Addressing a changing paradigm of technology innovation and transfer in clean energy technologies: The implications for the climate change negotiation

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In the recent climate change negotiation, technology transfer as well as financial mechanism to assist the developing countries has become a central issue. In 2010 in Cancun, the parties agreed to organize the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN). The developed countries have committed to provide $100 billion yearly to assist the developing countries in mitigation and adaptation through the Green Climate Fund. The scheme of the Fund is currently under discussion at the Transitional Committee for the design of the Green Climate Fund. From the perspective of the developing countries, however, they need more assistance beyond this fund to diffuse clean energy technologies.

This paper has three components. First, it reviews the historical development of discussion on technology transfer in the multilateral development negotiation from the 1960s. Especially, it highlights two different perspectives of the developed and the developing countries on technology transfer addressed since the 1960s. The review of the fundamental differences in the perspective on technology transfer leads to a better understanding why there is still a large gap between the developed and the developing countries in their approaches for technology transfer under the current United Nations Framework Convention on Climate Change (UNFCCC) negotiation. In the 1960s, the developing countries argued that resources tended to flow unilaterally from the developing countries to the developed countries. For the developing countries, the United Nations Conference on Trade and Development (UNCTAD) was the central forum to request their needs for transfer of technology to the developed countries. On the other hand, the developed countries recognized that a system to guarantee a free flow of trade contributed to technology transfer to the developing countries. They emphasized that the free trade regime was the essential institution to ensure a free flow of trade and technology to the developing countries.

Second, the paper illustrates key changes in the world economic scene since the 1970s that have challenged the previous views of the developed and the developing countries on technology transfer. The world has dramatically changed through accelerated globalization and the emergence of new economies. A group of the developing countries departed from the dependent cycle of development by making remarkable economic growth from the 1970s. Some of the developing countries have become on the transferring side of technology, especially in the area of clean energy technologies. On the other hand,

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3 This paper is dedicated to the memory of Professor Mikoto Usui who passed away on January 24th 2012. Professor Usui was an academic supervisor as well as a personal mentor for the authors of this paper. Professor Usui worked as the Director of Research at the UNIDO from 1986 to 1989, as the Head of the Industrialization & Technology Program at the OECD Development Center from 1972 to 1976 and as an Economic Affairs Officer with at the UN DESA from 1960 to 1967. Technology transfer was one of the main subjects he worked in his career at these international organizations.
many developing countries are still lagging behind in receiving or generating clean energy technologies.

Lastly, the paper provides a few insights on possible roles of international institutions to overcome barriers in promoting clean energy technologies in the developing countries. It introduces a few examples of research in the area of innovation theory that have attempted to identify roles of institutions. It concludes that there are strong and urgent needs for further research on their roles in diffusing clean energy technologies, as the deadline for the negotiations on the post-Kyoto regime comes closer.

1. Two different perspectives on technology transfer

1.1 Perspectives of the developing countries: Dependency theory

In 1990, the Intergovernmental Panel on Climate Change (IPCC) published a report titled as “Methodological and Technological Issues in Technology Transfer”. This is the first report published by the IPCC that formally copes with technology transfer in the area of climate change. The report defines technology transfer as “a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NGOs) and research/education institutions” (IPCC, 1990). While this is the first formal report on technology transfer in the area of climate change, there is a previous extensive history of negotiations on technology transfer in the area of development cooperation.

Technology transfer emerged as a key negotiation agenda in the context of development assistance from the North to the South in the 1960s. In the late 1960s, the developing countries began to demand technology transfer to the developed countries through UNCTAD negotiations. Technology transfer was added to the third pillar of the mandates of the UNCTAD in 1970. Prior to this, trade and financial assistance to the developing countries were two pillars of the mandates since its foundation in 1964 (Patel, 2006).

The focus on technology transfer at the UNCTAD coincided with the time of a proposal submitted to the UNCTAD by the group of the developing countries (Group of 77 or G77) named as the New International Economic Order (NIEO). Under the NIEO, the developing countries requested the developed countries to improve their term of trade and increase a flow of development assistance. In the declaration of NIEO’s establishment in 1974, there was a specific request from the developing countries about technology transfer expressed as “giving to the developing countries access to the achievements of modern science and technology, and promoting the transfer of technology and the creation of indigenous technology for the benefit of the developing countries in forms and in accordance with procedures which are suited to their economies” (United Nations, 1974). This request was based on the shared sentiment among the G77 members that the Bretton Woods system including the free trade regime did not bring about technology transfer from the developed to the developing countries.

