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Green Innovation and Finance in Asia

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Title

Green innovation and finance in Asia

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Highlights

- Environmentally adjusted multifactor productivity growth trends in China, Korea, and India outstripped those of the U.S., the U.K., Japan, and Germany
- Japan led global green patent registrations, while registrations increased markedly in China and Korea since the turn of the 21st century
- Green bond and green foreign direct investment (FDI) in Asian economies expanded considerably
- Revenue growth of large firms in Japan, China, and Korea generally coincided with increased environment, social, and governance (ESG) information disclosure

Abstract

Green innovation and green finance are two key components of sustainable development. In the most populous, fastest growing region in the world, Asian countries are pressed to maintain economic growth while addressing climate change and environmental externalities. Japan, South Korea, China, and India have each implemented policies to promote green innovation and finance conducive to such ends. While each country possesses unique capabilities, there is a growing imperative for them to increase their environmentally adjusted multifactor productivity, green patents, green bond issuances, green foreign direct investment, and environmental, social, and governance information disclosures to successfully shift to sustainable growth paradigms.

Keywords

environmentally adjusted multifactor productivity; green patents; green bonds; green FDI; ESG information disclosure

1. Introduction

Against the backdrop of expanding global economic activity, there are growing concerns about climate change, natural resource scarcity, and a multitude of widespread environmental challenges. Many industries undertake corporate social responsibility (CSR) initiatives and pursue sustainable production alternatives to mitigate the environmental risks inherent in their operations (Korhonen, 2001). Green or eco-innovation have become increasingly central to corporate management and coordination of activities (Fujii and Managi, 2013).

The Organization for Economic Cooperation and Development (OECD) defines green or eco-innovation as “the development of products (goods and services), processes, marketing methods, organizational structure, and new or improved institutional arrangements which, intentionally or not, contribute to a reduction of environmental impact in comparison with alternative practices” (OECD, 2009b). Complementary to the green innovation process are green finance mechanisms that shore up public and private financial capital for product research, development, and diffusion. At its core, green finance comprises “all forms of investment or lending that consider environmental effects and enhance environmental sustainability” (Volz et al., 2015).

In recent years, green innovation and finance are of increasing importance to Asian economies with resource and carbon intensive growth models. Most developing Asian economies are more carbon intensive than their advanced economy counterparts. This can be inferred from Figures 1 and 2, where the precipitous growth of total primary energy consumption (TPES) and the concomitant spike in carbon dioxide (CO₂) emissions in China and Asia reveal their higher carbon intensity compared with OECD countries, Japan, and the rest of the world. Note, specifically, the most pronounced growth periods between 2000 to 2015. While China’s TPES increased by nearly 200% from 48.87 million terajoules (TJ) to 125.07 million TJ, greater Asian TPES grew by nearly 100% from 144.63 million TJ to 272.66 million TJ. This greatly surpasses the respective OECD and global TPES growth rates of -1% and 42%.

Regarding CO₂ emissions, China experienced a nearly 300% increase from 3,127 million tonnes of CO₂ (mtCO₂) to 9,085 mtCO₂ emissions over the aforementioned period. At the same time, greater Asia demonstrated a more than 150% increase from 8,156 mtCO₂ to 17,259 mtCO₂.

These growth rates once again outstrip changes in OECD and global CO₂ emissions, which demonstrated -7% and 54%, respectively.

TPES and CO₂ emissions growth throughout Asia coincided with the 12% population increase from just 1.7 billion to over 2 billion over the same period (World Bank, 2019). This positioned Asia as the most populous region on the planet. Yet many developing Asian countries are among the most vulnerable to climate change and lack the economic, social, and governance means to improve resilience. Considering the substantial energy demand that will accompany the Asian population boom that is forecasted to surpass 5 billion by 2030 (United Nations, 2015), Asia is pressed to leverage green finance for sustainable energy and other low-carbon green innovation conducive to climate change mitigation and adaptation.

Bridging the green innovation finance gap in Asia will be no simple feat. The Asian Development Bank (ADB) estimates that there is a \$3.6 trillion gap in climate-resilient infrastructure investments throughout 45 of its member countries (ADB, 2017). Similarly, the Association of Southeast Asian Nations (ASEAN) and the United Nations Conference on Trade and Development (UNCTAD) expect Asian countries will require \$110 billion in yearly investments in power, transport, information and communication technology, water, and sanitation infrastructure through the year 2025 (ASEAN and UNCTAD, 2015). Deriving modern, localized solutions to these challenges requires a holistic analysis of green finance and innovations.

The aim of this paper, therefore, is to review the state of green innovation and finance throughout Asia. In doing so, this paper compares recent trends in major Asian economies with those of other regions and provides a comprehensive overview of country and firm-level developments. It also outlines the relevant policies that fundamentally influence such developments. Furthermore, this paper outlines both conventional and “up-and-coming” financial mechanisms that will continue to spur specific green innovations through the future. Overall, the analysis highlights both objective and subjective priorities for expediting and expanding green finance and innovation throughout Asia.

The remainder of this paper is structured as follows. Chapter 2 compares the green growth and patent trends in select Asian and Western economies. Chapter 3 describes recent green bond, green foreign direct investment (FDI), and firm-level environmental, social, and governance (ESG) performance trends in select economies. Chapter 4 outlines the policies

behind green economies and green growth. Finally, Chapter 5 provides concluding remarks and suggestions for future studies.

2. Green growth, innovation, and patents

2.1. Overview of green growth

The OECD (2011) describes the central tenets of green growth as “fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies.” In order to accomplish this, it adds, green growth must “catalyze investment and innovation which will underpin sustained growth and give rise to new economic opportunities” (OECD, 2019). Examining a nation’s green growth, therefore, sheds light on the green technology and process innovations at its core.

Measuring a country’s green growth requires a thorough assessment of a broad basket of indicators. The OECD (2014) groups “green growth indicators” into four categories: 1) those that monitor an economy’s environmental and resource productivity; 2) those that describe a country’s natural asset base; 3) those that monitor environmental dimensions of the quality of life of a nation’s citizenry; and 4) those that capture both policy responses and economic opportunities. Though the number of indicators in each category can be adjusted to account for the particular conditions and circumstances of an economy, a number of indicators are regularly applied.

2.2. Environmentally adjusted multifactor productivity (EAMFP)

As a growth indicator, multifactor productivity measures labor, produced capital, and other factor inputs through an underlying production function. Still, this leaves “a need for an unbiased measure of productivity that accurately captures the economic impacts of environmental protection” (Nanere et al., 2007). As such, environmentally adjusted multifactor productivity (EAMFP) “measures a country’s ability to generate income from a given set of inputs, while accounting for the consumption of natural resources and production of undesirable environmental outputs” (Cárdenas Rodríguez et al., 2018). More specifically, growth of EAMFP “measures the residual growth in the joint production of both desirable and undesirable outputs that cannot be explained by changes in the consumption of factor inputs (including labor, produced capital and natural capital)” (Cárdenas Rodríguez et al., 2018). By measuring both the

extent to which a country's output growth is attributable to domestic natural resource use and correcting the value of a country's gross domestic product (GDP) growth with reference to pollution abatement activities, EAMFP could proxy for green growth.

Figure 3 depicts EAMFP growth for seven major economies. China experienced explosive growth, with the largest, 41.63% growth rate from 1991 through 2003. Regarding this, Fujii et al. (2015) note that productivity in Chinese industrial sectors increased largely due to greater environmental and economic performance improvements between 1992 and 2008. Korea's growth trend is one of the most remarkable, rising by roughly 65% from 1991 to 2012. While Germany, the United States, and the United Kingdom each demonstrated roughly 40% growth from 1991 to 2013, Japan experienced the lowest level of 24.87% growth over the same period. India's growth from a local low of -3.3% from 1991 to 1992 to 45.96% by 2013 is notable especially when compared with developed countries levels.

Overall, the substantially greater EAMFP growth throughout Asian economies suggests that green innovation significantly impacted economic growth. As developing countries, China, South Korea, and India start from positions of comparatively lower EAMFP. They also show higher potential to reduce CO₂ emissions at lower cost and increase their productivity through improving technological adoption, property rights, and contracting rights (Kumar and Managi, 2014), they demonstrate promising potential for EAMFP growth in coming years.

2.3. *Overview of green innovation*

Fundamental to any overarching green growth strategy is green innovation. Green innovation encompasses new products, processes, and business models that allow firms to meet the environmental, economic, and social performance aspects (e.g. the "triple bottom line") of sustainable development (Fujii and Managi, 2019). Studies show that green innovation is an important driver of toxic emission reductions (Carrión-Flores and Inne, 2010). Firms that effectively adopt green innovations induce technological spillovers that lead to higher green innovation in their region (Antonioli et al., 2016) and improved interregional environmental performance (Constantini et al., 2013). Furthermore, green innovating firms reduce or avoid environmental damages and stand to improve their reputation and financial viability (Johnstone et al., 2017). As a concept, green innovation extends circular economy reasoning to include value creation and resource use. Not only does this encompass new business models and consumer

behaviors, it also drives technology and process transfers to the emerging countries aspiring to OECD income levels as the global community addresses climate change (Crespi et al., 2016).

2.4. *Green patents*

Green or environmentally related patents are often associated with energy intensity improvements (Wurwood and Noailly, 2018) and more broadly indicate the progress of green innovation (Haščiči and Migottoi, 2015). In general, patent data provide inherent advantages compared to alternative measures of innovation, including that:

- 1) It is commensurable and based on objective standards;
- 2) It measures intermediate outputs of the inventive process;
- 3) It is quantitative and thus highly conducive to statistical analysis;
- 4) It is widely available in the public domain; and
- 5) It can be disaggregated into specific technological fields to assess very specific environmental outcomes (Haščiči and Migottoi, 2015).

The OECD classifies green patent data based on the technologies related to achieving four policy objectives: 1) air, water pollution, waste disposal, and other “traditional domains” of environmental management; 2) adaptation to water scarcity; 3) protection for ecosystem health and biodiversity; and 4) energy, greenhouse gas emissions abatement, transportation, and buildings conducive to climate change mitigation (OECD, 2014).

The OECD triadic patent families is a set of patents from the European Patent Office (EPO), Japan Patent Office (JPO), and US Patent and Trademark Office (USPTO) that protect the same invention. In light of the statistical limitations of individual patent office data, the data from the triadic patent family enhances international comparability and improves the quality of patent indicators in three major ways. First, since only patents applied for in all three are included in the dataset, they eliminate home advantage and geographical location influences. Second, since patentees only accept additional costs and delays to international extension of patent protections if they are worthwhile, patents in the triadic families are typically of higher value: Finally, as they are counted according to the first patent application worldwide, the domicile of the patentee, and fractional counts, they more clearly reflect country-level inventive performance (OECD, 2009b).

Figure 4 provides an overview of OECD triadic patent family-sourced global and country-level environment-related (green) technology patents between 1985 and 2013. Beyond the marked upward trend in global patenting, the figure clearly demonstrates that Asian countries have led this growth and that a few have, in recent years, consistently increased their relative share of global green patents. Specifically, global patents rose by 600% from 1,396 in 1985 to a peak of 6,487 by 2010. Much of this upswing occurred in Japan, where the number of patents increased by nine times from 322 to 2,854 over the same period.

The United States and Germany also consistently demonstrated large numbers of annual patents. The former rose from 441 in 1985 to peak at 1,221 by 2009, while the latter grew from 255 in 1985 to peak at 729 by 2009. Regarding Asian economies, South Korean patents increased from just 2 in 1985 to over 354 by 2013 while Chinese patents grew from just 1 to 133 over the same period. These trends, alongside negligible patent activity in India, suggest that there is great room for green patent-led growth throughout Asia.

As a global leader in patent registrations, Japan produced more green patents than the U.S. and Germany combined from the early 2000s onward. In fact, between the years 2005 to 2009, Japanese firms dominated the green technology patent arena, yielding 32% of all green patents registered with the USPTO. Specifically, Panasonic Corp. (579 patents), Honda Motor Co. Ltd. (396 patents), Toyota Motor Co. (316), Sony Corp. (248 patents), Nissan Motor Co. Ltd. (229 patents), and Hitachi Ltd. (159 patents) were among the top 10 green patent producing companies (Breitzman and Thomas, 2011).

Beyond the number of green patents previously discussed, the Korea Intellectual Property Office (2010) reported the number of international patent applications in Korea to have steadily risen by a factor of six from 1,573 in the year 2000 to 9,639 by 2010. Over a similar period from 2002 to 2008, the number of new and renewable energy-related patent applications grew from 13 to 113, alluding to an increasing degree to which technological innovations supported green growth and sustainable development.

