comprehensive investigations based on the situation as it pertains to the East Asian region.

The analysis in this book is the result of a long-standing collaboration between researchers in East Asia and the UK. Over the past eight years, Research Group for East Asia Environmental Policy Studies (REEPS) and Cambridge Econometrics developed a version of the E3ME-FTT model to specifically analyze the East Asian region (E3ME-FTT-Asia). The scenarios presented in this book are the results of that effort.

Significance and summary of this book

This book consists of three parts, providing answers to the following key questions:

- How to build a sustainable, low-carbon power generation sector that does not dependent on nuclear power and that is economically viable?
- How to promote innovation in low-carbon technologies in final energy use, so as to keep East Asia consistent with the Paris climate agreement?
- How to promote efficient use of other natural resources to reduce environmental pressures across the region?

We hope that this book will contribute to the development of policy packages to boost renewable energy, innovation of low carbon technologies and resource efficiency in East Asia, thereby, putting the region on a path towards a sustainable future. We test a variety of different policies, including market-based instruments, regulatory policies and measures to boost the adoption of key technologies. Policy simulations that use a large-scale macro-econometric model facilitate the provision of persuasive analysis in areas such as provision of low-carbon, resource-efficient social infrastructure; investment in technological development, and deployment and more-efficient use of water and material resources.

As noticed above, East Asia is increasingly interdependent, not just in economic terms but also in terms of energy, resources and the environment. We aim for this research to contribute to a close energy and environmental cooperation in East Asia and, ultimately, the establishment of an East Asian Community, thereby, contributing to peace in the region.

Abstracts

Chapter 1. Modelling the book : Introduction to the E3ME and FTT models

by Hector Pollitt et al.

Throughout this book, computer modeling is used to illustrate the effectiveness of different public policies. Specifically, we draw upon results from the E3ME macro-econometric model and the FTT (Future Technology Transformations) energy technology bottom up sub models that are linked to E3ME. This chapter introduces the E3ME model and provides a set of references for further reading.

The modelling approach in E3ME is compared to the more common Computable General Equilibrium (CGE) approach that is often used for economic analysis. We discuss the key underlying assumptions relating to human behavior and the operation of economic markets, and show how they may impact on the results of the analysis. Finally, we introduce the FTT family of models, which is used extensively in the second part of the book.

Part 1 – Building low carbon power generation while simultaneously reducing the role of nuclear power generation

The power sector remains the single largest contributor to CO_2 emissions in East Asia. If carbon targets for 2030 and 2050 are to be met, it is clear that the power sector must reduce emissions substantially. Its main options for doing this are shifting to renewable generation, or expanding the role of nuclear power.

The future of nuclear in East Asia remains controversial. Since the 2011 Fukushima accident, many of Japan's existing nuclear plants have remained closed and there is strong opposition to new plants being built. In contrast, China and Korea still consider nuclear power to be the centrepiece of their low-carbon policies, and have maintained their plans for nuclear power (although with less support from the current Korean government). In Taiwan, the government's denuclearization policy was rejected by its people in a referendum in December 2018.

Increases in the use of nuclear power pose substantial potential safety risks to neighbouring countries. Ever-increasing costs have also made nuclear power less attractive economically; in 2018-19, Japanese companies abandoned plans to build new plants in Turkey(Mitsubishi) and the

UK(Hitachi). However, at the same time pressure to move away from fossil fuel generation and, in particular, coal-fired plants (due to air quality issues) has been growing.

Part 1 of this book describes and assesses the environmental and economic impacts of policies that are aimed at developing a sustainable, low-carbon power generation system by 2050 in East Asia(in Chapter 2 and 3). The policies that we consider include direct coal and nuclear regulations, feed-in-tariffs to promote renewable generation and carbon taxes to promote low-carbon development more generally(in Chapter 4).

Chapter 2. Regulation policies to reduce the amount of nuclear and coal-fired power generation in East Asia

by Aiko Azuma et al.

This chapter investigates the effects of nuclear and coal power regulation on future power generation mixes and CO_2 emissions in East Asia. We apply the E3ME model, linked to the FTT:Power model, to carry out the analysis. The model results indicate that a phasing out of nuclear power without further policy is likely to result in increases in electricity generation from coal, and does not therefore contribute much to the diffusion of renewable technologies. If policy focuses only on phasing out coal, we see a similar pattern of results. Without further policy, a reduction in coal power generation results in a higher nuclear share (and also in gas-fired generation).

