
Policies to Promote Green Economy Innovation in East Asia and North America[†]

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Abstract

Although there is progress in developing green sectors in North America and East Asia, the key challenge facing the expansion of economy-wide green innovation and structural change in these regions is the absence of relevant policy follow-up to the green stimulus enacted during the Great Recession. The boost to green sectors provided by such measures is waning quickly, given that much of the green stimulus focused on energy efficiency. The biggest obstacles to sustaining green growth in North America and East Asia are major market disincentives, especially the under-pricing of fossil fuels and market failures that inhibit green innovation. A three-part strategy to overcome these obstacles would involve: first, removing fossil fuel subsidies; second, employing market-based instruments to further reduce the social costs of fossil fuel use; and third, allocating any resulting revenue to public support for green innovation and investments. Such a strategy would ensure that green growth is not about promoting niche green sectors but instigating economy-wide innovation and structural transformation in North America and East Asia.

Keywords

green economy, green growth, North America, East Asia

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1. INTRODUCTION

A green economy results in “improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities,” and thus “in a green economy, growth in income and employment should be driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. These investments need to be catalyzed and supported by targeted public expenditure, policy reforms and regulation changes” (UNEP, 2011). Similarly, “green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies” (OECD, 2011).

The purpose of this paper is to compare and contrast recent progress towards building a green economy in six countries, South Korea, China, Japan, United States, Canada and Mexico, and to suggest a policy strategy for further expanding science, technology and innovation (STI) to promote the burgeoning green economy in East Asia and North America. Over the past decade, progress in green growth for these two regions has been promising. During the 2008-9 Great Recession, the major global economies devoted nearly 16% of their total fiscal stimulus to “green investments”, such as low-carbon energy, energy efficiency, pollution abatement and materials recycling, natural resources conservation and environmental compliance, and other green sectors (Barbier, 2010a; 2010b; Robins, Clover, & Saravanan, 2010; Robins, Clover, & Singh, 2009). However, the amounts devoted to green investments varied considerably across East Asia and North America; South Korea allocated 79%, China 34%, the US 12%, Canada 9%, Mexico 10%, and Japan 6%.

Today, the nascent green economy in East Asia and North America is at a crucial crossroad: Will “green” sectors remain a small niche within an overall “brown” economy, or will the green economy foster a new wave of sustainable industrial innovation, R&D and employment that ultimately replaces the brown economy?

As this paper outlines, which path the green economy in East Asia and North America takes will depend crucially on the policy choices made in the coming years and decades. To make these choices, it is important to understand the state of the major green sectors in the six countries that are the focus of this paper (South Korea, China, Japan, United States, Canada and Mexico), the current policy climate for developing these sectors, and the challenges and obstacles to sustaining green growth. After briefly reviewing these trends, the paper proposes a three-step strategy for building a green economy in all countries.

2. GREEN STIMULUS DURING THE GREAT RECESSION

A unique feature of the global policy response to the 2008-9 recession is that, as part of their efforts to boost aggregate demand and growth, some governments adopted expansionary policies that also incorporated a sizable “green fiscal” component. Such measures were wide-ranging, including support for renewable energy, carbon capture and sequestration, energy efficiency, public transport and

rail, and improving electrical grid transmission, as well as other public investments and incentives aimed at environmental protection.

Of the 3.3 trillion USD allocated worldwide to fiscal stimulus over 2008-9, 522 billion USD was devoted to such green expenditures or tax breaks (see Table 1). Almost the entire global green stimulus was by the Group of 20 (G20), which comprises the world's twenty largest and richest countries, including the six that are the focus of this paper. Although South Korea, China, Japan, United States, Canada and Mexico accounted for around 85% of the global green stimulus over 2008-9, the levels of spending varied significantly by economy. The United States and China accounted for over two thirds of the global expenditure on green fiscal stimulus, followed by South Korea (11.5%) and Japan (8.3%). In comparison, Canada contributed only 0.5% of the global green stimulus, and Mexico 0.1%.

