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SOUTH–SOUTH TECHNOLOGY TRANSFER ADDRESSING CLIMATE CHANGE:
The Emerging Role of Developing Countries in the Global Climate Governance

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ABSTRACT:

Given the ongoing discussion on the crucial role of technology to address climate change and the increasing international pressure on developing countries to combat global warming, this paper analyses the potential of South–South technology transfer as an interesting alternative to the traditional pathway of North–South transfer of technological innovation through financial flows, emphasizing the role of developing countries as sources and not only as recipients of international technology innovations. Until now, no coherent or comprehensive international regulations for the new phenomenon of South–South technology transfer has yet been

formulated and the UNFCCC CDM addresses essentially North–South movements of technologies. The different WTO Agreements offer only indirect and partial regulation of specific aspects of the movements of knowledge and technology between developing countries.

"Bonum Diffusivum Sui"- St. Thomas Aquinas

I. INTRODUCTION TO SOUTH-SOUTH TECHNOLOGY TRANSFER ADDRESSING CLIMATE CHANGE

Technology plays a crucial role as a practical instrument to address climate change. The development of less greenhouse gas (GHG) intensive technologies and the diffusion of innovations for mitigation of and adaptation to climate change is crucial for the reduction of emissions in developing and developed countries[1]. For this reason, technology innovation and its subsequent diffusion are at the core of current negotiations about the post-Kyoto climate governance[2]. While efforts in this direction have to be undertaken primarily by developed countries as part of the "*common but differentiated responsibilities and respective capabilities*", the potential role developing countries can play as a source and vehicle for climate-related technologies should not be underestimated.

Developing and emerging countries are facing increasing international pressure to make serious efforts to combat global warming, and especially to reduce emissions of GHGs[3]. The key difficulty hampering the efforts of developing countries to limit global warming consists in their limited access to climate friendly technologies[4], and the problems this causes. Article 4.5 of the United Nations Framework Convention on Climate Change (UNFCCC) suggests a mechanism of North–South technology transfer as a possible solution, which would allow developing countries to deal with the challenges of climate change. It asks developed country signatories to "*promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties*". The UNFCCC, however, falls short of sufficiently considering the potential of South–South technology transfer; and other fora such as the

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[1] De Coninck, H., Fischer C.,Newell, R.G., Ueno, T. "International technology-oriented agreements to address climate change" in *Energy Policy* vol.36, 2008, pp. 335–356.
[2] UNFCCC, *Bali Action Plan*, Document FCCC/CP/2007/L.7/Rev.1, 2007.
[3] In the past four decades the overall growth of GHG emissions is mostly attributable to developing and emerging countries; the current GHG emissions of industrialized countries fell have fallen considerably (by almost 40% in 2008). UNCTAD, *Trade and Development Report 2009*, Geneva, 2009 pp. 135–138.
[4] David V., Raustiala K. and Skolnikoff E.,.*The implementation and effectives of international environmental commitments: Theory and Practice*, MII Press Cambridge, MA, 1998.

WTO framework give equally little attention to it. This paper aims at exploring this gap by considering the potential of technology flows between developing countries as a complementary and interesting paradigm to address climate change.

Indeed, South–South technology transfer constitutes an interesting alternative to the traditional pathway of North–South transfer of technological innovation through financial flows, emphasizing the role of developing countries as sources and not only as recipients of international technology innovations. Several developing countries are emerging as world leaders in some key climate-related technologies, involving other developing countries in numerous projects, and spreading clean technology through trade and investments flows. Furthermore, South–South technology transfer is relevant from a broader development perspective. The implementation of a mitigation and adaptation strategy, at a national or international level, cannot be analyzed without considering the framework of sustainable development and without taking into account the possible impact on economic growth, equity and poverty alleviation. South–South technology transfer has the potential to increase the "*development dividend*", the social and developmental benefits that are associated with adaptation measures and the implementation of policies on GHG emissions in developing countries[5].

Until now, the effective achievement of the transfer of climate-related technologies has not been an easy process, but has faced the challenge of needing to respond to the specific economic situation of the different recipient countries with regard to the efficient diffusion and assimilation of new technologies. Moreover, the transfer of technologies should also involve a long-term capacity building goal tailored to the particular situation of the host developing country, a process sometimes too burdensome for regular development assistance. These reasons have contributed to the lack of progress in technology transfer under formal mechanisms (UNFCCC's Clean Development Mechanism) or along the traditional North–South pathway. The South–South approach to technology transfer may overcome some of these difficulties, as foreign direct investments transmit technological innovations between developing countries, which share some similarities, and thus may

[5] Forsyth T., "Promoting the 'Development Dividend' of Climate Technology Transfer: Can Cross-sector Partnerships Help?" in *World Development* Vol. 35, No. 10, 2007, pp. 1684–1698.

have a better mutual understanding of their markets, financial and social situations.

II. THE COMPLEXITY OF TECHNOLOGY TRANSFER ADDRESSING CLIMATE CHANGE

Technology transfer refers to a comprehensive notion, including the tacit knowledge and "*a broad set of processes covering the flow of know-how, experience and equipment*"[6] following different pathways, where different entities intervene and influence these processes[7]. Except where the information traded is available within the public domain, technology transfer consists in a very costly process of learning[8], where the costs are essentially related to how the information is traded between the partners[9]. The transfer of technology is embodied, in fact, in a wide range of activities[10]; however, there are three main ways in which it is possible to exploit and acquire technology across national boundaries: trade, licensing and foreign direct investment (FDI). Trade in goods and services[11] represents a channel for the international diffusion of technology together with technology licensing that typically consists in the purchase of the technical information, know-how, production and distribution rights on the innovation, within firms or between unrelated firms. By contrast, the technology transfer through FDI encompasses not only the horizontal and vertical linkage between firms, thanks to the supply of intermediate goods and services, or between firms at the same phase of the production chain, but also cross-border movement of personnel and the process of the internalization of research and development (R&D) activities[12]. In this paper, I concentrate on the diffusion of technology via trade and

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[6] IPCC Special Report*: Methodological and Technological Issues in Technology Transfer*, Cambridge University Press, Cambridge, 2000.
[7] Hoekman B.M. & Smarzynska Javorcik B.K., *Global integration and technology transfer*, Washington, DC: World Bank and Palgrave Macmillan, 2006.
[8] The phenomenon of technology transfer is defined as "*the process originating from the countries and the companies that developed and produced the innovation technology to the countries and subjects that will receive and facilitate their effective implementation and dissemination*". UNFCCC, Extracts from the secretariat's technical paper on *Barriers and opportunities related to the transfer of technology*, Document FCCC/TP/1998/1.
[9] Maskus K.E., *Encouraging International Technology Transfer*, ICTSD Intellectual Property Rights and Sustainable Development Issue Paper n. 7, 2004, p. 31.
[10] Bell, M., "Technology Transfer to Transition Countries: Are there Lessons from the Experience of the Post-war Industrializing Countries?" in Dyker, D.A. (ed.), *The technology of transition*, Budapest: Central European University Press, 1997, pp. 63–94.
[11] Trade through the purchase of equipment and knowledge not commercially available in the recipient country.
[12] OECD, *Foreign Direct Investment and Development. Maximizing Benefits, Minimizing Costs*, Paris: OECD, 2002.

investments, which is by far the most common channel for flows of technologies across countries.

