Working Paper 2014-03

Finance for the International Transfer of Climate Change Mitigation Technologies

Institute for Global Environmental Strategies

Yuqing YU

Rabhi ABDESSALEM

Kazuhisa KOAKUTSU

Kentaro TAMURA

November 2014

Contact: Yuqing Ariel YU

Senior Researcher/Task Manager, Climate and Energy Area

Institute for Global Environmental Strategies (IGES)

2108-11 Kamiyamaguchi, Hayama, Kanagawa, Japan 240-0115

Email: yu@iges.or.jp

Disclaimer:

The views expressed in this working paper are those of the authors and do not necessarily represent those of IGES. Working papers describe research in progress by the authors and are published to elicit comments and to further debate. Their contents may be revised and eventually published in another form.

Ⓒ 2014 Institute for Global Environmental Strategies. All rights reserved.

Key messages:

1. **Technological absorptive capacity (consisting of the factors of general governance and business climate, basic technological literacy, access to finance, and technologically proactive policies) is the key determinant of successful technology transfer.** Access to finance is one necessary but insufficient condition for technology transfer, as technology receptivity is also grounded in the stakeholder and country context, the technology type and scale, and transfer mechanisms. Technology transfer by itself does not lead to or guarantee the leapfrogging of local innovation capabilities to a more indigenous stage, although it is the start of the evolution of the technology latecomer's domestic innovation modes.
2. **High cost of debt is the most pressing problem that restricts technology diffusion in developing countries.** Firms in developing countries pay a significantly higher lending interest rate, rely on internal funds for investments to a much greater extent, and suffer from a heavier burden imposed by collateral requirements than their counterparts in developed countries. The cost of debt is even higher for climate mitigation projects, because such projects have low collateral value, fail to secure attractive debt terms, and must compete with mature, brown technologies in the same sector for loans.
3. **Equity investors in developing countries are willing to take a low initial internal rate on return (IRR) for strategic considerations**. By sacrificing initial IRR, equity investors aim to gain the market share and play a dominant role in the long-term once the technology matures. Equity investors also expect IRR to increase by 10-15% in the future. These strategic considerations lead to the concern that equity costs will increase in the future once the market is mature enough to provide more rational risk pricing.
4. **Technology procurement is costly and challenging.** Procurement costs can account for more than 95% of the total costs of a technology transfer project. International technology suppliers are easily deterred by narrow technical specifications, cumbersome bidding processes and small contract values, making the procurement process inefficient. In addition, few private beneficiaries of technology would retransfer technology to other domestic counterparts, fearing competition and hence limiting the overall impact of diffusion.
5. **IGES's experience on the ground shows that, rather than private firms owning proprietary technology (at least technology for demonstration purposes), it is a public institution that can provide more incentives to the private sector and accordingly generate a larger impact of diffusion.** Private firms are willing to install the imported technology because they pay a lower import tax of equipment in such cases. A public institution is also willing to disseminate the technology, as it is not afraid of competition.
6. **Inadequate lending for business investment and particularly for mitigation projects reflects developing countries' wider credit market failures, including onerous collateral requirements.** This has left one fundamental question to be answered: What types of policy interventions and instruments can move money from old to new technologies? In essence, an investment shift to low-carbon electricity, new industrial processes and radical production processes is particularly important for developing countries to avoid carbon lock-in effects in the long run.

1 Introduction

Technology is the cornerstone of climate negotiations, as great hopes to address climate change are pinned on technology. Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC) states that developed country Parties and other developed Parties included in Annex II are to take “all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing Parties” and are to “support the development and enhancement of endogenous capacities and technologies of developing countries Parties” (United Nations, 1992).

There is an emerging literature that focuses on the receptivity and adaptation of technology transfer (TT) in developing countries. Empirical evidence shows that some of the determinants are inherently associated with the domestic characteristics of sending and receiving countries, and these determinants are difficult to influence with policy interventions. For example, higher geographical distance is found to result in a lower probability of knowledge flows (Verdolini and Galeotti, 2011). Other conditions (i.e., educated workforce, the strength of intellectual property laws, and institutional quality) can be influenced and the impact of these conditions under which TT are most likely to take place varies across different transfer channels (Dechezlepretre et al., 2012; Perkins and Neumayer, 2011).

However, the literature says little about whether and how the cost and availability of finance in developing countries has an influence on the transfer and receptivity of mitigation technologies. IPCC (2014) identifies the understanding of financing costs and credit constraints as one key knowledge gap, and hence this paper aims to fill this gap. This paper aims to answer the following questions: (1) What are the additional financing costs resulting from differences in country contexts (i.e., investing a mitigation technology in a developing country as compared to making the same investment in a developed country)? (2) What are the additional financing costs due to the characteristics of mitigation technologies (i.e., investment of climate mitigation technology as compared to investment of general technology)?

2 Conceptual framework

TT is a complex, challenging and unspontaneous process, which has not had a universally-agreed definition. We define TT as a process that transfers the technologies at the stages of demonstration, deployment and diffusion from a country advanced in such technology (technology advanced country) to a country that is a latecomer to such technology (technology latecomer country), in either embodied or disembodied form, that leads to the imitative deployment and/or cooperative innovation of the technologies in the recipient country (Fig. 1). Outside the UNFCCC framework, TT takes place predominantly through private-driven pathways, including international trade, foreign trade investment (FDI), and licensing, with the three channels being convertible and licensing being the most transfer-induced channel (Keller, 2004). Under the UNFCCC process, the Clean Development Mechanism (CDM) and the Global Environment Facility (GEF) are the main instruments for TT. On the recipient side, technological absorptive capacity, which consists of the factors of general governance and business climate, basic technological literacy, access to finance, and technologically proactive policies, is the key determinant of successful transfer (World Bank, 2008). However, TT by itself does not lead to or guarantee the leapfrogging of local innovation capabilities to a more indigenous stage, although it is the start of the evolution of the technology latecomer's domestic innovation modes (Ru et al., 2012). Since South-South TT has been sparsely observed, our focus is TT between the North and the South.