TABLE 1. Green Stimulus During the 2008-9 Great Recession

Economies	Green stimulus (\$US billion)				Share (%) of green stimulus in:		
	Low carbon power ^a	Energy efficiency ^b	Waste and water ^c	Total	Global total	Fiscal stimulus	GDP ^d
China	1.6	182.4	34.0	218.0	41.8%	33.6%	3.1%
United States	39.3	58.3	20.0	117.7	22.5%	12.0%	0.9%
South Korea	30.9	15.2	13.8	59.9	11.5%	78.7%	5.0%
Japan	14.0	29.1	0.2	43.3	8.3%	6.1%	1.0%
Canada	1.1	1.4	0.3	2.8	0.5%	8.7%	0.2%
Mexico		0.8		0.8	0.1%	9.7%	0.1%
Total six countries	86.8	287.2	68.3	442.3	84.7%	18.0%	1.5%
Total G20	105.3	330.1	78.1	513.5	98.3%	17.1%	0.8%
Global total	107.6	335.4	79.1	522.1	15.7%	15.7%	0.7%

Sources: Barbier (2010a), Robins et al. (2009), Robins et al. (2010)

- a. Support for renewable energy (geothermal, hydro, wind and solar), nuclear power, and carbon capture and sequestration.
 - b. Support for energy conservation in buildings; fuel efficient vehicles; public transport and rail; and improving electrical grid transmission.
 - c. Support for water, waste and pollution control, including water conservation, treatment and supply.
 - d. Based on 2007 estimated Gross Domestic Product (GDP) in terms of purchasing power parity, from the US Central Intelligence Agency The World Factbook, available at <https://www.cia.gov/library/publications/the-world-factbook/rankorder/2001rank.html>.
- * G20 is the Group of 20 countries. The members of the G20 include 19 countries (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the UK and the US), plus the European Union. The G20 total excludes the European Union.

South Korea devoted nearly 80% of its total fiscal stimulus to green measures, whereas China allocated around one third (see Table 1). In contrast, Japan spent only 6% of its fiscal stimulus on green expenditures and tax breaks. The North American economies spent approximately the same amount of their total stimulus on green measures: 12% for the United States, 10% for Mexico and 9% for Canada.

The six economies also differed substantially in terms of the share of gross domestic product (GDP) devoted to green stimulus (see Table 1). South Korea spent 5% of its GDP on its Green New Deal,

and China just over 3% on its variety of green measures.¹ This is considerably higher than the global share across all countries of 0.7%. In contrast, the United States and Japan spent around 1% of GDP on green stimulus, which is just above the global share. Finally, Canada allocated a much more modest 0.2% of GDP, and Mexico just 0.1%.

To summarize, most the world's green stimulus during the 2008-2009 Great Recession occurred in North America and East Asia. However, in North America, it was really only the United States that spent a significant amount on green stimulus; Canada and Mexico allocated much smaller amounts to these measures. Even in the three East Asian countries there were some important differences. Whereas South Korea and China devoted a large share of their total fiscal stimulus and GDP to green tax breaks and expenditures, Japan was much more conservative.

3. THE EMERGING GREEN ECONOMY

Over the past decade, progress in green growth for North America and East Asia has been promising. This may be due, at least in part, to the green stimulus enacted during 2008-9. However, even before the recession, nascent green sectors were emerging. Today, there are five key sectors that are considered part of the burgeoning green economy in North America and East Asia:

- energy from renewable resources,
- energy efficiency
- pollution abatement and materials recycling
- natural resources conservation and ecological restoration
- environmental compliance, education, training and public awareness.

The first sector comprises electricity, heat, or fuel generated from renewable sources, such as wind, biomass, geothermal, solar, ocean, hydropower, landfill gas, and municipal solid waste. The second sector includes energy-efficient equipment, appliances, buildings, and vehicles, as well as products and services that improve the efficiency of energy storage and distribution. The third sector includes pollution abatement, which involves the reduction or elimination of pollution and hazardous wastes, and recycling materials, which involves the collection, reuse, remanufacturing, or recycling of waste materials and water. The fourth sector includes natural resources conservation, such as organic agriculture and sustainable forestry, land management, soil, water, or wildlife conservation, and storm water management, as well as ecological restoration, which is the practice of renewing and restoring by active human intervention and action the degraded, damaged, or destroyed ecosystems and habitats in the environment. Finally, the fifth sector comprises products and services that enforce environmental regulations, provide education and training related to green technologies and practices, or increase public awareness of environmental issues.

¹ South Korea's Green New Deal included around US\$19 billion for the Four Rivers Project that featured plans to dam and dredge four major rivers, which could have some negative environmental impacts (Nubile, 2010).