The notion of technology transfer addressing climate change can be defined, according to the UNFCCC Glossary, as "*a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change among different stakeholders*"[13]. Due to its complexity, this phenomenon can be analyzed by looking at the different actors and the specific modalities to finance the technology diffusion that are involved in the actual flow of technology[14]. For example the diffusion of technologies can be supported by a public sector contribution in the form of finance and investment.

The traditional paradigm of this type of technology transfer is represented by North–South technology and financial flows, essentially employed in bilateral and multilateral official development assistance (ODA) programs for supporting climate change projects and it has been adopted in the context of UNFCCC within the technology transfer projects associated with the Clean Development Mechanism. Alternative means for spreading technological innovation related to climate change emerge in the context of international agreements establishing the cooperation between public and private sectors in a specific project on specific environment-friendly technologies[15].

A third possible means of transfer of technology is through multinational firms that operate on the sole basis of their market and competitive business strategies, but are effective vehicles of technology diffusion, particularly through trading flows in goods and services and FDI[16]. In my research, I focus on private-sector technology transfer because "*when considering means to enhance investment and financial flow to address climate change in the future, it is important to focus on the role of private-sector investments as they*

[13] UNFCCC, Glossary of climate change acronyms, available at www.unfccc.int/essential_background/glossary/items/3666.php#

[14] Brewer T., *International Energy Technology Transfer for Climate Change*, paper prepared for CESifo Venice Summer Institute Workshop Europe Global Environmental Issues, Venice 14-15 July 2008.

[15] Currently, these technology-specific arrangements, involving not only governments but also firms and industry associations, are being promoted and developed by the European Union (EU) in its bilateral agreements with China and India and by the US, for example in the Asia Pacific Partnership on Clean Development and Climate.Fujiwara N., *The Asia Pacific Partnership on Clean Development and Climate*, CEPS Policy Brief, No. 144, 2007.

[16] Brewer T., "Climate Change Technology Transfer: A New Paradigm and Policy Agenda" in *Climate Policy*, n. 5, vol. 8, 2008, pp. 516-526.

constitute the largest share of investment and financial flow"[17]. This private paradigm of international technology diffusion is particularly interesting because this is the mode of technology transfer that exploits the role of developing countries as sources not only of private investment but also of climate-friendly technologies. It is this paradigm that draws attention to the current changes in the traditional geography of technology transfer in the form of South–South technology transfer, since until now attention has been focused on the North–South flows disregarding the fact that developing countries are becoming increasingly relevant sources of climate friendly technologies.

III. TRENDS IN INNOVATIONS AND INVESTMENTS TO ADDRESS CLIMATE CHANGE

The transfer of environmentally sound technologies between developing countries is not only an attractive suggestion for possible evolutions of the current exchange of knowledge but it represents an important reality in the technological cooperation across countries. Some developing and emerging countries are casting themselves, on the international stage, in the role of leading exporters of climate friendly technologies, transferred from South to South and from South to North.

The level of innovation across countries has changed rapidly in recent years, in particular the geographical distribution of climate mitigation innovations and their international diffusion. Patent data represent a good indicator of the geographical and temporal trends of innovative activities, allowing cross-country comparisons[18]. In terms of geographical distribution of innovations, the European Patent Office/Organization for Economic Co-operation and Development (EPO/OECD) World Patent Statistical Database (PATSTAT) database clearly shows that the level of innovation is highly concentrated: the

[17] UNFCCC, *Investment and Financial Flows To address Climate Change*, Bonn, 2007, available at http://unfccc.int/cooperation_and_support/financial_mechanism/items/4053.php

[18] Apart from the count of patent applications, there are other possibilities to measure the level of innovation, first of all, R&D expenditures, with the big disadvantage that it only focus on the input of the inventive process and the data cannot de disaggregated between specific technological areas. Also patent-data indicators are limited instruments because they are essentially means of protecting innovations and are dependent of a number of variables, like the nature of technology and the risk of imitation in that country. However, patent-data are useful proxies because it is possible to isolate the study of specific climate mitigation technologies, identifying not only the countries where the innovation is developed but also where it is used and commercialized. Dechezleprêtre A., Glachant M., Hascic I., Johnstone N. and Ménière Y., "Invention and Transfer of Climate Change Mitigation Technologies on a Global Scale: A Study Drawing on Patent Data", Prepared for the *Review of Environmental Economics and Policy*, 2010.

top 12 countries account for nearly 90% of the world's climate-related inventions. Apart from the predictable fact that Japan, the USA and Germany are the three main inventor countries for most mitigation technologies, what is particularly interesting is that these three world leaders are followed by three emerging economies: China, South Korea and Russia.

Geographical and sectorial concentration of climate related inventions

COUNTRY	RANK	AVERAGE % WORLD'S INVENTIONS	AVERAGE % WORLD'S HIGH-VALUE INVENTIONS	LEADING TECHNOLOGIES
Japan	1	37.1	17.4 (2)	All
USA	2	11.8	13.1 (3)	Biomass, insulation, solar
Germany	3	10.0	22.2 (1)	Wind, solar, geothermal
China	4	8.1	2.3 (10)	Cement, geothermal, waste
South Korea	5	6.4	4.4 (6)	Lighting, heating, waste
Russia	6	2.8	0.3 (26)	Cement, hydro, wind

From: Dechezleprêtre A., Glachant M., Hascic I., Johnstone N. and Ménière Y.