However, in a combined scenario that phases out coal and nuclear power simultaneously, there is an increase in the use of renewables. Our analysis concludes that strong and integrated regulation is required and that there may be an important role for further measures to promote renewables specifically (picked up in Chapter 4). These measures must be considered in the context of long-term climate targets.

Chapter 3. The economic impacts of reduced reliance on coal and nuclear power generation in East Asia

by Soocheol Lee et al.

In this chapter, we build on the results from Chapter 2 and carry out an economic analysis of the impacts of reducing the shares of coal and nuclear power in the electricity sector's fuel mix. Based on results from the E3ME model, we present impacts on key indicators, including GDP and employment, alongside the environmental impacts of the scenario.

We show that reductions in the use of nuclear and coal power would lead to higher electricity prices, which could have a negative socio-economic impact. However, the negative impacts are offset by increased investment in renewables and an improvement to trade balances through reduced levels of fossil fuel imports. The conclusion is that for the power sector it would be possible to reduce emissions substantially, while simultaneously increasing prosperity in East Asia.

Chapter 4. The impacts of combined policies to promote sustainable low carbon power generation in East Asia

by Tae-Yeoun Lee et al.

Chapters 2 and 3 demonstrated the potential benefits of regulations to reduce the use of coal and nuclear power in East Asia. However, these measures may not be the most effective at promoting the use of renewables, which is seen as key to meeting long-term climate targets. In this chapter we expand the potential set of policies by covering carbon taxes and specific support mechanisms for renewables in the form of Feed-in-Tariffs.

Using the E3ME and FTT models, we assess how these policies could promote the use of renewables and reduce coal power generation in each East Asian country. We find that, when combined with a phase-out of coal power and carbon tax, they can be effective at reducing CO_2 emission and increase renewable energy. Furthermore, we find that there are small economic impacts from implementing the policies.

Part 2 – Innovating to reduce CO2 emissions and promote low carbon technologies in industry, transport and buildings

While near-complete decarbonisation of the power sector by 2050 will be necessary for meeting long-term climate goals, emissions from other sectors must also be reduced. In Part 2 of this book we turn attention to these other sectors.

Reducing emissions in these sectors is a considerable challenge. The technological options vary between sectors and in many cases are not yet established in the market place – or may not exist at all. However, the same principles of technology development and diffusion apply and therefore there is scope to apply a similar modelling approach to that for the power sector.

The nature of the challenge also has policy implications, which the modelling demonstrates. We start Part 2 of the book with an economy-wide carbon tax scenario in Chapter 5. We find that

it is impossible to meet East Asia's emissions reduction targets through a carbon tax alone (at least within a reasonable price range). However, when the carbon taxes are accompanied by measures to promote the use of specific technologies, the targets become not only possible, but apparently feasible with only moderate carbon prices.

Part 2 of the book therefore takes us through some of the key sectors of the economy in terms of decarbonisation. Using three FTT models(FTT: Steel in Chapter 6, FTT: Transport in Chapter 7, FTT: Heat in Chapter 8), we explore the policy options needed to support each stage of the innovation cycle in each sector. We will show that carbon taxes with a policy mix of regulations and subsidies applied to the steel, transport and heating sectors boost the uptake of low-carbon technologies.

The final two chapters in Part 2 address two specific issues that relate to the low-carbon transition. Chapter 9 discusses how the revenues from carbon pricing measures might be used to boost economic performance at the same time as lower emissions, that is 'double dividend'. Chapter 10 describes the issue of finance more generally (and how it is modelled), demonstrating how it plays a crucial role not just in enabling the transition but in determining its economic impacts.

Chapter 5. Policy mixes to meet the low-carbon emission reduction targets across the whole economy in East Asia

by Hector Pollitt et al.

The adoption of the Paris Agreement laid out emission reduction targets for East Asian countries in 2030 and the world as a whole in 2050. Policy makers now face the question of how best to reduce emissions to meet these targets, while still promoting economic development and national prosperity. Economists often recommend carbon pricing measures as being the most efficient policy option but, from a policy maker's perspective, carbon pricing alone may not be attractive, or even feasible.

In this chapter we assess a range of options and show that a combination of instruments including carbon taxes, low carbon subsidies and regulations is likely to produce the best results for national economies in East Asia. While some pricing measure appears necessary, our modelling approach shows that implementing a mix of measures could reduce the necessary carbon price required to meet long-term emission reduction targets, benefitting energy-intensive

industries. Our conclusion is that the modelling tools used by economists must be able to assess a range of different policies, so as to meet the current requirements of policy makers.

Chapter 6. Decarbonizing the East Asian steel industry in 2050 using E3ME-FTT:Steel

by Pim Vercoulen et al.

