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**Navigating Low-Carbon Finance Management
at
Banks and Non-Banking Financial Institutions**

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Abstract: *Lack of long-term financing, the existence of various risks, the low rate of return, and lack of capacity in market actors are major challenges for the development of low-carbon projects. This paper attempts to provide guidelines for governments and financial institutions by highlighting practical solutions as enabling conditions of low-carbon finance and investment. Such solutions include increasing the role of public financial institutions, increasing the share of non-banking financial institutions in long-term investments, using the spillover tax to increase the rate of return, developing green credit guarantee schemes to reduce the credit risk, and addressing low-carbon investment risks via financial and policy de-risking. These solutions are analysed in detail and considerations for their implementation are discussed throughout the paper. Tools and instruments for low-carbon investments and a practical example of the implementation of the proposed tools are also provided in this paper.*

Keywords: low-carbon investment; banks; non-banking financial institutions; green credit guarantee scheme.

JEL Classification: Q56;E62;G23

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1. Introduction

In recent years, several new methods for financing low-carbon projects have been developed, including green bonds, green banks, and village funds. The advantages of green banks include improved credit conditions for clean energy projects, the aggregation of small projects to reach a commercially attractive scale, the creation of innovative financial products, and market expansion through the dissemination of information about the benefits of clean energy (Sachs et al., 2019). Supporters of green bonds believe that they can provide long-term and reasonably priced capital to refinance a project once it has passed through the construction phase and is operating successfully (Coquelet, Dougherty, and Herrera, 2016).

Although such methods have been somewhat helpful in the development of green projects, data suggest that they are inadequate. Fossil fuel investments continue to be much larger than investments in renewable energy. In 2013, renewable energy received investments of only about \$260 billion, which is only 16% of the \$1.6 trillion in total energy sector investments (International Energy Agency, 2014). Meanwhile, investment in fossil fuels in the power sector, where they compete directly with electricity from renewable energy, rose by 7% from 2013 to 2014 (Frankfurt School–United Nations Environment Programme Collaborating Centre for Climate and Sustainable Energy Finance and Bloomberg New Energy Finance, 2015). Clearly, fossil fuels still dominate energy investment. A major concern in the transition to low-carbon energy provision, therefore, is how to obtain sufficient finance to steer investments towards low-carbon energy (Mazzucato and Semieniuk, 2018).

Banks are reluctant to finance low-carbon energy projects because of the limitations of the Basel capital requirements on lending by financial institutions and since banks consider most renewable energy projects to be risky. Hence, it is important to take the necessary steps for mitigating the risks of low-carbon financing to unlock the participation of financial institutions in these projects (Yoshino and Taghizadeh-Hesary, 2018a). A method that will be presented in this paper is the introduction of green credit guarantee schemes (CCGSs), developed and introduced in Taghizadeh-Hesary and Yoshino (2019), to reduce the risk of financing. It is also important for

banks to have specific programs for a precautionary approach to low-carbon lending as well as compliance and risk management, which will be highlighted in this paper.

Non-banking financial institutions (NBFIs) – especially pension funds and insurance companies – are also suitable institutions for low-carbon financing and investments. Asian economies are usually bank-oriented economies, as banks account for the major share of the financial system in almost all Asian countries while Western economies are more capital market-oriented. When looking at the financial assets of households in Asian countries, bank deposits and cash account for the largest share in most of them, with insurance companies and pension funds providing the second largest share. In Japan in 2013, 55% of the total financial assets of households were in the form of cash and deposits at banks, 28% in the form of insurance and pensions, 12% in the form of securities and stock, and 5% in other forms. For American households, these ratios were 15% (cash and deposits), 28% (insurance and pension funds), 53% (securities and stock), and 4% (others) (Yoshino and Taghizadeh-Hesary, 2015). Even in Japan, which has a developed capital market, the share of cash and deposits is much larger than that of securities and stock. In other Asian economies, banks also dominate the financial system, pension funds and insurance companies provide a second level, and the share of the capital market is small. This means that banks, insurance companies, and pension funds are the main source of finance for projects and businesses. However, the advantage of pension funds and insurance companies over banks is that they hold money for the long term (10, 20, or 40 years). Infrastructure projects, including large low-carbon energy projects such as large hydropower, can be financed by insurance companies or pension funds, as they are long-term (10–20 year) projects. Therefore, it is very important to develop pension funds and insurance companies in developing countries to fill the financing gap of infrastructure projects, including energy and low-carbon energy projects (Yoshino and Taghizadeh-Hesary, 2018a).

Our paper contributes to the literature by providing innovative solutions for unlocking low-carbon finance and investment from banks and NBFIs. These solutions will help financial institutions to minimise and manage the risk of low-carbon financing. They include developing GCGSs for reducing the financial risk, introducing

insurance mechanisms and de-risking to cover non-financial risks, and using the spillover tax to increase the rate of return on low-carbon projects.

The paper is structured as follows. In section 2, we highlight the challenges of developing low-carbon projects. Section 3 focuses on introducing and analysing the enabling conditions for low-carbon financing. Section 4 provides an example of the implementation of the proposed tools and instruments, and section 5 delivers concluding remarks and outlines policy implications.

2. Challenges for the Development of Low-Carbon Projects

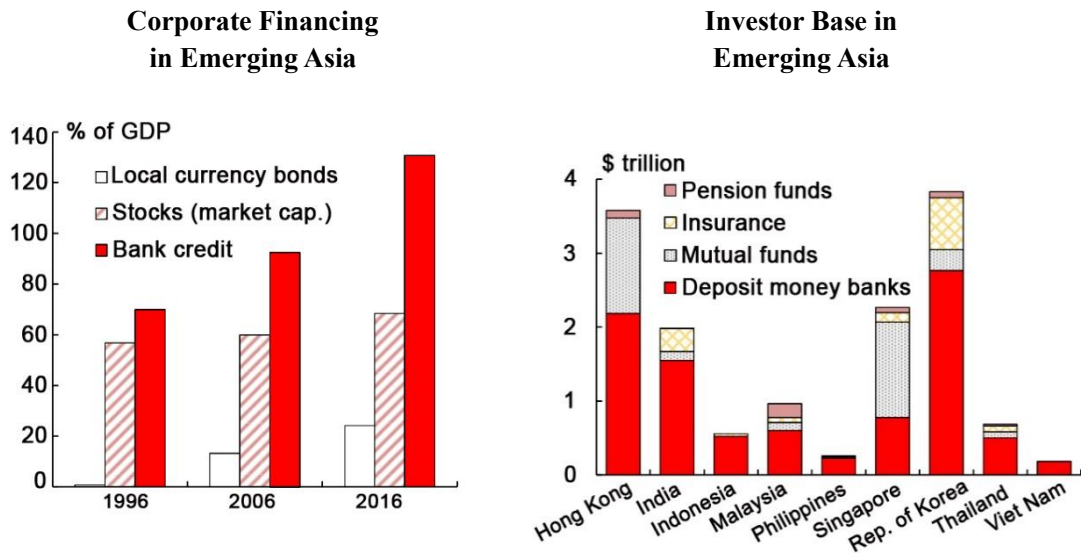
This section highlights the challenges for the development of low-carbon projects.

2.1. Lack of Long-Term Financing

Low-carbon energy projects such as other infrastructure projects are long-term projects, hence they need long-term financing. A shortage of long-term finance blunts the progress of low-carbon development. Asian economies are still dominated by banks, and the banking sector constrains long-term finance. The development of public financial institutions (PFIs) that provide long-term finance or the development of pension funds and insurance companies are major solutions for filling the long-term financing gap.

