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International Entrepreneurship and Technology Transfer: The CDM's Reality in China

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International Entrepreneurship and Technology Transfer: the CDM's Reality in China

Abstract:

The Clean Development Mechanism (CDM) is one of three flexible mechanisms emerging out of the Kyoto Protocol, which poses binding reduction targets for the emission of greenhouse gases (GHGs) by industrialised countries. The CDM allows governmental and business entities from these countries to invest in projects leading to the reduction of GHGs in the developing world. By doing so, they are expected to assist host countries in achieving sustainable development needs and contribute to the transfer of the so-called 'environmentally sound technologies'. This study aims to frame the CDM into a state-of-the-art of the literature streams on international entrepreneurship and technology transfer. We contend that the CDM is a public policy tool aimed at stimulating private sector investments in developing countries in the low-carbon sector, potentially contributing to the transfer of technologies across borders, with sustainable development benefits. Moreover, the CDM is posed as a potential mechanism for international technology transfer, and the CDM's reality in China is analyzed. For this purpose, a benchmarking scorecard is designed and applied to the Chinese experience with climate friendly technologies. On the basis of an empirical analysis, CDM projects are evaluated and the findings contrasted against a set of case studies outside the CDM framework. The analysis undertaken revealed that there is limited scope for the international transfer of technologies into China through the CDM, and that such transfers are more likely to occur outside the CDM framework. We concluded that this is due, to a large extent, on the Chinese internal regulations for CDM project development which, compounded by the minimum-local content requirements for domestic installations utilizing environmentally sound technologies, considerably hamper inward Foreign Direct Investment by entrepreneurs engaged in the low-carbon sector and, consequently, the transfer of foreign technologies into China.

Key words: Benchmarking; Clean Development Mechanism; International Entrepreneurship; Technology Transfer.

Empreendedorismo e Transferência de Tecnologia Internacional: Avaliação do Mecanismo de Desenvolvimento Limpo na China

Resumo:

O Mecanismo de Desenvolvimento Limpo (MDL) é um dos três mecanismos flexíveis propostos no âmbito do Protocolo de Kyoto, que estabelece metas de redução nas emissões de gases com efeito de estufa por parte de um conjunto de países industrializados. O MDL permite que entidades governamentais e empresas destes países possam investir em projectos localizados em países em vias de desenvolvimento que conduzam à redução de gases com efeito de estufa. À luz deste mecanismo espera-se que os países receptores de projectos de MDL possam alcançar objectivos de desenvolvimento sustentável e beneficiar com a transferência das chamadas ‘tecnologias limpas’. O presente estudo propõe enquadrar o MDL no âmbito das mais recentes tendências da literatura em empreendedorismo internacional e transferência de tecnologia. É argumentado que o MDL consiste num instrumento de política pública com o objectivo de encorajar empresas do sector privado a investir em projectos em países em vias de desenvolvimento envolvendo tecnologias limpas, potencialmente contribuindo para a transferência deste tipo de tecnologias além fronteiras. Mais ainda, o MDL é proposto como um mecanismo de transferência de tecnologia internacional, e a realidade chinesa relativa ao desenvolvimento de projectos de MDL é analisada. Para este fim, é proposta uma abordagem de *benchmarking* que é subsequentemente aplicada à experiência chinesa no sector das tecnologias limpas. Tendo como base uma análise empírica, projectos de MDL são avaliados e os resultados obtidos são confrontados com um conjunto de casos de estudo fora do âmbito do MDL. A análise revelou que os projectos de MDL apresentam uma contribuição limitada para a transferência de tecnologias para a China. Concluiu-se que tal se deve, em larga medida, ao ambiente de regulação chinesa para o desenvolvimento de projectos de MDL que, conjuntamente com a existência de requisitos mínimos para a utilização de componentes produzidos localmente, dificultam substancialmente o surgimento de Investimento Directo Estrangeiro no sector das tecnologias limpas neste país e, como consequência, a transferência internacional deste tipo de tecnologias.

Palavras-chave: *Benchmarking*; Mecanismo de Desenvolvimento Limpo; Empreendedorismo Internacional; Transferência de Tecnologia.

国际促进和技术转移：中国的CDM 现状

摘要：

清洁发展机制（CDM）是《京都议定书》中引入的三个灵活履约机制之一，它规定了工业化国家应履行的温室气体减排量。CDM允许这些国家的政府和企业实体在发展中国家投资减少温室气体的项目。通过这种方式，期望协助东道国达到可持续发展的需求以及对所谓“合乎环境要求工艺”的转移作出贡献。本文旨在将CDM纳入文献研究领域的最新水平----