The iron and steel sector accounts for around 30% of total industrial emissions in East Asian countries. They are among the largest producers of crude steel and also produce a large share of the emissions. Unless there is a large unexpected fall in steel demand, innovation within the sector is required to curb the carbon intensity of crude steel production; otherwise the long-term emission reduction targets will become unattainable. From a policy maker's perspective, the key question is how to incentivize the required technological shift.

In this chapter we apply the FTT:Steel model for the first time and test a set of carbon tax scenarios. The model results show that the carbon taxes cause some shift in the choices of technologies used, but not by a sufficient amount to meet emission reduction targets. We also see some economic costs, due to higher costs of production and prices for steel.The technology transitions that do occur tend to be within technology groups, for example by adding CCS or switching to biofuel inputs. This finding give some clues to the further policies that are required, for example support to particular nascent technologies. At this time, however, this points to a direction for further research.

Chapter 7. Policies to decarbonize passenger vehicles in East Asia using E3ME-FTT:Transport

by Aileen Lam et al.

As the power sector decarbonizes, road transport is likely to become the single largest source of CO_2 emissions globally. Road transport is therefore a high-priority sector to decarbonize. In this chapter we apply the FTT:Transport technology diffusion model, linked to the E3ME macro-econometric model, to study possible future technological transitions in personal passenger transport.

Similarly to the other chapters in Part 2 of the book, we define a set of scenarios based on carbon taxes and a combination of other policies, here including fuel taxes and subsidies for electric vehicles. We find that although the uptake of low-carbon vehicles is already underway, it will need to speed up considerably to meet emission reduction targets through the widespread adoption of electric vehicles. A comprehensive set of policies will be required to make this happen and, again similarly to the findings of other chapters, the interaction of these policies is important.

Chapter 8. Policies to decarbonize household heating systems in East Asia using FTT:Heat

by Florian Knobloch et al.

Household heating is recognized as one of the most challenging sectors to decarbonise. There is strong inertia in the system, which is made up of many small actors and in which low-carbon technologies are not well established. In many parts of the world, policy makers are only just beginning to tackle emission reductions in the sector.

In this chapter, we apply the FTT:Heat model of technology diffusion within household heating to assess policies to promote low-carbon heating systems. Our results show that a decarbonisation of residential heating in East Asia is achievable by 2050, based on existing technologies, and assuming improved insulation of houses. However, such a decarbonisation requires substantial policy efforts from 2020 onwards, involving both residential carbon taxes and subsidy payments for renewable heating options. As in the other chapters, policy mixes are projected to be more effective than a sole carbon tax for driving the take-up of low-carbon systems. Such mixes could lead to a combination of both lower emission levels and reduced cost burdens for households.

Chapter 9. Using the revenues from carbon pricing measures as a part of Environmental Tax Reform in East Asia

by Unnada Chewpreecha et al.

In this chapter, we use the ambitious policy mix scenario of Chapter 5 as our starting point. The scenario achieves the ambitious 2°C target in 2050 in the four East Asia regions and the main price-based instrument is the carbon tax, which generates revenue for national governments. Our analysis in this chapter consists of scenarios that are designed to enforce budget neutrality.

We explore different ways in which the revenues from carbon taxes might be used to reduce other tax rates, i.e. through Environmental Tax Reform (ETR). The options for other taxes to reduce are income taxes, VAT, and employers' social security contributions. Additionally, we also look at a scenario where revenues are recycled back as lump-sum payments to households as a basic income. The analysis is carried out using the E3ME model, with the same set-up that was used in Chapter 5. It shows that a carbon tax as part of ETR could lead to a smaller loss of GDP than the carbon tax alone or could lead to an overall increase in GDP.

Chapter 10. Financing the low-carbon transition

by   Hector Pollitt   et al.

In Chapter 5, we showed that it is possible for the countries in East Asia to reduce emissions to levels that are consistent with the world limiting average temperature changes to below 2°C. The model results also allude to substantial shifts in resources, for example in the types of technologies used, or the level of output in the different sectors in the model. It is therefore reasonable to ask how much investment will be needed to bring about such a shift, and where the financing for that investment might come from.

This chapter explores these questions, drawing on the previous model results. It also discusses how, in the process of transition there could be debt defaults and the possibility of 'stranded' fossil fuel assets. Although the countries in East Asia are not heavily exposed to the fossil fuel sector, they could be affected if there was a wider global recession caused by a sudden loss of value in stocks. Finally, the chapter explores how large-scale investment-debt dynamics can drive economic growth in the short term, but lead to slower rates of growth in the long term. The results from E3ME are contrasted to the results often obtained to standard Computable General Equilibrium models to highlight the importance of considering the financial system.