While the political negotiation on technology transfer centered at the UNCTAD, technology transfer began to be a target work area for other UN agencies and international organizations. The United Nations Industrial Development Organization (UNIDO) organized a consultative group meeting on “appropriate
industrial technology” for the developing countries in Vienna in 1978. The term “appropriate industrial technology” came from the understandings and the experiences among the developing countries that “the multinational corporations (MNCs) are blamed for transferring inappropriate technology. This is because the technology is often capital intensive and ill-suited to the local production needs” (Madu, 1989; Steenhuis and de Bruijn, 2005). From the beginning of the 1980s, The UNIDO has begun to place the Investment and Technology Promotion Offices (ITPOs) in several countries to promote a flow of appropriate industrial technologies from the developed countries to the developing countries. At the Organization for Economic Cooperation and Development (OECD), technology transfer started to become an issue of policy coordination among member countries as well as an issue of dialogue with non-member countries through the Development Assistance Committee (DAC) (OECD, 1994).

More recently, the World Intellectual Property Organization (WIPO) has new mandates to encourage technology transfer to the developing countries. The followings are two of the forty-five recommendations adopted as its development agenda in 2007 (WIPO, 2007):

- To explore intellectual property-related policies and initiatives necessary to promote the transfer and dissemination of technology, to the benefit of developing countries and to take appropriate measures to enable developing countries to fully understand and benefit from different provisions, pertaining to flexibilities provided for in international agreements, as appropriate.
- To encourage Member States, especially developed countries, to urge their research and scientific institutions to enhance cooperation and exchange with research and development institutions in developing countries, especially LDCs.

It is noted that WIPO’s recommendations include a request from the developing countries to consider intellectual property issues. The developing countries have started to recognize the protection of intellectual property rights as a major hindrance in technology transfer since the 1990s.

These demands for development assistance and technology transfer from the developing countries are associated with the idea of dependency theory or world system theory. Dependency theory indicates that resources flow from a “periphery” of poor and underdeveloped states (developing countries) to a “core” of wealthy states (developed countries). It also claims that developing countries are impoverished and developed countries enriched by the way developing countries are integrated into the “world system”. Later, the idea of dependency theory was refined especially among scholars from Latin America with some focusing on the role of technology in the process of development. At this point, Vernengo argues “the importance of technology, the role of multinationals in the process of technology transfer, and the role of the State in promoting technological innovation through industrial policy then became the focus of the Latin American Structuralists” (Vernengo, 2004).

The perspectives addressed by the dependency theorists are often observable in the current negotiation on technology transfer at the UNFCCC. The developing countries contend that public financing from the developed countries to the developing countries is essential to overcome barriers in technology transfer. Furthermore, as seen in the case with WIPO’s recommendations, the developing countries recognize the
protection of intellectual property rights as a major hindrance in technology transfer and claims for “TRIPs (Trade-related Aspects of Intellectual Property Rights) flexibilities” or loose interpretations of intellectual property rights. At this point, a background paper published by the International Centre for Trade and Sustainable Development (ICTSD) has a list of several concrete proposals from the developing countries to improve their conditions of intellectual property rights (ICTSD, 2008):

- China and India proposed the Multilateral Technology Acquisition Fund and the Multilateral Climate Technology Fund respectively, both of which request financial assistance for the transfer of technologies to developing countries through, inter alia, the buying-out of intellectual property rights;
- Key climate change mitigation and adaptation technologies should be exempted from patentability. The developed countries should exclude inventions of these technologies from the patent claim such was the case with certain pharmaceutical products and agricultural methods based on their development priorities and strategies;
- The TRIPS Agreement recognizes that the rights of a patent owner to prevent third parties from exploiting the patented product are not absolute. That is, countries may, under certain circumstances, automatically allow the use of the patented invention by a third party without consent of the patent holder. It would also allow companies in developing countries to “invent around” patent claims to gain access to environmentally sound technologies;
- Granting of compulsory licenses should be provided to the developing countries in accordance with the TRIPs agreement. An administrative or judicial authority can grant the non-voluntary licenses to a third party, allowing the exploitation of the patented invention without consent of the patent owner. Developing countries consider this possibility as essential to ensuring that they can implement the TRIPS Agreement in a way that responds to broader public policies.