国际促进和技术转移。我们声称CDM作为一项公共的政策性工具，它旨在鼓励私营部门在发展中国家投资低碳领域，对潜在的跨境技术转移作出贡献，并有益于可持续发展。此外，CDM被认为是一项国际技术转移的潜在机制，本文分析了中国的CDM现状。为此，我们设计了基准积分卡，并应用在与中国气候友好技术的实践中。基于实证分析，被评估的CDM项目和评估结果与CDM框架外的一系列案例有明显差异。该分析显示通过CDM转移到中国的技术是有限的，而且这些转移更倾向于发生在CDM框架之外。我们推断这在很大程度上是中国对CDM项目开发的规定造成的，这些规定结合了对地方利用合乎环境要求技术的最低要求，这样就相当妨碍参与到低碳领域企业家的国外直接投资，结果就妨碍了国外技术引入中国。

关键词:基准；清洁发展机制；国际促进；技术转移。

General Index

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Abbreviations Used

AAU	Assigned Amount Unit
CDM	Clean Development Mechanism
CDM EB	CDM Executive Board
CER	Certified Emissions Reduction
CIF	Climate Investment Fund
COP	Conference of the Parties
CRADA	Cooperative Research and Development Agreement
CSR	Corporate Social Responsibility
DNA	Designated National Authority
DOE	Designated Operational Entity
ECA	Export Credit Agency
EGTT	Expert Group on Technology Transfer
ERPA	Emissions Reduction Purchase Agreement
EST	Environmentally Sound Technology
ETS	Emissions Trading Scheme
EU	European Union
FDI	Foreign Direct Investment
GBEP	Global Bio-Energy Partnership
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GWh	GigaWatthour
HFCs	Hydrofluorocarbons
HSBC	Hong Kong and Shanghai Banking Corporation
IE	International Entrepreneurship
IEA	International Energy Agency
INV	International New Venture
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
IRENA	International Renewable Energy Agency
ITT	International Technology Transfer
JI	Joint Implementation

JV	Joint Venture
KPI	Key Performance Indicator
kW	kiloWatt
kWh	kiloWatthour
LDCF	Least Developed Country Fund
MNC	Multinational Company
NEET	Networks of Expertise in Energy Technology
NGO	Non-Governmental Organization
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PDD	Project Design Document
R&D	Research and Development
SCCF	Special Climate Change Fund
SME	Small and Medium Enterprise
TNA	Technology Needs Assessment
TRIPs	Trade Related Aspects of Intellectual Property Rights
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
W	Watt
WIPO	World Intellectual Property Organization
WMO	World Meteorological Organization
WTO	World Trade Organization

Introduction

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), scientific evidence of human induced climate change is now unequivocal. International collective efforts to address this challenge – the greatest challenge the humanity has ever faced, according to Nicholas Stern (2007) – have intensified during the past two decades, and culminated with the entrance into force of the only treaty binding industrialized countries to the reduction of greenhouse gas (GHG) emissions: the Kyoto Protocol.

Along with the ’Emissions Trading’ and the ‘Joint Implementation’ mechanisms, the Clean Development Mechanism (CDM) is one of the three flexible arrangements established under the Kyoto Protocol. This mechanism allows industrialized nations with GHG abatement targets to invest in projects that lead to the reduction of emissions in developing countries (Olsen, 2005). While enabling developed nations to achieve lower compliance costs on their GHG reduction commitments, CDM projects are expected to contribute to the mitigation of climate change effects and sustainable development needs in the host countries (Castro and Michaelowa, 2008).

The CDM is the core topic of analysis in this dissertation, and we propose to examine it against the backdrop of two literature streams: international entrepreneurship and international technology transfer.

Entrepreneurship is one of the driving forces of endogenous growth in modern economies (Acs and Szerb, 2006). As a primary source of job creation, economic competitiveness and innovation, many governments worldwide are aware of its importance and have been shaping national policies to encourage entrepreneurial initiatives (Monitor Group, 2009; Leitão and Baptista, 2009a; Leitão and Baptista, 2009b). With the increasing globalization of markets, the scope for opportunity exploitation has expanded across national borders, and the study of international entrepreneurship has emerged as an independent research stream during the last two decades.

Technological solutions are essential to address the challenges posed by climate change (de Coninck *et al.*, 2008). Indeed, it is now widely recognized that one of the fundamental ways upon which GHG emissions can be avoided is through the development and utilization of the so-called ‘environmentally sound technologies’ (ESTs). Because many of these technologies already exist in developed countries (Pascala and Socolow, 2004) and also due to the fact that most technological innovations occur in these countries (Popp, 2008), the tackling of climate change will only be possible if technology transfers between developed and developing countries take place.

Technology transfer has been a central and, sometimes, contentious issue during climate change negotiations (Ockwell *et al.*, 2008). Notwithstanding national and international policy makers’ efforts in achieving low carbon technology transfers, they can not be imposed in developing countries only by public policy action and, under certain circumstances, they have to emerge out of entrepreneurial action.

Given the key role of international entrepreneurship and technology transfer in the global fight against climate change, the goal of part one of this work is to analyze the CDM in light of the main theoretical constructs of the two previously referred research streams. For this purpose the reference literature is reviewed, and the CDM is posed as an international technology transfer mechanism.