Figure 1 shows the structure of financial markets in selected Asian countries. Banks dominate the financial systems in Asia. Bank loans are suitable for financing short- to medium-term projects because the resources of banks are deposits, which are typically short- or medium-term resources – usually 1, 2, or at most 5 years (deposits longer than 5 years are very rare). Hence, if banks allocate their resources to long-term infrastructure projects (such as bridges, highways, ports, and airports) and mega low-carbon energy projects (such as large hydropower projects), there would be a maturity mismatch. Therefore, as banks' liabilities (deposits) are short- to medium-term, their assets (loans) also need to be allocated to short- to medium-term projects rather than to long-term projects.

Figure 1: Bank-Dominated Financial Systems in Asia



GDP = gross domestic product, cap. = capital.

Note: Emerging Asia is the aggregate of China, India, Indonesia, the Republic of Korea, Malaysia, the Philippines, Thailand, and Viet Nam.

Source: Bank of Japan (2017).

Notes: As of the end of 2013, except for India's deposit money banks figure, which refers to the end of March 2014. Figures for pension funds and mutual funds for Indonesia and Viet Nam, and insurance for Hong Kong, are not available.

Source: Bank of Japan (2017).

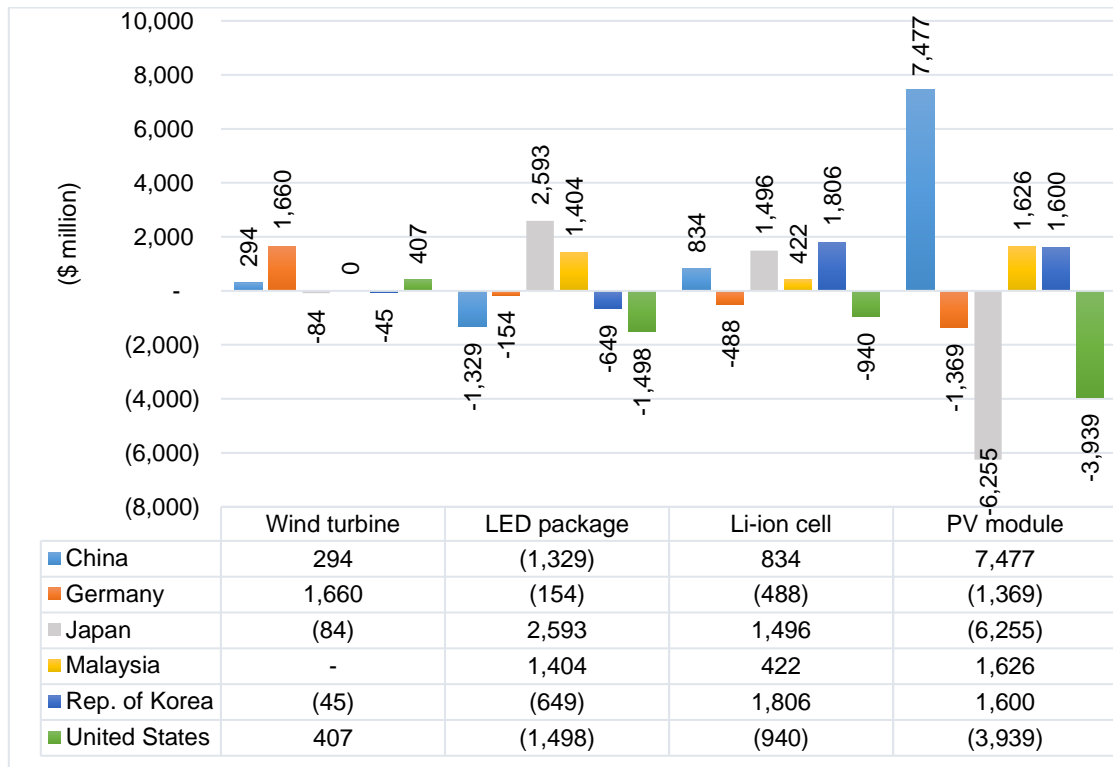
2.2. Existence of Various Risks

As most low-carbon energy technologies are new, several risks are associated with them (Yoshino, Taghizadeh-Hesary, and Nakahigashi, 2019). From mechanical breakdowns of wind power generator gearboxes to the panels of photovoltaic projects breaking, potential losses can reach millions of dollars, with major damage interrupting projects and businesses. This is not the whole story, however, as other risks are associated with these projects – especially the weather. Most low-carbon energy projects depend on climate and sunlight. The unpredictability of the weather, such as clouds that reduce the sun's irradiation or changes in wind strength, can have a significant negative impact on energy production and affect the feasibility of these projects. In addition, as most equipment for low-carbon projects is new and high-tech, it is expensive, creating a feasibility risk. Manufacturing low-carbon technologies depends on cross-country supply chains and trade. Economies that are net importers

of final products may be major exporters of materials or subcomponents for the same technologies. Hence, the exchange rate is another risk for low-carbon technologies.

Figure 2 shows the balance of trade for the four major clean energy technologies. Crystalline silicon (c-Si), photovoltaic (PV), and LED packages are the most heavily traded, perhaps because they are more easily shipped than other end products. The balance of trade is not the full story, however. While major PV deployment markets such as the United States and Germany are net importers of PV modules, they are also the largest exporters of polysilicon to make those modules, purchased mainly by Japan and China.

Figure 2: Balance of Trade in Select Clean Energy Technology End Products and Across the C-Si PV Module Supply Chain, 2014 (\$ million)



() = negative, c-Si = crystalline silicon, PV= photovoltaic.

Source: Developed by the authors based on data from CEMAC (2017).

Other risks are also associated with low-carbon projects. Some of them are project-specific (demand risk) and some are general (e.g. natural disaster and political risks).

2.3. Low Rate of Return

Low-carbon technologies are often earlier in the development stage and less commercially viable than technologies in the fossil fuel field, many of which date back 100 years. This makes low-carbon technologies more expensive and riskier ventures. Lack of access to conventional financing sources increases the debt cost (borrowing interest rate). New and expensive low-carbon technologies and access to expensive debt markets reduce the rate of return in low-carbon projects compared with fossil fuel projects. On the other hand, the majority of energy subsidies globally go to fossil fuels rather than the low-carbon sector. In 2015, both consumers and producers of fossil fuels received about \$425 billion in subsidies globally – via direct payments, tax breaks, loan guarantees, cheap rental of public land, and research and development (R&D) grants (Merrill et al., 2017). According to the Organisation for Economic Co-operation and Development (OECD), the production or consumption of fossil fuels is supported by almost 800 individual policies (OECD, 2015). Another form of subsidy, an indirect one, takes place when fossil fuel companies are not taxed efficiently (Coady et al., 2017). This means that the price consumers pay for coal, gas, or oil does not consider the damage caused by these products, such as climate change or air pollution, making low-carbon projects less viable than fossil fuel energy projects.

2.4. Lack of Capacity in Market Actors

Investments in low-carbon projects are also undermined by lack of familiarity, limited information and knowledge, and limited expertise on low-carbon and green infrastructure amongst investors. For example, OECD research indicates that most institutional investors have limited experience with direct investment in green infrastructure projects, and it is expensive to build an internal team with an appropriate skill set (investors need a minimum of \$50 billion in assets to build such a team) (Kaminker et al., 2013). Green infrastructure investment performance data are generally not collected systematically. (Kaminker et al., 2013). The absence of transparent information, data, and financial research that can act as a signal to investors or means of performance comparison in any given sector creates significant barriers to entry.

3. Enabling Conditions of Low-Carbon Finance

To overcome the challenges mentioned in section 2, this section provides practical solutions to create enabling conditions for low-carbon finance.