This section briefly reviewed the historical development of discussions on technology transfer in the multilateral development negotiation from the 1960s. Initially, the UNCTAD was the central forum for the developing countries to demand their needs for transfer of technology to the developed countries. This movement was directly based on the observation among the developing countries that resources tend to flow unilaterally from the developing countries to the developed countries. The developing countries contended that public financial assistance as well as loose interpretation of intellectual property rights was essential to encourage transfer of technology to the developing countries. The next section addresses the perspectives of the developed countries on technology transfer.

1.2 Perspectives of the developed countries: Neo-classical economics

The developed countries have also recognized that technology transfer has an important role in economic growth. Neoclassical economics, which is the backbone philosophy of policymakers among the developed countries, recognizes technology as a key independent factor of production that leads to economic growth (Mill, 1848).
On the other hand, there is a sharp difference between the developing countries and the developed countries as to how the developing countries can enjoy technology transfer from the developed countries. Policymakers from the developed countries contend that the improvement of business enabling environment in the developing countries is the key for the private sector from the developed countries to transfer technology to the developing countries. In particular, institutional support for the protection of intellectual property is especially important to attract the business sector. On the contrary, according to their view, the arrangements that the developing countries have requested such as compulsory licensing and loose interpretation of intellectual property rights discourage a flow of technology transfer. This is because these measures result in the loss of economic incentives for the business sector to transfer technology to the developed countries.

Policymakers in the developed countries have also recognized that the system to guarantee a free flow of trade has greatly contributed to the transfer of technology to the developing countries. In particular, they have emphasized that the General Agreement on Trade and Tariff (GATT) and the World Trade Organization (WTO) are the appropriate institutions to ensure a free flow of trade as well as technology. The developed countries placed a strong pressure in the international negotiations to bring the issue on technology transfer to the WTO. To the contrary, the developing countries address their skeptical view on the effects of free trade on technology transfer (sometimes discussed as trickle-down effects or spillover effects). They are not convinced that free trade leads to technology transfer through spillover effects.

In reality, however, the central venue where the developing countries make their case on technology transfer has shifted from the UNCTAD to the WTO since the beginning of the 1990s. The change has occurred largely due to the fact that some of the key developing countries started to obtain their status of membership at WTO since the early 1990s. Especially, the discussions on intellectual property rights have moved from the UNCTAD to the WTO quickly after the agreement on the TRIPs was formulated in 1995. In 2001, the WTO established a Working Group on Trade and Technology Transfer to examine the relationship between trade and technology transfer and explore ways to increase technology flow to the developing countries (Hoekman et. al., 2005).

This section addressed the views of the developed countries on technology transfer. While recognizing the important of technology transfer in economic growth, the developed countries contend that the improvement of business enabling environment in the developing countries is essential for technology transfer. They also emphasize free trade as an essential mechanism to ensure a free flow of technology. This section also highlighted the differences on the perspectives towards intellectual property rights. While the developing countries regard the protection of intellectual property rights as a major hindrance in technology transfer and they claims the “TRIPs flexibilities” to the developed countries, the developed countries contend that compulsory licensing or the TRIP flexibilities would only discourage a flow of technology transfer. Graph 1 summarizes these differences between the developing countries and the developed countries on their views on technology transfer.
Graph 1: Differences between the developing countries and the developed countries on their perspectives on technology transfer

<table>
<thead>
<tr>
<th>Perspectives of the developing countries</th>
<th>Perspectives of the developed countries</th>
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<tbody>
<tr>
<td><strong>Supporting theory:</strong> Dependency theory or world system theory.</td>
<td><strong>Supporting theory:</strong> Liberalism or neoclassical economics.</td>
</tr>
<tr>
<td><strong>Main idea:</strong> International public financing from the developed countries to the developing countries is essential to overcome barriers in technology transfer.</td>
<td><strong>Main idea:</strong> The system to guarantee a free flow of trade will promote technology transfer from the developed to the developing countries.</td>
</tr>
<tr>
<td><strong>Barriers in technology transfer:</strong> Lack of financial resources including lack of international public financing. High license fee for the business sector in the developing countries to obtain technology.</td>
<td><strong>Barriers in technology transfer:</strong> Lack of business enabling environment including both both tangible (e.g. lack of infrastructure) and intangible aspects (e.g. lack of institutional support for business).</td>
</tr>
<tr>
<td><strong>IPRs:</strong> The protection of IPRs is a major hindrance in technology transfer. “TRIPS flexibilities” or loose interpretations of intellectual property rights is necessary.</td>
<td><strong>IPRs:</strong> The improvement of business enabling environment including the protection of IPRS in the developing countries is the key for the business sector.</td>
</tr>
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<td><strong>Venue:</strong> The UNCTAD was the main venue to discuss technology transfer. However, the venue have shifted to the WTO as many of them obtain a new status of membership at the WTO in the 1990s.</td>
<td><strong>Venue:</strong> The GATT and the WTO is the appropriate forum to discuss the improvement of business enabling environment in the developing countries.</td>
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2. Changing paradigm: globalization and emerging economies