A hallmark policy that ushered in sweeping green patents related to emissions reductions was its cap-and-trade programme that covered nitrous oxide (NO_x), sulfur oxide (SO_x), and particulate matter (PM) emissions from 136 factories throughout Seoul, Incheon, the Gyeonggi area, and over 24 counties. Both before and during the programme, technological patents were crucial to emission reduction strategies. For example, between the years 1995 and 2004, Korea

introduced a wide range patents related to NO_x emission reduction technologies. These included 94 selective catalytic reduction (SCR) patents, 37 selective non-catalytic reduction (SNCR) patents, 2 SCR/SNCR hybrid patents, 11 corrugated-type catalyst patents, and 19 nano-type TI catalyst patents. (KIPO, 2007). Subsequently, from the years 2005 to 2010, Korea accounted for 23.1% of global SCR patents for NO_x emission abatements, surpassed only by the 32.7% yielded by the United States and considerably larger than the 16.7% yielded by Europe (Kim and Kang, 2010). Meanwhile, Korea also introduced 17 combustion modification (CM) and 32 post-combustion (PC) technology patents for SO_x emissions abatements and 11 CM and 66 PC technology patents for NO_x emission abatements from 1995 through 2006 (OECD, 2009a).

Between 1990 and 2014, the number of Chinese green technology patents increased by sixty times and surpassed the respective three-fold and 18-fold increases experienced in OECD and fellow BRIICS countries (Linster and Yang, 2018). While each of China's five-year plans targeted specific green technology developments, green patent publications throughout China increased due to efficiency improvements, sustainable green patent prioritization, greater shares of R&D expenditures, and economic growth (Fujii and Managi, 2019). From 2010 to 2014, 20% of patents related to environmental management (e.g. air and water pollution abatement) technologies, while 76% related to eco-friendly buildings and energy technologies conducive to climate change mitigation (OECD, 2017a).

While the environmental information disclosure system of the *11th Five-Year Plan* (2006 through 2010) was meant to induce corporate eco-consciousness via stock market mechanisms (Fujii et al., 2011). However, Chinese green patenting really took off following the *12th Five-Year Plan* (2011 through 2015) and strong government promotion of pollution control technologies for addressing air and water contamination (Fujii and Managi, 2019). Despite this surge in green patents, however, the share of green to total patents in China remained lower than OECD and BRIICS levels. Moreover, the majority of patents were design or utility patents that were not registered in the triadic patent families (OECD, 2017a). These aspects collectively demonstrate the exigency for China to catch up with both OECD and emerging country green patent-based innovations.

While there are only a few Indian patents included in the scope of this analysis, policy supports nevertheless provided clear and stable signals that patent investments would lead to long-term benefits. Substantial public research reinforced such signaling. In fact, over 30% of

green patents in India between the years 2000 and 2007 were the result of efforts of India's Council of Industrial and Scientific Research (OECD, 2010).

3. Green finance mechanisms and performance

3.1. Overview of green finance

Volz et al. (2015) defined green finance as “all forms of investment or lending that consider environmental effects and enhance environmental sustainability.” In the arena of green investing, socially responsible investment (SRI) and environmentally friendly (EF) funds each outperform conventional funds in achieving social and environmental gains while also garnering financial returns (Ito et al., 2011). As far as specific investment avenues are concerned, green bonds and green foreign direct investment (FDI) continue to funnel growing volumes of public and private capital into green investments year after year. As such, this paper focuses on the history and trends of these mechanisms throughout Asia and elsewhere.

3.2. Green bonds

The Green Bond Principles published by the International Capital Market Association (ICMA, 2018) define green bonds as “any type of bond instrument where the proceeds will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible Green Projects.” These projects include renewable energy, energy efficiency, low-carbon transportation, green buildings, sustainable agriculture and forestry, biodiversity and ecosystem conservation, and eco-friendly technologies and processes. When an institution issues green bonds, an independent party is often employed to provide a Second Party Opinion to verify the issuer's overarching objectives, strategy, policy, and Use of Proceeds alignment with the Green Bond Principles (GBP) or other objective framework.

Additionally, issuers can have their green bonds certified against a recognized external green standard or label of a qualified, accredited third party. To date, prominent green bond certification standards include:

- 1) The Climate Bond Initiative (CBI) Climate Bonds Standard;
- 2) The Green Bond Assessment and Verification Guidelines of the People's Bank of China (PBoC) and China Securities Regulatory Commission (CSRC);

- 3) The European Union (EU) Green Bond Standards of the EU High-Level Expert Group on Sustainable Finance; and
- 4) The Association of Southeast Asian Nations (ASEAN) Green Bond Standards.

As certification standards are transparent and based on rigorous scientific criteria, certified bonds are generally more appealing to a broader range of socially responsible and environmental profit-seeking investors aiming to line their portfolios with eco-friendly, fixed payment securities (Chatzitheodorou et al., 2019). Moreover, though green bonds are issued at negative premiums compared with conventional bonds (Hachenberg and Schierek, 2018; Zerbib, 2019), issuers benefit from paying interest rates that cost less than certification costs (Gianfrate and Peri, 2019) while the recent municipal green bonds issued at positive premiums are increasingly attractive to investors (Karpf and Mandel, 2018).

Global green bond issuance volumes have expanded precipitously from the inaugural, €600 million (roughly \$848 million) European Investment Bank (EIB) Climate Awareness Bond (CAB) in 2007 to include some \$1.45 trillion outstanding from roughly 900 issuers worldwide (Climate Bonds Initiative, 2018a). Of this, issuances throughout the Asia-Pacific accounted for nearly half of the \$180 billion outstanding in proceeds earmarked to renewable energy. The Asia-Pacific also accounted for \$241 billion outstanding for low-carbon transportation and nearly 3 billion outstanding for waste management, making it a leader in green bond earmarking for both of these sectors (Climate Bonds Initiative, 2018a).

Figure 5 depicts yearly green bond issuance volumes among the countries assessed in this study between 2013 and 2017. Prior to this period, none of the countries included in this assessment had reported labelled green bond issuances. Note, also, that each of these issuances are certified by the Climate Bonds Standard. From 2013 onward, the United States issued the greatest volume of more than \$84 billion, rising from roughly \$754 million in 2013 to peak at more than \$46 billion by 2017. China issued nearly half the volume of the United States (approximately \$47 billion), rising from its first-year issuances of \$161 million in 2014 to over \$22 billion by 2017. While the \$25 billion in German issuances emerged from the 25-fold growth from just over \$407 million in 2013 to over \$9 billion by 2017, the remaining countries demonstrated comparatively smaller issuances. Among the Asian countries, India, Japan, and Korea respectively issued \$6.5 billion, \$5.6 billion, and \$2.1 billion, collectively accounting for 8.13% of the issuances throughout the countries examined.

Table 1 provides an overview of green bond issuers throughout Japan, Korea, China, and India. Between 2013 and 2017, Japanese financial corporations and development banks accounted for 80% of large issuances. Both groups issued approximately \$2.2 billion, with both the Development Bank of Japan and Sumitomo Mitsui Banking Corporation each earmarking their proceeds to green building, transportation, water, waste, and energy infrastructures. In Korea, development banks issued roughly \$1.9 billion or nearly 60% of the total \$3.3 billion produced by top issuers. As the country's largest green bond issuer, the Export-Import Bank of Korea earmarked green bond proceeds for green building, transportation, water, waste, and energy assets.

The top five issuers Chinese green bond markets issued nearly \$27 billion. This is equivalent to nearly five and nine times the volumes generated by their Japanese and Korean counterparts, respectively. Four of five of the largest issuers were financial corporations that collectively accounted for \$18 billion, most of which (with the exception of the Industrial and Commercial Bank of China) earmarked proceeds to finance a broad spectrum of green projects and assets. Finally, the top five green bond issuing firms in India delivered \$3.2 billion or nearly half of the roughly \$7 billion issued between 2013 and 2017. With the exception of the Indian Railway Finance Corporation, the remaining four of the top five issuing firms dedicated their green bond proceeds to energy-related investments.

Though rising issuances throughout Asia are a promising sign, tracking proceeds allocations provides a more in-depth means to assessing how environmental impacts of green bond-driven innovations and growth. Between 2008 and 2017, over \$2.9 billion was allocated to low-carbon transportation, renewable energy, clean water and wastewater treatment, ecosystem and resource management, energy efficiency, and waste management projects in China (Tolliver et al., 2019a). Firms operating in India also reported \$2.7 billion in allocations over the same period to a similar set of investments. However, these reported allocations pale in comparison the \$11 billion allocated in the United States over the same period (Tolliver et al., 2019a). While national green development policy supports throughout China, India, and Korea stand to bolster green bond market growth, various macroeconomic factors, institutional factors and climate agendas will all affect the capacity of each country to expand green bond issuances (Tolliver et al., 2019b) to meet growing demand for green finance.

3.3. *Green foreign direct investment (FDI)*

As recently as 2016, foreign direct investment (FDI) inflows totaled nearly \$1.45 trillion globally and accounted for roughly 10% of global gross fixed capital formation (UNCTAD, 2017). As a conduit of transfer for capital and modern technology across borders, FDI can serve as an important channel for spurring green innovation and investment behind environmentally sound economic growth and development (Johnson, 2017). There is empirical evidence that FDI inflows stimulate regional economic growth, reduce emissions intensities, and contribute to green growth strategies (Hille et al., 2019). Importantly, FDI is “the largest source of financing across all public and private sources” (Buchner et al., 2011) and has the potential to deliver the greening effects of clean technology transfer, technology leapfrogging, and domestic spillovers of environmental management best practices (Gallagher and Zearsky, 2007). There is therefore a growing call for “green FDI” to incite the international transfer of environmentally-friendly industries, technologies, and practices (Golub et al., 2011).

The United Nations Commission on Trade and Development (2010) defines low-carbon green FDI as “the transfer of technologies, practices, or products by MNEs [multinational enterprises] to host countries – through equity and non-equity forms of participation – such that their own and related operations, as well as use of their products and services, generate significantly lower GHG emissions than would otherwise prevail in the industry under business-as-usual (BAU) circumstances.” This paper compares green FDI for environmentally-friendly technologies listed in Financial Times fDi Markets data (2019). The data comprises a total of 288,885 FDI projects worth total capital investments of \$15,105.5 billion between January 2003 and November 2019. The environmentally technology cluster of the FDI dataset represents investments in technologies that are conducive to greenhouse gas emissions reductions, cleaner production and less pollutive industrial processes, and other environmentally beneficial outcomes.

Between January 2003 and November 2019, 8,125 FDI projects for environmental technologies throughout 30 industrial sectors were registered globally. This represents capital investments of \$1,039.56 billion, or 2% of total global FDI, with an average investment of \$127.9 million per project. As depicted in Figure A1, the renewable energy, electronic components, business services, engines and turbines, industrial equipment, metals, and chemicals

were the sectors that employed the largest volumes (greater than \$7 billion USD in capital expenditures between 2003 and 2019) of green FDI for environmental technologies.

Table 2 depicts the inter-country FDI investments in environmental technologies in 30 industrial sectors between the years 2003 and 2019. Overall, \$142 billion in investments were made across these seven countries alone. The countries that received the largest green FDI volumes were India, The United Kingdom, and the United States, while the countries that provided the largest volumes of green FDI included Germany, the United States, and China. As the second largest recipient and allocator of green FDI, the United States has played a significant role in global green technology transfers via FDI.

Approximately 80% of the FDI provided by Germany, the country that allocated the largest volume of FDI, went to fellow developed countries of the United Kingdom (totaling over \$27.4 million) and the United States (totaling over \$12.7 million). Roughly 75% of the green FDI allocated to India, the largest recipient country, was provided by the United States (roughly \$15 million), China (roughly \$9.4 million), and the United Kingdom (roughly \$9.3 million). Japan stands out among major economies as providing and receiving some of the lowest green FDI volumes. Namely, it allocated the third lowest volume of \$8.4 million and received the second lowest volume of \$5.8 million.

3.4. Environmental, social, and governance (ESG) performance

Recent decades have shown substantial shifts in business models and management theory as the number of firms reporting environmental, social, and governance (ESG) information increases. Conventional management theory focuses on enhancing financial performance and maximizing shareholder benefits, (Friedman, 1970). Green or sustainable business theory, on the other hand, emphasizes the reduction of externalities and the maximization of social value through ESG-related activity that takes into account the needs of not only shareholders, but also consumers, customers, communities, and other relevant stakeholders (Freeman and McVea, 2001). As disclosure of ESG information has strong positive linkages with corporate efficiency, return on assets, and market value components of corporate financial performance (Xie et al., 2019; Broadstock et al., 2019), ESG activities will be crucial to both attracting green finance and enhancing green performance at firms throughout Asia.

In Asia, many government-backed investment funds channel considerable capital into ESG activities, signaling their importance to society and effectively inducing similar capital allocations from private investors. Two prominent examples include the Government Pension Investment Fund of Japan (GPIF) and the Government Employees Pension Service (GEPS) of South Korea. The former began investing in global environmental stock indices and, to date, has benchmarked roughly ¥ 1.2 trillion (Japanese yen) to global environmental stock indices that overweigh comparatively carbon-efficient companies and encourage integration of better carbon disclosure in ESG equity (GPIF, 2018). The latter plans to add ESG factors as evaluation criteria for \$100 million in private equity investments. This follows the \$83 million it allocated to an ESG-incorporating global equity fund that pioneered ESG investing among South Korean pension schemes (Kim, 2019).

The MSCI ESG Indices, the Dow Jones Sustainability Index (DJSI), the FTSE4Good Index, the Asian Sustainability Rating (ASR) and other rating tools each measure corporate ESG performance. Of existing indices, Bloomberg's ESG disclosure scores targets over 3,600 firms in 73 countries with coverage that is growing by 11-12% annually (Siew, 2015). Additionally, Bloomberg ESG disclosure scores weigh each firm's Environmental Disclosure, Social Disclosure, Governance Disclosure, and overall ESG Disclosure scores uniquely based on their sector. Due to this breadth of coverage and sectoral sensitivity, this study employs Bloomberg's ESG disclosure scores in assessing firm-level ESG performance.