These countries are asserting themselves as important sources of innovation with a strong position in specific technological fields. China is responsible for 8% of the world's inventions and is a leading country for the cement, geothermal and solar sector, whereas South Korea is the source of more than 6% of the world's investment, dominating the market in lighting technology. Russia is elevating its position as inventor country in the sectors of cement, and hydro and wind energy production. The results of the analysis of the patent data have been confirmed by the World Bank study that identifies the top ten exporting countries in each of four categories of key products for mitigation technologies, which also noted that at least one developing country has a prominent position in each technological assemblage: Mexico in clean coal technology; China in wind energy; China, Taiwan, Malaysia and South

Korea in solar energy; and China and Indonesia in compact fluorescent lamps[19].

However, the analysis of patent data has to be integrated with the private investment perspective where the role of developing countries cannot be underestimated: they currently hold 20–25% of global private investments and their expected rapid economic growth is predicted to lead to a further increase in the level of outflow investments[20]. The private sector driven technology transfer, for this reason, is expected to become a crucial strategy for the diffusion of mitigation technologies. Moreover, the roles of individual countries in the development and transfer of technologies depend essentially on the activities of the multinational firms in these countries. Multinational firms are engaged in intensive technology transfer activities; the investment, licensing and joint venture arrangements of multinational firms are therefore key channels for international technology transfers. In the specific context of the diffusion of climate-related technologies, two important trends can be noted.

From one side, many developed countries' multinationals have located important R&D activities in developing countries. General Electric has large 'Global Research Centres' in its foreign subsidiaries in China and India, as well as within its parent firm in US: it has been conducting extensive R&D activities in China and India in electric power systems electronics, and it has an R&D project in China on coal- based technologies for generating electric power. Likewise, Siemens not only has 22,000 employees in R&D centers' in its home country, Germany, but another 7,000 in China and 2,000 in India (specialized in energy efficiency in building and lighting). On the other hand, there are also a significant number of multinationals, in particular in industries important for reducing GHG emissions, essentially based in developing countries, as in the case of Suzlon and Goldwind, two of the world's major producers of wind turbines, based in India and China. However, in the analysis of the rising trend of South–South transfer of technology, it has been noted that single developing and emerging countries are acquiring importance, in

[19] World Bank, *International Trade and Climate Change: Economic, Legal and Institutional Perspective*, NewYork, 2007.
[20] UNCTAD, *World Investment Report 2010: Investing in Low-Carbon Economy*, Geneva, United Nations Publications, 20010.

term of trade and investments, only in specific technological fields and not in terms of a broad spectrum of mitigation and adaptation technologies.

IV. THE LACK OF AN INTERNATIONAL LEGAL FRAMEWORK AND THE TRANSFER OF TECHNOLOGY UNDER THE UNFCCC AGREEMENTS

The international legal aspects of technology transfer started to attract the interest of the international community in the 1970s and 1980s. International regulation of technology transfer was initially part of the debate concerning the "new international legal order"[21] and, in the context of sustainable development, during the United Nations Conference on Environment and Development (UNCED) Rio Declaration in1992[22] and in the UN Agenda 21, which specifically support the diffusion of environmentally sound technology to developing countries[23]. Positive measures to encourage the transfer of environment-friendly technology have been progressively included in multilateral environmental agreements like the Convention on Biological Diversity and the Montreal Protocol that also establish a Multilateral Fund providing interesting positive measures and a participatory approach between the different stakeholders in order to facilitate the transfer of technology[24]. On the other hand, the technology transfer addressing climate change finds in the UNFCCC Agreements – first the UN Framework Convention on Climate Change of 9 May 1992 and then the Kyoto Protocol to the UNFCCC of 11 December 1997 – its natural legal framework and a broader systematization.

The technology transfer discipline under the UNFCCC is, in general, inspired by the principle of the common but differentiated responsibility in the efforts to combat climate change and it is rooted in the strong negotiation position that developing countries pursued in the UNFCCC negotiations until now. The developing countries were aiming to avoid any strict environmental protection obligation without receiving financial or technical support as counterpart from developed countries, like the introduction of a specific technology transfer

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[21] The issue of technology transfer has been raised in the negotiations related to the transfer of deep sea- bed mining technology in the context of the entry into force of the UN Convention of the Law of the Sea. Yuwen Li, *Transfer of technology for deep seabed mining: the 1982 Law of the Sea convention and beyond*, Dordrecht, Martinus Nijhoff Publishers, 1994.

[22] Principle 9 of the Rio Declaration says *"States should cooperate to strengthen endogenous capacity-building for sustainable development … through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies."*

[23] Chapter 34 of Agenda 21 was entirely devoted to technology transfer.

[24] Kaniaru D., *The Montreal Protocol: celebrating 20 years of environmental progress*, London: Cameron May, 2007.

commitment for developed countries[25]. In order to implement the general objective set out in Article 4.1 to "*promote and cooperate in the full, open and prompt exchange of relevant scientific, technological, technical, socio-economic and legal information related to the climate system and climate change*", it is essential that developed countries which are Parties to the Convention respect the obligation under Article 4.5 that requires them 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 country Parties*"[26]. These two provisions, read together, institutionalize the paradigm of the North–South transfer of technology for addressing climate change, translating it into a binding commitment for developed countries to transfer technology and provide financial resources. The financial instrument for the obligation set in Article 4.5 is established in the second sentence of Article 4.3 in conjunction with Article 11 that sets up a "*a mechanism for the provision of financial resources on a grant or concessional basis, including for the transfer of technology*" and that consists in the Global Environmental Facility.

In order to fulfill these commitments an Expert Group on Technology Transfer (EGTT) has been created in the context of the seventh Conference of the Parties to the UNFCCC (COP-7)[27]. To provide advice to Parties, the Technology Transfer Information Clearing House (TT Clear) has been established by the Climate Change Secretariat with the main purpose of obtaining a "technology needs assessment" to be prepared by many developing country Parties. To enhance the implementation of Article 4.5 of the Convention, the developing countries are encouraged to undertake assessments, in a consultative process with the different stakeholders involved, concerning their country-specific technology needs by sector, the barriers to technology transfer and the appropriate measures to remove these barriers[28].

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[25] Bodansky D., "The United Nations Framework Convention on Climate Change: a Commentary" in *the Yale Journal of International Law*, vol. 18, 1993, pp. 451-558.

[26] Article 4.5 of the UNFCCC clearly reminds Article 10A of the Montreal Protocol that ask to the contracting Parties to "*take every practicable step, consistent with the programmes supported by the financial mechanism, to ensure that the best available, environmentally safe substitutes and relate technologies are expeditiously transferred to Parties*".

[27] UNFCCC/CP/2001/13/Add.1, Decision 4/CP.7, Annex.