In North America, the United States was an early leader in these five green sectors. Pew (2009) found that, between 1998 and 2007, jobs in the clean energy sector grew more quickly than overall US employment growth, and by 2007 accounted for over 770,000 jobs, or approximately 0.5% of employment in the United States.² The green sectors in the United States may now employ more than three million workers (3% of US employment), produce around 3% of the gross domestic product (GDP), and have exceeded economy-wide GDP growth every year since 2000.³

In Canada, between 2007 and 2009, clean technology investments dramatically increased by 47%, and by 2010 this sector employed 45,000 jobs (Sustainable Prosperity, 2012). In 2013, there were over 730,000 environmental professionals in Canada, just over 4% of the labor force (ECO Canada, 2013). The number of jobs in this area have grown ten-fold since 1993 and nearly tripled in the past ten years; in comparison, total Canadian employment from 2003 to 2013 grew only 13% (ECO Canada, 2013).

Very little is known about the development of green sectors in Mexico. However, in March 2012, Mexico launched its Sustainable Development Centre, a public-private non-profit organization that will develop policies to promote the concept of a green economy and support activities tackle climate change (UNEP, 2012).

Even before it adopted green fiscal measures, China viewed the promotion of green sectors as sound industrial policy, aiming to be the world market leader in solar panels, wind turbines, fuel-efficient cars, and other clean energy industries (Aizawa & Yang, 2010; Ho & Wang, 2015; Mathews, 2012; Ping, Danui, Pengfe, Zhenyu, & Zhou, 2013). By 2008, its renewable energy sector already had a value of nearly 17 billion USD and employed close to 1 million workers (Barbier, 2010a). From 2006 to 2010, the expansion of renewable energy in China may have resulted in a further 472,000 net employment gains, and in 2010, there was a 0.68% increase in total employment for every 1% increase in the share of solar photovoltaic generation, larger than any other power generation technology in China (Cai, Wang, Chen, & Wang, 2011). In December 2013, China announced that it would modify further the twelfth Five-Year Plan (2011 – 2015) - which already contains binding environmental targets such as a 17% reduction in carbon intensity - to give even more weight to environmental protection, resource efficiency, and other goals compatible with supporting green sectors (Ho & Wang, 2015).

South Korea also sees its industrial strategy tied to green growth (Barbier, 2010a; Hwang, Oh, & Lee, 2014; Mathews, 2012). In addition to the Green New Deal adopted during the Great Recession, the South Korean government established a \$72.2 million USD renewable energy fund to

² In comparison, Pew (2009) found that the biotechnology sector employed fewer than 200,000 workers, or approximately 0.1% of total US jobs in 2007, and the fossil fuel sector, including utilities, coal mining, and oil and gas extraction, employed 1.27 million workers in 2007, or about 1% of total US jobs.

³ See the Green Goods and Services Survey of the U.S. Bureau of Labor Statistics <http://www.bls.gov/ggs/news.htm> (accessed on 2 February 2015) and Environmental Business International <http://ebionline.org/ebj-archives/1944-ebj-v26n07-08> (accessed on 2 February 2015).

attract private investment in solar, wind and hydro electric power projects. In July 2009, South Korea launched a five-year Green Growth Investment Plan, spending an additional US\$60 billion on reducing carbon dependency and environmental improvements, with the aim of creating 1.5-1.8 million jobs and boosting economic growth through 2020 (Barbier, 2010a).

Despite its relatively modest green stimulus during the Great Recession compared to China and South Korea, as early as the 1990s Japan developed a lead position in green manufacturing, especially for consumer durables, motor vehicles, parts and accessories, electrical equipment, and other special purposes machinery (Fankhauser, Bowen, Calel, Dechezleprêtre, Rydge, & Sato, 2013). This has allowed Japan to maintain a leading edge in these industries, and in green innovation overall.

To summarize, there is considerable progress in developing green sectors in North America and East Asia. These sectors are providing significant employment opportunities and contributing to overall GDP. However, whether these sectors can become the fulcrum for widespread green transformation and innovation in economies will depend critically on overcoming key policy challenges.

4. POLICY CHALLENGES

Perhaps one of the most limiting features of green growth policies in North America and East Asia is that, to be successful, they must eventually foster a degree of structural transformation and industrial development that is well-beyond simple expansion of the five green sectors identified above. For example, Fankhauser et al. (2013) “interpret green growth as an economy-wide transformation, rather than the expansion of the environmental goods and services sectors (p. 903).” The authors argue that there are several strategic sectors whose transformation is central to the creation of a green economy. These areas include industrial processes, which need to become cleaner and more resource efficient (e.g. iron and steel); sectors that are important for energy efficiency on the supply side (electricity distribution systems) and the demand side (domestic appliances); the energy supply chain for electricity generation and other industrial processes (steam generators, engines and turbines, electric motors and transformers); and car manufacturing (low-emission and electric vehicles) and key components (accumulators, primary cells and batteries).