Since technology transfer was raised as an agenda in the multilateral negotiation in the 1960s, there have been drastic changes in the world economic scene. This section highlights three main changes that have challenged both the view of the dependency theorists and the view of neoclassical economists on technology transfer.

Firstly, a group of the developing countries, especially the Asian Newly Industrializing Economies (NIEs) including South Korea, Taiwan, Hong Kong and Singapore, departed from the dependent cycle of development by marking a sharp economic growth since the 1970s. Other countries in Asia such as Thailand and Malaysia have followed this trend, together with the emerging BRICS countries including Brazil, Russia, India, China and South Africa more recently. In particular, the success of the Asian NIEs countries is due to the successful adoption of foreign technologies and increased capacity to produce their
indigenous technologies to export them in the global market.

Secondly, many developing countries including the NIEs and the BRICS countries have obtained a membership status at WTO since the early 1990s. As discussed earlier, the accessions of these countries into the WTO have resulted in a shift of the main venue on technology transfer from the UN system in favor of the developing countries being united as the G77 under the one country one vote system toward the WTO system where countries tend to be united on an issue-specific basis. In WTO negotiations, it is harder for the developing countries to be united as the group of the G77, especially under the circumstances where the economic gap started to grow among the developing countries. Their interests in the WTO negotiation have become divergent among themselves.

Thirdly, as many developing countries including China and India started to produce indigenous technologies, they have successfully exported their technologies to other countries in the global market. As a result, this group of countries has gradually shifted their position from the transferred side to the transferring side of technology. With their efforts into R&D, some of the key technology innovations, especially in the area of clean energy, began to take place in these countries. Table 1 shows a comparison of the rankings of wind and photovoltaic (PV) producers as well as their market shares in the global market between 2003 and 2010.

Table 1: A comparison of the rankings of wind and photovoltaic producers and their market shares in the global market between 2003 and 2010

<table>
<thead>
<tr>
<th></th>
<th>Wind turbines</th>
<th></th>
<th>Photovoltaics</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>2010</td>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Vestas (Denmark)</td>
<td>14.3%</td>
<td>21.7%</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Sinovel (China)</td>
<td>11.1%</td>
<td>18%</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>GE WIND (U.S.)</td>
<td>9.9%</td>
<td>14.5%</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Goldwind (China)</td>
<td>9.5%</td>
<td>11.5%</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Enercon (Germany)</td>
<td>7.2%</td>
<td>10.2%</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>Suntech Power (China)</td>
<td>5.8%</td>
<td>26.6%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>JA Solar (China)</td>
<td>5.4%</td>
<td>9.7%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>First Solar (U.S.)</td>
<td>5.2%</td>
<td>7.0%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Trina (China)</td>
<td>3.9%</td>
<td>5.4%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Q-Cells (China)</td>
<td>3.7%</td>
<td>4.7%</td>
<td></td>
</tr>
</tbody>
</table>

(Source: Information compiled by the authors from various sources.)
Table 1 indicates that, while the wind and PV producers from the developed countries occupied the market in 2003, Chinese wind and PV producers were dominant in the market in 2010. Outside of this ranking, there are several wind and PV producers from India rising as important players in the market including a wind turbine producer called Suzlon. Nowadays, a high level of technology innovation in clean energy takes place in China and India. Apart from wind and PV technologies, there are many other examples where producers from the developing countries started to grow including heat pump from China, clean coal technology from Mexico, and compact fluorescent lamps from China and Indonesia (Brewer, 2008). As indicated above, some of these technologies are now transferred abroad. An example is a project in South Africa where a Chinese company is providing its technologies for 1,500MW wind project and solar project (SouthAfrica.info, 2010). In this case, China is transferring technologies to South Africa. Nowadays, this type of technology transfer is often referred as South-South transfers.