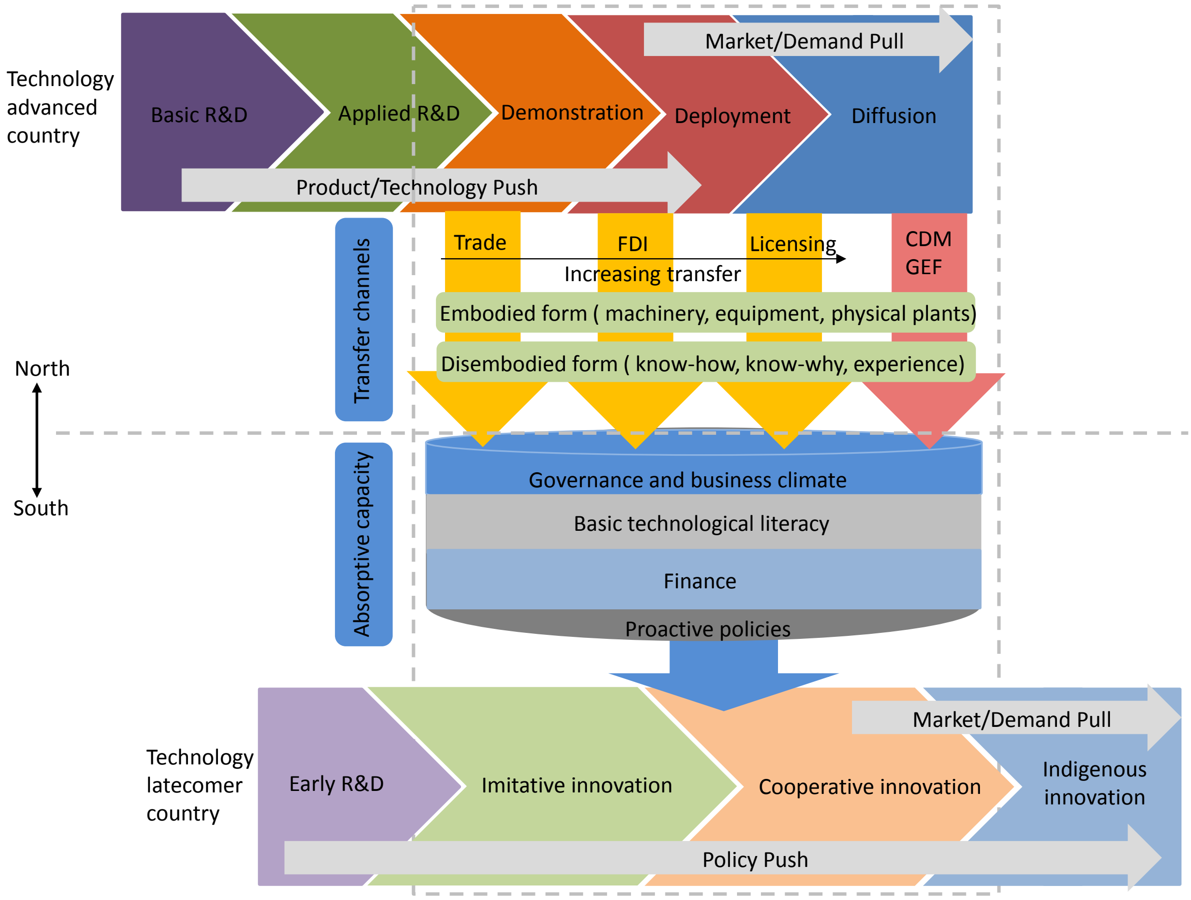

Fig. 1 Conceptual framework of TT

Finance is a necessary condition for successful TT, because affordability at the levels of the firm, the consumer, and the nation can be a major impediment to the diffusion of technology within a country (World Bank, 2008). However, finance is not a sufficient condition, because the receptivity of TT is also grounded in the stakeholder and country context, the technology type and scale, and transfer mechanisms (IPCC, 2000; World Bank, 2008).

The prominent nature of TT is the cross-border flow of a technology-related business activity. The variance in financing costs (i.e., lending interest rate, collateral requirements, debt maturity terms, variability of interest rate, spread between debt and equity, and returns on equity) between countries in the North and South therefore circumscribes the ability to invest mitigation technologies and hence the receptivity of TT.

From a business perspective, an investment decision depends on two related but distinct considerations: investment profitability and finance availability. It should be noted that the meaning of profitability and availability is strongly subject to technologies, sites, investors and country contexts. Profitability indicates that the return on investment is larger than the costs of investment that include but are not limited to the incremental cost of a mitigation technology compared to a Business-as-Usual (BAU) technology (the capital cost), the operation cost, the maintenance cost, and the financing cost. However, profitability itself does not guarantee an investment decision, because investors are constrained by access to finance.

Table 1 demonstrates four cases that combine different conditions of investment profitability and finance availability. Case I represents a technologically profitable and financially abundant condition, which indicates that the investor will make a BAU investment decision. Case II is characterized as technologically profitable but financially infeasible, which implies the need for policy interventions to increase the access to upfront finance. Case III features abundant finance but low profitability, which also suggests the need for public support for reducing the costs of investment. Case IV is not considered suitable for TT, because the project is neither technologically profitable nor financially feasible. Therefore, financing for TT will focus on Case II and Case III, which demonstrate the need for either increasing finance availability or increasing investment profitability.