In the international context, although the CDM does not have an explicit technology transfer mandate, it may contribute to technology transfer by financing emission reduction projects that use technologies and know-how that are not available in recipient countries. Several authors, such as Schneider *et al.* (2008), consider the CDM as the strongest mechanism to the transfer of technologies that mitigate climate change. However, a caveat was identified in the reference literature in the sense that, until now, few studies have analyzed alternative mechanisms for the transfer of this type of technologies other than the CDM.

In order to address the referred caveat, the central research question of this dissertation is to assess how the CDM fares as an international transfer mechanism for environmentally sound technologies. For this purpose, a benchmarking framework to compare the CDM against other technology transfer mechanisms is proposed. In complement to this, and due to the fact that these mechanisms are difficult to directly benchmark, an empirical study is developed, by using a set of case studies selected from the Chinese experience with climate change mitigation efforts, whose information was collected from several sources, namely the Project Search database available from the official CDM website; the Global Environmental Facility database; the World Bank database; the Energy Technology Data Exchange World Energy Base; the RenewableEnergyWorld.com initiative; and EnergyCentral.com. In total, we analyze eight case studies: four CDM projects and four non-CDM cases.

The focus on the Chinese reality is justified by four main reasons. First, China is currently the world's largest emitter of GHGs (IEA, 2007), making it imperative the deployment of low-carbon technologies. Second, Chinese policy makers are increasingly aware of the unsustainable path the country is taking, and have been directing their efforts in order to address this shortcoming. Third, China is one of the countries with the highest number of CDM projects implemented so far, enabling a more comprehensive study of this phenomenon in comparison to other CDM host countries. Fourth, since the end of 2008 until present that the author of the study has been involved in international business development activities focused in setting-up CDM projects in China on behalf of a Norwegian technology based company, with the implication that the study of the CDM phenomenon in China is also aligned with the author's professional research interests.

This dissertation has two parts – the first consists on a literature review and the second is an empirical study based on a benchmarking analysis. It is structured as follows: after this introduction, in Chapter 1 we provide a review on the main streams of research on international entrepreneurship, including an overview of the main types of venture and relevant foreign entry modes. In Chapter 2, a similar analysis is elaborated, although the focus is on international technology transfer issues. A significant emphasis is placed on the identification and characterization of technology transfer mechanisms, as this aspect is of key importance for the remainder of the study. Chapter 3 has the CDM as a focal point and, in addition to the characterization of this ‘Kyoto-mechanism’, a background on the most relevant issues regarding the challenges of climate change is presented. Moreover, an overview of the main mechanisms for the transfer of environmentally sound technologies is also provided.

The empirical study initiates with Chapter 4, where we propose a benchmarking methodology to analyze technology transfer mechanisms for environmentally sound technologies. Chapter 5 provides an illustration of how this benchmarking approach can be applied in practice, as this framework is used to assess the CDM reality in China. As previously noted, this analysis also incorporates other cases outside the CDM framework. The conclusions and implications of this investigation are provided in Chapter 6. Furthermore, limitations of the current study and guidelines for future research are also presented.

Part I – Literature Review

Chapter 1 – International Entrepreneurship

1.1 Introduction

The goal of this chapter is to make a review of some relevant issues on the research field of international entrepreneurship (IE). The study of IE is a relatively recent phenomenon (Young *et al.*, 2003; Mtigwe, 2006) and has its roots in two different research traditions: international business and entrepreneurship (Nummela and Welch, 2006). Scholars familiar with both areas are few and far between (Oviatt and McDougall, 2005), and the convergence of these areas into a holistic field of study has been acknowledged as particularly challenging, with most scholars tending to favour either one of the two sides (Coviello and Jones, 2004).

The identification and exploitation of business opportunities lies at the core of entrepreneurship. While, for many years, opportunities available to entrepreneurs were confined to domestic borders, the globalization of markets has expanded the scope of opportunity exploitation to the global arena. This has enabled many companies to adopt a global focus from inception and pursue a rapid internationalization path (Oviatt and McDougall, 1994). Due to this, the study of IE has raised considerable interest among academics and practitioners in recent years.

In the context of this work, the study of IE should be understood in the backdrop of international efforts to curb climate change. As we will see in Chapter 3, the engagement of the private sector is fundamental to climate change mitigation, and will create innumerous business opportunities to individuals and companies directly or indirectly involved in the ‘decarbonization’ of our economies. According to Stern (2007), these markets could be worth hundreds of billions of dollars per year, and be an important source of employment generation.

With this background in mind, in the next section of this chapter some of the basic concepts underpinning the field of IE, such as the definitions of entrepreneurship and IE, are reviewed in order to stress the importance of entrepreneurship in stimulating economic growth. Furthermore, an assessment of the main types of venture studied by IE researchers, namely international new ventures (INVs) and born-globals, is performed. In the third section, it is provided an overview of the most important theoretical constructs that help explain the emergence of companies which are internationally entrepreneurial in their behaviour, as well as their entry mode into foreign markets. In the fourth section different market entry modes available for firms to internationalize are examined, such as exporting, foreign direct investment and alliances. To finalize, conclusions and implications are provided.