3.1. Increasing the Role of PFIs

The first and most important challenge for financing low-carbon projects is lack of access to long-term finance and investment (subsection 2.1). PFIs could be important entities for filling the financing gap of the low-carbon sector. PFIs, or publicly created and/or mandated financial institutions that have often been created to correct the lack of market-based finance through the provision of missing financial services, have a potentially important role to play in scaling up private sector investment in low-carbon projects. For example, five PFIs in Europe – France’s Caisse des Dépôts Group, Germany’s KfW Bankengruppe, the United Kingdom’s Green Investment Bank, the European Union’s European Investment Bank, and the European Bank for Reconstruction and Development for transition economies – have provided more than €100 billion in equity investment and financing for energy efficiency, renewable energy, and sustainable transport projects during 2010–2012 (Cochran et al., 2014). These PFIs use both traditional and innovative approaches to link low-carbon projects with finance by enhancing access to capital, facilitating risk reduction and sharing, improving the capacity of market actors, and shaping broader market practices and conditions.

It is important for PFIs to open a separate file for low-carbon financing. They also need to integrate environmental considerations in conventional project financing. For example, the Japan Bank for International Cooperation (JBIC) launched GREEN¹ operations in 2010, using measurement, reporting, and verification (J-MRV) as a method to evaluate the greenhouse gas emission reductions of the projects that JBIC finances. Along with the basic concept and procedures of quantifying the reductions, the J-MRV guidelines include individual methodologies for each sector of the project and/or technology, which vary from renewable energy to transport. When GREEN

¹ https://www.jbic.go.jp/wp-content/uploads/page/2013/08/47261/env_2015.pdf

operations began, J-MRV had only three methodologies for the projects which were most in demand, including renewable energy and the installation of energy-efficient industrial equipment. However, JBIC gradually developed new methodologies, increasing to 10 in 2016 (JBIC, 2016).

Although the role of PFIs could be very important, some important points need to be considered regarding the involvement of PFIs in low-carbon financing. The first point is that they need to focus more on long-term financing (long-term loans) than commercial private banks, whose resources (deposits) are short-term (1, 2, or 3 years). Private banks are not able to provide long-term loans, so the maturity of PFI loans has to be longer than that of private banks. The second point is to set a stable and fixed interest rate that is lower than that of private banks, which often fluctuate their interest rates, since low-carbon projects need a stable and fixed interest rate for steady growth. Private banks have to pay taxes and set up branch offices, so they have more costs than governments, which translates to higher interest rates than those of PFIs. The third point is to mitigate the negative effects of government lending through PFIs by limiting the government's role as lender. This implies making PFI loans only where private banks cannot provide loans and avoiding the crowding out effect on private banks. A successful case in this regard is the German KfW, whose government funding goes through private banks to low-carbon projects, housing, small and medium-sized enterprises (SMEs), etc. rather than via direct lending from the government to projects.

3.2. Increasing Share of NBFIs in Long-Term Investments

Institutional investors are the largest suppliers of capital to listed companies, managing almost \$100 trillion in assets in OECD countries alone. Because of their size and their role as a conduit of savers' climate concerns to the capital markets, institutional investors are ideally positioned to steer corporate capital allocation towards more sustainable uses. An increasing number of institutional investors has adopted strategies to mitigate climate exposure. These include negative screening (exclusion of non-green sectors/companies from portfolios), positive screening (proactive identification of positive climate themes), active ownership (exercise of statutory rights to promote green standards in portfolio companies), sustainability ratings (portfolio scoring based on green criteria) and hedging of climate risks (through

portfolio allocation or use of derivatives). These strategies reflect specific fund manager mandates and the recognition that climate risks can have a tangible impact on corporate valuations and, as a result, institutional fund performance (Gianfrate and Lorenzato, 2019). Two major pressures from the side of investors and regulators can also boost the participation of institutional investors in low-carbon projects. From the side of investors, environmentally friendly low-carbon concerns increasingly affect people's saving and investment decisions. This trend is particularly visible in developed economies and amongst younger generations. Savers at NBFIs are demanding stricter compliance with environmental, social, and governance criteria as well as the broadening of product offerings to include more environmentally responsible investment options. From the side of regulators, some jurisdictions debate whether financial institutions should be mandated to integrate environmental, social, and governance issues into their investment decision policies. While such a debate mostly concerns banks, the repercussions on NBFIs would be immediate and straightforward. As an example, the Financial Stability Board created the Task Force on Climate-Related Financial Disclosures, which has recommended global organisations to enhance their financial disclosures related to the potential effects of climate change (Gianfrate and Lorenzato, 2019).

However, when we look at the actual activities of institutional investors, their asset allocation to direct infrastructure investment in general remains small – less than 1% for OECD pension funds – and the 'low-carbon' investment components are even more limited. These issues are linked to the perception that green investments do not offer a sufficiently attractive risk-adjusted financial return, and because institutional investors still lack knowledge and expertise, as well as investment channels (Kaminker et al., 2013). Using the spillover effect of green energy supply and reducing the risk of their investment through GCGSs will increase their eagerness for low-carbon projects (subsections 3.3 and 3.4).

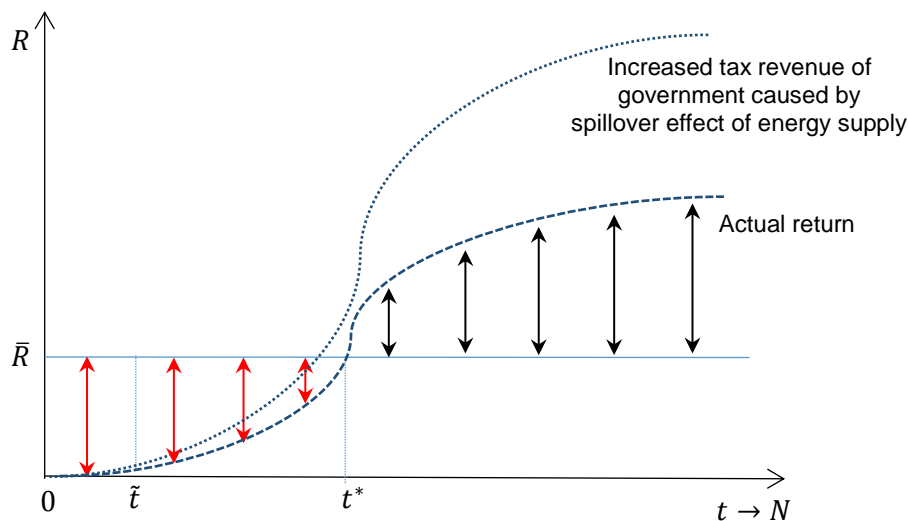
3.3. Using Spillover Tax to Increase the Rate of Return

Electricity tariffs are often regulated by governments and are usually not determined based on market mechanisms. This makes it difficult for private investors to invest in infrastructure projects because of a low rate of return on their investment.

Increasing investment incentives requires using the spillover effects originally created by energy supplies and refunding the spillover tax revenues to investors in energy projects. Energy supply brings factories and businesses into the electrified region. New residences are constructed and property values rise thanks to power supply. Corporate income tax and sales taxes also rise in the area of new energy supply. These spillover tax revenues are collected by local or central governments and are usually not returned to investors in energy projects. Investors only receive user charges/electricity tariffs accruing from the electricity supply. If part of the spillover tax revenues were returned to private investors, their rate of return would increase over a prolonged period, and their maintenance costs could be supported (Yoshino, Taghizadeh-Hesary, Nakahigashi, 2019).

Figure 3 shows that the total rate of return on a low-carbon energy project in the first year is almost zero because of the large initial investment. In addition, the spillover impact of energy supply to the region is very low or almost zero, as it takes time until the spillover impact on the regional output and tax revenue of local and central governments emerges.

Figure 3: Using GCGS and Spillover Tax in Low-Carbon Projects



GCGS = green credit guarantee scheme.
 Source: Authors' compilation.