[28] UNDP, Handbook on conducting technology needs assessment for climate change, June 2009, available at http://unfccc.int/ttclear/jsp/index.jsp

The Kyoto Protocol of 1997 represents a strengthening of the discipline concerning the technology transfer set out in the Framework Convention. The establishment of the Clean Development Mechanism (CDM) in Article 12 of the Protocol represents a translation into concrete actions of the commitments already fixed in Article 4.5, officially recognizing the great potential for private sector investment in the diffusion of technology. With regard to technology transfer, the Kyoto Protocol, in Article 10.C, not only reaffirms the obligation under Article 4.5 UNFCCC, but it adds two important clarifications of the issue. Recalling the necessity to "*take all practicable steps to promote, facilitate and finance*" the transfer of technology, it recognizes that not all the climate-related technologies are protected by intellectual property rights, specifically referring also to the "*environmentally sound technologies that are publicly owned or in the public domain*". On the other hand, the Kyoto Protocol underlines the importance of the role of the private sector and the necessity to create a favorable business climate for the transfer of technology, asking the contracting parties to aim at "*the creation of an enabling environment for the private sector*".

In particular, the CDM invites Annex I Parties to work and invest in developing countries creating incentives for private investors involved in concrete projects and based on measurable, certifiable emission performance. Even if there is no provision that specifically refers to technology transfer, the CDM could be a potentially useful instrument for the development and finance of climate-friendly technologies, but it could also represent a valuable vehicle for transferring them, stressing the importance of the role of private investments as a channel.

However, questions have also been raised as to the effectiveness of the contribution of the CDM to stimulating the involvement of private investors in combating climate change: according to some critics, the CDM did not result in a real and verifiable reduction in emissions and, so far, it has not led to the provision of adequate assistance to developing countries from the North[29].

[29] De Sepibus J., The environmental integrity of the CDM mechanism – A legal analysis of its institutional and procedural shortcomings, NCCR Working Paper No 2009/24, May 2009, available at http://www.nccr-trade.org/index.php?option=com_content&task=category&sectionid=33,34,35,36&id=118&Itemid=199&afilter=S%E9pibus ; Delbeke J., "Time to rethink the CDM. Current uncertainty around the Clean Development Mechanism has deeper roots than the EU ETS review and needs longer-term solutions", in Environmental Finance, 2008. Wara Michael W., Measuring the Clean Development Mechanism's Performance and Potential, 2008, available at SSRN: http://ssrn.com/abstract=1086242 .

With specific reference to technology transfer, studies conducted in the renewable energy sectors have shown poor results for the diffusion of innovation connected with CDM projects. In particular, because renewable have not reached a mature stage of technology development and the individual projects require supplemental finance, the CDM projects essentially maximize the short-term profits of private actors, without focusing on the long-term benefits provided by investments in R&D[30]. Unfortunately, the investors that benefit from the CDM incentives tend to adopt small-scale projects involving "*the cheapest opportunities for emissions reductions*",[31] without involving any kind of long-term strategy to use substitutes for fossil fuels and other polluting energy sources. Lutken demonstrated that 90% of the CDM projects analyzed were unilaterally financed by actors from developing countries and did not incorporate unfamiliar technologies for the host country or stimulate any successful diffusion of climate-friendly innovations[32].

In the Bali Action Plan[33], the diffusion of climate- related technologies is a key element in the satisfactory implementation of the Framework Convention, and for this reason, the Bali Action Plan specifically encourages the contracting Parties to take into consideration the negotiation of proper measures for "*(d)(i) Effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies; (ii) Ways to accelerate deployment, diffusion and transfer of affordable environmentally sound technologies*". Unfortunately the outcome of the Copenhagen conference on this topic is particularly meager: it makes only a vague reference to the creation of "*a Technology Mechanism to accelerate technology development and transfer*"[34]. The Copenhagen Accord makes no

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[30] Driesen D.M., Design, Trading, and Innovation, 2005, available at http://ssrn.com/abstract=770424

[31] Moon S., Does TRIPS Art. 66.2 Encourage Technology Transfer to LDCs? An Analysis of Country Submissions to the TRIPS Council (1999-2007), ICTSD Policy Brief Number 2, December 2008, pag 6.

[32] Lutken S.E., "Developing Country Financing for Developed Country Commitments?" in: Holm et al., *A reformed CDM – including new mechanisms for Sustainable Development*, UNEP Risø Centre, 2008, pp. 85–100.

[33] The Bali Action Plan was adopted by the Conference of the Parties of the UNFCCC in December 2007 (Decision 1/CP.13) and it defined the directions of the negotiations for a global and comprehensive post-2012 climate agreement.

[34] The technology mechanism would be administrated by a 'technology executive committee' and a 'climate technology centre' with the mandate of "*facilitating access to affordable and appropriate technologies required by developing countries for enhanced action on adaptation and mitigation; assess the adequacy and predictability of funds for development and transfer of, or access to, environmentally sound technology (EST); remove barriers to technology development and transfer and enhance means*

mention of the complex role of intellectual property rights in the transfer of technology, the point on which the positions of developed and developing countries were absolutely incompatible. Elements worth reflecting on have been reached in the context of the Ad hoc Working Group on Long-term Co-operative Action (AWG-LCA)[35] in terms of the establishment of a network of regional technology and innovation centers, but unfortunately the paradigm of the South–South technology transfer continues to be almost disregarded in the UNFCCC negotiation framework.

V. IDENTIFICATION AND REGULATION OF THE BARRIERS AFFECTING THE INTERNATIONAL DIFFUSION OF INNOVATION

To improve the quality and efficiency of the transfer of environmentally sound technologies, especially those coming from developing countries, it is essential to locate these technology flows within a broader context, including the analysis of the main obstacles to the diffusion of technology. Moreover, due to the lack of comprehensive regulation of the phenomenon of the South–South technology transfer, the focus on the international disciplines that affect the obstacles to the diffusion of technology represents the only feasible strategy that, at the moment, could encourage the sustainable use and diffusion of environmentally sound technologies.

The principal factors that inhibit the technology transfer process can be categorized into technological, financial, institutional, information and social barriers, existing at every stage of the technology transfer sequence and mostly involving systemic socio- political circumstances.

First, the lack of access to essential information, skills and infrastructure can undermine the process of the acquisition of the technology,[36] resulting in a sub- optimal performance[37]. Another primary obstacle to the diffusion of technology is the lack of the financial resources necessary to obtain the

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to promote technology transfer (bracketed); develop and enhance endogenous capacities of, and technologies in, developing country parties; and capacity-building to enhance the capability of developing country parties for the development and transfer of EST and know-how".