Table 1. Cases combining different conditions of profitability and availability

Finance		**Availability**	
		High	**Low**
Profitability	**High**	I: BAU investment	II: Increase the access to finance
	Low	III: Reduce costs	IV: Not suitable for TT

3 Current status of technology transfer

3.1 The indicator of technology transfer

Patents, the number of technologies invented in country A and patented in country B, are widely used as the indicator of the number of inventions transferred from country A to country B. Patent number is a useful indicator of TT, because a patent gives the exclusive right to exploit the technology commercially in the country where the patent is filed (Dechezlepretre et al., 2011, 2012; Verdolini and Galeotti, 2011). Even if useful, using a patent as the indicator has several limitations. First, the tendency to patent differs widely between sectors and countries, depending on the nature of the technology and the risk of imitation in a country. The sectoral limitation indicates that a number of important mitigation technologies such as energy efficiency technologies have been omitted due to data constraints (Dechezlepretre et al., 2011). The country limitation implies that many developing countries, in particular the least developed countries (LDCs), are excluded from our sight, because those countries have few inventive activities and hence raise the least risk of leakage and imitation. Moreover, patent data is only useful for embodied flows (TT embedded in machinery, equipment and physical plants) and cannot provide insight on disembodied flows (TT embedded in know-how, know-why and experience).

However, because patents are available at a highly technologically disaggregated level, using a patent as the indicator enables us to precisely identify innovations in various climate-related technologies, whereas other data (i.e., R&D investments, trade or FDI data) cannot always be disaggregated with the same level of granularity (Glachant et al., 2013).

3.2 The level of TT and the destination of TT

A linear function was found between a technology's abatement potential and the level of international transfer (Fig. 2). Fig. 2 shows that several technology types, including hydro energy (hydro power stations, hydraulic turbines, submerged units incorporating electric generators, and devices for controlling hydraulic turbines), heating equipment in buildings (hot water and hot air central heating systems using heat pumps, energy recovery systems in air conditioning, ventilation or screening, and heat pumps), solar photovoltaic energy, biomass (solid fuels based on materials of non-mineral origin), solar thermal technologies (use of solar heat for heating and cooling), and wind energy, are the ones that have significant abatement potential but little transfer so far (Glachant et al., 2013). In contrast, the technologies located above the line are the ones that are popular for international transfer.

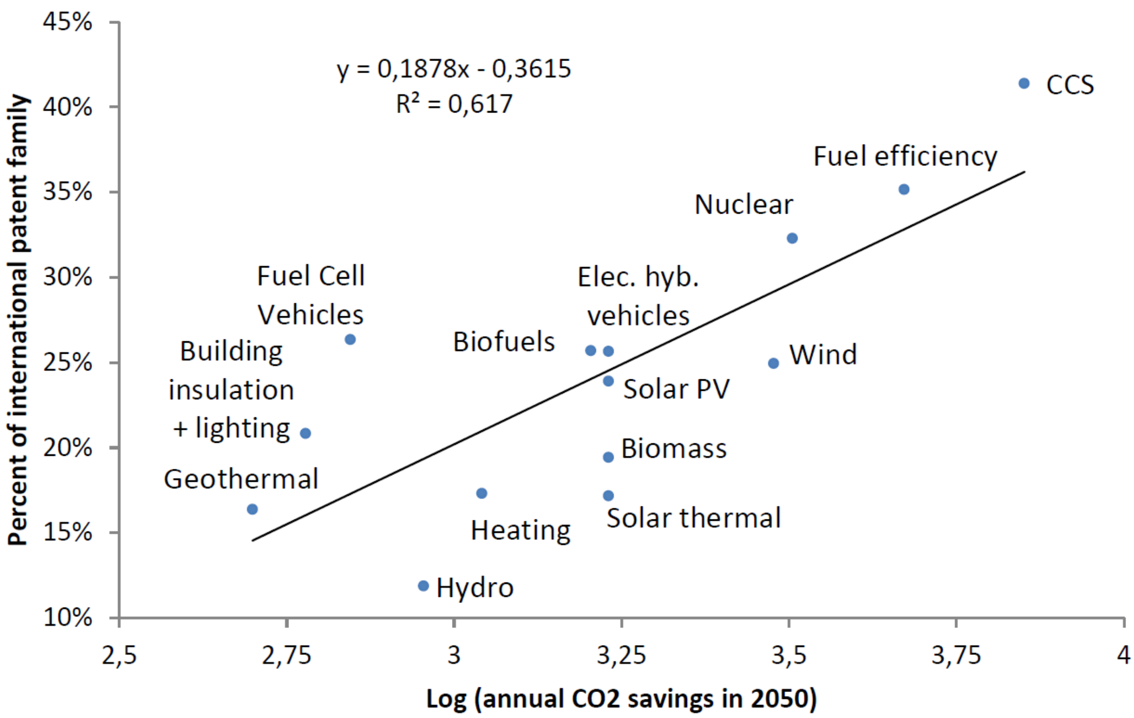

Fig. 2 The relationship between the abatement potential and the share of international inventions by technology (using 2007-2009 data)

Source: Glachant et al. (2013)

A positive correlation was also found between a country's abatement potential and its level of technology import (which is captured by an index that represents the average of three indicators: patent imports, FDI links and trade of low-carbon equipment goods) (Fig. 3). Fig. 3 indicates that India and the rest of developing Asia are regions where the level of TT does not match their abatement potential. In other words, these regions should be given enhanced support to address the barriers to TT and hence to improve their technological absorptive capacities (Glachant et al., 2013).