1.2 Definitions

The concept of IE has first appeared in 1988 in an article authored by J. F. Morrow, but it was a study by McDougall (1989) that paved the way for academic studies in IE (Oviatt and McDougall, 2005).

The development of IE as a field of study is likely to be bound with challenges and difficulties, as it demands the integration of the perspectives of two richly multidisciplinary schools of thought: entrepreneurship and international business (Dimitratos and Jones, 2005).

The study of entrepreneurship dates back to the eighteenth century (Kuratko and Audretsch, 2009). Among the most significant historical contributions were those of authors such as Cantillon, Mill, Knight, Schumpeter and Kirzner, who advanced the understanding of the role of entrepreneurs in the economy (Sobel, 2003). Schumpeter's legacy continues to be important to modern entrepreneurship theories, most in particular his theory of 'creative destruction', which contends that new firms with entrepreneurial spirit displace rivals who fail to innovate (Schumpeter, 1934; 1942).

According to several authors (e.g. Wennekers *et al.*, 2005; Stearns and Hills, 1996), no singular definition of 'entrepreneurship' exists. Grilo and Thurik (2004) contend that entrepreneurship is a multidimensional concept, whose definition largely depends on the focus of the research undertaken. Concurrent with this view, the OECD (2008) considers that entrepreneurship manifests itself in many different ways, with the result that several definitions have been proposed and no single definition has been generally agreed upon.

Historically, the concept of entrepreneurship has, at least, two meanings (Acs, 2007). The first, the 'occupational notion', views entrepreneurship as the ownership and management of a business. Within this approach, a distinction can be made between a 'dynamic' and a 'static' perspective (Wennekers *et al.*, 2005). While the 'dynamic' perspective focuses on the creation of new businesses, the 'static' perspective relates to the number of business owners or ownership rate.

The second notion of entrepreneurship, the 'behavioural notion', refers to entrepreneurship in the sense of seizing an economic opportunity, pertaining therefore to the existence of an entrepreneurial behaviour. Under this approach, entrepreneurs do not necessarily need to be business owners. It should be noted that, at the crossroads of the behavioural and dynamic perspectives, a new focus has arisen that considers new venture creation as the main trait of entrepreneurship (Acs, 2007). We will return to this point forward in this section, when examining the type of ventures studied within international entrepreneurship studies.

Regardless of the approach adopted, there is some consensus that entrepreneurship revolves around the process of change (Audretsch, 2002) and innovation (Michael, 2007).

Audretsch (2002) asserts that entrepreneurship is about change, since entrepreneurs are agents of change. Nevertheless, such conceptualization poses considerable complexity. More specifically, the concept of change is relative to some benchmark, that is, what may be perceived as change to an individual or organization may not imply any novelty to the related industry. As such, the concept of entrepreneurship is embedded in the local context.

While ‘invention’ can be defined as the creation of something new, ‘innovation’ refers to an invention which is brought into use (Bozeman and Link, 1983). Taking into consideration this notion, authors such as Michael (2007), and Dimitratos and Plakoyiannaki (2003), contend that innovation is at the heart of entrepreneurship. The entrepreneur is then seen as an agent of change, bringing innovation to the customer when innovation takes place.

According to Birkinshaw (1997), there is broad recognition that the generation of new business activities, does not necessarily constitute, by itself, an entrepreneurial act. A R&D group, for example, has a clear mandate to innovate, but the behaviour expected of its employees falls within the established guidelines and norms. In this line of reasoning, entrepreneurship suggests something more: willingness to assume risks and proactiveness; use of resources beyond the individual’s direct control; or a clear departure from current practices.

Lumpkin and Dess (2001) suggest that there are five dimensions to an entrepreneurial behaviour, which are: autonomy; innovativeness; risk taking; competitive aggressiveness; and proactiveness. Autonomy is defined as an independent action taken by the individual or team, with the goal of taking forward a business idea or vision. Innovativeness refers to a firm’s tendency for supporting new ideas, novelty and creativity that may result in the introduction of new products/services or technological processes. Risk taking means a tendency to take bold actions such as venturing into unknown new markets. Competitive aggressiveness reflects the intensity of a firm’s efforts to outperform industry rivals. And proactiveness consists in a response to opportunities, acting in anticipation of future demand in order to create change and shape the environment.

It should be noted at this stage that the efforts to curb climate change create opportunities of a special kind to entrepreneurs. These opportunities are ‘special’ because they result from a market failure – climate change – which, according to Stern (2007), is the greatest market failure the world has ever faced. In common with many other environmental problems, climate change is an externality at its most basic level, and requires public intervention in order to be corrected. As Dean and McMullen (2007), and Cohen and Winn (2007) observe, market failures that contribute to environmental degradation are important to entrepreneurs because they provide significant opportunities for the creation of new technologies and innovative business models.