From \tilde{t} , the rate of return and the spillover tax start to increase. If the private investor relies only on user charges for the revenue of the project, the rate of return in the initial stages is very low and it takes time until it increases, so the project would not be viable. Hence, we suggest that the increase in the tax revenue generated from the spillover effect of the energy supply needs to be injected into the low-carbon project for securing at least the \bar{R} rate of return (benchmark rate). However, the spillover tax is not sufficient until t^* , so governments can issue long-term government bonds with N years of maturity for supporting the private investors until then. The absence of a bond market, a green credit guarantee fund/corporation could provide a supporting role for securing the \bar{R} rate of return. We believe although in initial years until t^* , establishment of GCGS will have cost and budget burden for the government, the future increases in the tax revenue due to spillover effect of energy supply would compensate it. In addition, thanks to the tax revenue resulting from the spillover effect, additional revenue would be provided for the government, as shown in equation 1:

$$\int_0^{t^*} (\bar{R} - \text{Actual return}) < \int_{t^*}^N (\text{Actual return} - \bar{R}) \quad (1)$$

3.4. Collecting Carbon Tax from Polluting Industries and Injecting it into Low-Carbon Projects

One way to increase the rate of return on low-carbon projects is to inject the carbon tax collected from polluting industries and firms into low-carbon projects. This policy would make low-carbon projects attractive for private investors while forcing polluting firms to shift to more low-carbon technologies. Although this policy may increase production costs and raise price levels in the beginning, it would increase R&D expenditures on these technologies in the medium term because of higher demand for low-carbon technologies – thus reducing costs via technological progress. In this subsection, we show how imposing carbon taxation can change firms' behaviour and induce them to use more low-carbon technologies.

Here, we assume that an economy with two firms (firms 1 and 2) has production functions as in equations 2 and 3:

$$y_t^1 = F_t^1(K_t^1, L_t^1) = (K^1)^{\alpha_1}(L^1)^{\beta_1} \quad (2)$$

$$y_t^2 = F_t^2(K_t^2, L_t^2) = (K^2)^{\alpha_2}(L^2)^{\beta_2} \quad (3)$$

where y_t^1 and y_t^2 are their total output, K_t^1 and K_t^2 denote their capital inputs, and L_t^1 and L_t^2 are their labour inputs. We consider the Cobb–Douglas production function for these firms, while α_i and β_i are the elasticity of production of capital and labour, respectively. There is a constant return to scale, hence $\alpha_i + \beta_i = 1$.

Equations 4 and 5 show the profit equations for firms 1 and 2:

$$\pi_t^1 = P_t^1 y_t^1 - r_t^1 K_t^1 - w_t^1 L_t^1 \quad (4)$$

$$\pi_t^2 = P_t^2 y_t^2 - r_t^2 K_t^2 - w_t^2 L_t^2 \quad (5)$$

where π_t^1 and π_t^2 denote the profit of firms 1 and 2; P_t^1 and P_t^2 show the output prices for products of firms 1 and 2, respectively; r_t^1 and r_t^2 denote the interest rate that firms 1 and 2 pay on their borrowed capital from the bank; and w_t^1 and w_t^2 denote the wage rates that firms 1 and 2 pay to their labour inputs.

Firms follow profit maximisation behaviour. To find the optimal level of K_t^i that maximises the profit of each firm, we obtain the first order condition as in equations 6 and 7:

$$\frac{\partial \pi_t^1}{\partial K_t^1} = \frac{\alpha_1 y_t^1}{K_t^1} = r_t^1 \rightarrow K_t^1 = \frac{\alpha_1 y_t^1}{r_t^1} \quad (6)$$

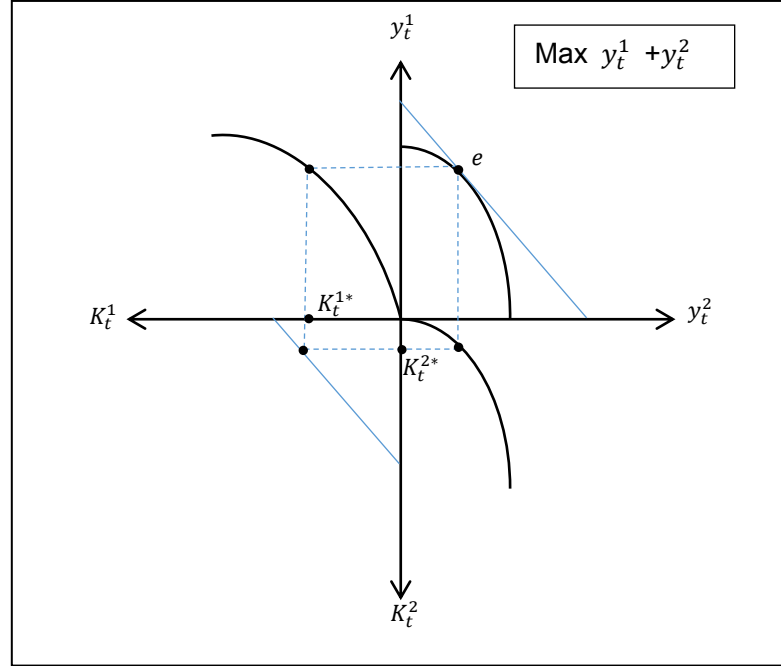
$$\frac{\partial \pi_t^2}{\partial K_t^2} = \frac{\alpha_2 y_t^2}{K_t^2} = r_t^2 \rightarrow K_t^2 = \frac{\alpha_2 y_t^2}{r_t^2} \quad (7)$$

The allocation of total funds in this economy is equal to the sum of the capital of both firms, as in equation 8:

$$K_t^T = K_t^1 + K_t^2 \quad (8)$$

The objective of the government in this economy is to maximise the sum of the outputs of both firms, as in Figure 4.

Figure 4: Allocation of Funds to Firms and Output Maximisation



Notes: e is the equilibrium point, K_t^{1*} denotes the optimal of capital for firm 1, and K_t^{2*} denotes the optimal capital for firm 2.

Source: Authors' compilation.

In the previous case, we did not consider the level of emissions (carbon dioxide). However, in reality, each firm has carbon emissions. In the case below, we consider that not only each firm has a different level of output but also a different level of emissions, and the production functions are as in equations 9 and 10:

$$g_1(y_t^1, CO_t^1) = f_t^1(K_t^1, L_t^1) \quad (9)$$

$$g_2(y_t^2, CO_t^2) = f_t^2(K_t^2, L_t^2) \quad (10)$$

where CO_t^1 and CO_t^2 show the carbon emissions of firms 1 and firm 2, respectively, in time t .

In addition to output (gross domestic product (GDP)) maximisation, the second objective of the government is to minimise the carbon emissions of both firms (equation 11):

$$\text{Min } CO_t = CO_t^1 + CO_t^2 \quad (11)$$

Therefore, the ultimate objective of the government is to maximise the cumulative output (GDP) and minimise the cumulative carbon emission, as in equation 12:

$$W = W_1(y_t - y^*)^2 + W_2(CO_t - CO^*)^2 \quad (12)$$

where y^* is the GDP in full employment (desired GDP level) and $(y_t - y^*)$ is the GDP gap. CO^* is the desired emission level and $(CO_t - CO^*)$ is the gap between the current emission level and the desired emission level.

The chart on the left in Figure 5 shows two extreme cases. Case A reflects conventional economic theory – profit maximisation without consideration of the environment. Point A is where the GDP (sum of the outputs of firms 1 and 2) is maximised. Point B is just having environmental concern, and shows the point that minimises the sum of the emissions of firms 1 and 2. Since firm 1 has more carbon emissions, point B is where, only firm 2 that has lower emissions is producing and the output of firm 1 is zero. Points C and D show the optimal level of production for each firm, when the production function includes both output and carbon emissions levels, as in equations 9 and 10.