[35] UNFCCC/AWGLCA/2009/L.7/Add.3

[36] Unfortunately, access to adequate information is often difficult in developing countries where the appropriate transfer of climate friendly innovation is frequently distorted by the resistance of local governments, end users and operators. UNCTAD, *Promoting the transfer and use of environmentally sound technology, A review of policies*, New York: UNCTAD Publications, 1997.

[37] On the other hand, the misinformation of donors and providers of technology about the specific needs of the recipient country can also represent a key obstacle to the appropriate diffusion of the technology IEA/OECD, *Technology without Borders, Case Studies of Successful Technology Transfer*, Paris: OECD, 2001.

technologies, due to the absence of a sufficient infrastructure of the financial markets in many developing countries. Financial barriers are particularly burdensome for developing countries: domestic capital markets are often extremely weak, dominated by small and medium-sized businesses with high risk profiles and a limited access to credit, and long-term loans are rarely granted. As proved in the IPCC study on the methodological and technological issues in technology transfer, the lack of investment because of high start-up costs has until now been the main obstacle to technology transfer in the renewable energy sector[38]. For this reason, the impact of technical and financial results in an increased protection of market from international investment concurrence, depriving countries from the exchange of innovation and know how. The main barrier to technology transfer in the transport sector is “the lack of a suitable enabling environment” in most developing countries, which would encourage the involvement, and the investments of the private sector[39]. In particular, the absence of the necessary manufacturing capabilities, in terms of training and R&D in the recipient country, could create not only serious obstacles for an effective transfer of technology, but sometimes could also completely prevent large transport companies to undertake a sub-contracting their operations to some developing countries. Moreover, due to the high costs implicit in the development of transport infrastructure, the main financial barrier to transport technology transfer is related to access to capital to invest in the development of the technology.

Furthermore, institutional barriers also have a significant impact on technology transfer, often taking the form of a "*lack of legal and regulatory frameworks, limited institutional capacity, or excessive bureaucratic procedures*"[40]. Closely related to the concept of institutional barriers is the idea of political obstacles to technology transfer, typically exemplified by interventions in domestic markets, such as subsidies, corruption and a lack or weakness of the civil society. Three issues related to the institutional and political framework are of particular relevance.

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[38] Leijon M., Bernhoff H., Berg M.and Ågren O., “Economical considerations of renewable electric energy production—especially development of wave energy”, in *Renewable Energy*, Vol 28, Issue 8, July 2003, pp. 1201-1209.

[39] IPCC Special Report: Methodological and Technological Issues in Technology Transfer, Cambridge University Press, Cambridge, 2000.

[40] UNFCCC, Extracts from the secretariat’s technical paper on Barriers and opportunities related to the transfer of technology, Document UFCCC/TP/1998/1.

First, it has been shown that the existence of an appropriate framework of environmental regulation in the receiving country represents an important variable in the facilitation of diffusion of climate friendly technologies[41]. A strong environmental regulation is an incentive to create a favorable market for mitigation and adaptation technologies and a good stimulus for firms to acquire and implement new technologies. A regulation based on low environmental standards is undoubtedly a strong disincentive for the development of the existing climate-friendly technologies. Moreover, the fact that the recipient country is a signatory country to a multilateral environmental agreement is a factor whose importance cannot be underestimated in terms of institutional barriers or opportunities[42].

Secondly, the academic literature has traditionally emphasized the importance of intellectual property rights (IPRs). The role of IPR protection in the process of technology transfer is, nevertheless, particularly controversial. Strict regulation of IPRs has traditionally been seen as a safeguard against the risk of losing control of information along the chain of transmissions, representing an incentive to transfer technology[43], with positive impacts in terms of productivity and increment in trade flows[44]. As confirmed in the 2009 report of Chatham House, a "*patent portfolio is a currency for attracting venture capital, entry into strategic alliances, protection against litigation, as well as opening opportunities for mergers and acquisitions*"[45]. However, IPR regimes could also be interpreted as presenting an important obstacle to technology transfer; by definition IPRs constitute a restriction on the availability of a specific innovation and obstruct the use, the further development and the diffusion of

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[41] Tebar Less C. & McMillan S., *Achieving the Successful Transfer of Environmentally Sound Technologies: Trade-Related Aspects*, OECD Trade and Environment Working Paper No. 2, 2005.

[42] The Convention on Biological Diversity welcomes the transfer of technologies for conservation and sustainable use of biodiversity, as referred to in Articles 1 and 16. Article 12 and Article 18 of the UN Convention to Combat Desertification specifically refer to the transfer of technologies to developing countries. Article 10 of the Montreal Protocol on Substances that Deplete the Ozone Layer in particular provides for the diffusion of "the best available, environmentally safe substitutes and related technologies" to developing countries. OECD, *Multilateral Environmental Agreements and Private Investment*, Paris: OECD, 2005.

[43] In her study on the transfer of US technologies, Smith proved that weak patent right enforcement and the consequent high risk of imitation in the destination country are strongly related with a decrease in the technology diffusion. Smith P., "Are weak patent rights a barrier to U.S. exports?" in *Journal of International Economics*, Vol. 48 Issue 1, June 1999, Pages 151–177.

[44] Maskus K., *Transfer of Technology and Technological Capacity Building*, presented at the ICTSD-UNCTAD Dialogue, 2nd Bellagio Series on Development and Intellectual Property, 2003.

[45] Lee B., Iliev I. and Preston F., *Who Owns Our Low Carbon Future? Intellectual Property and Energy Technologies*, Chatham House Report, September 2009, available at http://www.chathamhouse.org.uk/publications/papers/view/-/id/775/

the technologies covered, also resulting in prohibitive prices for commercialization[46].

Moreover, focusing the analysis on the role of IPR protection and patent systems in the context of climate change, the relationship between IPR protection and technology transfer is not even based on incontrovertible findings. As shown in the case study analysis of the OECD, IPRs do not seem to constitute the main barrier to technology flow[47]. In the case of mitigation technologies; patents and IPRs are not the major concern for exporters or investors, because they are more concerned about other costs like capital investments in new plants and machinery or running costs. It is recognized, however, that IPR protection has a much broader influence in the field of adaptation technologies if one just considers, for example, the efforts in the pharmaceutical sector to deal with the effects of climate change on health from changes in the pattern of diseases such as malaria[48]. In terms of geographical distributions of patented adaptation and mitigation technology, it should be noted that, according to OECD data, large developed countries such as Germany, the US and Japan control the highest number of patents[49]. The developed nations receive 93.8% of royalties and license fees, 89% of them from US patents. However, the fact that the North–South gap still persists for patented technologies is relevant to the North–South transfer of technology, where IPR protection can really represent an important barrier to technology flows. In the diffusion of innovations between developing countries, due to the limited number of patents, the IPR barriers do not seem to be so relevant.