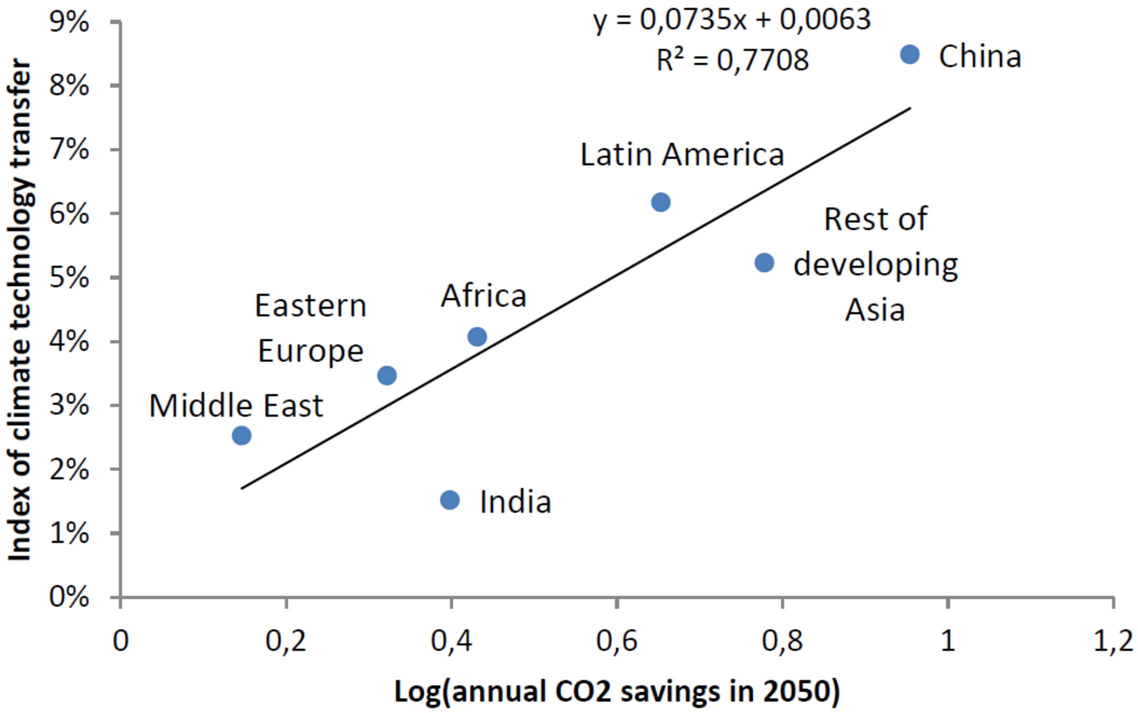

Fig. 3 The relationship between the abatement potential and level of technology import by country (using 2007-2009 data)

Source: Glachant et al. (2013)

3.3 Multilateral support for TT

TT has been a key theme for the GEF since its establishment. Most of the GEF-5 (2010-2014) climate change portfolio can be characterized as supporting TT for mitigation (GEF, 2014). In addition, the GEF initiated the Poznan Strategic Program on Technology Transfer, under which the GEF has supported TT in multiple areas and through various activities (Annex 1).

Moreover, the World Bank Group, including International Finance Corporation (IFC) and Multilateral Investment Guarantee Agency (MIGA), has contributed to the development and transfer of new energy technologies. These efforts build on donor-funded programs, particularly the GEF and the Climate Technology Funds (CTFs), as well as balance sheet investments by IFC's clean tech unit and funds department (IEG, 2010).

Despite various efforts, TT has generated concerns in numerous countries and these concerns have been especially acute in developing countries (IPCC, 2014). The concerns partially result from GEF's modest funding budget (a total of $1.25 billion allocation for climate change focal area during the GEF-5 period), which indicates that the GEF could not really play a quantitatively significant role in TT. In addition, the co-financing requirements and high transaction costs prevent most of the LDCs from accessing international finance. Empirical evidence suggests that the LDCs have been the recipients of only a limited amount of climate technologies (Glachant et al., 2013). In general, international climate finance has not succeeded in addressing the wider credit market failures in developing countries and has not figured out the mechanisms that can solve the difficulty of procuring licenses and patents during the transfer process (IEG, 2010). The domestic financial barriers to TT are therefore further elaborated in the next session.

4 Financing and procurement costs in Asian developing countries

4.1 Debt finance

4.1.1 General debt finance

Three indicators—(1) the lending interest rate, (2) the reliance on internal funds for investment, and (3) collateral requirements—are used to demonstrate financing costs. The three indicators of Asian developing countries are significantly higher than those of developed countries, which indicate that financing costs in developing countries are significantly higher than those in developed countries (Fig 4). Cost advantages such as cheap labour, resources and construction costs in developing countries are therefore easily eliminated due to high financing costs.

The lending rate for Asian developing countries is noticeably higher than for OECD countries (Fig 4-a). Laos had the highest lending interest rate of 22.6% in 2013, followed by Mongolia's 18.5% and Afghanistan's 15.1%. Seven South Asian (SAS) countries[1] and 5 South East Asian (PAS) countries had lending interest rates higher than 10% in 2013. In contrast, three quarters of the OECD countries enjoyed a lending rate lower than 7% and had the lowest rate of 1.6% in 2013.

Moreover, enterprises in Asian developing countries are found to rely excessively on internal funds for investment (Fig 4-b). For more than 75% of the enterprises in South East Asia and South Asia, the proportion of investments (i.e., purchase of fixed assets) that are financed by external funds (i.e., borrowing from banks, borrowing from non-bank financial institutions, purchases on credit from suppliers and advances from customers, or other moneylenders) account for less than 15% of total investments. In contrast, more than half of the OECD enterprises rely on a larger share of external funds (40%) for investments.