Next, the government charges a carbon tax, which affects the profits of polluting firms. Equations 13 and 14 show the carbon production, which is a function of the capital and labour inputs. A higher level of output will emit more carbon dioxide.

$$CO_t^1 = \varphi^1(K_t^1, L_t^1) = (K^1)^{\gamma_1}(L^1)^{\delta_1} \quad (13)$$

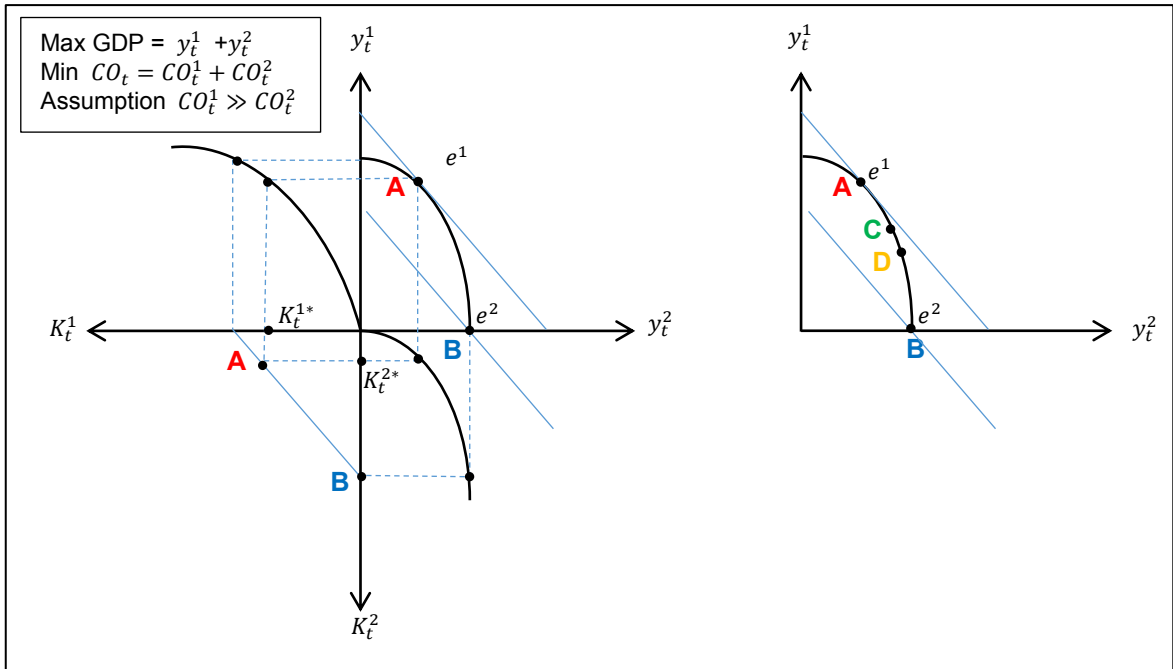
$$CO_t^2 = \varphi^2(K_t^2, L_t^2) = (K^2)^{\gamma_2}(L^2)^{\delta_2} \quad (14)$$

Equations 15 and 16 show the new profit equations of firms 1 and 2 after charging the carbon taxes, which will reduce their profits. We assume that the carbon tax rate is progressive, so a higher tax rate is charged on emissions levels when industries pollute more. This is why firms 1 and 2 have different carbon tax rates, as in equations 15 and 16 (τ_t^1 and τ_t^2):

$$\pi_t^1 = P_t^1 y_t^1 - r_t^1 K_t^1 - w_t^1 L_t^1 - \tau_t^1 CO_t^1 \quad (15)$$

$$\pi_t^2 = P_t^2 y_t^2 - r_t^2 K_t^2 - w_t^2 L_t^2 - \tau_t^2 CO_t^2 \quad (16)$$

Figure 5: Equilibrium Levels of Output with Different Objectives



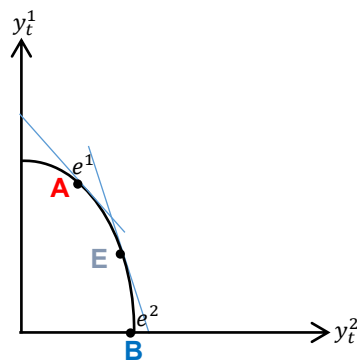
GDP = gross domestic product.

Note: e is the equilibrium point by considering different objectives, K_t^{1*} denotes the optimal of capital for firm 1, and K_t^{2*} denotes the optimal capital for firm 2.

Source: Authors' compilation.

As is clear from Figure 6, the optimal level of production of both firms in the case of a carbon tax being charged is not A or B, but E, which is in-between; and its position depends on many factors, including the level of emissions and the tax ratio.

Figure 6: Optimal Level of Output When Carbon Tax is Charged



Note: Point E is the new equilibrium point after charging the carbon tax.

Source: Authors' compilation.

This carbon tax system will induce new firms to start investment in low-carbon technologies and establish their industries with low-carbon technologies. This will create a spillover effect of low-carbon industry/infrastructure in that region, as explained in section 3.3.

The spillover effects of low-carbon (green) technologies may be expressed as follows:

$$y_t^{Gi} = h(K_t^{Gi}, L_t^{Gi}, E_t^{Gi}) \quad (17)$$

where y_t^G is the output of the firm that has green production (e.g. low-carbon or green energy); and K_t^G, L_t^G, E_t^G are capital, labour, and green energy production inputs, respectively.

The spillover effect of green energy supply is depicted in equation 18:

$$dy_t^{Gi} = \underbrace{\frac{\partial h}{\partial K_t^{Gi}} \frac{\partial K_t^{Gi}}{\partial E_t^{Gi}} + \frac{\partial h}{\partial L_t^{Gi}} \frac{\partial L_t^{Gi}}{\partial E_t^{Gi}}}_{\text{Spillover effect}} + \underbrace{\frac{\partial h}{\partial E_t^{Gi}}}_{\text{direct effect}} \quad (18)$$

The spillover effect of green (low-carbon) energy supply will increase the tax revenue of the government from the region that has green energy supply. In equation 19, we assume that 50% of the increase in government tax revenue will be injected into low-carbon projects and the other 50% will be the government's ultimate revenue:

$$\tau dy_t^{Gi} = 50\% (\text{Government}) + 50\% (\text{low - carbon projects}) \quad (19)$$

As equations 20 and 21 show, the injection of tax revenue originally generated from the spillover effect of green energy supply and the carbon taxes collected from polluting industries will increase the rate of return on low-carbon projects and induce private sector investment in the low-carbon sector:

$$r_t^{G1} = \frac{\alpha^{G1} y_t^{G1}}{K_t^{G1}} + \tau_t^1 CO_t^1 + a(\tau dy_t^G) \quad (20)$$

$$r_t^{G2} = \frac{\alpha^{G2} y_t^{G2}}{K_t^{G2}} + \tau_t^2 CO_t^2 + b(\tau dy_t^G) \quad (21)$$

where r_t^{Gi} is the rate of return on the low-carbon (green) project and $\frac{\alpha^i y_t^{Gi}}{K_t^{Gi}}$ is the initial rate of return on the green project, which is very low. By relying on this alone, the project is not feasible or attractive to private investors. $\tau_t^i CO_t^i$ is the carbon tax that the government charges on i polluting projects (firms) and then injects into low-carbon projects, while τdy_t^G is the tax revenue of the government from the spillover effect of green energy supply. a percent of this increase in tax revenue will be returned to project 1 and b percentage will be returned to project 2 to increase their rates of return. We earlier assumed that $a + b = 0.5$, which means that 50% of the increase in tax revenue caused by the spillover effect of green energy supply will be injected into low-carbon projects, and the government will take the other half as final tax revenue. As shown by the implementation of this scheme, the rate of return on low-carbon projects will increase, and on the other hand the carbon taxation will force the polluting industries to shift to cleaner industries and low-carbon technologies.