In the context of the entrepreneurship field of study, the importance of policy instruments is not confined to the correction of market failures that may give rise to new business opportunities. Further than that, policy makers are increasingly recognizing entrepreneurship as a fundamental lever to build and sustain economic growth (Acs and Szerb, 2006). According to van Stel *et al.* (2005), there are several ways through which entrepreneurship may have an impact on economic growth. For example, entrepreneurs may introduce innovations by entering in markets with new products or production processes. Moreover, entrepreneurs may increase the productivity of a certain industry by increasing competition. As a corollary of this, Acs and Szerb (2006) contend that entrepreneurship makes a unique contribution to economic growth by leading to the commercialization of ideas that would otherwise remain non-commercialized. Therefore, it comes to no surprise the growing tendency among policy makers to promote entrepreneurship (Parker and Praag, 2006).

It is against this backdrop that the shift from the model of a ‘managed economy’ towards that of an ‘entrepreneurial economy’, as proposed by Audretsch and Thurik (2001), should be understood. The ‘managed economy’ can be defined as the political, social and economic response to an economy dictated by the forces of large-scale production, which reflects the predominance of the production factors of capital and (unskilled) labour as the sources of competitive advantage. By contrast, the model of the ‘entrepreneurial economy’ is the political, social and economic response to an economy dictated not just by the dominance of the knowledge production factor, but also by the presence of entrepreneurial activity to accommodate knowledge spillovers (van Stel *et al.*, 2005).

The importance of entrepreneurship in public policy is reflected, for example, in the EU Commission’s acknowledgment that the challenge for the EU is to identify the main factors that create an enabling environment for entrepreneurial initiatives in all sectors of the economy (EU Commission, 2003). In respect to a sector intrinsically related to the transition towards a low-carbon economy, Jacobsson *et al.* (2009) observe that such concerns should be taken into consideration in the EU’s renewable energy policy, which should be designed to secure attractive conditions for new entrants and entrepreneurs across the whole value chain of the energy industry and for a broad range of technological solutions.

Drawing on Acs and Szerb’s (2006) assertion that there is no such thing as ‘entrepreneurship policy’ *per se*, but only policy in an entrepreneurial economy, there are distinct areas where public policies may impact entrepreneurship, such as: (i) the fiscal policies; (ii) the education policies; and (iii) the science and technology policies. Acs and Szerb (2006) also alert for the fact that, as we live in a globalized economy, entrepreneurs will increasingly consider the global market as their competitive arena. As such, if policy makers want to promote entrepreneurship, they must think globally rather than locally or even nationally.

A literature review of the International Business field of study could be an endless task in itself (Chandra and Newburry, 1997). Notwithstanding these difficulties, some authors have endeavoured to review this field, such as Wright and Ricks (1994), Chandra and Newburry (1997) and Mtigwe (2006).

While for many years the study of international business considered the ‘nation’ as the main unit of analysis, the post second world war period shifted the analytical emphasis to the firm. The main focus since then has been on the activities of multinational companies (MNCs) (McDougall and Oviatt, 1996; Acs *et al.*, 2003), and a more significant attention to small and medium enterprises (SMEs) in this field of study has only been observed since the mid-1970s (Gilroy *et al.*, 2008).

Some authors assert that the reduction in international transportation and communication costs, and the shortening of product’s life cycle, are some of the motivations that enabled smaller firms to operate internationally (Hashai and Almor, 2004). Other authors contend that the increasing globalisation of markets has made international business as much a sphere of activity for multinational firms as for entrepreneurs, an aspect which encouraged companies to expand internationally and explore new revenue streams (Karra *et al.*, 2008; Zahra and Hayton, 2008).

Mtigwe (2006) considers IE as the practical expression of the motivations and *rationale* of international business theory. However he himself acknowledges that such assertion raises a number of questions, most in particular if there is any difference between the concepts of international business and IE.

While Mtigwe (2006)’s vision points out that IE is the corollary of international business studies, many authors consider that IE lies at the intersection path between the fields of entrepreneurship and international business (e.g. Dimitratos and Jones, 2005; Gabrielsson *et al.*, 2008).

One of the most consensual and quoted definitions of IE was proposed by McDougall and Oviatt (2003:7), who assert that «international entrepreneurship is the discovery, enactment, evaluation, and exploitation of opportunities – across national borders – to create future goods and services».

In a similar direction, Zahra and George (2005:6) consider IE as «the process of creatively discovering and exploiting opportunities that lie outside a firm’s domestic markets in the pursuit of competitive advantage».

Dimitratos and Plakoyiannaki (2003), develop a different perspective about IE, by making use of organizational theory. In this line of reasoning, they consider IE as an organization-wide process embedded in the culture of the firm and which seeks to generate value through the exploitation of opportunities in the international marketplace.

From the definitions above mentioned, we can conclude that the opportunity concept is incorporated in all of them, as well as the idea of crossing borders. This comes to no surprise, as the opportunity exploitation lies at the core of entrepreneurship research (Lumpkin and Dess, 1996), and international entrepreneurial firms should have the ability to identify and exploit opportunities in the international marketplace (Dimitratos and Plakoyiannaki, 2003). In short, irrespective of the definition that is adopted, it is widely agreed that IE broadly involves the recognition and exploitation of overseas opportunities (Spence *et al.*, 2008).