For a comparison of private firm-level ESG performance in Asia, Table 3 displays the ESG-performance of the top five largest firms (by net revenues) in China, Japan, and Korea for the years 2012, 2014, and 2016. Firms are ranked in by the size of their corporate revenue. In the case of China, among the firms that consistently generated the largest revenues, the Agricultural Bank of China (AGRICULTURAL-A) showed marked improvement in its ESG and environmental disclosure scores as its revenues increased from 2012 to 2014. The Industrial and Commercial Bank of China (IND & COMM BK-A) showed no ESG or environmental disclosure score improvements despite its revenues increasing by \$30 billion over the same period.

Despite empirical evidence that there is a significant positive relationship between financial performance and environmental performance in Japanese firms (Fujii et al., 2013), Japan's case is more nuanced. While the Toyota Motor Company (TOYOTA MOTOR) showed a respective rise and fall in both revenues and ESG disclosure scores from 2012 to 2014 and

from 2014 to 2016, its environmental disclosure remained constant and then decreased over the same two time periods. Meanwhile, NTT (NIPPON TELEGRAPH) and Hitachi (HITACHI LTD) showed steady ESG and environmental disclosure score improvements despite eventual decreases in revenue by 2016. Finally, though 2016-year data for Korea was limited, with the exception of the environmental score for LG (LG ELECTRONICS), Samsung (SAMSUNG ELECTRON), Hyundai (HYUNDAI MOTOR), and LG increased ESG and environmental disclosure scores alongside increases in annual corporate revenues between 2012 and 2014.

4. Policies behind green economies and green growth

In a green economy, investments in carbon emission and pollution reductions, energy and resource efficiency enhancements, and biodiversity and ecosystem service preservation are the main drivers of growth and employment (UNEP, 2011). Green growth fosters sustainable economic development while preserving the environmental services and resources provided by natural assets (OECD, 2017b). The green economy is therefore a conduit through which green growth is achieved, and the interplay between economic growth and environmental quality remains salient to a long line of literature (Copland and Taylor, 2004; Stern, 2004; Dasgupta et al., 2006).

Targeted policies for the above-mentioned green economy investment initiatives are important yet non-uniform across countries and regions. Biodiversity and ecosystem preservation yields carbon sequestration, raw material, watershed protection, ecotourism-based income, rare species habitat, and other benefits that bolster ecosystem health, social well-being of local citizens, and global climate sustainability. Nevertheless, regional heterogeneity and concomitant discrepancies in ecosystem and biodiversity knowledge, value, needs, and priorities among local populations renders it difficult for policymakers to implement effective strategies for preserving natural capital (Halkos and Managi, 2017). Understanding how such divergences tie into economic activity is thus necessary for effective ecosystem and biodiversity-related policy measures (Wilson, 2010; Perrings and Halkos, 2012; Halkos and Jones, 2012; Halkos, 2013; Halkos and Matsiori, 2017), especially in Asia.

Though each deserves special attention, the remaining investment priorities of emission and pollution reductions and energy and resource efficiency enhancements are highly interrelated. In particular, as carbon and pollution reductions are largely influenced by energy performance and efficiency (IEA, 2018), energy system improvements are increasingly salient to

a growing number of countries (Löschel and Managi, 2019). In many contexts, Feed-in-tariffs (FiTs) that mandate guaranteed prices for the sale of renewable energy-based electricity over pre-determined periods are the most effective, cost-efficient policies for promoting low-carbon energy development (Menanteau et al., 2003; Butler and Neuhoff, 2008; Fouquet and Johansson, 2008; Couture and Gagnon, 2010). Renewable portfolio standards (RPSs) in which electric power utilities are obligated to procure a minimum percentage of their power from renewable generation sources are additional national and subnational policy tools for reducing electricity sector CO₂ intensity (Upton Jr. and Snyder, 2017). Though they are mainly credited with increasing both the overall supply of low-carbon energy and energy efficiency (Martin and Saikawa, 2017), in many cases they are also linked to greater and more cost-effective greenhouse gas emission reductions than comparable policy enactments (Johnson, 2014).

Of course, effective approaches for reducing emissions through energy improvements vary by sector, community, and country. While gross domestic product (GDP) growth (Lee and Chang, 2008; Karanfil and Li, 2015; Osman et al., 2016; Tolliver et al., 2018) and urbanization (Holtedahl and Joutz, 2004; Lin and Ouyang, 2014) are important drivers of residential energy (e.g. electricity) demand in Asia and elsewhere, effective energy conservation strategies rely on price (Ayres et al., 2012; Jessoe and Rapson, 2014; Jessoe and Rapson, 2015) and non-price (Allcott, 2011; Asensio and Delmas, 2015) policy interventions throughout host communities. In transportation sectors of Asian and developed countries, the link between rising energy consumption and increasing greenhouse gas emissions, air and noise pollution, and traffic congestion led to fuel economy standards, fuel taxes, and other policy incentives to curb negative environmental effects (Anderson et al., 2011).

Furthermore, addressing energy consumption in the manufacturing sector is a complex yet integral component of enhancing energy efficiency and curbing emissions. Addressing development level-related technology gaps in the steel and iron manufacturing industries could result in energy efficiency improvements that drive down net emissions (Fujii et al., 2010; Lin and Wang, 2014; Takayabu et al., 2019). On the policy side, while the precedent-setting European Union Emissions Trading System (EU ETS) increased firm-level efficiency during its first period of compliance (Löschel et al., 2019), cap and trade systems throughout Japan, China, and greater Asia have had varying, sector-specific impacts on energy consumption and emissions patterns.

As policymakers throughout Asian nations increasingly view the “greening” of the economy as a key driver of growth, many countries continue to incentivize green growth through unique policy mandates and ancillary supports. An overview of country-level policy backgrounds and developments growth is provided in Appendix 2.

5. Conclusions

The amount of green innovation and finance in Asia has increased to meet growing demand for sustainable economic development. National policies for green growth throughout Japan, China, Korea, and India have coincided with greater green patent registrations and green bond issuances in each country. While Japan has been a global leader in green patenting from the mid-1980s through the present, South Korea and China have largely increased their pollution abatement-related green patents due to growing market demand to address environmental concerns. Conversely, while China has been a global leader in green bond issuances since 2015, Japan, South Korea, and India have demonstrated marginal upscaling in green bond issuances, usually among large domestic financial corporations and development banks.

Somewhat surprisingly, with the exception of China, Japan, South Korea, and India received far fewer volumes of green foreign direct investment than the United States, the United Kingdom, and Germany. Still, despite their comparatively lower development levels, environmentally adjusted multifactor productivity growth was larger in China, Korea, and India than in developed country counterparts. Moreover, in terms of the large-revenue firms in Japan, Korea, and China, most showed revenue increases that coincided with greater environmental, social, and governance information disclosure.

The findings of this study reveal insights for future contributions to the literature on green innovation and finance throughout Asia and at the global level. First, as robust data is published and updated, future studies could add to the discussion on ESG information disclosure and firm-level performance in India and other developing Asian economies that was previously infeasible due to the data limitations of this work. Additionally, as firm-specific green bond and green FDI allocation information become more prevalent, future research could highlight the ESG impact of particular firms in particular countries by comparing the frequency, volume, estimated environmental impacts, and other relevant data pertinent to such green capital investments. Finally, as EAMFP growth stands to bolster green growth, innovation, and finance, an

investigation of EAMFP policy supports in both developing and developed countries could provide well-needed insights for policymakers and industrial leaders alike.

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Table

Table 1: Major green bond issuers and total issuance volumes in Japan, Korea, China, and India from 2013-2017

Country	Rank	Issuer	Type	Volume
Japan	1	Development Bank of Japan	Development bank	\$2,155,745,000
	2	Mitsubishi UFG	Financial corporate	\$1,214,810,000
	3	Sumitomo Mitsui Banking Corp	Financial corporate	\$1,086,450,000
	4	Toyota	Non-financial corporate	\$710,490,000
	5	Mizuho Financial Group	Financial corporate	\$588,850,000
	⋮	⋮	⋮	⋮
	20	Japan Excellent	Financial corporate	\$36,056,000
	Total Issuances in Japan			
Korea	1	Export-Import Bank of Korea	Development bank	\$1,350,115,200
	2	Korea Hydro & Nuclear Power	Government-backed entity	\$600,000,000
	3	Korea Development Bank	Development bank	\$576,913,704
	4	Hyundai Capital Services	Non-financial corporate	\$500,000,000
	5	K-Water	Government-backed entity	\$300,000,000
	6	Hanjin International	Non-financial corporate	\$300,000,000
	7	Lotte Property & Development Company	Non-financial corporate	\$200,000,000
	Total Issuances in Korea			
China	1	Shanghai Pudong Development Bank	Development bank	\$7,589,050,000
	2	Bank of China	Financial corporate	\$6,005,865,000
	3	Bank of Beijing	Financial corporate	\$4,456,200,000
	4	Industrial and Commercial Bank of China	Financial corporate	\$4,451,708,614
	5	Bank of Communications	Financial corporate	\$4,355,100,000
	⋮	⋮	⋮	⋮
	95	China Jushi	Non-financial corporate	\$31,414,000
	Total Issuances in China			
India	1	Greenko Investment Co.	Non-financial corporate	\$1,000,000,000
	2	State Bank of India	Government-backed entity	\$650,000,000
	3	Indian Renewable Energy Development Agency Ltd.	Non-financial corporate	\$560,573,900
	4	Indian Railway Finance Corp.	Government-backed entity	\$500,000,000
	5	Azure Power Energy	Non-financial corporate	\$500,000,000
	⋮	⋮	⋮	⋮
	19	Hero Future Energies (Hero Wind Energy)	Non-financial corporate	\$72,223,000
	Total Issuances in India			

Source: Created by authors using data from the Climate Bonds Initiative (2018b)

Table 2: Green foreign direct investment (FDI) between select countries, 2003-2019

	Destination countries							Total
	<i>China</i>	<i>Korea</i>	<i>Japan</i>	<i>India</i>	<i>United States</i>	<i>United Kingdom</i>	<i>Germany</i>	
<i>China</i>	0	190.8	1672.8	9443.3	5283.9	3369	868.9	20828.7
<i>South Korea</i>	620.6	0	561.1	1752.9	3094.2	576.7	0	6605.5
<i>Japan</i>	1715.9	196.2	0	1671.1	2801.8	1930.3	177.3	8492.6
<i>India</i>	66.7	7.9	0	0	424.3	83.2	434.4	1016.5
<i>United States</i>	6300.1	1451.4	2653.1	15149.8	0	6594.1	3821.7	35970.2
<i>United Kingdom</i>	610.7	227.4	43.3	9352.1	8641.8	0	946.1	19821.5
<i>Germany</i>	1928.5	1352.4	934.4	5160.8	12701.7	27403.8	0	49481.5
Total	11243	3426	5865	42530	32947.7	39957.1	6248.4	142217

Note: All values represent capital expenditures (CAPEX) expressed in millions of US Dollars (USD)

Source: Created by authors using Financial Times fDi Markets data (2019)

Table 3: Environmental, social, and governance (ESG) scores of top 5 largest firms by revenue in China, Japan, and Korea

Year	Rank	China				Japan				Korea			
		Company	Rev. ¹	ESG ²	Env. ³	Company	Rev.	ESG	Env	Company	Rev.	ESG	Env.
2012	1	IND & COMM BK-A	\$133	33.33	10.71	TOYOTA MOTOR	\$236	34.3	29.46	SAMSUNG ELECTRON	\$179	59.92	65.12
	2	AGRICULTURAL-A	\$103	24.12	8.04	JX HD	\$136	34.71	30.23	HYUNDAI MOTOR	\$75	50.41	52.71
	3	BANK OF CHINA-H	\$98	28.51	8.04	NIPPON TELEGRAPH	\$133	44.21	45.74	POSCO	\$56	44.63	31.78
	4	CHINA STATE -A	\$87	42.15	31.01	HITACHI LTD	\$123	49.17	50.39	LG ELECTRONICS	\$49	56.2	57.36
	5	SAIC MOTOR-A	\$75	28.93	20.93	NISSAN MOTOR CO	\$119	44.63	51.16	KOREA ELEC POWER	\$44	36.36	24.81
2014	1	SINOPEC CORP-H	\$451	36.51	19.01	TOYOTA MOTOR	\$257	35.54	29.46	SAMSUNG ELECTRON	\$196	61.16	69.77
	2	PETROCHINA-H	\$371	34.44	21.49	JAPAN POST HOLDI	\$152	6.22	9.92	HYUNDAI MOTOR	\$85	54.96	57.36
	3	IND & COMM BK-A	\$163	33.33	10.71	HONDA MOTOR CO	\$125	45.45	48.06	SK INNOVATION	\$63	51.65	43.41
	4	CCB-H	\$143	28.51	8.04	JX HD	\$124	37.19	34.88	POSCO	\$62	45.87	38.76
	5	AGRICULTURAL-A	\$130	29.82	12.5	NIPPON TELEGRAPH	\$109	49.17	51.16	LG ELECTRONICS	\$56	56.61	54.26
2016	1	LENOVO GROUP	\$45	50.41	50.39	TOYOTA MOTOR	\$237	33.06	27.13	--	--	--	--
	2	ALIBABA GRP-ADR	\$16	7.85	0	HONDA MOTOR CO	\$122	44.63	46.51	--	--	--	--
	3	HUIZHAN DAIRY	\$0.71	14.88	0	NISSAN MOTOR CO	\$102	54.96	61.24	--	--	--	--
	4	--	--	--	--	NIPPON TELEGRAPH	\$96	52.07	54.26	--	--	--	--
	5	--	--	--	--	HITACHI LTD	\$84	52.07	54.26	--	--	--	--