Fankhauser et al. (2013) find that the “green race” to become global competitive leaders in these industries is between eight high-income or large emerging market economies: China, France, Germany, Italy, Japan, South Korea, the United Kingdom, and the United States. Of the North American and East Asian economies, only Japan has a large number of sectors (61) with above-average green innovation, which accounts for two-thirds of the country’s manufacturing output. In contrast, in the other seven economies, green innovation is occurring in at most of 20-40% of manufacturing. Japan also has the highest green innovation in its 15 largest manufacturing sectors. However, China has significant green innovation in its fabricated metal products, and Fankhauser et al. (2013) maintain “that we should expect China’s performance to improve as the objective of the five-year plan are implemented” (p. 906). South Korea has a competitive advantage and green innovation in basic chemical industries (excluding fertilizer) and special purpose machinery; the United States leads in

electronic equipment manufacturing, basic chemicals, automobile parts and accessories, measuring/testing/navigating appliances, and aircraft manufacture.

Overall, Fankhauser et al. (2013) conclude that, in developing a competitive advantage in green transformation and innovation, “public policy is important. A key challenge for the green economy is to overcome persistent market failures (e.g. on innovation) and externalities (e.g. pricing the environment), which requires well-designed and consistent public policy intervention. Business decisions on investment and R&D in particular respond to such policy signals (p. 911).”

Similarly, the Asian Development Bank (ADB & ADBI, 2013, p. 18) identifies “low-carbon green growth” in Asia as “a process of structural change”, which envision patterns of industrial development, specialization and innovation, “thereby defining low-carbon development as the capacity of an economy to generate new dynamic activities”. Thus, a major component of this strategy is to ensure the dissemination of low-carbon and energy-saving technologies, the adaption and dissemination of these technologies throughout the economy, support for infant green firms, government procurement policies to achieve mainstream emission reduction targets, and public sector investments to support these industrial developments. In other words, the approach advocated is to enhance economy-wide “green” structural transformation through a combination of “public investment and industrial as well as trade policies, aiming at encouraging in both cases a strong private sector response” (ADB & ADBI, 2013, p. 19).

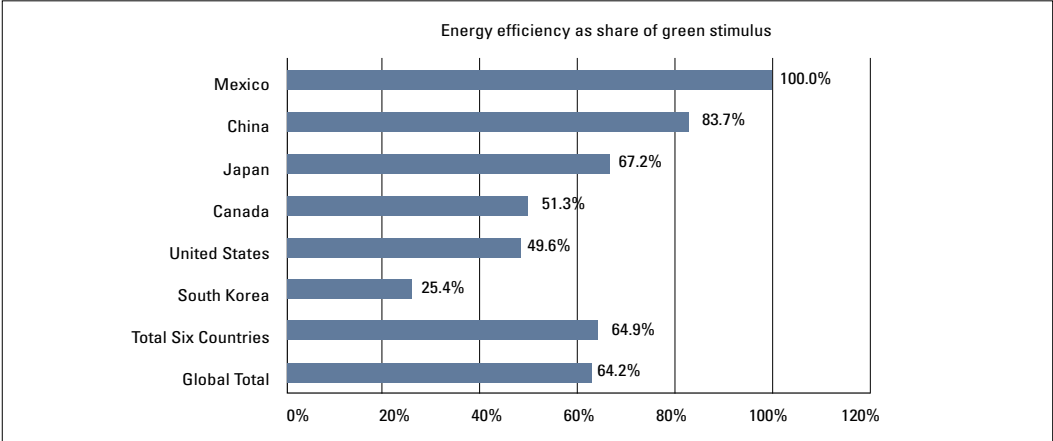
With the exception of China and South Korea, a major obstacle to green structural transformation in North America and East Asia is the “policy void” since the green stimulus policies enacted during the Great Recession. In North America especially, the expansion of the green economy could remain confined to a few niche sectors rather than lead to sustained, economy-wide green growth. Key difficulties include outdated utility business models, inadequate transmission infrastructure for renewables, and complications caused by decreasing energy and resource prices. (“Top U.S. Green Economy,” 2014) The clean technology industry in Canada is also under-funded by venture capitalism and public research and development (R&D) financing (Sustainable Prosperity, 2012). China also faces unique obstacles, such as overcoming the reluctance of some provincial policy-makers to meet key environmental and green sector targets (Ho & Wang, 2015). In addition, there is concern that, in the absence of implementing an economy-wide carbon tax and other complementary policies, China may have difficulty to achieving its ambitious green industrial strategy and greenhouse gas reduction targets (Lu, Ton, & Liu, 2010). South Korea may also incur significant economic costs, if it tries to achieve its mid-term green growth targets without introducing policies that support economy-wide green innovation and technological change (Hwang et al., 2014).