As we will show in Chapter 3, the fight against climate change is opening a wide range of opportunities to entrepreneurs, with policy makers worldwide seeking to create the adequate environmental settings to encourage the exploitation of these opportunities. The Clean Development Mechanism, one of the most innovative tools originating from the Kyoto Protocol, should be mentioned as having been specifically designed to stimulate entrepreneurs in industrialized countries to cross national borders and invest in greenhouse gas reduction projects in developing countries. By doing so, they are also contributing to the transfer of technologies to the developing world and contributing to sustainable development goals. We will come back to these issues in more detail in Chapter 3.

The act of internationalizing is inherently entrepreneurial and, as such, the theoretical framework of IE encompasses the actions undertaken by companies regardless of their size, age or industrial sector where they operate (Di Gregorio, 2005). However, IE's practitioners and researchers main focus has been on ventures that internationalise from or near inception (Karra *et al.*, 2008). This phenomenon has been researched under several terms (Thai and Chong, 2008), and in Table 1.1 we provide a brief overview of the main types of venture studied in the IE literature. In the same table, we indicate, for each type of venture, the authors who have coined and studied the concept, its definition, the theoretical framework(s) explaining its emergence and behaviour, the mode(s) of foreign entry, and the criteria suggested by the authors for distinguishing their venture from other venture typologies[1].

From the types of venture examined in Table 1.1 presented below, it is relevant to note that the concepts of born-global and international new venture are the most frequently used in the IE literature (McDougall and Oviatt, 2003). It should also be noted that, in addition to the similarities that exist between these two concepts, authors such as Gabrielsson and Kirpalani (2004), for example, define born-globals in line with Oviatt and McDougall's (1994) notion of international new venture. This is one of the reasons why several authors use the two concepts interchangeably (e.g. Rialp *et al.*, 2005; Thai and Chong, 2008). For the sake of convenience, we will do the same from this point forward.

[1] In sections 1.3 and 1.4 the underlying theories and modes of foreign entry that support our analysis are also reviewed.

Table 1.1 – Typology of new ventures studied in the framework of International Entrepreneurship

Type of Venture	Authors	Definition	Theoretical Constructs used	Mode of Foreign Entry	Criteria
Born-Global	Knight and Cavusgil (1996)	Small, technology-oriented companies that operate in international markets from the earliest days of their establishment.	- Knowledge-based view - Network theory	- Licensing - Alliances (e.g. JVs, use of agents, distributors) - Exporting	- Begin exporting one or several products within 2 years of establishment
International New Venture*	Oviatt and McDougall (1994)	A business organization that, from inception, seeks to derive significant competitive advantage from the use of resources and the sale of outputs in multiple countries.	- Transaction cost theory - Resource-based view - Network theory - Knowledge-based view	- Exporting - FDI - Alliances	- Firms that are global from inception or inter-nationalize within 2 years of establishment - Begin with a proactive international strategy
Born-Again Global	Bell *et al.* (2001)	Well-established firms that have previously focused on their domestic markets, but which suddenly embrace rapid and dedicated internationalisation.	- Network theory - Resource-based view - Knowledge-based view - internationalization process model	- FDI - Acquisition - Franchising - Exporting	- Predominantly, 'traditional' firms, whose internationalization process was prompted by a 'critical incident'
International Start-up	Johnson (2004)	A new venture that exhibits an innate propensity to engage in a meaningful level of international business activity at or near inception, with the intent of achieving strategic competitive advantage	- Knowledge-based view - Network theory	- Exporting	- Firms internationalize within five years of founding, and - International sales represent a minimum of 20% of the total revenue
International Venture	Kuemmerle (2002)	Companies that, from their inception, engage in either home-base-augmenting (HBA) or home-base-	- Knowledge-based view - Network theory	- HBA** activities and/or - HBE*** activities	- The ventures are built from one rather than several home bases - Rapid growth of the venture

		exploiting (HBE) activities or both, thus viewing their operating domain as international from the initial stages of the firm's operation.			
Micro-multinational	Dimitratos *et al.* (2003)	A small- and medium-sized firm that controls and manages value-added activities through constellation and investment modes in more than one country.	- Network theory - Resource-based view - Knowledge-based view	- 'Constellation and investment' modes, such as licensing, franchising, JV or strategic alliances	- In comparison to large multinationals, micro-multinationals possess a lower level of resources; have a lower degree of value-added activities abroad; and tend to engage in higher degrees of networking.

Source: Own elaboration.

* Note: these authors distinguish 4 types of international new ventures: (i) import-export start-up; (ii) multinational trader; (iii) geographically-focused start-up; and (iv) global start-up.

** By Home-base-augmenting (HBA), we mean that the firm seeks to benefit from a specific local environment by absorbing knowledge available from that environment. More specifically, HBA activities consist essentially of those that provide insights about new products, markets, and business models.