VI. THE WTO COVERAGE OF THE DIFFERENT BARRIERS TO AND CHANNELS FOR TECHNOLOGY DIFFUSION

What seems to be particularly relevant in the context of the transfer of technologies between developing countries are the third set of relevant institutional barriers to technology diffusion: trade policy measures. Tariffs and subsidies have a strong influence on knowledge diffusion, as do requirements

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[46] Foray D., *Technology Transfer in the TRIPS Age: The Need for New Types of Partnerships between the Least Developed and Most Advanced Economies*, ICTSD Working Paper, 2008.
[47] OECD, *Trade issues in the transfer of clean technologies*, Paris: OECD, 1992.
[48] Stern N., *The Economics of Climate Change: The Stern Review*, Cambridge: Cambridge University Press, 2006, pp. 563–568.
[49] Only the Stuttgart regions of Germany, for example, has the highest number of patents in vehicle pollution control technologies, with 37.4% of car emission control patents. OECD, *Compendium of Patent Statistics*, Paris: OECD, 2008.

for domestic ownership of ventures or the concentration of local content in the technology.

For this reason, the issue of international transfer of mitigation and adaptation technology has also an increasing relevance from the multilateral trade perspective. Even if there is no multilateral agreement that explicitly deals with the issue of the transfer of technology, different norms in various WTO agreements address particular aspects of the phenomenon of transfer of climate related technology. In particular, the different channels and the specific trade barriers to technology diffusion are subject to the regulation of different WTO Agreements. Of all the WTO Agreements, the protection of IPRs guaranteed in the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS) is expected to have the most substantial impact on the dynamics of technology transfer. Moreover, the movement of technology through FDI can potentially fall within the scope of the Agreement on Trade-related Investment Measures (TRIMs). Moreover, the diffusion of climate-related technology through trade is strictly related to the Doha negotiations on environmental goods and services. However, within the WTO context, it is difficult to capture the increasing importance of the paradigm of South– South technology transfer, either in the actual regulation of the different agreements, or in the possible results of the Doha negotiations.

Of all the different WTO rules that might be relevant in addressing the legal aspects of the phenomenon of South–South transfer of technology addressing climate change the TRIPS Agreement appears to contain the most significant obligations for WTO Members[50]. The access to and the diffusion of technological innovations from a more general perspective not limited to the field trade are emphasized as a general objective of the TRIPS Agreement[51]. As a counterbalance to Article 7 TRIPs[52], Article 8 has the purpose of safeguarding the international diffusion of technologies from the abuse of IPR protection in the formulation of national legislations, and it guarantees the

[50] The issue of international technology transfer in a climate change regime fully falls under the coverage of the TRIPS Agreement, especially if the provision of Article 7 is interpreted in conjunction with the importance of non-trade concerns stressed in the Preamble of the Marrakesh Agreement, which requires that the trade relations between the WTO Members should be conducted "*in accordance with the objective of sustainable development… to protect and preserve the environmen*t".

[51] Cottier T., Véron P., *Concise International and European IP Law: TRIPS, Paris Convention, European enforcement and transfer of technology*, Kluwer Law International, 2008, pp., 27–28.

[52] Article 7 requires that the international regime of IPR protection "*should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare*".

proper diffusion of technologies against the risk arising from national policies that regulate the different aspects of the technology transactions, for example restrictive business practices in the licensing agreements[53].

In order to assure the full implementation of the TRIPS provisions in developing countries and to achieve the balance between IPR rights and obligations necessary to facilitate the development and diffusion of technology, special guarantees are provided. Article 66.2 establishes the specific obligation for developed countries to encourage the transfer of technology to least developed countries that are WTO Members[54]. To guarantee the regular monitoring and the constant implementation of this provision, the Decision on Implementation of Article 66.2 on 19 February 2003 was adopted by the TRIPS Council, with the creation of the WTO Working Group on Trade and Transfer of Technology, to which the developed countries have to submit detailed annual reports[55].

Article 66.2 consists in a positive legal obligation for developed countries, as reaffirmed in paragraph 11.2 of the Decision on Implementation-Related Issues and Concerns of 2001[56]. Moreover, it is not just an obligation for developed WTO Members, it clearly affirms the responsibility of these governments not only to create incentives for their "enterprises and institutions" but also to assure the real effectiveness of these incentives, in order to facilitate the transfer of technology to developing countries. Unfortunately the academic literature on the impact of this provision on the facilitation of the transfer of technology to developing countries is sparse. Recent studies have started to show that the mechanism instituted by Article 66.2 has not so far resulted in excellent performance: many OECD countries have never submitted reports and the majority of the national policies

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[53] Correa C., *Trade related aspects of intellectual property rights: a commentary on the TRIPs Agreement*, Oxford University Press, 2007, pag. 112.

[54] Article 66.2 says that: "*Developed country Members shall provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least-developed country Members in order to enable them to create a sound and viable technological base*".

[55] The Doha Declaration defines the mandate of the WTO Working Group on Technology Transfer, clarifying that the main goal of the Working Group should be the analysis of "*the relationship between trade and transfer of technology, and of any possible recommendations on the steps that might be taken within the mandate of the WTO to increase flows of technology to developing countries*".

[56] Paragraph 11.2 of the Decision of 14 November 2001 on Implementation-related issues and concerns (WT/MIN(01)/17) declares that: "*Reaffirming that the provisions of Article 66.2 of the TRIPS Agreement are mandatory, it is agreed that the TRIPS Council shall put in place a mechanism for ensuring the monitoring and full implementation of the obligations in question. To this end, developed-country members shall submit prior to the end of 2002 detailed reports on the functioning in practice of the incentives provided to their enterprises for the transfer of technology in pursuance of their commitments under Article 66.2. These submissions shall be subject to a review in the TRIPS Council and information shall be updated by Members annually*".

examined do not specifically target least-developed countries or technology transfer issues[57]. Even if it represents a positive obligation for the governments of developed countries, the nature of technology transfer covered by this provision is not specified or narrowed down and considerable discretion in designing the different measures is given to Members[58].