Source: Created by authors using Bloomberg ESG data (2016)

1 – Revenue, expressed in billions of USD;

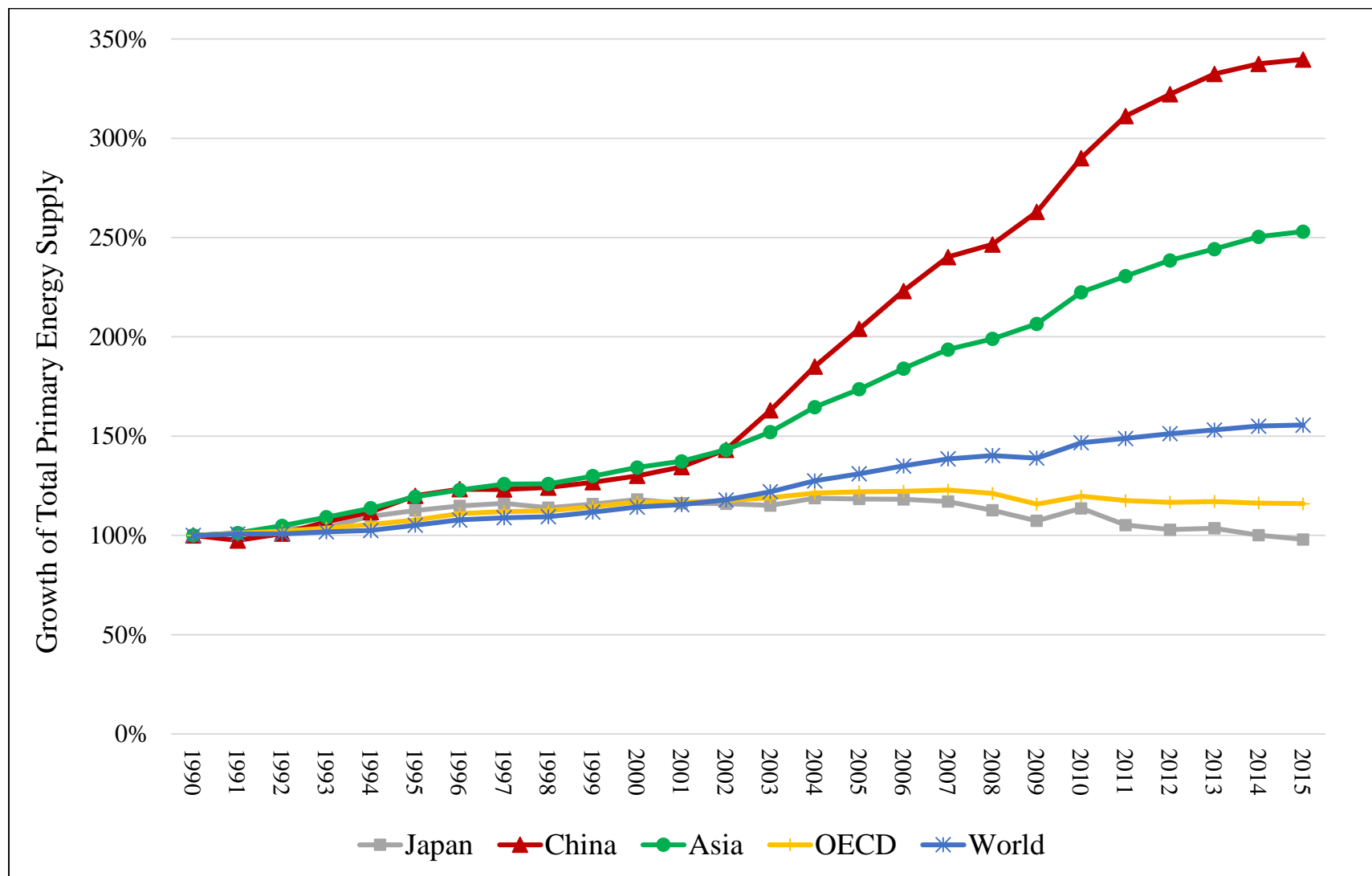
2 – Proprietary Bloomberg Environmental, Social, Governance Disclosure Score (ESG);

3 – Proprietary Bloomberg Environmental Disclosure Score (Env.)

Note: Table 3 includes only companies that disclosed ESG data that were thereby included in data collected by Bloomberg; Data for Indian firms is lacking from the year 2011 onward.

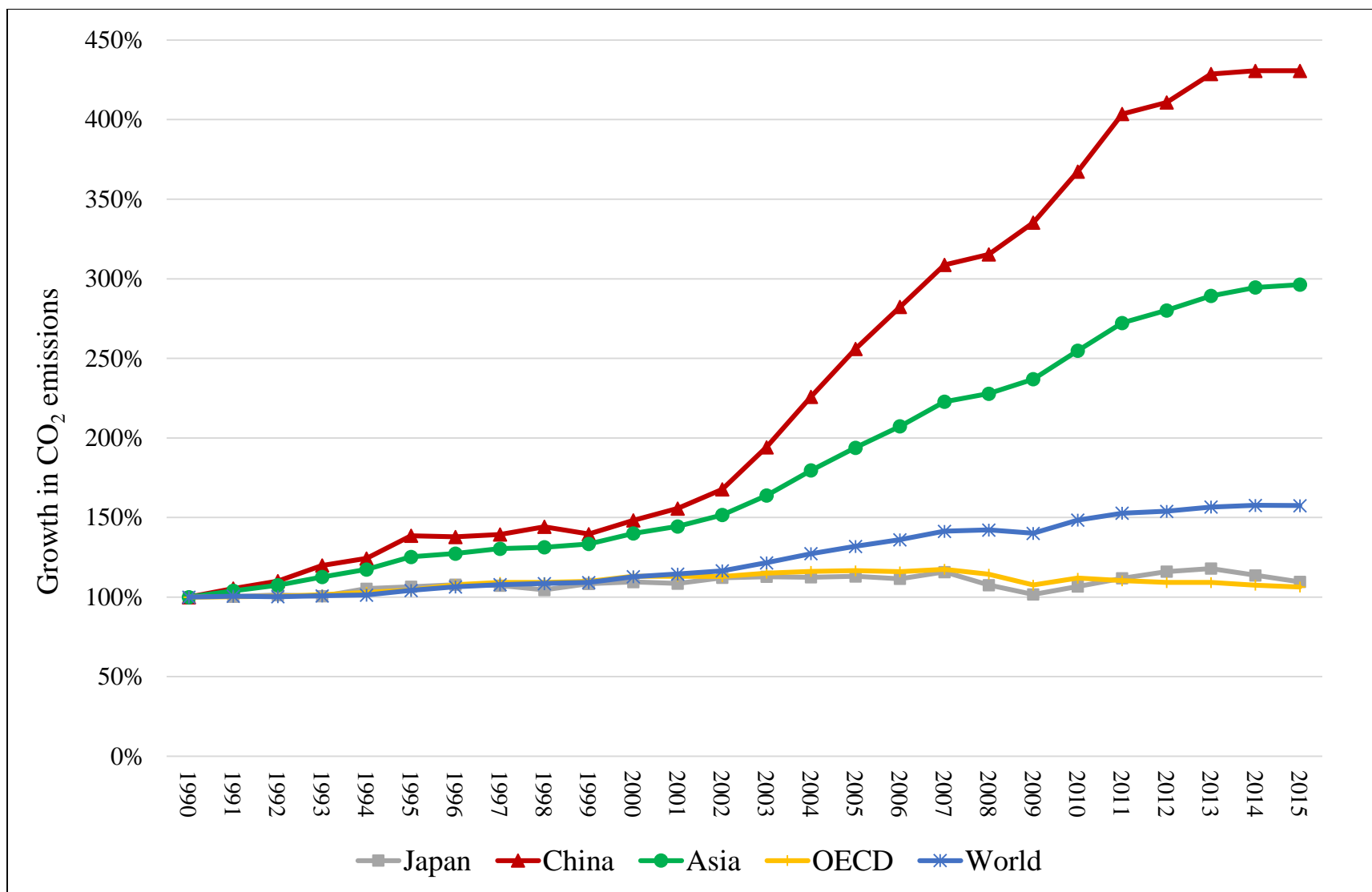
Figures

Figure 1: Growth of Country and Regional Total Primary Energy Supply, 1990-2015



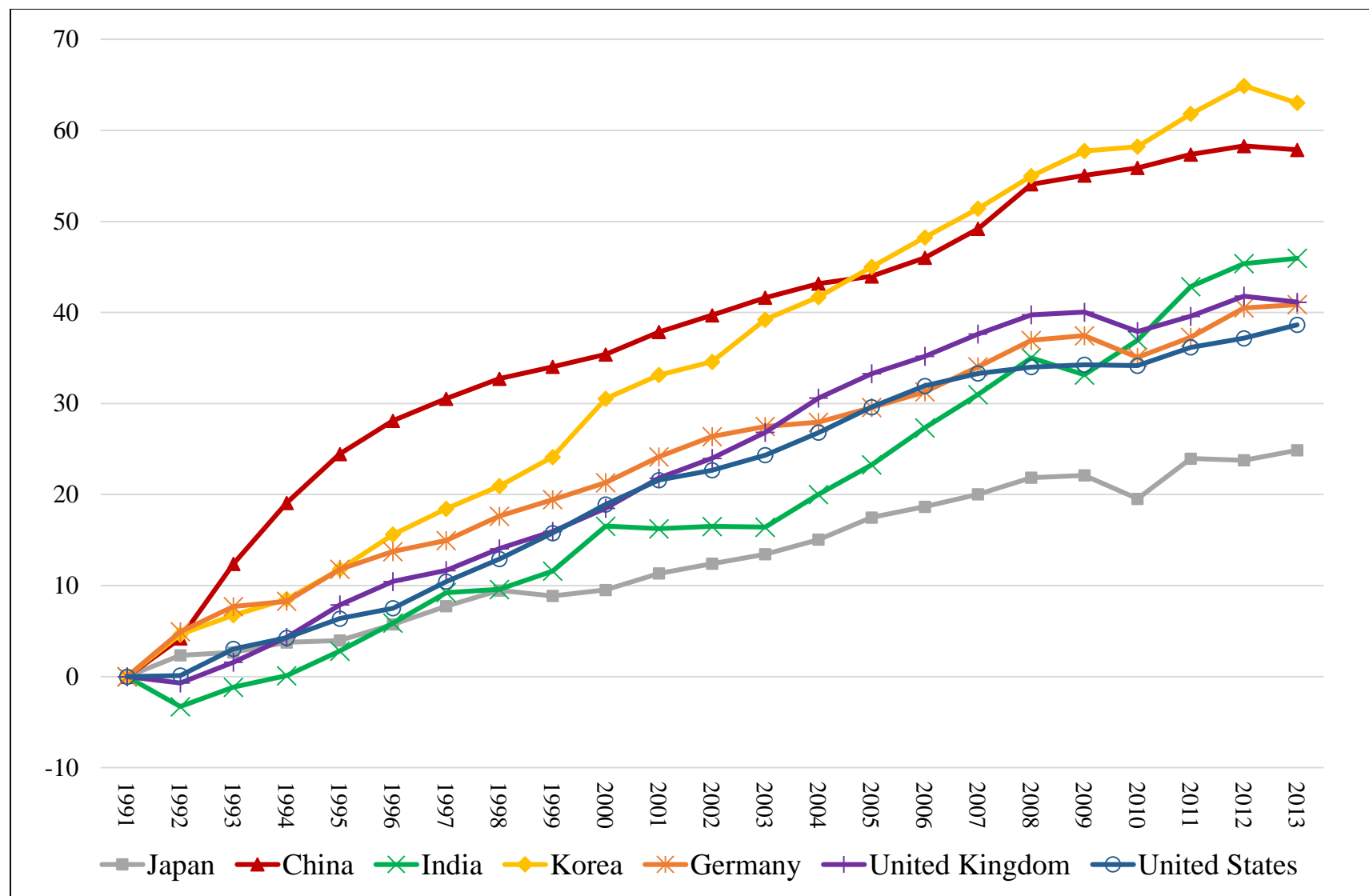
Source: Adapted by authors from IEA World Energy Balance 2017 data