It was hardly possible to foresee these movements in technology transfer when technology transfer was raised as an agenda for the first time at the UNCTAD in the 1960s. As opposed to the argument addressed by dependency theorists that developing countries are destined to be impoverished and developed countries enriched by the way developing countries are integrated into the “world system”, a group of the developing countries departed from the dependent cycle of development by making remarkable economic growth since the 1970s. Furthermore, as shown above, some of the developing countries are now on the transferring side of technology, especially in the area of clean energy technologies.

As some of the developing countries have risen as key players in the global market, there is a potential risk for a conflict among countries. An example is a dispute between the United States and China over a local subsidy for wind turbine producers in China. In 2008, China established a special fund for wind turbine manufacturers providing individual grants ranging from $6.7 million to $22.5 million on the use of 70% domestic contents (Platzer, 2011). The US, together with the EU and Japan, saw this subsidy as a measure for trade protectionism. More specifically, they considered the measure as a violation on the WTO Agreement on Subsidies and Countervailing Measures (SCM). As the US requested consultations with China at the WTO, China withdrew the subsidy measures for wind turbine producers. Another example is the case where the US, the EU and Japan have filed a complaint at the WTO about export quota for rare earth materials (Bloomberg, 2012). Rare earth metals are important materials for producing clean and renewable energy products such as batteries for hybrid and electric vehicles. The WTO appeals panel earlier ruled that China must dismantle its system of export quotas for these materials (New York Times, 2012). For the US, Europe and Japan, these examples are viewed as new phenomena for trade protectionism over natural resources or clean energy sources.

While some developing countries have increased their capacity to produce their own technologies, many developing countries are lagging behind in generating or receiving clean energy technologies. As opposed to the argument being presented by neoclassical economists, the positive effects of free trade on technology transfer are not visible yet among them. In the cases where the economic incentives for the private sector to innovate or transfer technologies are low, public financing deem to play an important role in overcoming economic barriers in technology innovation and transfer. In addition, the developing countries recognize the protection of intellectual property rights as a major barrier in technology innovation and transfer. A certain level of flexibilities in the interpretations of intellectual property rights is necessary to
consider in the TRIPs negotiation in order to promote further clean energy in the developing countries. Graph 2 summarizes reflections of international relation theories on technology innovation and transfer.

Graph 2: Reflections of international relation theories on technology innovation and transfer

3. Research wanted: What are the roles of institutions in technology transfer?

The previous section highlighted the main changes in the world economic scene that have been challenging both the view of the dependency theorists and the view of the neoclassical economists on technology innovation and transfer. A group of the developing countries departed from the dependent cycle of development by making remarkable economic growth since the 1970s. Some of the developing countries are on the transferring side of technology now especially in the area of clean energy. Many developing countries are lagging behind, however, in generating or receiving clean energy technologies. What are the roles of international (and national) institutions in technology innovation and transfer?

There are theoretical explorations about the roles of international and national institutions in the area of innovation economics and innovation theory. For Joseph Schumpeter who is regarded as the patron of innovation economics, an evolving institution is an important factor for economic growth (Schumpeter, 1943). Inspired by the idea of innovation economics, innovation theory attempts to define functions or roles of international and national institutions. According to Borrás, for example, they are 1) competence-building
and generation of incentives including production of knowledge, diffusion of knowledge, financial innovation, alignment of actors, guidance of innovators; 2) generation of incentives and reduction of uncertainty including appropriation of knowledge, reduction of technological diversity; and 3) establishment of limits and reduction of uncertainty including reduction of risk and control of knowledge usage (Borrás, 2004). Another example is a study by Suurs and Hekkert. According to Suurs and Hekkert, there are seven functions of institutions including entrepreneurial activities, knowledge development, knowledge diffusion, guidance of the search, market formation, resource mobilization, legitimization (Suurs and Hekkert, 2009; Schmidt and Dabur, 2011). If the issues discussed in this paper applied to these classifications of the functions of institutions, public financing falls into the area of “financial innovation” or “resource mobilization”, while the intellectual property issue is a part of “appropriation of knowledge” or “legitimization”.

In the formulation of the TEC and the CTCN as well as the establishment of the Green Climate Fund, several studies are submitted to identify the functions of international and national institutions. According to the study presented by Benioff et. al. (2010), there are three roles of international institutions for innovation and transfer of clean energy technologies including research, development, and demonstration (RD&D) cooperation, enhancement of enabling environment, and financing facilitation and support (Benioff and de Coninck et al. 2010).

What are the roles of international and national institutions in technology transfer? There are strong and urgent needs for further research on their roles, as the deadline for the negotiations on the post-Kyoto regime comes closer.

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