These policy challenges across North America and East Asia are significant impediments to green structural economic transformation. This is due to two principal reasons (Barbier, 2010b).

First, nearly 65% of the global green stimulus in North America and East Asia was devoted to energy efficiency (see Figure 1), much of which was aimed at boosting short-term employment and not promotion long-term structural transformation. In the U.S. and Canada, around half of green

stimulus spending was on energy efficiency, and Mexico’s entire green stimulus went to energy efficiency. Nearly all of Canada’s low-carbon power investments (1.1 billion USD) went into carbon capture and storage (920 million USD), which is a narrow green sector (Robins et al., 2009). Although only one quarter of South Korea’s Green New Deal was devoted to energy efficiency, it accounted for 84% of the green stimulus in China and 67% in Japan (see Figure 1).

FIGURE 1. Energy Efficiency and Green Stimulus in North America and East Asia, 2008-9



Sources: Barbier (2010a), Robins et al. (2009), Robins et al. (2010)

Second, major market disincentives to long-term development of the green economy in the form of environmentally harmful subsidies, the absence of pollution taxes and other market-based incentives, and the lack of public investments to support private green R&D, remain a fundamental obstacle to long-run development of the green economy in North America and East Asia. Unless a greater effort is made to remove these major market disincentives, then the long-term prospects for green innovation and transformation in North America and East Asia may be severely hindered.

To summarize, the key challenge facing the expansion of economy-wide green innovation and structural change in North America and East Asia is the absence of relevant policy follow-up to the green stimulus enacted during the Great Recession. The boost to green sectors provided by the latter measures is waning quickly, given that so much of the green stimulus focused on energy efficiency. But perhaps the most serious obstacles are major market disincentives, such as environmentally harmful subsidies, the absence of pollution taxes and other market-based incentives, and persistent market failures that inhibit green innovation.

5. MARKET DISINCENTIVES

This section focuses on two sets of market disincentives that are prevalent in North America and East Asia, which are significant deterrents to green structural transformation and innovation. The first is the persistent under-pricing of fossil fuels. Current markets for coal, oil and natural gas, as

well as for their key products – electricity generation, diesel and gasoline – not only exclude these environmental damages and other impacts, but the prices in these markets are frequently subsidized. The second disincentive is the widespread market failure that leads to under-investment in green research and development (R&D) and innovation.

5.1. Fossil Fuels

Barbier (2011) has documented how cheap and accessible fossil fuels – first coal and then oil and natural gas – were essential to the two phases of innovation that characterized the long process of industrialization that began around 1750. It was during this process, approximately around the middle of the 19th century, that the global spread of industrialization and the growing dependence of virtually every economy on the new sources of energy ushered in the fossil fuel era, which persists to this day. Thus, in the modern era, all economies have become entirely dependent on fossil fuels, and access to inexpensive supplies of these natural assets is considered strategically essential to economic development globally. Carbon-dependent development, mainly through the consumption of fossil-fuel energy, is the model of successful economic development to which all economies aspire. This is especially apparent for the six economies that are the focus of this paper: South Korea, China, Japan, United States, Canada and Mexico.

The persistent under-pricing of fossil fuels remains a major market disincentive to green structural transformation and innovation in North America and East Asia. As noted in the introduction, a green economy aims to reduce carbon emissions and pollution, as well as enhance energy and resource efficiency (UNEP, 2011). As long as fossil fuel markets are heavily subsidized and fail to account for pollution and other social costs, clean energy and low carbon investments, energy efficiency, and pollution abatement are placed at a competitive disadvantage.