Figure 2: Growth of Country and Regional CO₂ emissions, 1990-2015



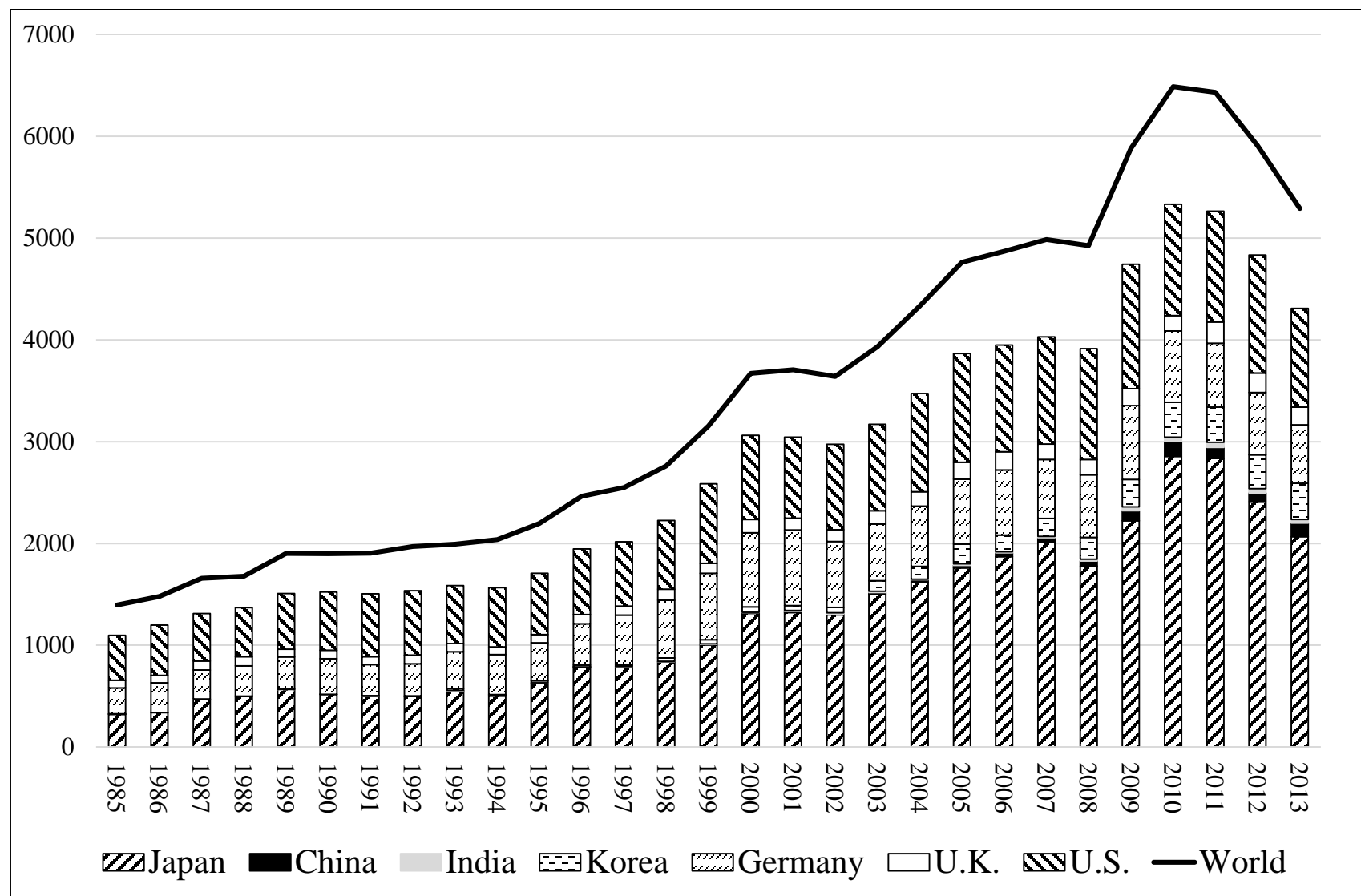
Source: Adapted by authors from IEA CO₂ emissions from Fuel combustion 2017 data (IEA, 2017)

Figure 3: Cumulative environmentally adjusted multifactor productivity (EAMFP) growth for seven major economies, 1991-2013



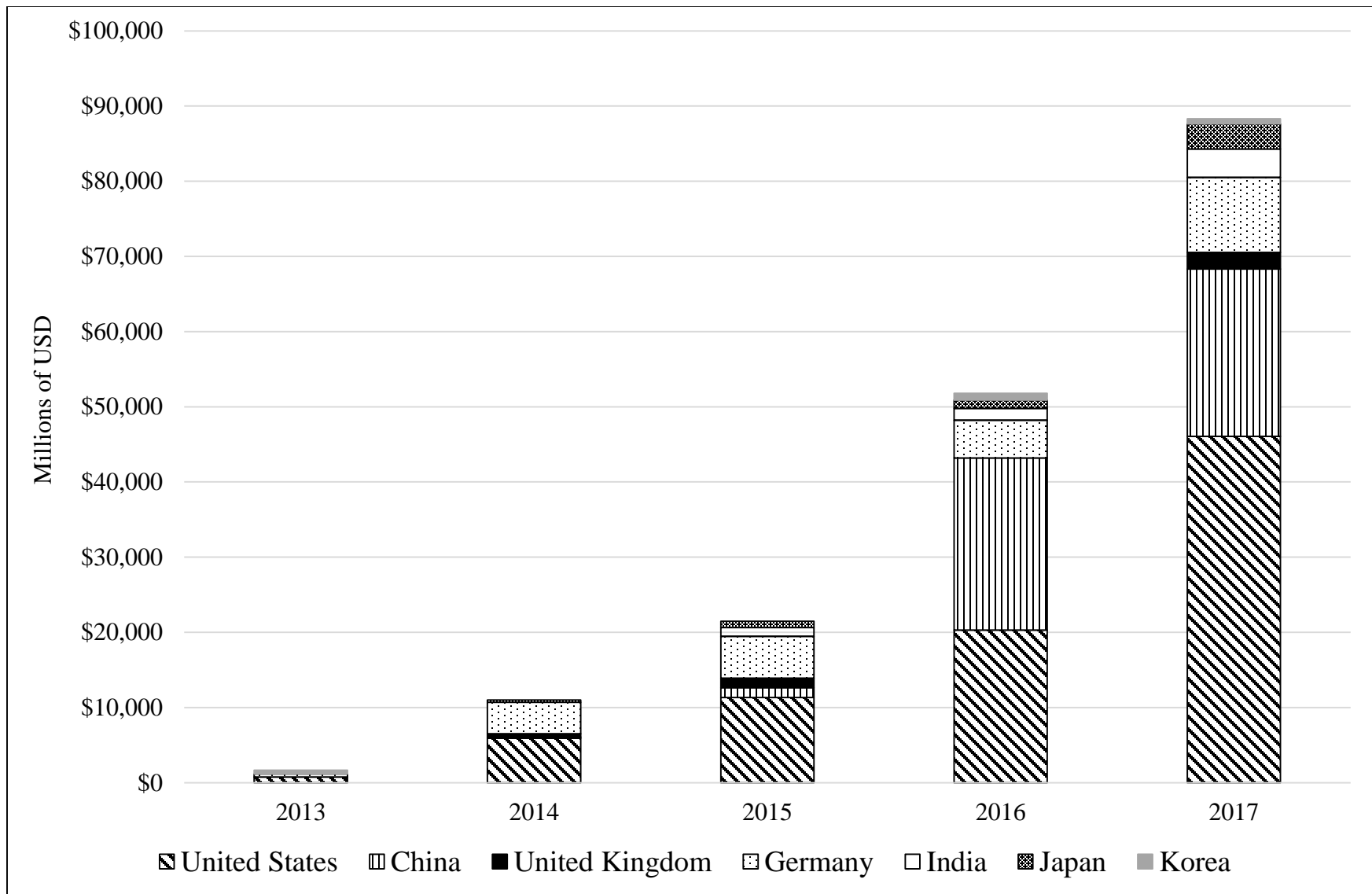
Source: Adapted by authors using OECD Statistics data (OECD, 2019)

Figure 4: Number of global and country-level green patents, 1985-2013 (Number of items)



Source: Adapted by authors using OECD Statistics data (OECD, 2019)

Figure 5: Annual green bond issuances per country, 2013-2017



Source: Created by authors using Climate Bonds Initiative (2018b) data

Appendix 1: Tables & Figures

Table A1: Annual environmentally adjusted multifactor productivity (EAMFP) growth (%) for seven major economies, 1991-2013

Year	Japan	China	India	Korea	Germany	United Kingdom	United States
1991	2.35	4.20	(-3.30)	4.64	4.93	(-0.69)	0.13
1992	0.32	8.20	2.15	2.12	2.78	2.28	2.93
1993	1.10	6.69	1.27	1.75	0.57	2.73	1.22
1994	0.20	5.37	2.70	3.28	3.52	3.56	2.11
1995	1.77	3.66	3.07	3.84	1.95	2.57	1.13
1996	2.00	2.41	3.35	2.82	1.22	1.20	2.92
1997	1.72	2.19	0.35	2.49	2.66	2.40	2.48
1998	(-0.61)	1.31	2.01	3.18	1.81	1.89	2.85
1999	0.66	1.36	4.93	6.41	1.87	2.55	3.15
2000	1.81	2.47	(-0.28)	2.61	2.85	3.32	2.67
2001	1.07	1.84	0.24	1.45	2.21	2.16	1.07
2002	1.05	1.93	(-0.08)	4.63	1.11	2.86	1.66
2003	1.60	1.54	3.60	2.47	0.47	3.77	2.48
2004	2.42	0.81	3.24	3.32	1.61	2.67	2.80
2005	1.19	2.04	4.06	3.24	1.71	1.92	2.35
2006	1.36	3.18	3.66	3.17	2.76	2.44	1.35
2007	1.82	4.89	4.05	3.57	2.91	2.11	0.71
2008	0.25	0.98	(-1.88)	2.76	0.51	0.29	0.26
2009	(-2.57)	0.82	3.81	0.47	(-2.38)	(-2.13)	(-0.10)
2010	4.41	1.48	5.89	3.60	2.21	1.68	2.01
2011	(-0.19)	0.93	2.53	3.08	3.22	2.21	0.99
2012	1.10	(-0.42)	0.59	(-1.86)	0.37	(-0.66)	1.48

Source: Adapted by authors using OECD Statistics data (OECD, 2019)

Table A2: Green growth policy precedents and agendas for Japan, China, South Korea, and India

Country	Green growth policy precedent	Agenda
Japan	<i>Becoming a Leading Environmental Nation in the 21st Century: Japan's Strategy for a Sustainable Society (2007)</i>	<ul style="list-style-type: none"> (1) Demonstrate international leadership to overcome the climate change (2) Conserve biodiversity for the sustainable use of nature's blessings by current and future generations (3) Create sustainable material-cycles through waste reduction, reuse, and recycling (e.g. the 3Rs) (4) Cooperate with the international community to utilize the experience and knowledge derived from having overcome pollution (5) Foster environmental and energy technology-based economic growth (6) Create vibrant local communities that utilize the blessings of nature (7) Educate people to feel, think, and act for the environment (8) Create a system to support the country as a "Leading Environmental Nation"
China	<i>The 12th Five Year Plan (2011)</i>	<ul style="list-style-type: none"> (1) Maintain farmland reserves (2) Decrease water consumption per unit of value-added industrial output (3) Increase water efficiency coefficient in agricultural irrigation (4) Increase non-fossil fuel usage in primary energy consumption (5) Decrease energy consumption per unit of GDP (6) Decrease CO2 emissions per unit of GDP (7) Decrease emissions of major pollutants, including Chemical Oxygen Demand, Sulphur Dioxide, Ammonia Nitrogen, and Nitrous Oxides (8) Increase forest coverage rate and stock

Table A2 (continued)

Country	Green growth policy precedent	Agenda
South Korea	<i>The National Strategy for Green Growth (2009)</i>	<ol style="list-style-type: none"> (1) Effectively mitigate greenhouse gas emissions (2) Reduce fossil fuel use and the enhance energy independence (3) Strengthen climate change adaptation capacity (4) Develop green technologies (5) Make existing industries green and promote green industries (6) Advance the industrial structure to increase the role of services (7) Engineer a structural basis for the green economy (8) Make land, water, building, and transport infrastructure green (9) Implement the green revolution into the daily lives of the citizenry (10) Become a green growth role-model for the international community
India	<i>The National Action Plan on Climate Change (2008)</i>	<ol style="list-style-type: none"> (1) Promote solar energy for power generation and other uses (2) Decrease energy consumption in large energy-consuming sectors (3) Promote energy conservation building codes, strengthen automotive fuel economy standards, and incentivize public transportation and fuel-efficient vehicle purchases (4) Improve water efficiency (5) Prevent the melting of Himalayan glaciers and protect biodiversity in the Himalayan region (6) Reforest 6 million hectares of degraded forest and expand forest cover (7) Support climate adaptation in agriculture through the development of climate-resilient crops, agricultural practices, and weather insurance mechanisms (8) Utilize a Climate Science Research Fund and private sector initiatives to develop adaptation and mitigation technologies

Source: Created by authors

Table A3: Annual green growth, innovation, and investment trends in Japan, China, South Korea, and India since the implementation of their respective green growth strategies, 2011-2016