3.5. Development of Green Credit Guarantee Schemes to Reduce the Credit Risk

Credit guarantee schemes (CGSs) have been used in several countries since the early 20th century (Beck, Klapper, and Mendoza, 2008). Japan was an early innovator in CGSs in the 1930s. CGSs spread first throughout Europe and the Americas in the 1950s and then to Africa, Asia, and Oceania in the 1960s and 1970s (Zander, Miller, and Mhlanga, 2013). In 2011, 8,402 credit guarantee institutions were established around the world (Asian Development Bank (ADB), 2015).

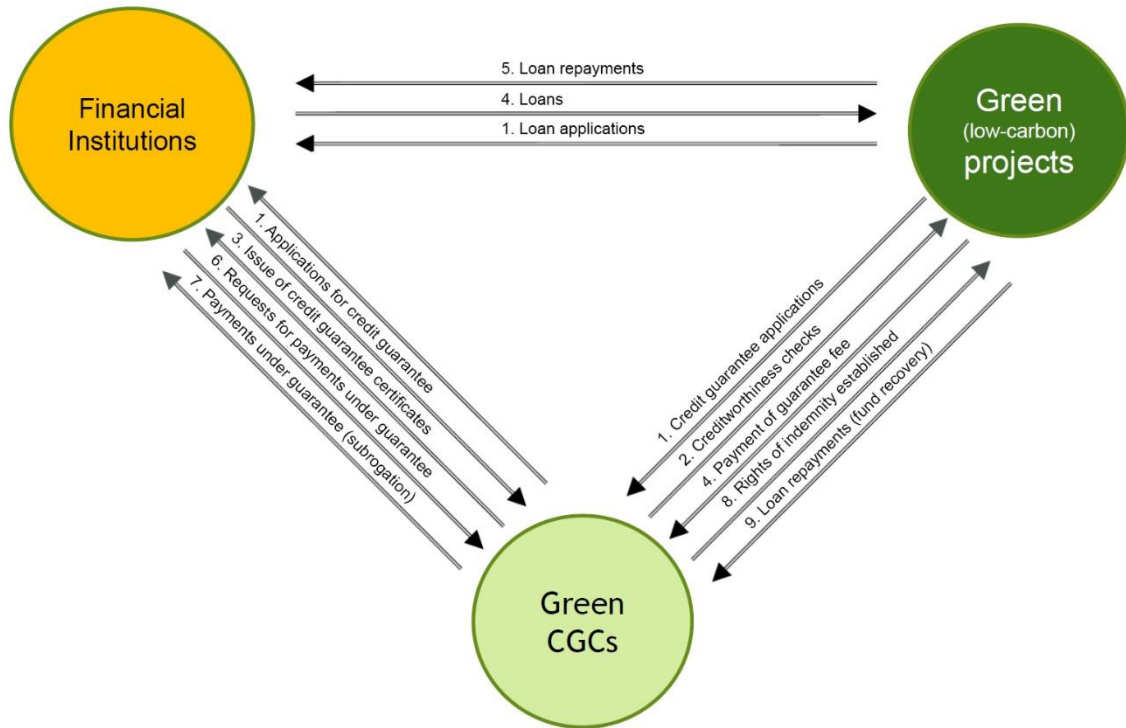
Credit guarantee corporations (CGCs) are public institutions which support sectors that lack access to finance (SMEs and start-ups) by serving as guarantors to make it easier for them to borrow the funds necessary for their business operations from financial institutions. The green CGCs initially proposed by Taghizadeh-Hesary and Yoshino (2019) improve the creditworthiness of low-carbon (green) projects, which lack physical collateral and have weak credit ratings. This helps direct funds to them from private financial institutions and provides them with smoother access to finance.

A CGS normally consists of three parties: a borrower, a lender, and a guarantor. The borrower is often an SME or a project owner seeking finance. The borrower typically approaches a bank or other financial institution for a loan, but the loan request

is often turned down because of information asymmetry. This is where the guarantor comes in. The guarantor is a CGC or agency, usually run by a government or trade association, which seeks to facilitate access to debt capital by providing lenders with the comfort of a guarantee for a substantial portion of the debt (Riding and Haines, 2001).

Figure 7 shows three participants in the GCGS – banks, green projects, and green CGCs. Green CGCs will increase the loan supply to low-carbon projects. The green credit guarantee to low-carbon projects will reduce the asymmetry of information and decrease the expected default losses because a portion of the loan default is guaranteed by the CGC (government), so banks will want to lend money to guaranteed low-carbon projects. An investor in a green project applies for a green credit guarantee when submitting the loan application. Then, a green CGC performs a creditworthiness evaluation of the project and the project owner (individual or corporate). Not all green projects are eligible to receive a guarantee – this depends on the borrower’s credit score and an evaluation of the probability of success of the green project. Depending on the results of the creditworthiness assessment of a GCGC, the investor is charged a guarantee fee or premium. The fee depends on the project risk rating and the borrower’s credit score. Using the same guarantee fee for all borrowers would create a moral hazard (Yoshino and Taghizadeh-Hesary, 2019). Banks also need to apply for a green credit guarantee to a GCGC, which issues the relevant certificate. Next, the bank disburses the loan to the green project (borrower) and the borrower starts to pay the loan instalments. In the case of default, a portion of the loan amount – the credit guarantee ratio – is compensated and subrogated from the GCGC to the bank. An adjustment of the optimal credit guarantee ratio is necessary to avoid moral hazard (Yoshino and Taghizadeh-Hesary, 2019). This means that healthy banks which manage their non-performing loans and have higher creditworthiness should receive a higher credit guarantee ratio from the government, while unsound banks need a lower guarantee and very risky banks do not obtain a guarantee. The selection of an optimal guarantee ratio by the regulator for low-carbon finance also creates an incentive for financial institutions to improve their creditworthiness to receive a higher guarantee ratio.

Figure 7: GCGS for Management of Low-Carbon Credit Risk



CGC = credit guarantee corporation, GCGS = green credit guarantee scheme.

Note: Numbering shows the sequence of the workflow.

Source: Made by the authors, inspired by Taghizadeh-Hesary and Yoshino (2019).

3.6. Addressing Low-Carbon Investment Risks Via De-Risking

Various financial and non-financial risks are associated with low-carbon projects, as explained in section 2-2. Since risks have an impact on access to credit, it is very important to mitigate them. De-risking is a potentially powerful policy option to redirect financial flows from high- to low-carbon investments in two ways: financial and policy. Financial de-risking can be done by transferring a large portion of the risk to another party, e.g. insurance risks provided by governments or development banks. Policy de-risking reduces the likelihood of a negative event by removing barriers in the investment environment and improving local institutions, e.g. a streamlined permit process reduces the likelihood of construction delays (Schmidt, 2014).

In April 2013, the United Nations Development Programme published a report that develops the concepts of measuring the effects of de-risking in quantitative terms and applies them to onshore wind power in four developing countries (Waissein et

al., 2013). The results indicate that de-risking can increase the effectiveness and efficiency of policies aiming to attract low-carbon investments (Schmidt, 2014).

3.7. Summary of Tools and Instruments for Low-Carbon Investments

The Table 1 presents the tools and instruments outlined in this section as well as suggestions for reducing the risk of low-carbon projects, raising the rate of return, increasing the capacity of the investors and other stakeholders, and facilitating access to finance and investment.