TABLE 2. Under-pricing of Fossil Fuels, North America and East Asia

Economies	Annual exploration subsidies (US\$ billion) 2010-2013 ^a	Annual fossil fuel subsidies (US\$ billion) 2011 ^b	Share (%) of world total	Annual fossil fuel subsidies, tax breaks and environmental costs (US\$ billion) 2011 ^b	Share (%) of world total
Canada	3.5	21.1	4.4%	26.4	1.4%
China	11.5	0.0	0.0%	257.4	13.5%
Japan	6.0	0.0	0.0%	46.0	2.4%
Mexico	3.0	0.0	0.0%	27.6	1.5%
South Korea	3.1	0.2	0.0%	16.7	0.9%
United States	6.5	8.8	1.8%	502.1	26.4%
Total six countries	33.6	30.1	6.3%	876.2	46.1%
Total G20	87.9	186.9	38.9%	1,272.0	66.9%
Global total	-	480.0	-	1,900.0	-

Sources: Bast et al. (2014), Clements et al. (2013)

- Bast, Makhijani, Pickard, & Whitley (2014). Exploration subsidies include government subsidies for exploration, public investment on exploration through state-owned enterprises, and public finance from domestic and international sources for exploration.
- Clements, Coady, Fabrizio, Gupta, Alleyne, & Sdalevich (2013). Annual fossil fuel subsidies plus tax breaks for fossil fuels and the failure to price (tax) negative externalities, such as the costs of climate change, local pollution, traffic congestion, accidents and road damage.

Table 2 summarizes estimates of subsidies and further under-pricing of fossil fuels in North America and East Asia. Support for exploration amounts to approximately 34 billion USD per year in these economies, and annual fossil fuel subsidies are a further 30 billion USD, or approximately 6% of the global total. However, when further under-pricing is accounted for – tax breaks and the failure to take into environmental damages such as such the costs of climate change, local pollution, traffic congestion, accidents, and road damage – the losses in North America and East Asia amount to nearly 880 billion USD, which is almost half of the world total. The United States alone accounts for 502 billion USD in under-pricing, or over a quarter of the world total, followed by China with 257 billion USD, or 14% of the world total.

The prevalence of fossil fuel subsidies and the failure to account for pollution and other social costs create another problem for North American and East Asian economies. They provide the rationale for implementing environmentally motivated subsidies as the main policy for fostering the green economy: First, to counter the price advantage that under-pricing of fossil fuels gives to the brown economy, and second, to promote expansion of employment in the emerging sectors of the green economy.

Barbier and Markandya (2012, ch. 6) document the growing use of environmentally motivated subsidies, in the form of tax discounts, grants and soft loans, and tariff subsidies to promote various green sectors in North American and East Asian Economies. Already, the number of environmentally motivated subsidies implemented is large (Barbier & Markandya, 2012). For example, Canada employs 18 such subsidies to promote a variety of green sectors, the United States uses 17, and South Korea seven. Japan has the fewest, with only four, which consist of rebates for miningsite reclamation, and grants, soft loans and similar subsidies for environmental improvement, renewable energy and greenhouse gas reduction, and cleaner vehicles and fuels.⁴

Some of these subsidies could be relatively minor in their impact, and others may be necessary. However, it is also clear that every major green sector in North America and East Asia has already benefited from some form of major subsidy (Barbier & Markandya, 2012, ch. 6). Employing subsidies to foster temporarily the expansion of nascent green sectors and industries may seem like a reasonable policy. Unfortunately, as the persistence of both fossil fuels and environmentally harmful subsidies in the North America illustrate, once any subsidy is implemented, it becomes difficult to remove and thus often remains in place indefinitely. The growing and widespread use of environmentally motivated subsidies in North America and East Asia may in turn become an obstacle to green economic development over the long term. Just like any other subsidy, they can lead to inefficiencies, lack of competitiveness and over-use.

5.2. Green Innovation and Investments

An important impetus for rapid economy-wide innovation is “technology spillovers”, which occurs

⁴ There was no available information on environmentally motivated subsidies in China and Mexico.

when the inventions, designs and technologies resulting from the research and development (R&D) activities by one firm or industry spread relatively cheaply and quickly to other firms and industries. However, such technology spillovers also undermine the incentives for a private firm or industry to invest in R&D activities. The private investor bears the full cost of financing R&D, and may improve its own technologies and products as a result, but the investor receives no returns from the subsequent spread of these innovations throughout the economy. The consequence is that private firms and industries routinely under-invest in R&D, and the result is less economy-wide innovation overall.