	2011				2012				2013			
	EAMFP ¹	GP ²	GB ³	GFDI ⁴	EAMFP	GP	GB	GFDI	EAMFP	GP	GB	GFDI
Japan	-0.19	2,834	--	\$58.30	1.10	2,407	--	\$580.00	--	2,607	\$0.00	\$1,712.16
(% change)	(-1.04)	(-0.01)	--	(-0.25)	(-6.79)	(-0.15)	--	(8.95)	--	(0.08)	--	(1.952)
China	0.93	110	--	\$3,005.27	-0.42	88	--	\$1,031.37	-0.28	133	\$0.00	\$2,592.63
(% change)	(-0.37)	(-0.25)	--	(-0.27)	(-1.45)	(-0.20)	--	(-0.66)	(-0.33)	(0.51)	--	(1.51)
South Korea	3.08	346	--	\$219.70	-1.86	334	--	\$100.00	2.93	354	\$500.00	\$317.20
(% change)	(-0.14)	-0.01	--	(-0.02)	(-1.60)	(-0.03)	--	(-0.54)	(-2.58)	(0.06)	--	(2.17)
India	2.53	49	--	\$5,370.60	-0.59	42	--	\$1,531.36	2.45	36	\$0.00	\$322.19
(% change)	(-0.57)	(-0.14)	--	(-1.47)	(-0.77)	(-0.14)	--	(-0.71)	(3.14)	(-0.14)	--	(-0.79)
	2014				2015				2016			
	EAMFP	GP	GB	GFDI	EAMFP	GP	GB	GFDI	EAMFP	GP	GB	GFDI
Japan	--	--	\$316.00	\$1,680.62	--	--	\$840.17	\$3,725.13	--	--	\$1,097.78	\$3,276.75
(% change)	--	--	(316.00)	(-0.02)	--	--	(-1.66)	(1.22)	--	--	(0.31)	(-0.12)
China	--	--	\$161.00	\$3,187.81	--	--	\$1,294.52	\$1,480.37	--	--	\$22,893.74	\$1,114.60
(% change)	--	--	(161)	(0.23)	--	--	(-7.04)	(-0.54)	--	--	(-16.69)	(-0.25)
South Korea	--	--	\$0.00	\$112.05	--	--	\$0.00	\$698.44	--	--	\$900.00	\$21.78
(% change)	--	--	(-500.00)	(-0.65)	--	--	(0.00)	(5.23)	--	--	(900.00)	(-0.97)
India	--	--	\$0.00	\$1,448.03	--	--	\$1,151.21	\$19,684.31	--	--	\$1,569.84	\$13,741.26
(% change)	--	--	(0.00)	(3.49)	--	--	(1151.21)	(12.59)	--	--	(-0.36)	(-0.30)

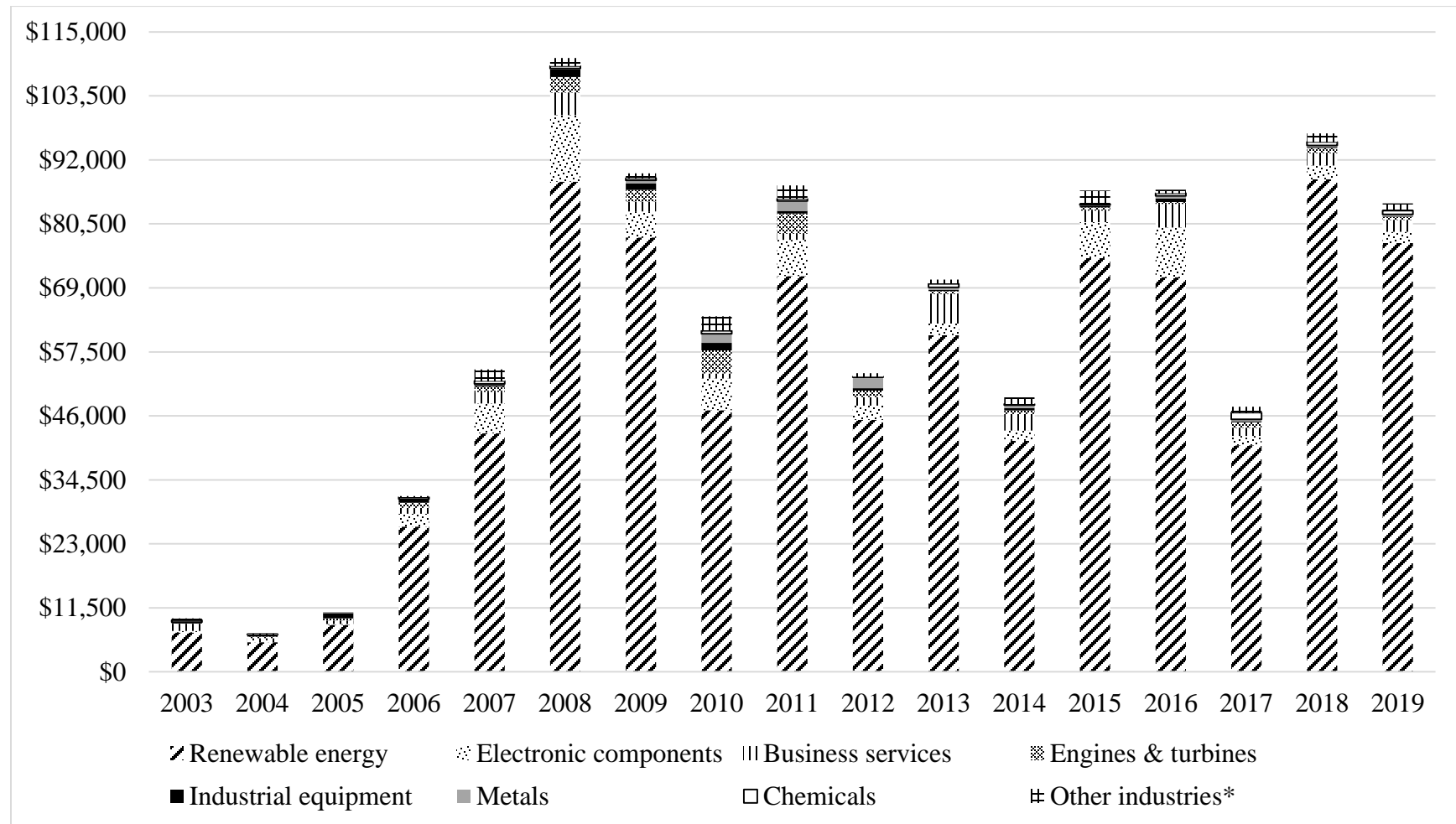
¹ Annual environmentally adjusted multifactor productivity growth; ² Annual number of green patents; ³ Annual volume of green bond issuances (in millions of USD); ⁴ Annual green foreign direct investment capital expenditures (in millions of USD)

Note: Fields marked "--" depict gaps in the data of the original sources

Sources: Created by authors using data from OECD Environment Statistics (2019), Climate Bonds Initiative Q3 2018 Dataset (2018), Financial Times Ltd. fDi Markets (2019)



Figure A1: Annual FDI capital expenditures per industrial sector (in millions of USD)



* Other industries: Plastics; Food & beverages; Ceramics & glass; Semiconductors; Coal, oil, & gas; Wood products; Paper, printing, & packaging; Transportation & warehousing; Business machines & equipment; Building materials; Software & IT Services; Consumer electronics; Rubber; Communications; Financial services; Automotive components; Non-automotive transport OEM; Real estate; Automotive OEM; Minerals; Textiles; Consumer products; Aerospace

Source: Created by authors using Financial Times fDi Markets (2019) data

Appendix 2: Country policy backgrounds and developments

A2.1. Overview

Asian economies have been among the first to pursue long-term green growth. Indeed, urgent priorities to address environmental issues through sustainable development render green growth necessary for rapidly growing countries throughout the region (Choi et al., 2016). Accordingly, among indicators of green growth, Asia has demonstrated the highest volumes of green sales and shares of global climate change mitigation technology (CCMT) exports, and values of CCMT patents (Fankhauser et al., 2017). Developments in Japan, South Korea, China, and India reveal not only the degree to which national governments have recognized the potential benefits of green growth, but also the extent to which they have consistently revised and expanded policy targets over time. This study notes the green bond issuance guidelines, renewable energy policies, and cap-and-trade programs throughout the countries assessed which effectively supported the pursuit of said green growth targets.

Green bonds with proceeds earmarked to environmentally friendly projects and assets provide financing mechanisms and investment avenues for green growth. In 2019, roughly 25% of global green bonds were issued in markets throughout the Asia-Pacific region. \$31.1 billion in Chinese issuances accounted for the majority of this share (Climate Bonds Initiative, 2020). Recent developments of national green bond frameworks and issuance guidelines throughout Asian economies suggest that bonds will provide increasing support to regional green growth in the years to come.

Simultaneously, many Asian countries have reformed existing or ratified novel renewable energy policies in pursuit of greenhouse gas emissions reductions and other green growth-related objectives. Each with unique natural resource stocks, energy generation potential, and other contextual considerations, Japan, South Korea, China, and India implemented national and local policies with varying impacts on clean energy deployment and low-carbon growth.

Finally, carbon cap-and-trade or carbon trading programs are environmental management tools for limiting carbon emissions by putting a price on CO₂ emissions and allowing emitters to purchase and vend reduction obligations. Parties that emit volumes beyond the acceptable emissions limits may purchase emissions rights from parties that emit less than acceptable limits, thereby keeping national emissions within a pre-determined threshold (Koehane et al., 2015;

Zhao et al., 2016). Japan, South Korea, and China have implemented pilot and national-scale programs, though with varying degrees of impact on emissions reductions.

The European Union Emissions Trading System (EU-ETS) was the first multinational cap-and-trade scheme that, upon its implementation in 2005, included 31 European countries. Thus far, the EU ETS has been implemented in three phases: Phase I from 2005 through 2007, Phase II from 2008 through 2012, and Phase III from 2013 to 2020. European emissions have indeed reduced over the life of the program (Bel and Joseph, 2015) with many of the changes in spatially concentrated, especially in heavy industries (e.g. iron and steel, refining) in specific countries (Stuhlmacher et al., 2019). The multinational precedent set by the EU ETS may provide useful insights for a potential regional scheme for Asia as Japan, China, and Korea each pursue their own national programs in the meantime.

A2.2. Japan

A2.2.1. Green growth targets in Japan

The Japanese Ministry of Economy, Trade, and Industry (METI) defines green or eco-innovation as “techno-social innovations to meet environment challenge, resource constraints and diversification of values among the people with compatibility between economy and environment” (OECD, 2008). In its *Economic and Fiscal Reform 2007 – Basic Policies*, the Government of Japan (2007) also defined green innovation as “the comprehensive initiative for technology development and social reform, using its dominance of high level technologies in *monozukuri* [production of goods] area and in environment or energy saving as a driving force, in order to achieve the sustainable society.” Encouraging sustainable manufacturing through resource recycling at the industry level, deploying zero-emission infrastructure such as efficient carbon capture and storage power generation plants, and leading consumers towards sustainable consumption patterns are all concrete measures by which Japan has supported green innovation in recent years. Moreover, each of the following Japanese policies have coalesced to incentivize broad green innovations throughout multiple sectors of the economy:

- 1) The *Becoming a Leading Environmental Nation Strategy in the 21st Century* outline of comprehensive measures to move towards a low carbon, sound material cycle society that is in harmony with nature;
- 2) The *5th Science and Technology Basic Plan* that makes grants available for science and technology research in pursuit of sustainable growth;

- 3) The *Intellectual Property Strategic Programme* through which the government promotes and protects intellectual creation and accelerates its appropriate applications;
- 4) The *Economic Growth Initiative* which targets economic development through enhancing domestic technological capability; and
- 5) The *Cool Earth-Innovative Energy Technology Program* which proposes the long-term objective to cut current global greenhouse gas emissions in half by 2050 through international cooperation in power, transportation, industrial processing, commercial construction, and crosscutting technology development and diffusion.

Though smaller than regional and developed country counterparts, Japan's green growth as measured by environmentally adjusted multifactor productivity (EAMFP) was nevertheless a key driver of its overall economic growth. Notable contributions to its EAMFP growth include its second lowest carbon dioxide (CO₂)-intensity per capita (as of 2012) and the substantial pollution abatement it achieved between the 1990 to 2010 period (OECD, 2014). Furthermore, the bulk of its income growth was largely a result of EAMFP improvements (Cárdenas Rodríguez, 2011).

Despite the green growth strategies outlined in Japanese policy precedents, technology-based approaches such as these are necessary but not sufficient steps towards sustainable developments as population growth and affluence are also critical factors (Lorek and Spangenberg, 2014). The expanding presence of information and communication technologies (ICTs) that are relatively prevalent in Japan provides illustrative implications. On the one hand, these technologies are thought to enhance green growth by bolstering digital consumerism that in turn accelerates the formation of smart cities. On the other hand, they may also obstruct green growth by promoting lifestyle changes that increase consumer demand for energy and material resources while displacing undesirable economic, social, and environmental impacts and risks on those with less purchasing power (Viitanen and Kingston, 2014).