Furthermore, enterprises in Asian developing countries suffer from the heavy burden imposed by collateral requirements. For example, all banks in Mongolia require collateral as a guarantee of loan repayment (Fig 4-c), which implies that Mongolian banks are very risk adverse and only large companies that have high value collateral assets such as land, buildings or financial securities can secure loans. The same trend is observed in South and Southeast Asia, where very few companies can obtain unsecured loans. In contrast, the OECD enterprises are more likely to get project loans, as fewer banks require collateral.

[1] East Asia (EAS): China, Korea, Mongolia; South-east Asia and Pacific (PAS): Cambodia, Malaysia, Singapore, Brunei, Philippines, Thailand, Papua New Guinea, Vietnam, Indonesia, Myanmar, Laos; South Asia (SAS): Nepal, India, Maldives, Pakistan, Sri Lanka, Bangladesh, Bhutan, Afghanistan.

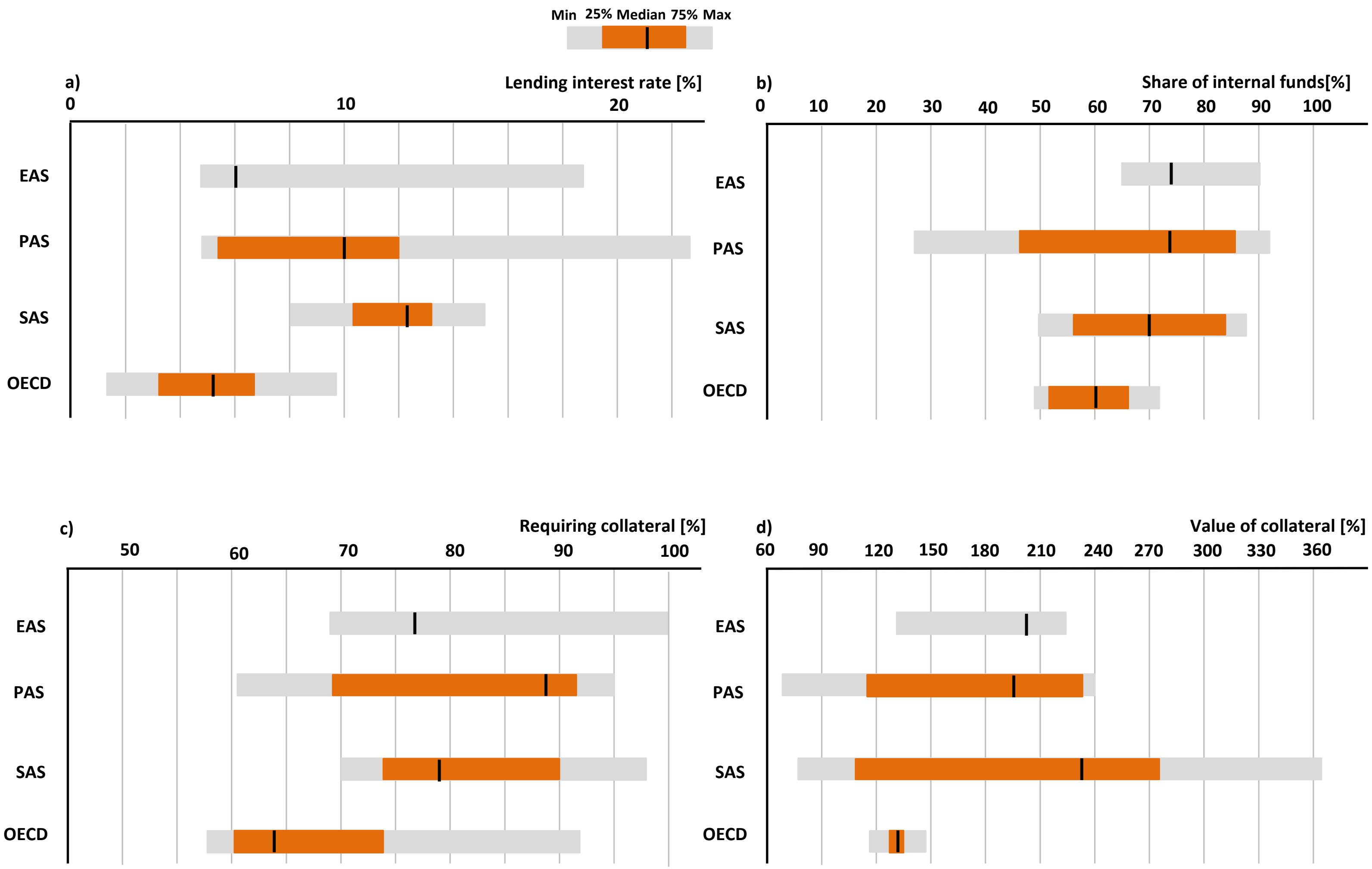

Fig 4. The cost of debt in Asia (three sub-regions) and in the OECD

Source: Enterprise Surveys (2014); World Bank Data (2014). Statistics refer to the year 2013 or the most recent year available.

Note: Data are aggregated at the sub-regional levels according to IPCC (2014)'s definition of 10 sub-regions: East Asia (EAS); South-East Asia and Pacific (PAS); South Asia (SAS). Firm level data of the OCED countries in Fig b, c, and d are limited to Ireland, Germany, Greece, Spain and Portugal.

Finally, banks in Asian developing countries demand a significantly higher value of collateral than their OECD counterparts (Fig 4-d). For example, Nepalese banks require that enterprises provide collateral assets that have a value 3.6 times higher than the loan value. Mongolia and the Philippines both require collateral value at least double the loan value. In contrast, no OECD country requires a collateral value higher than 1.5 times of the loan value.