Table 1: Tools and Instruments for Low-Carbon Investments

Goal	Functions	Tools and instruments
Facilitate access to finance/investment	<ul style="list-style-type: none"> • Providing long-term finance/capital • Facilitating access to private finance/capital 	<ul style="list-style-type: none"> • Equity investment • International climate funds • Public–private partnerships • Institutional investors (pension funds, insurance companies,...)
Reduce risk	<ul style="list-style-type: none"> • Risk sharing • Credit enhancement mechanism 	<ul style="list-style-type: none"> • Green credit guarantee scheme • Financial de-risking • Policy de-risking • Structured finance • Public–private partnership
Raising the rate of return	<ul style="list-style-type: none"> • Making low-carbon projects feasible 	<ul style="list-style-type: none"> • Utilising the spillover effect in the form of tax refunds to private investors
Increasing capacity	<ul style="list-style-type: none"> • Aiding project development • Reducing project risks 	<ul style="list-style-type: none"> • Technical assistance • Capacity building • Information tools (e.g. energy certificate tracking,...)

Sources: Authors; Taghizadeh-Hesary and Yoshino (2019); Yoshino, Taghizadeh-Hesary, and Nakahigashi (2019); Cochran et al. (2014); United Nations Conference on Trade and Development (UNCTAD, 2012); and Schmidt (2014).

4. Example for Low-Carbon Finance Management

In this section, we provide an example for the development of an environmental project. The objective is to show how the implementation of a GCGS, proposed in this paper, can reduce the risk of investment in projects. One of the major challenges that cities, mainly mega cities, in developing countries face is the environmental impact of generating huge amounts of solid waste. This issue is severe in Asia, as 44 million people are added to the Asian urban population every year. By 2050, half of the world's population will live in Asia-Pacific countries (ADB, 2011). China generates 150 million tons of waste annually and is the world's largest producer of municipal solid waste (ADB, 2009). India has the second-largest population in the world after China, with 1.27 billion people or 17.6% of the world's population. Some 68% of India's population live in rural areas, while 32% live in urban areas. The urban population has been increasing for the last few decades. India generates about 133,760 tons of solid waste per day, of which around 91,152 tons are collected and only around 25,884 tons are treated. One of the major obstacles behind the development of solid waste management projects is the lack of municipal budget and the low interest of private investors in this sector because of the low rate of return. In many municipalities in large Asian cities, more than 20% of the municipal budget is allocated to solid waste management.

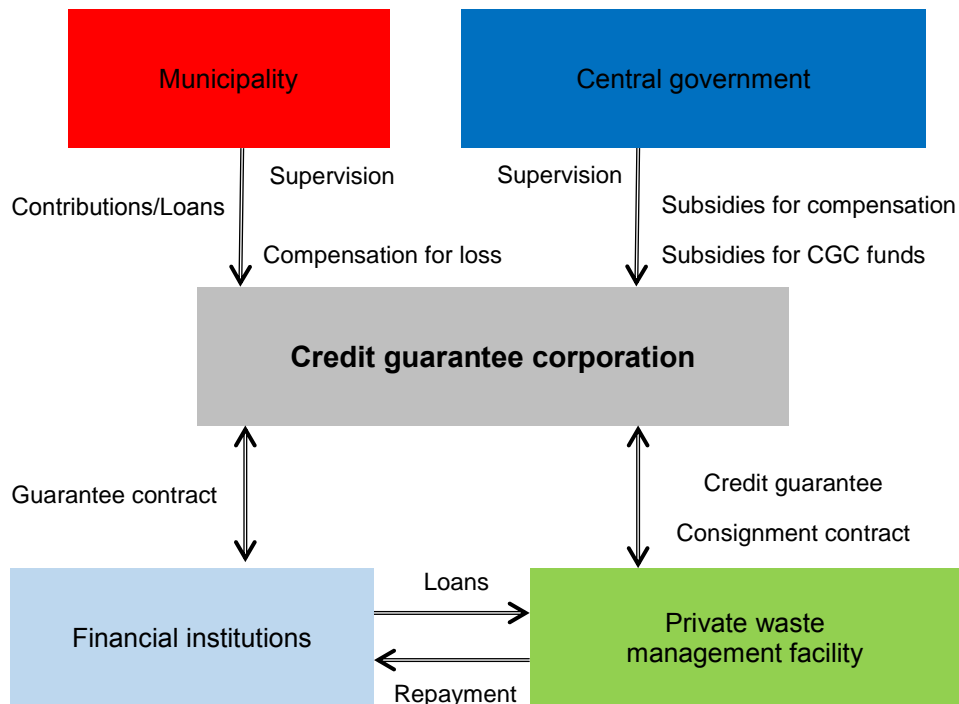
In this section, we suggest practical funding schemes for fixed capital and working capital to incentivise solid waste management for private investors. These schemes are applicable for low-carbon projects, which have similar barriers.

4.1. CGS for Providing Fixed Capital for Waste Management Projects

As mentioned earlier, CGSs have been used over the decades in many countries and in various forms to increase the flow of funds to targeted sectors and segments of the economy that have difficulties accessing finance, including SMEs. A CGS absorbs the risk, and the guarantee it provides acts as collateral. Therefore, by reducing the level of risk, banks are more willing to lend to borrowers. In addition, as the CGS acts as a guarantor, it needs to assess the creditworthiness of the borrower by monitoring the status of the project or borrower to improve the quality of lending.

Figure 8 shows that a CGS has three players. The first is the borrower, which can be a low-carbon project. In this example, it is a waste management project seeking finance. When borrowers approach a bank, they often refuse to lend because of asymmetry of information and lack of collateral. The second player is the lender, which is a financial institution (bank). The third player is the guarantor, which is the CGC, usually run by the government, which provides a full or partial guarantee. The CGS has a cost, so the borrower needs to pay a credit premium to the CGC. However, in the early stages of development of a CGC, it needs enough capital to cover the risks so it requires government support. After some years, it can become financially sustainable. For this example, this scheme is especially applicable to sectors that require large fixed capital, such as recycling, waste treatment, waste-to-energy, or low-carbon projects. In this example, as is clear from Figure 8, the CGC is funded by the central government or the municipality. After assessing the credit history of the borrower (individual or corporate) and evaluating the feasibility of the project, the CGC accepts to provide a guarantee to this project. Then, a certain amount is guaranteed (e.g. 80%) and the borrower proceeds to approach a bank to apply for a loan. When a bank sees that about 80% of the loan amount is guaranteed, it is eager to lend to this project. For the remaining 20%, the bank may ask for collateral. As this is a small amount, it is easier for the project owner to provide it.