With these considerations in mind, the race for Japan to provide a 5G mobile data network in time for the 2020 Tokyo Olympics may prove to be a highly informative pursuit. Namely, the extent to which communities throughout the country are able to reap the benefits of digitalization (e.g. limiting physical resource dependency by adopting less paper or plastic-intensive practices and processes) while keeping the aforementioned obstacles to green growth in check could reveal key insights into the risk-reward nature of ICT proliferation moving forward.

A2.2.2. Green bond frameworks in Japan

Out of the green finance mechanisms assessed in this study, the hallmark for Japan was its domestic green bond issuance volume. As depicted in Table 1, just 20 Japanese firms were behind a higher net volume of green bonds issuances compared with South Korean and Indian firms. Incidentally, this volume also surpassed roughly \$5 billion in green FDI that Japan received from the other major regional and global allocators assessed in this study. By 2018, cumulative green bond issuance in Japan increased by 22% from the previous year to reach \$9.7 billion. Financial corporations that earmarked proceeds to green buildings, renewable energy infrastructure, and related green loans drove 72% of this increase. Moreover, 91% of green bonds included second-party opinions from such organizations as Sustainalytics, DNV GL, Vigeo EIRIS, and over 45% of issuances were denominated in Euro currency (Climate Bonds Initiative, 2019a). This compliance with international best practices suggests great potential for Japanese firms to garner further capital from both domestic and overseas investors.

Various national frameworks were behind the push for greater domestic green bond issuances. In 2017, its Ministry of Environment published the nation's *Green Bond Guidelines*. Importantly, these guidelines comply with the International Capital Market Association's *Green Bond Principles* in promoting the expansion of green bond issuances, information transparency, and market integrity. Furthermore, in 2018, the Ministry began providing subsidy grants of up to ¥ 50 million for external reviews and other green bond framework compliant activities through its *Financial Support Programme for Green Bond Issuance*.

A2.2.3. Renewable energy promotion in Japan

Policies that support renewable energy, resource efficiency, and other factors that enhance low material growth-oriented consumption and lower resource and energy intensity are essential to green growth pathways (van Vuuren et al., 2017; O'Neill et al., 2017). Policies that supported renewable energy development in Japan, the world's third largest electricity generator behind the U.S. and China, laid the foundation for green growth in the years leading up to the *Becoming and Environmental Leader* strategy. Still, there are notable limitations among even the more successful renewable energy support measures.

For example, the era of the 1993 *New Sunshine Project* and 1997 *New Energy Act* introduced net metering for excess solar and wind energy in 1992. By 2003, a Renewable Portfolio Standard (RPS) was enacted to induce domestic retailers to utilize 16 terawatt hours (TWh) of renewable energy-based electricity per year by 2014. Subsequently, solar photovoltaic (PV), biomass, and wind power generation grew to respectively account for 12.5%, 8.4%, and 6.4% of cumulative renewable energy generation by 2010 (Chen et al., 2014). Still, strict land use regulations and network infrastructure limitations undermined broader renewable integration into electricity grids since the enactment of the RPS (Dong and Shimada, 2017).

More recently, the 2014 *Strategic Energy Plan* called for the creation of an energy secure, environmentally mindful, economically efficient, and supply-safe (termed the “3E + S”) energy system through renewable energy and other green technology deployment in the wake of the 2011 Fukushima Daiichi Nuclear Power Station incident. Additional policy aims include a 22-24% share of renewable energy in the national energy mix by 2030, a 26% reduction in greenhouse gas emissions (GHG) by 2030 (in line with its Nationally Determined Contribution [NDC] to the Paris Agreement), and an 80% reduction in GHG emissions by 2050. Leading up to the plan, two feed-in-tariff schemes affected the widespread deployment of specific renewable energy technologies throughout the country.

The 2009-year solar FiT (formally titled the *New Purchase System for Solar Power Generated Electricity*) required utilities to purchase solar electricity for ten years at a fixed rate of 48 Japanese yen (roughly 0.6 USD) for residential PV installations under 10 kilowatts (kW). It resulted in 1.4 billion kilowatt hours (kWh) in annual surplus solar electricity purchases by 2010 and Japan becoming as the country with the third largest installed solar PV capacity in the world by 2011 (Chen et al., 2014). The 2012-year FiT, implemented under the *Act on Special Measures concerning the Procurement of Renewable Electric Energy by Operators of Electric Utilities* (e.g. the *Renewable Energy Act*), drew criticism despite inducing net increases in domestic renewable energy capacity.

Specifically, without explicit diffusion targets for specific renewable energy generation technologies, deployment in the wake of the 2012 FiT varied by source. Within the first two years of the program, solar power accounted for 98% of the 12 gigawatts (GW) of additional renewable energy capacity and 96% of the 72 GW in new renewable energy installation applications to the Ministry of Economy, Trade, and Industry (METI) of Japan (Kuramochi,

2015). Meanwhile, despite considerable wind and geothermal energy development potential throughout the country, each still represent negligible fractions of net power generation (Schumacher, 2017) since the start of the FiT.

Other issues involve costs that may affect the longevity and outcomes of the solar power projects under the FiT. Though domestic firms are leading a push for solar PV proliferation, module manufacturers face intense competition with Chinese firms that develop, improve, and produce PV modules at fractions of the costs of their Japanese counterparts. Moreover, the average household requires 10 years to recoup installation expenses, consistent government subsidies and tax incentives, exclusive solar electricity feeding into the grid, and long-term income guarantees are vital to alleviating consumer costs (Chowdhury et al., 2014). Supports such as these may thus be necessary to enhance the overall stability of the FiT.

A2.2.4. Cap-and-trade program in Japan

Japan implemented two pilot emission-trading systems: The *Tokyo Emissions Trading System* in 2010 and the *Saitama Emissions Trading System* in 2011. The former covered included 2010 to 2014 and 2015 to 2019 compliance periods, the first of which sets a 6% emissions reduction target and the second of which sets a 15% reduction target. It also covers 1,400 facilities that consumed over 1,500 kiloliters (kl) of crude oil equivalent and accounted for 20% of Tokyo's total CO₂ emissions and 40% of its commercial and industrial sector emissions. Though 93% of covered facilities exceeded their obligatory reductions and net emissions were reduced by 23% of base year volumes, failure to establish an effective marketplace hindered inter-firm trading is among the system's critical design flaws (Nguyen et al., 2019). Furthermore, more than the system design itself, exogenous factors such as the 2011 Fukushima incident affected the success of the system to a greater degree than intra-system credit trading did (Wakabayashi and Kimura, 2018).

A2.3. South Korea

A2.3.1. Green growth targets in South Korea

Many of the policy supports behind South Korean green innovation and finance date back to the 2008 global financial crisis. At the time, with its greenhouse gas emissions nearly doubling between 1990 and 2005, the government set an emissions reduction target of 30% by 2020. In the wake of the crisis, the 2009 *National Strategy for Green Growth* aimed to form a new

development track through which green technologies and clean energies drive low-carbon industrial growth and quality of life improvements. Ultimately, South Korea aimed to become the fifth best green economy by 2050. Similarly, the government's *Five-year Plan for Green Growth* outlined strategies to push past the pitfalls of the 2008 global financial crisis and stimulate low-carbon growth. Through public investments in infrastructure (e.g. mass transit, urban charging grids), public R&D expenditures for energy and other low-carbon technologies, tighter pollution controls through regulatory schemes (e.g. Feed-in-Tariffs and Renewable Portfolio Standards), and other policy instruments (Mathews, 2012), both strategies coalesced to incentivize green innovation and financial activity.

Similar to Japan and other advanced economies, much of South Korea's economic growth was based on EAMFP improvements. Its comparatively lower level of domestic subsoil natural resource extraction largely influenced these trends. However, its emissions have steadily increased and its output growth relies on pollution-intensive activities to a greater degree than most other OECD member states (Cárdenas et al., 2018).

South Korea's 30% emissions reduction by 2020 target came on the heels of its national greenhouse gas emissions nearly doubling between 1990 and 2005. An emissions cap-and trade scheme, carbon taxes, and the elimination of environmentally harmful energy subsidies became the key market-based means to move beyond firm-level voluntary commitments and pioneer a shift from energy-intensive to low-carbon industries (Jones and Yoo, 2011). By 2008, "Low Carbon/Green Growth" became the paradigm through which the nation would develop for the subsequent 50 years.

The concept of green growth adopted by the Government of South Korea "supplements abstractness and extensiveness of sustainable development in terms of implementation of effective policies" (Lee et al., 2012). In accordance with its *Framework Act on Low Carbon Green Growth*, the country's *Five-year Plan for Green Growth* directs the efforts of national green growth policies, annual objectives, investment priorities, institutional authorities, and action plans. At the core of the plan are the following three strategies:

- 1) "Climate Change Responses and Energy Self-reliance," which calls to bolster forest-based greenhouse gas (GHG) absorption, raise the share of self-developed oil and gas, increase food self-sufficiency, improve the accuracy of rainfall forecasts, and dedicate government budgets to disaster prevention

- 2) “Creating New Growth Engine,” which promotes the sale of new renewable energy industrial technologies, government purchases of GHG emissions reductions, and the increase of ISO14001-certified businesses
- 3) “Improving Quality of Life and Enhancing National Status,” which aims to integrate inter-regional public transportation systems, increase per capita household energy consumption, and reduce GHG emissions under the Clean Development Mechanism (CDM).

The Korea Intellectual Property Office (2010) reported the number of international patent applications in Korea to have steadily risen by a factor of six from 1,573 in the year 2000 to 9,639 by 2010. Over a similar period from 2002 to 2008, the number of new and renewable energy-related patent applications grew from 13 to 113, alluding to an increasing degree to which technological innovations supported green growth and sustainable development. Moreover, the number of green patent applications is an integral indicator of the “planning green technology development for growth engine” component of the “Creating New Growth Engine” strategy of Korea’s *Five-year Plan for Green Growth* (Republic of Korea, Presidential Committee on Green Growth, 2009a).

A2.3.2. Green bond frameworks in South Korea

From 2013 through 2017, development bank green bond issuance volumes amounted to roughly \$1.9 billion (or nearly 60% of the total \$3.3 billion produced by top issuers). As the country’s largest issuer, the Export-Import Bank of Korea earmarked proceeds to green building, transportation, water, waste, and energy assets. Korea Hydro & Nuclear Power, the second largest issuer, earmarked its proceeds to green buildings, energy, and transportation. The third largest issuer, K-water, planned to allocate proceeds to energy, water, and other climate change-adaptation related infrastructures. The two remaining issuers focused on singular targets: Namely, the Korea Development Bank applied proceeds exclusively to energy projects, and Hyundai Capital Services applied proceeds to clean water projects.

The Export-Import Bank of Korea issued South Korea’s first, \$500 million green bond in 2013 to finance renewable energy, water, and energy efficiency projects. By 2017, roughly \$160 billion was issued, the majority of which earmarked proceeds to renewable energy and low-carbon buildings. Some additional \$18 billion outstanding in bonds not labeled as green were

also issued to finance rail transport, energy, and forestry-related climate infrastructure investments (Climate Bonds Initiative, 2018c).

South Korea's robust bond markets, bankable project pipelines, investor bases, and climate policies each support expanding domestic green bond markets. Still, high transaction costs, foreign currency risk, and information asymmetries among issuers and (both domestic and foreign) investors remain key obstacles to green bond proliferation (Climate Bonds Initiative, 2018c). Addressing these factors and establishing national green bond guidelines and issuance standards will be key to improving investor confidence and scaling up market activity.

A2.3.3. Renewable energy promotion in South Korea

Following the adoption of its FiT program in 2002, the South Korean government outlined clean and renewable energy as a staple of its low-carbon green growth initiative. With three phases of its *New and Renewable Energy Development and Deployment Basic Plan* (e.g. the *Basic Plan*) enacted for the periods of 2002 to 2011, 2003 to 2012, and 2009 to 2030, South Korea increased its initial target of producing 3% of its total primary energy supply (TPES) via renewable sources by 2006 to 11% by 2030. A number of renewable energy support mechanisms were introduced in each phase of the *Basic Plan*, including:

- 1) Regional deployment programs;
- 2) Financial support programs;
- 3) Tax support programs;
- 4) Certifications for buildings that utilize renewable energy;
- 5) Renewable portfolio standards;
- 6) A feed-in tariff program;
- 7) Tradeable green certificates;
- 8) Renewable energy technology standards; and
- 9) Renewable energy cluster development.

As a result, renewable energy production increased from 1.4% of TPES in 2002 to 2.75% of TPES by 2011 (Yoon and Sim, 2015). By 2012 however, South Korea's 1.9% new renewable energy contribution to TPES was lower than the 9% average of IEA counterparts (IEA, 2014), highlighting its poor deployment record and policy performance.

Similar to energy system developments in Japan over the first two decades of the 21st century, the South Korean government's strategies to implement nuclear power often conflicted with and hindered strategies for renewable energy proliferation. Moreover, the shift from the FiT to an RPS system in 2012 brought additional challenges. First, the change created unbalanced technological changes and negative signals across renewable energy sectors. At the same time, government strategic supports generally only promoted fuel cell development (Park and Kim, 2018). In response to these obstacles to more diverse, widespread renewable energy deployment, South Korea should aim to implement the following:

- 1) Citizen participation-driven renewable energy development goals
- 2) Clear definitions and legal oversight of renewable energies
- 3) New renewable energy-oriented public funds
- 4) Systematic monitoring and feedback mechanisms for assessing policy goals, and
- 5) Further government agency oversight (Yoon and Sim, 2015).