4.1.2 Debt finance for climate mitigation projects

The problem of general credit market failure in developing countries is more salient with regard to climate mitigation projects. Compared to large scale infrastructural projects (i.e., highway construction, real estate development), mitigation projects, in particular energy efficiency and small-scale renewable projects (i.e., small hydropower and distributed PV), face an additional debt barrier—low collateral value—that results from certain characteristics of mitigation projects. Such characteristics include the following: (1) a large part of such projects are taken up with non-equipment costs, such as buying licenses and patents, which in general are not considered as acceptable collateral; (2) the expensive monitoring equipment that is essential for mitigation projects cannot be universally used and has little value outside the project; and (3) the hardware purchased (i.e., a motor or pump) is only valuable when integrated into the whole product process and has little value if removed from the production system. In reality, banks usually give a large discount for the fixed assets of an energy efficiency project (IIP, 2012).

Furthermore, many banks do not lend, or limit lending, to mitigation projects due to the sector limit requirement. For example, Indian banks include renewable energy in the same sector as power, utility and energy production. Since banks have sector lending caps that limit their lending to a specific sector, renewable energy must compete for loans with other mature technologies, which banks are more familiar with. Over the last few years, due to large capacity additions of coal-based power projects, Indian banks came close to reaching their lending limits for the power sector and hence had little space left for renewable energy (CPI, 2012).

Finally, project loans, of which the sole source of repayment is the project's cash flows, are not available in most developing countries for mitigation projects. Since project finance is a non-recourse type of finance, which means that the bank has no recourse to the parent company of the project developer (no recourse beyond the project developer's assets or the ownership share of the company), it is a popular type of finance in developed countries because it is less risky to the parent company and can secure high financing leverage. However, project finance has not been popular in developing countries. For example, only conventional infrastructure and real estate projects in China, which need to borrow at least RMB 50 million to RMB 100 million from banks, are eligible for project finance (IIP, 2012). In contrast, the availability of project finance in India is controversial; some believe that pure project finance does not exist, while others indicate that it is becoming more popular (CPI, 2012). In any case, mitigation projects will benefit from project finance, because project loans are a particularly good match for the characteristics of mitigation projects.

Consequently, debt terms of mitigation projects in developing countries are not attractive. For example, the average maturity of debt is usually under 3 years for renewable projects in India (CPI, 2012). Interest rates for mitigation projects are generally floating and few banks offer fixed interest debt that can ensure a high degree of certainty around future cash flows to project developers (CPI, 2012; IIP, 2012).

4.2 Equity finance

Equity investors, including venture capital providers, private equity firms, infrastructure funds and institutional investors, use the Internal Rate of Return (IRR) of each project as the yardstick for investment decisions. Equity providers have an expectation of the minimum IRR they need to achieve and the IRR expectation is at least 15% and can be higher than 50% (Table 2).

Table 2. Investment profile and IRR expectation of equity investors

Equity investor	Investment area	IRR expectation
Venture capital	Early stage or growth stage companies, new technology prototypes	>50%
Private equity	Pre-IPO companies, mature technology, technology demonstrator, make returns in 3 to 5 years	35%
Infrastructure fund	Proven technology in infrastructure, a long term investment horizon	15%
Pension fund	Proven technology,	15%

Source: UNDP (2011)

Unlike equity investors in developed countries, equity investors in developing countries are observed to be willing to take low initial IRRs for renewable energy projects due to several strategic considerations (Table 3). First, project developers aim to gain the market share and play a dominant role in the long term once the technology matures. Second, project developers expect a reduction in technology costs and hence expect that IRR would increase by 10-15% in the future (CPI, 2012). However, one concern is that equity costs will increase in the future, because the strategy of accepting lower initial returns for the market is not sustainable in the long run, and these tactical considerations will disappear once the market is mature enough to provide more rational risk pricing.

Table 3. Investment profile and IRR expectation of equity investors

	Solar PV	Solar CSP	Biomass Power	Wind	Small hydro
IRR expectation	12-15%	14-20%	20-25%	15-18%	17-20%

Source: CPI (2012)

In sum, costs of debt, namely high interest rates, excessive dependence on internal funds and the heavy burden imposed by collateral requirements, is the most pressing problem that restricts technology diffusion into developing countries. Although equity finance has not been identified as a major problem in the short run, this is often a chicken-and-egg problem in practice; if loans can be secured, equity investments are easier to obtain and vice versa.

4.3 Procurement costs

Procuring technology and intellectual property rights (IPRs) is the most challenging and costly process. For example, the GEF China Industrial Boiler Project spent most of the $32 million GEF grant on acquiring technology for new or upgraded boiler designs and auxiliary equipment (such as grates) and transferring to domestic manufacturers, not to mention the additional $67 million of co-financing spent on license procurement. Procurement costs can account for more than 95% of the total costs of a TT project (World Bank, 2004).

In addition, technology procurement is a challenging process. International technology suppliers are easily deterred by narrow technical specifications, cumbersome bidding processes and small contract values (World Bank, 2004). When the TT project is designed to put emphasis on technical specifications and to aim for each of the market's submarkets, technical bidding may turn out to be inefficient because there will not be a large pool of available suppliers who are specialized in these technical specifications. Moreover, if the contract value is too small, financial bidding will not likely elicit a strong enough interest from many suppliers who are willing to overcome the difficulties of contract negotiations.