Under-investment in R&D may be a serious obstacle to the development of the green economy in North America and East Asia. Moreover, overcoming this disincentive cannot be achieved solely by the use of market-based incentives to correct inefficient pricing but requires the simultaneous implementation of “technology-push policies”, such as research and development (R&D) subsidies, public investments, protecting intellectual property, and other initiatives (Goulder, 2004). Market-based incentives may reduce pricing distortions that put green goods and services at a competitive advantage. However, only technology-push policies directly address the tendency of firms and industries to under-invest in green R&D.

Goulder (2004) finds that reducing the costs of low-carbon energy adoption in the United States stems both from the boost to private sector R&D and from learning-by-doing as firms gain familiarity with new low-carbon technologies, products and processes. He identifies both a set of technology-push policies and a set of direct emissions policies that consistently induce additional technological change by supporting private R&D and learning-by-doing (see Table 3). However, Goulder also finds that the direct emissions policies on their own cannot induce sufficient private-sector investment in innovations and learning-by-doing; rather, there needs to be complementary technology-push policies implemented as well.

TABLE 3. Induced Innovation and Public Policies for Reducing Carbon Dependency

Public policies for reducing carbon dependency	
Direct emissions policies	Technology-push policies
Carbon taxes	Subsidies to R&D in clean energy technologies
Carbon quotas	Public-sector R&D in clean energy technologies
Cap-and-trade for greenhouse gas (GHG) emissions	Government-financed technology competitions (with awards)
Subsidies to GHG emission abatement	Strengthened patent rules

Source: Goulder (2004)

Studies for reducing greenhouse gas emissions in the United States, Asia and Europe show that combining the two types of policies substantially lowers the costs of meeting targets compared to relying just on regulations or one set of policies (ADB & ADBI, 2013; Blesl, Kober, Bruchof, & Kuder, 2010; Fischer & Newell 2008; Hwang et al. 2014; Lu et al. 2010; Popp, 2010). The optimal portfolio of policies generally includes some form of subsidies and other public support for technology R&D and learning along with carbon pricing and other direct emissions policies. Such an outcome is likely to extend to other sectors of the green economy, especially when spillovers of knowledge make it difficult for private investors in R&D to reap the full social benefits of their innovations.

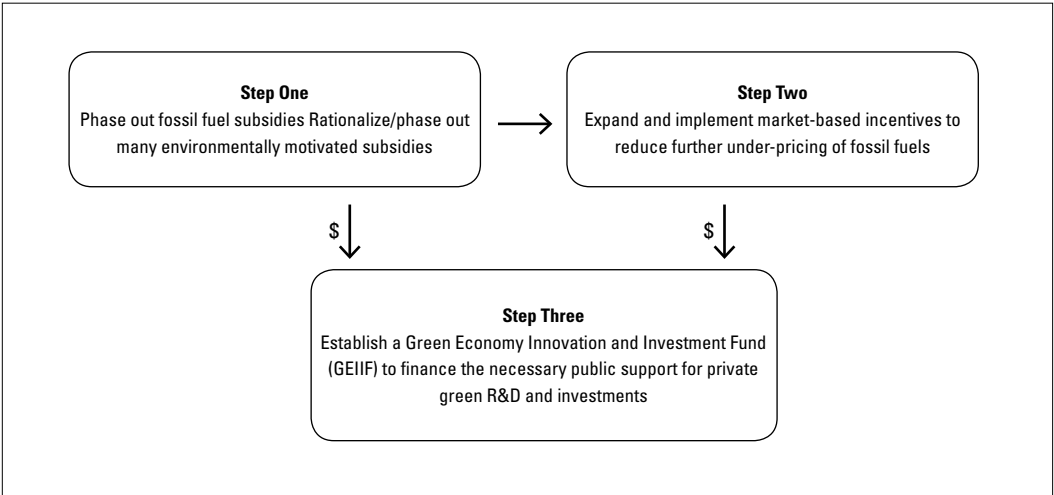
Public support and investments may also be critical for other bottlenecks to green growth in North America and East Asia (Barbier, 2010a). One obstacle is inadequate transmission infrastructure for renewables, which can only be overcome through public investments to design and construct a “smart” electrical grid transmission system that can integrate diffuse along with conventional sources of supply. Another is the development of green-growth policies in urban areas that combine municipal planning and transport policies to foster more sustainable cities. Finally, public investment in mass transit systems, both within urban areas and major routes connecting cities has been a long-neglected aspect of public infrastructure development throughout North America and East Asia.