Unfortunately, looking at the real possibilities for facilitating the transfer of technology for addressing climate change to developing countries, it seems that "*The room available within the TRIPS Agreement to foster technology transfer to developing nations is quite small*"[59]. Moreover, technology transfer is still understood as taking place only from developed countries to developing countries (i.e. North–South), even though the definitions of "developed" and "developing" countries in the WTO system are extremely vague, if compared with those of the UNFCCC. The lack of a regulation of technology transfer from emerging and developing countries to other developing countries, combined with the limited relevance of IPR protection contradicts the supposed pertinence of the TRIPS Agreement in the emerging phenomenon of South–South technology transfer.

If the TRIPS Agreement has been proved not to be particularly relevant in enhancing the access to and the exchange of clean energy technology for developing countries, liberalizing trade in environmental goods and services (EGS), which is on the agenda of the WTO's Doha Round, could have a crucial impact on it. Trade in goods and services is also an important channel for learning and capacity building, and lowering barriers to environmental goods and services would allow global market access to more efficient and less expensive goods and services and consequently to the technologies embedded in them[60]. Only the elimination of tariff and non-tariff barriers could lead to an increase in the volume of clean technologies exchanged, from 7% if tariffs were removed to 14% following removal of both tariffs and non-tariff

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[57] Moon S., Does *TRIPS Art. 66.2 Encourage Technology Transfer to LDCs? An Analysis of Country Submissions to the TRIPS Council (1999-2007),* ICTSD policy brief Number 2. December 2008.

[58] Abbott F., "The Future of IPRs in the Multilateral Trading System" in Bellmann C. Dutfield G. & Melendez-Otiz R., *Trading in Knowledge: development perspective in TRIPS, Trade and Sustainability*, London: Earthscan, 2003, p. 36–44.

[59] Correa, C., "Can TRIPS Agreement Foster Technology Transfer to Developing Countries?" In K. Maskus, Reichman, J.H. eds, *International Public Goods and Transfer of Technology Under A Globalized Intellectual Property Regime*. Cambridge: Cambridge University Press, 2005.

[60] Mytelka, L.*Technology Transfer Issues in Environmental Goods and Services. An illustrative Analysis of Sectors Relevant to Air-pollution and renewable Energy*, ICTSD Trade and Environment Series Issue Paper 6, International Centre for Trade and Sustainable Development, Geneva. (2007), Available at http://ictsd.net/downloads/2008/04/2007-04-lmytelka.pdf

barriers, with particularly evident results in the fields of clean coal, wind power, solar energy, and energy-efficient lighting[61].

The mandate of negotiations is set in paragraph 31(iii) of the Doha Declaration, stipulating "*the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services*". However, the negotiations on environmental goods and services are experiencing great problems. Finding an appropriate balance of interests between developed and developing countries on what "*environmental goods*" are, which would determine which goods to liberalize trade in[62] and how this should be done seems at the moment an insurmountable difficulty. These key areas of disagreement are important due to the perceptible effects that definitions and roles can have on the sustainable developments arising from trade liberalization, specifically for developing countries. Of particular interest with regard to technology transfer are the issues surrounding the liberalization of environmental goods and services according to the "list" approach and the "project" approach. Developed countries support a list approach while developing countries, such as India, prefer a project approach[63],

hypothesizing liberalization only for the duration of environmental projects involving liberalized imports of goods and services on a most-favored nation (MFN) basis[64], as well as the integrated approach proposed by Argentina[65]. An interesting negotiating suggestion has been promoted by Cottier and Baracol-Pinhao, the Environmental Area Initiative, which is based on the previous definition of detailed targets in specific environmental activities in a particular sector[66]. Focusing on the specific environmental area, it defines all the pertinent issues relating to a particular field in a rational manner, and aims to bring about a package of measures and commitments not only in environmental goods and services, but also in the field of IPRs. For this reason, this proposal emphasizes the importance of the transfer of technology,

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[61] World Bank, *International Trade and Climate Change: Economic, Legal and Institutional Perspective*, New York, 2007.

[62] The key issues concerning what to liberalize consist in: (i) dealing with single versus dual-use goods; (ii) the relative environment-friendliness of goods; (iii) dealing with the constantly evolving technology; (iv) assessing implications for domestic industries, especially in developing countries; (v) dealing with non-tariff barriers; (vi) enhancing opportunities for developing country exports; and (vii) dealing with agricultural environmental issues.

[63] TN/TE/W/51,TN/TE/54,TN/TE/60 and TN/TE/W/67.

[64] Mukherjee C., "India's New Approach on the Trade of Environmental Goods and Services" in *Journal of Environmental Economics,* Vol. 4, No. 1, pp. 81–86, 2008.

[65] TN/TE/W/62.

[66] UNCTAD, *WTO Negotiations on Environmental Goods and Services: A Potential Contribution to the Millennium Development Goals*, UN Publication, 2009.

addressing a broad range of barriers to innovation flows[67]. Unfortunately, negotiations on environmental goods and services are complex and highly controversial and do not give too much space to optimistic expectations. The basic problem remains in the geographical structure of the industries concerned. Most of the industrialized countries still maintain a comparative advantage in the development of advanced environmentally sound technologies, while developing countries continue to have fewer incentives to embrace freer trade in climate-friendly goods.

The TRIMs Agreement, because of the strong link between international technology transfer and FDI, represents another possible approach within the WTO legal system to the diffusion of innovation for addressing climate change driven by private investors. The relationship between international environmental law and international trade and investment law in the specific context of technology transfer is, however, an area with a high potential for conflict due to the big differences in the aims and scope of the two areas of law.

The TRIMs Agreement applies to investment measure related to trade in goods and provides that WTO Members shall not apply any investment measure that is inconsistent with the principle of national treatment (Article III GATT) and with the prohibition of quantitative restriction (Article XI GATT). The Illustrative List annexed to the Agreement provides some examples of measures not in conformity with these principles and that are essentially constituted by local content requirements, and trade-balancing requirement or export restrictions[68]. The TRIMs Agreement does not include other types of performance requirements, like export requirements, product mandating requirements or joint-venture requirements. Technology transfer requirements are, in fact, excluded by the coverage of the TRIMs Agreement as a result of the Uruguay Round negotiations[69], even if this Agreement would be the ideal framework for regulation of the transfer of technology embedded in FDI. It is

[67] Cottier T. & Baracol-Pinhao D.,"Environmental Goods and Services - The Environmental Area Initiative Approach and Climate Change", in Cottier, Nartova and Bigdeli (eds), *World Trade Forum: International Trade Regulation and the Mitigation of Climate Change,* Cambridge University Press 2009.