*** By Home-base-exploiting (HBE), we mean that the firm seeks to benefit from its existing knowledge and product base, and hence it invests abroad in order to exploit its knowledge in a better way. More specifically, HBE activities consist primarily of manufacturing and marketing operations abroad, including sales offices, market-specific product development, and facilities that provide engineering support for contract manufacturers.

1.3 Theoretical Frameworks

The identification of literature streams that explain the emergence of companies that can be considered internationally entrepreneurial in their behaviour has been extensively performed by IE scholars and practitioners. Examples include Coviello and Jones (2004), Rialp *et al.* (2005), Acs and Terjesen (2005), Canabal and White (2008), and Andersson (2000). In this section we focus in the most relevant theoretical frameworks utilized by IE researchers: Theory of the firm; Transaction cost theory; Theory of the growth of the firm; Resource-based view; Network perspective; Knowledge-based view; and the Internationalization process model.

According to Foss (1997), the theory of the firm corresponds to a theoretical framework that addresses several aspects, such as: (i) the existence of the firm (that is, why do firms emerge, and why do they exist as distinct mechanisms for resource allocation in a market economy); (ii) the boundaries of the firm (that is, which principles explain why certain transactions are performed in-house while others are performed by means of market relations); and (iii) the internal organization (that is, why do we observe different types of organizational structure within organizations).

The main tasks of the theory of the firm, as outlined above, were formulated in the seminal work of Ronald Coase (1937). With his contribution, Coase also set the ground for the transaction cost theory, which was one of the first attempts to theoretically define the firm in relation to the market. Coase argued that market exchanges entail certain costs, such as the determination of relevant prices or the negotiation and enforcement of contracts. These transaction costs may be reduced by coordinating these activities within the firm. However, internal organization brings other kinds of costs, derived from information asymmetry, incentives, and performance evaluation. The boundaries of the firm are, therefore, determined by the trade-off, at the margin, between the relative transaction costs of external and internal exchange (Foss and Klein, 2004).

In short, the basic premise underlying the transaction cost theory is that business activities conducted on behalf of the firm by external parties – the market – are costly and inefficient, and hence the firm benefits by internalizing as many activities as possible (Mtigwe, 2006). In addition, it is accepted a dichotomy between market and hierarchy as two main alternatives for exchange (Chen and Chen, 2003).

Notwithstanding the ground-breaking work by Coase, it was only in the mid-1970s that the ‘application’ of transaction cost notions began to blossom (Foss, 2005). One of the most notable authors has been Oliver Williamson, whose main contributions (namely Williamson, 1975 and 1985) helped advancing transaction cost economic theories.

According to Williamson (1975), transaction/exchange costs have three attributes: (i) asset specificity; (ii) uncertainty (that is, there is a certain level of uncertainty in a market transaction due to the tendency for opportunistic behaviour); and (iii) frequency of interaction (the higher the frequency, the higher the interaction between the parties involved, which results in higher policing costs).

The greater the asset specificity, the higher the frequency, or alternatively, the greater the uncertainty, the greater the transaction cost, and therefore the greater the incentive for the firm to internalize that transaction. Although the three dimensions should be taken into account, Williamson (1985) places a higher importance to the asset specificity attribute, because – unlike frequency and uncertainty, attributes that can always be handled by contractual means – it is the factor that gives rise to contractual hazards (Foss, 2005).

It is necessary to note that, underpinning Williamson's (1975; 1985) theory, there are two assumptions associated with the three transaction attributes mentioned above: bounded rationality and opportunism. 'Bounded rationality' pertains to the fact that people have limited memories and limited cognitive processing power. As we can not assimilate all the information at our disposal, we can not accurately sort out the consequences of the information we have. 'Opportunism' refers to the possibility that people will act in a self-interested way. That is, people may not be entirely honest about their intentions, and might take advantage of the possibility to exploit another party.

Transaction cost economics is perhaps most often applied to understanding vertical integration, but it has frequently been applied to internalisation/externalisation questions. For example, this theory is a fundamental construct to Oviatt and McDougall's (1994) conceptualization of the INV type of firm.

The logic of transaction cost economics can be extended to entrepreneurship issues, as Michael (2007) has shown in his article. According to this study, the entrepreneurial transaction differs in fundamental ways from transactions between existing organizations. Most in particular, when the transaction is 'novel' (that is, when it is new to the potential customer), the uncertainty associated with the transaction will be higher. The author concludes that there are three crucial transaction costs related to the entrepreneurship transaction: (i) quality measurement (that is, the inability to credibly measure and ensure quality may cause the customer to make in-house rather than to buy); (ii) identity risk (that is, the risk that the entrepreneur will not be able to fulfil the transaction); and (iii) transaction specific assets (that is, if the transaction fails, then the customer's transaction-specific investments will be lost).