Figure 8: Establishment of CGS for Reducing the Supply–Demand Gap of Finance in Waste Management Projects



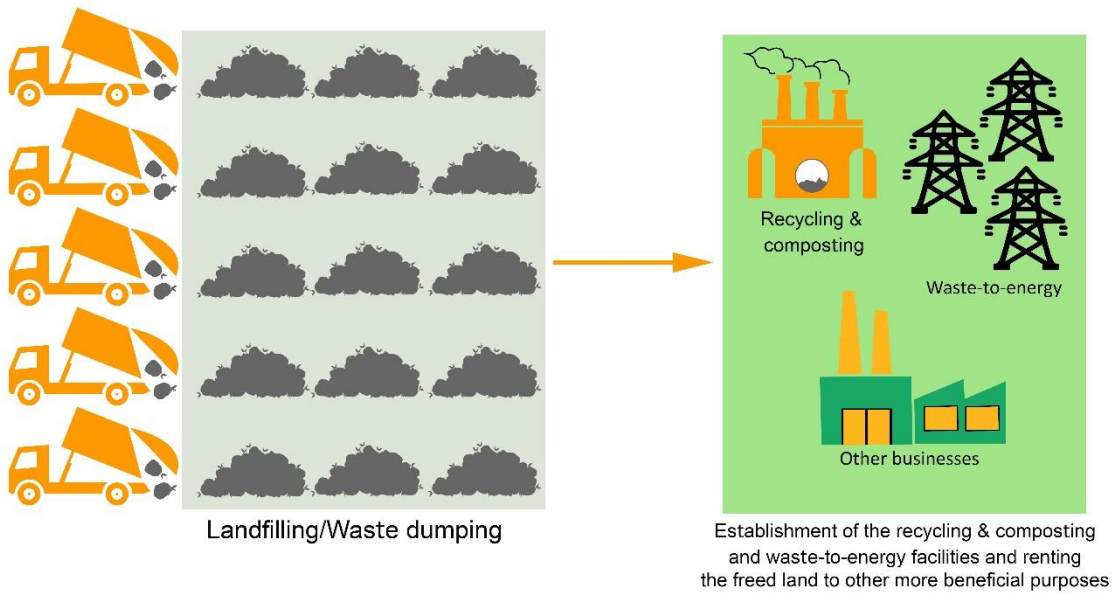
CGC = credit guarantee corporation.
 Source: Yoshino and Taghizadeh-Hesary (2018b).

4.2. Establishment of Community-Based Funds for Providing Working Capital

In addition to the fixed capital, the second major challenge facing waste management and many low-carbon projects is difficulty funding their working capital. Therefore, it is important to design a scheme which can adapt to the socio-economic environment in Asia to help the private sector fund the working capital of these projects.

In many large or mega cities in developing Asia, landfills occupy large tracts of land and the space in many large cities' landfills is running out. By establishing sorting, recycling, composting, and waste-to-energy facilities, the freed landfills could be better used to support other more beneficial purposes for generating rent, user charges, and revenue from the sale of electricity for municipalities or private investors, which could be a sustainable source of funding for the working capital (Figure 9).

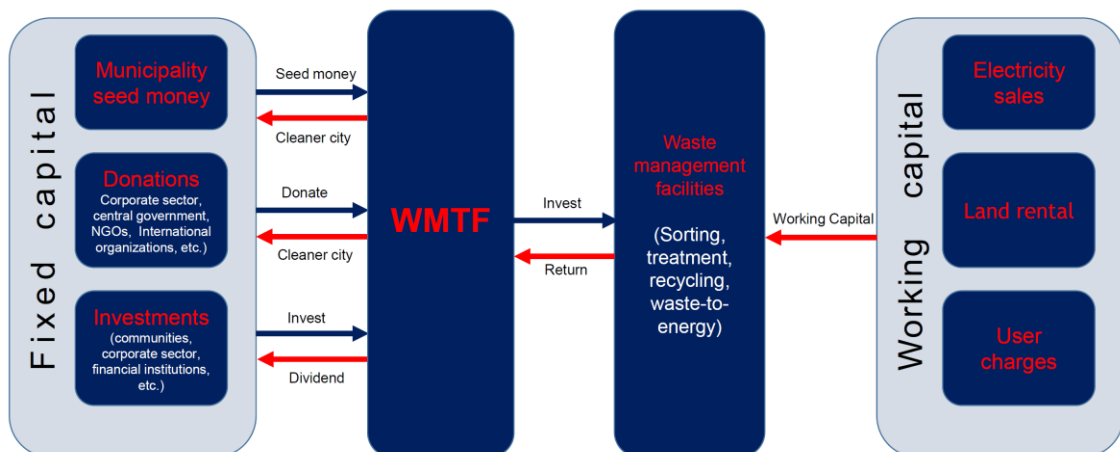
Figure 9: Allocation of Landfills for More Beneficial Purposes



Source: Yoshino and Taghizadeh-Hesary (2018b).

Figure 10 illustrates a waste management trust fund (WMTF), a type of community-based funding or hometown investment trust fund for providing working capital for these projects.

Figure 10: Establishment of Community-Based Funds for Waste Management Projects



NGO = non-governmental organisation, WMTF = waste management trust fund.
Source: Authors.

In Japan, the development of hometown investment trust funds (HIT funds) occurred mainly after the Fukushima nuclear power disaster in March 2011, when the government shut down the nuclear power plant as it was unsafe. Many people, especially in the affected region of Fukushima, showed an interest in renewable energy such as solar and wind instead of nuclear power (Taghizadeh-Hesary, Yoshino, and Rasoulinezhad, 2017). However, low-carbon projects carry a high risk and most banks are reluctant to lend to them. So, local people started to collect small amounts of money (\$100–\$5,000) from the region through a local fund to build a solar power plant and wind power generator. They planned to establish a green energy plant, generate electricity, use the power they generated, sell the excess to the power company, and make some profit. This was the reason for the establishment of the HIT funds, whose basic objective is to connect local investors with projects in their own locality where they have personal interests. Individual investors choose their preferred projects and make investments via the internet. Through these funds, many Japanese people invest small amounts of money in the construction of wind and solar power. The marketing of each wind and solar power project on the internet plays an important role in convincing people to invest in these projects. Internet marketing companies provide the platform for such investments and market these projects. Local banks have started to make use of the information provided by the HIT funds. If these projects are implemented successfully and attract individual investments, then banks can grant loans to them. We believe that HIT funds are applicable to waste management projects, and the WMTF is a new type of HIT designed for waste management projects. HIT funds have expanded from Japan to Cambodia, Viet Nam, Peru, and Mongolia. They are also attracting attention from the Government of Thailand and Malaysia's central bank (Yoshino and Taghizadeh-Hesary, 2018a). Similar funds are applicable in developing countries for low-carbon projects, especially in regions where communities are integrated and trust exists amongst their members. These funds will help high-risk sectors, including the low-carbon sector, to grow.

As Figure 10 shows, WMTFs can collect different forms of donations from the corporate sector, central government, or international organisations; seed money from the municipality; and even investments from communities, corporate sectors, and financial institutions. The fund is project-oriented and designed for running waste

management projects (sorting, treatments, recycling, and waste-to-energy). Investors receive the dividends of the investment, while donators and the municipality receive the benefits from the output of the waste management projects – a cleaner environment and hometown, and social welfare. The working capital of the project could be funded by three sources: (i) land rental (freed landfills); (ii) collection of user charges from waste generators (the facility can burn the waste of other regions or other countries and receive the charges and fees – as in many European cities); and (iii) the sale of the electricity generated by the waste.

5. Conclusions and Policy Recommendations

Lack of long-term financing, the existence of various risks, a low rate of return, and lack of capacity of market actors are major challenges for developing low-carbon projects. Using spillover effects to green energy projects would increase the rate of return on these projects. PFIs can use both traditional and innovative approaches to link low-carbon projects with finance by enhancing access to capital, facilitating risk reduction and sharing, improving the capacity of market actors, and shaping broader market practices and conditions. PFIs should avoid the negative effects of government lending (crowding out of private investment) by making long-term lending at stable rates and only lending where private banks cannot lend. The low-carbon R&D sector is amongst the sectors for which PFI lending is recommended. GCGSs will reduce asymmetry of information and decrease the expected default losses, thereby covering part of the risk and unlocking private investment and lending by financial institutions to low-carbon projects. GCGCs and PFIs can play an important role in credit enhancement and reducing the risk and improving capacity for the adoption of a low-carbon economy. To prevent moral hazard, the guarantee ratio of GCGCs needs to be variable, depending on the creditworthiness of borrowers and financial institutions, and not fixed. To have a sustainable financing scheme by banks and NBFIs, it is important for the government to consider *leverage*, *transparency*, and *specific results* in the financial scheme (case of waste management project).

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