[68] Appleton A.E. & Plummer M.J., *The World Trade Organization: legal, economic and political analysis*, Volume 1, New York, Springer, 2005, pag. 440.

[69] On this point, it is worth underlining that during the Uruguay Round, the US strongly supported the view of the technology transfer requirement as a particularly trade distorting measure. The technology transfer requirement would have helped to diffuse in the receiving country the knowledge necessary to reproduce products that would otherwise have been imported by the home country. Trebilcock M.J. & Howse R., *The regulation of international trade*, London: Routledge, 2005, pag. 456.

well proved, in fact, that the diffusion of technology is facilitated in an open trade regime, because firms have easy access to capital equipment[70] and capital equipment embodying foreign technologies and the host country can profit from the positive learning externalities related to inward FDI[71].

However, the most controversial aspect of the TRIMs provision consists in the regulation of local content programmes, which are useful instruments to facilitate the development and the diffusion of new technologies, particularly in the automobile sector[72]. In the field of climate change mitigation, it should be noted that the Chinese wind turbine industry has grown essentially thanks to local content requirements. As fixed by the Chinese National Development Reform Commission, requirements originally mandated 50% of local contents and increased this to 70% in 2004[73]; in this way foreign firms interested in selling wind turbines in China were obliged to contribute to the development of the industry for manufacturing wind turbines in order to meet these requirements. Although they may be a way to transmit technological innovation, local content requirements necessarily imply discrimination between imported and domestic goods, and for this reason are inconsistent with the principle of national treatment included in the TRIMs Agreement, as specified in the Annex.

Moreover, not only does the TRIMs deliberately avoid addressing the issue of international technology transfer through FDI and local requirements, but it also generates conflicts with the existing regulation of investment projects within the Kyoto Protocol. Some commentators have already pointed out the existence of incongruence between the CDM and the TRIMs Agreement, mainly because some of the conditions required for participation in the CDM projects could be interpreted as discriminatory requirements[74]. Moreover, the

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[70] For capital equipment, we refer to any equipment used by an organization to produce other commodities, including machinery, tools, vehicles, etc.. see Bronwyn H.H. "Innovation and Diffusion" in Von Fagerberg J., Mowery D.C. and Nelson R.R., *The Oxford handbook of innovation*, Oxford, Oxford University Press, 2005, pp. 473-479.

[71] Saggi, K., *Trade, foreign direct investment, and international technology transfer: A survey*. World Bank Research Observer, vol. 17, 2002, pag. 191–235.

[72] The development of technology in the automobile industry in South Africa has been essentially based on the application of a local requirement programme, as was the Indian drug policy, which started in 1978 and continued until 1994. UNCTAD *Transfer of Technology for Successful Integration into the Global Economy*, UNCTAD/ITE/IPC/2003/6, 2003.

[73] Lewis I.J., *A Review of the Potential International Trade Implication of Key Wind Power Industry Policy in China*, prepared for the Energy Foundation China Sustainable Energy Program, available at www.resource-solutions.org

[74] To benefit from the incentives of the CDM system the state should have ratified the Kyoto Protocol and it should have established a Designated National Authority in the host country. Both of the countries should also fully respect the obligations set out in the Kyoto Protocol. See Rechsteiner S., Pfister C. &

CDM projects should be conducted in a way that would assist the sustainable development of the developing country that hosts the investments, for example increasing the financial returns of local producers, providing a positive impact on the balance of payments of the host country or facilitating the transfer of technology. The adoption of local content requirements would be the perfect solution for the development purposes of the CDM but at the same time would constitute a prohibited performance requirement in the light of the TRIMs Agreement, and a serious negotiation on this point is becoming more and more urgent.

VII. CONCLUSION

The international transfer of climate-friendly technologies constitutes a key element in the strategy for mitigation of and adaptation to climate change. The brief analysis in this paper shows that an increasing number of developing countries are leading sources of climate-related technologies, diffusing them to other developing countries through trade and investment flows. In some technologies like biofuels and renewable energy South–South co-operation and joint development of technologies can even counterbalance the dominant position of firms from developed countries.

Unfortunately, no coherent or comprehensive international regulations for the new phenomenon of South–South technology transfer have yet been formulated and the UNFCCC CDM addresses essentially North–South movements of technologies. The different WTO Agreements offer only indirect and partial regulation of specific aspects of the movements of knowledge and technology between developing countries. Tackling the protectionist and anticompetitive trade policies that constitute obstacles to the diffusion of climate-related technologies could represent an interesting strategy for approaching this new paradigm. On the other hand, many negotiation proposals have been put forward to facilitate transfer and dissemination of technology, not only on the basis of the UNFCCC Bali Action Plan, but also in the context of the Doha Development Agenda. Their final success remains to be seen.

Martens F., "TRIMs and the Clean Development Mechanism (CDM) potential conflicts" in Cottier T., Nartova O. & S. Z. Bigdeli, *International Trade Regulation and the Mitigation of Climate Change - World Trade Forum,* Cambridge University Press, 2009.

What it is clear is that enhanced multilateral incentives are necessary to support the technological innovation in emerging and developing countries, and the development of mitigation and adaptation technologies cannot be left exclusively to market initiatives. A comprehensive solution to the regulation of technology transfer addressing climate change would be desirable, especially in the UNFCCC context. However, striking a balance between private interests and the interpretation of environmental technologies as global public goods is extremely difficult in a multilateral context, especially if the socio-economic needs of developing countries need to be taken into account. A comprehensive solution thus does not seem to be a realistic option in the short or medium term. The specific improvements in the negotiations of the different WTO Agreements, even if they do not offer comprehensive regulation, can constitute relevant progress in the regulation of technology transfer. A positive development of the negotiation of environmental goods and services, together with the appropriate reformulation of local content requirement schemes under the TRIMs Agreement, as discussed above, represent possible and feasible solutions with a relevant positive impact on the progressive evolution of the international regulation of the phenomenon.

The relevance of technology transfer, not only from an environmental perspective but also from a development one, underlines the need to develop the appropriate legal and financial mechanisms to support and encourage the diffusion of mitigation and adaptation technologies between developing countries. A range of barriers, in particular IPR, still exists but these challenges could be overcome with the right common actions. It is in the interests of the entire international community to adopt the appropriate instrument to regulate and facilitate the South–South exchange of climate-related technologies, and thereby to make a significant contribution to more effective protection of the environment.

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