Finally, the impact of procurement can be very limited, because few private beneficiaries of technology (i.e., the firms that procured licenses) would share proprietary technology with their competitors (IEG, 2010). In fact, none of the beneficiary manufacturers that were involved in the GEF China Industrial Boiler Project were found to relicense or retransfer their technologies to other firms in the domestic market and only one firm reported some informal diffusion by sharing unauthorized copies of its designs (IEG, 2010). The limited retransferring resulted in an extremely low dissemination rate of the transferred technology—the market share of the transferred technology only accounted for 3.3 percent of the domestic market in 2009, against an anticipated 35 percent by the project design (IEG, 2010).

5 Policy implications

IGES's experience on the ground shows that, rather than private firms owning proprietary technology (at least technology for demonstration purposes), it is a public institution that can provide more incentives to the private sector and accordingly generate a larger impact of diffusion. IGES's cooperative work with The Energy and Resources Institute of India (TERI) demonstrates that when technologies were exported to India in the name of TERI rather than in the name of private firms, the private firms were willing to install the technologies at their sites. TERI as a public entity is eligible for import tax reduction in the case where technology is for demonstration purposes. In cases when TERI owned the technologies, the participating firms only paid 6% import tax rather than 30% if the equipment was imported in their name. Moreover, TERI as a research institution does not fear competition and is more willing to retransfer the imported technologies to other firms.

Empirical experience also suggests that the use of an output-based approach for procurement, which focuses on overall, core targets to be achieved (e.g., energy saving targets) rather than narrow technical specifications, can simplify the technology procurement process and help improve procurement efficiency (World Bank, 2004). However, it should be noted that the procurement approach should match the domestic policy and market environment. If the developing country has a centralized, planning market, a flexible, output-based approach might not be able to be implemented.

As is typical for every developing country, growth comes with a need for investment in roads, buildings, and infrastructure, creating competition for mitigation projects to raise debt. The GEF and the World Bank have pioneered financial intermediations in many developing countries. However, contrary to expectations, GEF experience reflects that temporary loan guarantee programs have not turned out to be a market transforming measure that could be discontinued once the domestic banks gained familiarity with mitigation technologies (IEG, 2010). Indeed, inadequate lending for business investment and particularly for mitigation projects reflects developing countries' wider credit market failures, including onerous collateral requirements. This has left one fundamental question to be answered: What types of policy interventions and instruments can move money from old to new technologies? In essence, an investment shift to low-carbon electricity, new industrial processes and radical production processes is particularly important for developing countries to avoid carbon lock-in effects in the long run.

References

Climate Policy Initiative (CPI), 2012. Meeting India's Renewable Energy Targets: The Financing Challenge. Climate Policy Initiative, San Francisco, USA.

Dechezlepretre, A., Glachant, M., Hascic, I., Johnstone, N., Meniere, Y., 2011. Invention and transfer of climate change mitigaiton technologies: A global analysis. Review of Environmental Economics and Policy 5, 109-130.

Dechezlepretre, A., Glachant, M., Meniere, Y., 2012. What drives the international transfer of climate change mitigation technologies? Empirical evidence from patent data. Environ Resource Econ 54, 161-178.

Enterprise Surveys, 2014. Enterprise Surveys, in: World Bank (Ed.), Washington DC, USA.

Glachant, M., Dussaux, D., Meniere, Y., Dechezlepretre, A., 2013. Promoting the International Transfer of Low-carbon Technologies: Evidence and Policy Challenges. MINES ParisTech, Paris, France.

Global Environment Facility (GEF), 2014. Report of the Global Environment Facility on the Progress Made in Carrying out the Poznan Strategic Programme on Technology Transfer. Available from: <http://unfccc.int/resource/docs/2014/sbi/eng/inf03.pdf>. United Nations Framework Convention on Climate Change, Bonn, Germany.

Independent Evaluation Group (IEG), 2010. Phase II: The Challenge of Low-Carbon Developmnt. The World Bank and Independent Evaluation Group, Washington DC, USA.

Institute for Industrial Productivity (IIP), 2012. China Energy Efficiency Financing Landscape Report. Institute for Industrial Productivity, Washington DC, USA.

Intergovernmental Panel on Climate Change (IPCC), 2000. Methodological and Technological Issues in Technology Transfer, in: Metz, B., Davidson, O., Martens, J., Van Rooijen, S., Van Wie Mcgrory, L. (Eds.), IPCC's Third Assessment Report. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 432.

Intergovernmental Panel on Climate Change (IPCC), 2014. Regional Development and Cooperation, IPCC's Fifth Assessment Report. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Keller, W., 2004. International technology diffusion. Journal of Economic Literature 42, 752-782.

Perkins, R., Neumayer, E., 2012. Do recipient country characteristics affect international spillovers of CO2-efficiency via trade and foreign direct investment? Climatic Change 112, 469-491.

Ru, P., Zhi, Q., Zhang, F., Zhong, X., Li, J., Su, J., 2012. Behind the development of technology: The transition of innovation modes in China's wind turbine manufacturing industry. Energy Policy 43.

United Nations, 1992. Division for Sustainable Development. Agenda 21: The Report on the United Nations Conference on Environment and Development, Chapter 34: Transfer of Environmentally Sound Technology, Cooperation & Capacity Building. Earth Summit, UN, Rio de Janeiro.

United Nations Development Programme (UNDP), 2011. Catalyzing Climate Finance: A Guidebook on Policy and Financing Options to Support Green, Low-Emission and Climate-Resilient Development (Version 1.0). UNDP, New York, NY, USA.

Verdolini, E., Galeotti, M., 2011. At home and abroad: An empirical analysis of innovation and diffusion in energy technologies. Journal of Environmental Economics and Management 61, 119-134.