Part 3 – Wider sustainability issues: Reducing water and material consumption, and improving air quality

Environmental sustainability covers a much wider range of issues than reducing carbon emissions and (hopefully) rates of global warming. Part 3 of this book widens the policy discussion to investigate how consumption levels of material and water resources could be reduced. It also considers issues of air quality and the effects of air quality on human health.

Current trends in increases in water and material consumption in the East Asian region are driven by economic development. The 'decoupling' of economic and resource consumption has

not yet taken place. Unlike in energy consumption, where the potential use of renewables may be near infinite, there are fixed limits on the availability of these other resources.

In general, resource use has been researched much less than energy consumption and emissions but in Chapters 11 and 12 we take some first steps in East Asia. Both chapters consider the interactions between energy consumption and the use of other resources and test tax instruments that could reduce consumption. We assess these taxes in the E3ME model.

Chapter 13 assesses the impacts of reduced particulate (PM) and sulphur emissions on human health. This chapter again draws on the modelling results from Chapter 5 and discusses the 'co-benefits' of reducing greenhouse gas emissions and air pollution simultaneously. It also considers how 'transboundary' emissions can affect human health across the East Asian region. The conclusion is that more policy integration may be required.

Chapter 11. Interactions between energy and material consumption in East Asia

by Hector Pollitt. et al.

East Asia is a net importers of raw materials and economic growth is driving increased rates of consumption. This chapter sets a focus on damages to the natural environment given by use of raw materials, which include: limited availability of natural resources and resource depletion, environmental destruction by resource mining, and environmental loads caused by economic activities related to resource mining.

This chapter explores some of the key linkage between energy and material consumption, including the potential resource requirements of reducing greenhouse gas emissions. Using the E3ME model, we estimate the economic and environmental impacts of applying a material (or resource) tax. We find that a simple material tax is effective at reducing material consumption, but it may give negative economic effects. A broader range of policy options, however, may mitigate some of these negative economic effects and could even lead to positive impacts on GDP.

Chapter 12. Sustainable use of water resources in East Asia

by Kiyoshi Fujikawa et al.

In recent decades, globalization has led to trade volumes of goods expanding at a faster rate than GDP. The trade volume of 'virtual water' (water embedded in traded goods) has also increased; in some regions globalization may be promoting water shortages.

In this chapter we explore the most recent data on the issue. We find that China 's water trade surplus expanded between 1995 and 2009, while the water trade deficit in the USA and EU widened sharply. It could therefore be said that the EU and the US have contributed to the drying of China.

To improve the sustainability of water use, this chapter uses the E3ME model to assess the effects of a tax on water consumption. We apply a 40% tax on water consumption from the public supply, which is levied on all industrial sectors that use water. The water tax is imposed for eight years starting in 2020. We find that water demand could be reduced by about 10%, with minimal economic loss.

Chapter 13. Transboundary air pollution and its health effects in East Asia

By Akihiro Chiashi et al.

Even though PM air pollution has been identified as a serious health hazard in China, Korea, and in parts of Japan, the allocation of responsibility has become a hindrance to negotiation and cooperation. As result, no international regime for PM mitigation so far has yet been established. This chapter observes the current situation of pollution and health hazards given by transboundary PM movement in China, Japan and Korea, and then explores potential for policy coordination to reduce air pollution based on an analysis using the E3ME model.

In the baseline case, emissions of air pollutants are expected to increase due to increased fossil fuel consumption and economic expansion. However, we find that, when climate change mitigation policies are implemented to discourage fossil fuel consumption (building on the results of Chapter 5), large reductions of air pollutants can be realized. China and Japan could reduce their direct PM emissions by 35% and 25% respectively while Korea could reduce direct PM emissions by as much as 61%.

Chapter 14. Concluding remarks and future challenges toward policy cooperation in East Asia

By Soocheol Lee et al.

We attempt to clarify the current state of understanding and direction of policies regarding three issues—the decarbonisation of power generation sector(Part 1), low carbon technological diffusion across the economy (Part 2), and resource conservation and PM air pollution problem (Part 3)—based on insights drawn from the investigations presented in this book. Each of the individual chapters in this book has used advanced modelling techniques to assess the effects of potential policies to improve sustainability in East Asia. In the final chapter of this book, the editors consolidate the key findings from the individual chapters. We make a set of policy recommendations for future policy in the region. We also reflect on the modelling that was carried out and how it may compare to similar exercises using different approaches.