To summarize, the under-pricing of fossil fuels, the increasing use of environmentally motivated subsidies to promote green sectors, and the lack of public support for private green R&D and investments to overcome other obstacles to green growth are serious impediments that need to be addressed. Without comprehensive policies to eliminate these barriers to green structural transformation and innovation, the long-term prospects for developing more sustainable and green economies in North America and East Asia are bleak.

6. POLICY STRATEGY TO PROMOTE GREEN INNOVATION

A comprehensive approach for promoting green innovation and structural transformation in North America and East Asia should be based on a three-part policy strategy: phasing out fossil fuel subsidies, and where possible, rationalizing or eliminating environmentally motivated subsidies; implementing various market-based incentives to correct any remaining under-pricing of fossil fuels; and finally, using any resulting financial savings and revenues to fund public support public for private green R&D and investments. This three-part strategy is outlined in Figure 2.

FIGURE 2. A Policy Strategy for Green Innovation and Structural Transformation



The first step requires phasing out fossil fuel subsidies. In addition, as the increasing reliance of the green economy on environmentally motivated subsidies may be counter-productive to its long-term development, many of these subsidies need to be rationalized or phased out as well. Based on the estimates for fossil fuel subsidies in Table 1, eliminating these subsidies would free up at least 3 billion USD annually in Canada, Mexico and South Korea, 6 billion USD in the United States, and 11 billion USD in China. The rationalization or phasing out of many environmentally motivated subsidies in North America and East Asia would also save additional funds that could also be re-allocated instead to public investments in support of green growth.

The second step to promoting sustained green growth in North America and East Asia is to expand the use of and implement more effectively a wide range of market-based incentives, such as taxes, charges, tradable permit schemes, and voluntary mechanisms, to curb the additional social costs associated with fossil fuels (see Table 2). Ending the under-pricing of oil, gas and coal would generate environmental and health benefits, boost existing green sectors, and stimulate economy-wide green growth. In addition, any revenues resulting from taxes, charges and auctioned permits could also finance public support for green R&D and investments.

The final step in building a green economy is to allocate the revenues saved or generated from the phasing out of fossil fuel subsidies, the rationalization or phasing out of many environmentally motivated subsidies, and the use of various market-based incentives to establish a Green Economy Innovation and Investment Fund (GEIIF). The purpose of the GEIIF should be to finance the necessary public support for private sector green R&D and investments as well other public infrastructure and programs necessary for green growth. For example, the GEIIF could fund a number of necessary technology-push policies, such as subsidies to green R&D by the private sector as well as complementary public-sector R&D, government-financed green technology competitions, and stronger patent rules. Important public investments to support the green economy would include development of a “smart” electrical grid transmission system that can integrate diffuse along with conventional sources of supply, municipal planning and transport infrastructure to foster more sustainable cities, and expanding of mass transit systems both within urban areas and major routes connecting cities.

7. CONCLUSION

Ultimately, whether green sectors remain just one small niche within an overall brown economy, or green growth ushers in a new wave of industrial innovation, R&D, and employment, requires ending the current “policy void” that has emerged in North America and East Asia since the Great Recession. As long as this void persists, harmful subsidies, inadequate pollution taxes and other market-based incentives, and the dwindling public support of private green R&D and investments, will continue to hinder economy-wide green development. Another concern is that green sectors are becoming overly reliant on environmentally motivated subsidies, which could be detrimental to green growth over the long run.

The three policy steps proposed in this paper aim to foster a more economy-wide effort at fostering green innovation and structural transformation. All three policies are essential to an integrated strategy, and as outlined and summarized in Figure 2, they are also interdependent: Step one involves phasing out fossil fuel subsidies, not only because this policy is relatively straightforward to implement but also because determining which additional market-based incentives to employ to end the chronic under-pricing of fossil fuels requires first assessing the environmental and economic consequences of subsidy removal. This pricing policy should be step two in the strategy. Finally, establishing a Green Economy Innovation and Investment Fund (GEIIF) to finance the necessary public support for private sector green R&D and investments should be the subsequent policy, because the Fund's financing should come from any revenues saved from subsidy removal or generated from market-based incentives.

As argued in this paper, green growth is not about promoting niche green sectors; it involves economy-wide innovation and structural transformation. The economies of North America and East Asia have proven to be among the leaders in promoting certain green sectors and industries. Whether they can sustain, build on and expand this competitive edge in the near future will depend critically on developing a comprehensive policy strategy to promote private-sector green R&D and innovation that translates into economy-wide investments across a wide range of sectors and industries.

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