World Bank, 2004. Implementation Completion Report on a GEF Grant in the Amount of SDR 22.8 Million to the People's Republic of China for an Efficient Industrial Biolers Project. Available from: <http://www.thegef.org/gef/project_detail?projID=97>. World Bank and Global Environment Facility (GEF), Washington DC, USA.

World Bank, 2008. Global Economic Prospects: Technology Diffusion in the Developing World. World Bank, Washington DC, USA.

World Bank Data, 2014. The World Bank Data, in: World Bank (Ed.), Washington DC, USA.

Annex I GEF's Poznan Strategic Program on Technology Transfer

Area	Progress	Activity
Support for Climate Technology Centers and a Climate Technology Network	Pilot Asia-Pacific Climate Technology Network and Finance Center (ADB and UNEP)	Mainstreamed climate technology into development plans and strategies • Bhutan: A climate change risk management; • China: Integrate climate change technologies into the provincial development • Bangladesh: Scaling up rural solar and wind hybrid energy technologies
		Established a partnership with a local venture capital fund in India for at least three investments for cleantech startups
		Had meetings with active venture capital funds in China
		Organized a Low Carbon Technology Marketplace Seminar to engage regional stakeholders
		Conducted capacity building programmes on waste agriculture biomass technologies, buildings and NDE
		Conducted a study of energy efficient electric fans in ASEAN
		Plan to develop national and regional roadmaps to implement harmonized Energy Efficiency standards in the ASEAN countries
	Other regional centers include: Regional Climate Change Technology Transfer Center (EBRD), Climate Technology Transfer Mechanisms and Networks in Latin America and the Caribbean (IDB), and Pilot African Climate Technology Finance Center and Network (AfDB)	
	Enhancing Capacity, Knowledge and Technology Support to Build Climate Resilience of Vulnerable Developing Countries (UNEP)	Reduce risks from increased desertification, floods and erosion, and sea level rise to the target communities in Mauritania, Nepal and Seychelles with a focus on Ecosystem-based Adaptation (EBA).
	Facility for Low Carbon Technology Development (WB)	Deploy low carbon technologies in India through a Facility for Low Carbon Technology Deployment that brings together government, industry, consumer, academia, and CSO representatives in four technology areas (refrigeration, air conditioning, lighting, and low-temperature waste heat recovery).
	Mexico sustainable Energy Technology Development (WB)	Support the development of clean energy technologies (energy efficiency, renewable energy) through the linking of the public, academic and productive sectors in Mexico through the creation of regional Strategic Alliances and Innovation Networks for Competitiveness.
	GEF UNIDO Cleantech Programme	GEF Private Sector Strategy support for innovation and entrepreneurship among small and medium enterprises (SMEs)
	Local Development and Promotion of LED Technologies for Advanced General Lighting (UNIDO)	Support quality improvement of LED manufacturing in Vietnam to meet international quality standards and increase the use of LEDs in buildings
Piloting Priority Technology Projects to Foster Innovation and Investments	14 proposals of pilot projects, including 13 full-sized projects and one medium-size project	Brazil: Renewable CO_2 Capture and Storage from Sugar Fermentation Industry in Sao Paulo State (UNDP) Cambodia: Using Agricultural Residue Biomass for Sustainable Energy Solutions (UNIDO); Chile: Promotion and Development of Local Solar Technologies in Chile (IDB); China: Green Truck Demonstration Project (WB); Colombia, Kenya, Swaziland: Commercialization and Transfer of SolarChill (UNEP);

		Cote dÍvoire: Construction of 1000 Ton per day Municipal Solid Wastes Composting Unit in Akouedo Abidjan (AfDB); Jamaica: Introduction of Renewable Wave Energy Technologies for the Generation of Electric Power in Small Coastal Communities (UNDP); Jordan: DHRS Irrigation Technology Pilot Project to Face Climate Change Impact (IFAD); Mexico: Promotion and Development of Local Wind Technologies in Mexico (IDB); Russian Federation: Phase out of HCFCs and Promotion of HFC-free Energy Efficient Refrigeration and Air-Conditioning Systems in the Russian Federation through Technology Transfer (UNIDO); Senegal: Typha-based Thermal Insulation Material Production in Senegal (UNDP); Sri Lanka: Bamboo Processing for Sri Lanka (UNIDO); Thailand: Overcoming Policy, Market and Technological Barriers to Support Technological Innovation and South-South Technology Transfer: The Pilot Case of Ethanol Production from Cassava (UNIDO); Turkey, Cook Islands: Realizing Hydrogen Energy Installation on Small Island through Technology Cooperation (UNIDO)
Public-Private Partnership (PPP)	4 PPP programs have been approved by the GEF Council and one PPP was submitted for approval	
TNAs	Out of 36 participating countries, 33 finalized and submitted TNA reports	Africa: Cote d'Ívoire, Ethiopia, Kenya, Ghana, Mali, Morocco, Mauritius, Rwanda, Senegal, Sudan, Zambia; Asia and Europe: Azerbaijan, Bangladesh, Bhutan, Cambodia, Georgia, Indonesia, Kazakhstan, Laos, Lebanon, Moldova, Mongolia, Nepal, Sri Lanka, Thailand, Vietnam; Latin America and the Caribbean: Argentina, Bolivia, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Peru
	Additional TNAs and TAPs of 27 low- and medium-income countries	Armenia, Belize, Burkina Faso, Burundi, Bolivia, Egypt, Gambia, Grenada, Guyana, Honduras, Jordan, Madagascar, Malaysia, Mauritania, Mozambique, Panama, Philippines, Seychelles, Swaziland, Tanzania, Togo, Tunisia, Turkmenistan, Uruguay, Uzbekistan, Kazakhstan and Laos.

Source: GEF (2014)