A2.3.4. Cap-and-trade program in South Korea

South Korea's cap-and-trade programme ushered in sweeping innovations related to emissions reduction technologies. It covered nitrous oxide (NO_x), sulfur oxide (SO_x), and particulate matter (PM) emissions from 136 factories throughout Seoul, Incheon, the Gyeonggi area, and over 24 counties. Stage 1 of the programme went into effect in January of 2008 and aimed to limit annual NO_x and SO_x emissions to 30 and 20 tonnes, respectively. Stage 2 went into effect in July of 2009 and targeted emissions of both NO_x and SO_x that exceeded the annual limits of 4 tonnes (OECD, 2009a). By implementing initial emissions restrictions based on five-year averages and linking increasingly stringent targets to the capabilities of optimally developed technologies, the programme incentivized technological development, enhanced the cost competitiveness of improved technologies, and incited a dramatic increase in the number of emission reduction-related patents (Jones and Yoo, 2011).

The first enforcement period of the more recent ETS outlined in the 2012 *Act on the Allocation and Trading of Greenhouse Gas Emission Allowances* (e.g. the *ETS Act*) began in 2015. This programme placed emissions limits of 125 kilotonnes of carbon dioxide equivalent (ktCO₂e) for companies and 25 ktCO₂e for business units. According to its national emission reduction roadmap to 2020, emissions cuts in the industry, transportation, buildings, public,

agriculture/fisheries, waste, and power sectors that are covered by the ETS are expected to reduce national GHG emissions by 233 metric tonnes of carbon dioxide equivalent (MtCO_{2e}) and reach an upper limit of 766 MtCO_{2e} (Park and Hong, 2014).

The success South Korea's ETS was rooted in the government's ability to implement laws with clearly defined development timelines, establish a strategic governance architecture, stabilize markets by maintaining price allowance threshold, and provide support packages to compensate for losses incurred in the transition to low-carbon development. Insights from this program could prove useful to developing countries facing industrial opposition, less-than-optimal financial markets, and other institutional challenges (Oh et al., 2016).

A2.4. China

A2.4.1. Green growth targets in China

China's 12th Five Year Plan (2011) aimed to push the nation beyond its former economic growth patterns by harnessing the energy efficiency, natural resource management, and environmental sustainability tenets of green growth. The plan highlights the remarkable potential for "going green" to accelerate overall growth, noting such pursuits as addressing climate change as "an important opportunity to speed up economic restructuring as well as the transformation of China's mode of development and to hasten forth the new industrial revolution" (The World Bank, 2013). The plan strategically prioritizes green growth through development breakthroughs in high-value-added, exportable technologies across seven key industries:

- 1) Environmental protection and energy efficiency;
- 2) New energy;
- 3) Next generation information technologies (IT);
- 4) Biotechnologies
- 5) High-end manufacturing;
- 6) Clean energy vehicles; and
- 7) High-tech materials.

The plan also aims to spur continued economic growth while improving quality of life, energy security, resource intensity, agricultural output, and other economic factors more efficiently than conventional growth strategies through the following measures:

- 1) Greening traditional sectors of the economy

- 2) Expanding emerging industries;
- 3) Inciting new green product market formation
- 4) Accommodating new consumer preferences; and
- 5) Anticipating climate change impacts (The World Bank, 2013)

While technological progress is the primary driver of green total factor productivity in China (Liu et al., 2016), more generally, clean energy development has been the driver of green growth. As one of the largest generators of small hydroelectricity, China has also doubled its wind turbine capacity every year since 2005 (The World Bank, 2013) and is a global leader in solar panel manufacturing. Additional factors that support green growth throughout China include its large domestic markets, abundant investment capital, vast natural resource endowments, competitive edge in attracting foreign investment and R&D capital, and government power to mobilize high-priority action. Still, many of its industries are resource and waste intensive, environmental standards are weakly enforced and incentivized, there is low competition in domestic green sectors, and greater market-mechanisms are required to incentivize fiscal and regulatory reforms for environmental protections.

Between 1990 and 2014, the number of environmentally related technology patents in China increased by sixty times and surpassed the respective three-fold and 18-fold increases experienced in OECD and BRIICS countries (Linster and Yang, 2018). From 2010 to 2014, 20% of patents related to environmental management (e.g. air and water pollution abatement) technologies, while 76% related to eco-friendly buildings and energy technologies conducive to climate change mitigation (OECD, 2017a). Despite the surge in green patents, the share of green patents to total patents in China was still lower than those of OECD and fellow BRIICS countries. Moreover, the majority of patents were design or utility patents (as opposed to genuine inventions) that were not registered in the triadic patent families (OECD, 2017a). This, in effect, signifies the need for China to accelerate its green patent-based innovations.

A2.4.2. Green bond frameworks in China

Chinese green bond markets expanded to include over \$30.9 billion in domestic and overseas market issuances by 2018. This placed the Chinese green bond market as the second largest in the world behind the \$34.1 billion U.S. market. Moreover, the number of green bonds issued outside of internationally recognized frameworks decreased from over 80% in 2016 to

50% (totaling \$10.8 billion) by 2018 (Climate Bonds Initiative, 2019b). This is a positive sign overall, as adopting international standards incentivizes firms to promote sustainability reporting that is often preferred by potential investors (Ng, 2018).

In the backdrop of this massive upscaling of the Chinese green bond market, the People's Bank of China (PBoC) established stricter guidelines on operations, proceeds allocations, impact reporting, quarterly green credit performance, and numerous other oversight protocols for green bond issuers. At the core of the China Green Finance Committee (GFC), the China Central Depository & Clearing Company, Ltd. (CCDC) and the China Energy Conservation and Environmental Protection Group (CECEP) collaborated in 2018 with the government, financial institutions, and international organizations in an effort to establish a nationwide, transparency-enhancing *Green Bond Environmental Information Disclosure System*. Moreover, the Asset Management Association of China (AAMC) published *Green Investment Guidelines* to guide fund managers to finance climate change, resource conservation, and resource efficiency-related projects that attract investors with environmental, social, and governance (ESG) priorities. These and other institutional frameworks are fundamental to the continued expansion of Chinese green bond markets.

A2.4.3. Renewable energy promotion in China

From the *Renewable Energy Law* of 2006 to the 12th (2011-2015) and 13th (2016-2020) *Five-Year Plans*, renewable energy proliferation has been a key target among national government policies in China since the turn of the century. The 2007 *Medium and Long Term Plan of Renewable energy* set the target of 15% renewable energy consumption of total primary energy consumption by 2020. Subsequently, National Development and Reform Commission (NDRC) feed-in-tariffs such as the *Notice on Improving Wind Power Feed-in Tariff Policy* of 2009 and the *Notice on Exerting the Role of Price Leverage to Promote the Healthy Development of Photovoltaic Industry* geographically divided renewable energy resource areas and applied FiT pricing mechanisms accordingly.

Especially since 2013, increasing renewable energy support mechanisms highlight the importance of renewable energy in the national development strategies of the Chinese government (Liu et al., 2014; Mischke and Karlsson, 2014; Wang et al., 2014). For example, the 2014 *Measures for the Assessment of Renewable Energy Generation Quotas* issued by the

NDRC led to renewable energy quotas and tradeable renewable energy certificate systems that bolstered renewable energy production and consumption. Indeed, state-run policies and deployment strategies have been crucial to renewable energy proliferation throughout the country. Furthermore, recent proposals to expand renewable energy supports include:

- The National Energy Agency's (NEA) 2016 *Guidance on the Establishment of the Target-Guidance System for the Development and Utilization of Renewable Energy Sources*, which provides province-level recommendations for the proportions of total primary energy consumption that should be comprised of renewable energy consumption;
- The NDRC's 2016 *Management Measures for the Full Guaranteed Purchase of Renewable Energy Power Generation*, which promotes renewable energy consumption through power purchase guarantees; and
- The joint NDRC, NEA, and Ministry of Finance (MOF) 2017 *Notice on the Certification and Voluntary Subscription of Renewable Energy Green Electricity Certificates*, which encourages government agencies, institutions, and enterprises to subscribe to the national green energy certificate platform.

A2.4.4. Cap-and-trade program China

The carbon intensity reduction targets of China's 12th Five-Year Plan and 2009 Copenhagen Climate Conference commitment are the policy precedents behind an increasingly viable emissions trading system. The former aimed to decrease carbon intensity by 17% between 2011 and 2015, while the latter calls for a 40% to 45% reduction of 2005-level carbon intensity by 2020. In 2011, pilot carbon-emission trading systems were launched in the Beijing, Tianjin, Shanghai, Chongqing, Guangdong Province, Hubei Province, and Shenzhen, areas that collectively accounted for 18% of the country's population and 30% of its GDP. By 2014, five cities and two provinces had launched successful systems (Liu et al., 2015).

Among the earliest systematic challenges for China's ETS were inaccuracies of quota allocations, imperfect trading mechanisms, and lagging legislative instruments (Liu et al., 2015). More recently, unreasonable cap settings, unclear punishment and reward measures, and a lack of market balancing mechanisms that stabilize carbon prices, trading volumes, and liquidity are among the detrimental factors undermining market efficiency in ETS pilots (Zhao et al., 2016).f

A2.5. India

A2.5.1. Green growth targets in India

Despite experiencing marked economic growth, India still heavily relied on pollution and labor-intensive production that constrained its overall EAMFP growth. Eco-innovation and finance throughout India were driven by a handful of supportive policies, including the *Science, Technology and Innovation Policy* of 2013. Moving forward, R&D and employee investments throughout environmentally friendly manufacturing industries show particular promise to enhance green growth through innovation. This is because the success generated by these actions to cause a ripple effect of motivation among other sustainability-oriented firms throughout the economy (Ganapathy et al., 2014).

With that said, many of India's green innovations and patents were supported by policies that provided clear and stable signals that investments in such targets would lead to long-term benefits. Such signaling was complimented by substantial public research. In fact, over 30% of green patents in India over the first decade of the 21st century were the result of efforts of India's Council of Industrial and Scientific Research (OECD, 2010).

A2.5.2. Green bond frameworks in India

The top five green bond issuing firms in India delivered \$3.2 billion or nearly half of the roughly \$7 billion issued between 2013 and 2017. With the exception of the Indian Railway Finance Corporation that earmarked proceeds exclusively to railway-related transportation infrastructure, the remaining four top issuing firms allocated proceeds to energy-related investments.

In 2015, the Securities and Exchange Board of India (SEBI) issued disclosure requirements for green bond issuances and listings. These guidelines define the projects that qualify to receive green bond finance, prohibit the practice of "greenwashing" conventional bonds, and other critical considerations that aid in standardizing market procedures and practices. The remaining risk-inducing challenges for the Indian green bond market include high hedging costs, low government ratings, obstructive commercial borrowing regulations, and double taxation potential. Greening the agricultural sector and encouraging greater issuances from electric utilities and other government-backed organizations stand to promote green bond market growth (Climate Bonds Initiative, 2018d)

A2.5.3. Renewable energy promotion in India

Out of a lineage of earlier regulations, India's *Electricity Act* of 2003 set precedent by promoting cogeneration and grid connectivity for renewable energy-based electricity generation. Subsequently, the *Tariff Policy* of 2006 promoted the procurement of non-conventional energy by distribution companies through preferential tariffs and competitive bidding. To a large degree, however, non-financial instruments such as renewable purchase obligations, tradeable green certificates, solar capacity auctions and bundling, and wheeling and banking power with the grid have been among the most effective drivers of renewable energy growth in India (Thapar et al., 2016). Furthermore, district advisory committees, renewable energy shops, energy parks, and other initiatives of the Indian Planning Commissions 2006 *Integrated Energy Policy Report* further bolstered renewable energy integration and consumer awareness (Kumar et al., 2010).

Notable renewable energy-related policies include the *National Biofuel Policy* of 2008 and the *Strategic Plan for New and Renewable Energy Sector* for 2011 through 2017. The latter aimed to increase grid-connected renewable energy by 21.7 GW and increase rural renewable energy-based electrification, renewable energy-based cooking systems, and green building development over its six-year period of effect. Further green energy development was supported by a 2010-year FiT scheme that made renewable energy pricing more cost competitive with conventional generation technologies.

A2.5.4. Cap-and-trade program India

While India has yet to implement a cap-and-trade system for emissions reductions, under its *National Mission for Enhanced Energy Efficiency* included in its 2008 *National Action Plan on Climate Change*, the country established a “Perform, achieve and Trade” (PAT) mechanism to enhance the cost effectiveness of energy efficiency improvements in industrial plants. Similar to emissions cap-and-trade programs, the PAT employs tradeable permits that certify energy savings. The first compliance cycle between 2012 and 2015 aimed for 6.68 million tonnes of oil equivalent (toe) in energy savings across 478 companies throughout the cement, iron and steel, chlor-alkali, aluminum, thermal power, pulp and paper, fertilizer, and textile industries. The second compliance cycle expands the target companies and industries to include 143 firms across the refinery, railway, and electricity distribution (e.g. DISCOM) industries (Bhandari and Shrimali, 2018).

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