Adopting a different stance, Edith Penrose's work has been a key contribution to the theory of the firm, mainly as a precursor of the resource-based view and knowledge-based theories of the firm. In 1959, Penrose's book 'The Theory of the Growth of the Firm' described the firm as a collection of productive resources, under administrative and authoritative coordination, producing products for sale in the market for a profit (Penrose, 1959). Penrose suggested that the performance of these productive operations gave rise to the creation of knowledge within the firm. Most in particular, this originated 'excess resources', as an increase in productivity could lead to less time being required to perform a certain set of activities. According to Penrose (1959), these excess resources could be put into profitable use at zero marginal cost, which represented a strong incentive for the firm's expansion and innovation. Another noteworthy contribution from Penrose's work is the so-called 'Penrose effect', which asserts that there is a limit to the firm's growth rate due to the existence of managerial resources inherited from the past.

The resource-based view holds that firms can leverage their resources by building distinctive capabilities that allow them to gain competitive advantages (Zahra *et al.*, 2003). According to Rugman and Verbeke (2002), in the post-1980 academic work the resource-based approach shares the following four characteristics: (i) the firm's ultimate objective is to achieve sustained, above-normal returns, as compared to rivals; (ii) a set of resources, not equally available to all firms, and their combination into capabilities and competencies, are a precondition for sustained superior returns; (iii) in order to lead to sustained superior returns, resources must be valuable to customers, rare, difficult to imitate and non-substitutable[2]; and (iv) the fact that innovations, especially in terms of new resource combinations, can significantly contribute to sustainable superior returns.

A substantial body of research in international entrepreneurship has used the resource-based view of the firm to explain the INV/born-global phenomenon. This is most evident in Oviatt and McDougall's (1994) definition of INV as a business organization that seeks to gain competitive advantage from the use of resources and the sale of outputs in several countries. Other examples include Zahra *et al.* (2003), who examine the importance of leveraging tangible and intangible technological resources for the internationalization of high-tech new ventures, and Di Gregorio *et al.* (2008), who propose a classification of INVs based on two dimensions: resources and markets.

The networks approach considers markets as systems of social and business relationships, which are established between, for example, customers, suppliers and/or competitors (Coviello and Munro, 1997). At its most abstract, a network can be seen as a structure where a number of nodes are related to each other by specific threads. A market can then be imagined as a network where nodes are business units, and the relationships between them are the linkage threads (Hakansson and Ford, 2002). Networks are often viewed as embedded in different social, technological and market structures, which makes them context specific (Halinen and Törnroos, 2005).

Almost by definition, small entrepreneurial firms lack the resources of larger established firms. The networks approach suggests that entrepreneurs can gain access to valuable resources not under

[2] In respect to these four characteristics of resources – valuable, rare, imperfectly imitable, and difficult to substitute – it should be mentioned the seminal article written by Barney (1991), where the author proposed the previously referred characteristics and also analyzed the conditions under which firm resources may be a sustainable source of competitive advantage of the firm.

their control in a cost effective way by means of networking activities (Zhao and Aram, 1995; Gabrielsson and Kirpalani, 2004). Networks are a source of knowledge, and allow firms to leapfrog several stages in their learning process (Mtigwe, 2006). In addition, networking can also be seen as a strategic process in which relationships and actions are undertaken to place the firm in a reinforced competitive position (Mainela and Puhakka, 2008), which can influence a firm's choice of foreign market and entry mode (Coviello and Munro, 1997).

Drawing heavily from Penrose's theory of the firm's growth, the knowledge-based view considers firms as «social communities that serve as efficient mechanisms for the creation and transformation of knowledge into economically rewarded products and services» (Kogut and Zander, 1993: 627). According to Grant (2002), the knowledge-based view of the firm is more about a set of ideas pertaining to the existence and nature of the firm that emphasizes the role of knowledge, than a *de facto* theory of the firm. Thus, competitive advantage is based on knowledge instead of raw materials, and firms create and sustain competitive advantage by protecting valuable knowledge, either by preventing its migration or by eliminating the possibility of imitation (Prashantham, 2005).

As stated before, the knowledge-based view has been a recurrent construct used to explain the phenomenon of firms which are international entrepreneurial in their behaviour[3]. For example, for Kummerle (2002) the management of knowledge flows across national borders is fundamental for the success of recently established companies, which operate under considerable resource constraints. Due to this, the author proposes a framework that can be used to develop a new definition of IE by distinguishing two types of knowledge flows across national borders: (i) knowledge flows that augment the venture's home base; and (ii) knowledge flows that exploit this home base. According to Sharma and Blomstermo (2003), models that emphasize the issues of knowledge and network ties are adequate to explain the internationalization process of born-globals.

To finalize, the internationalization process model (also known as the Uppsala-Model), posits that firms internationalize in a gradual and incremental manner, through a series of evolutionary stages (Johanson and Vahlne, 1977; Bell *et al*., 2003). According to this model, a firm starts to export to a certain target country and, after acquiring some experience, it targets countries which are increasingly 'psychically' distant from its domestic market. The entry in a foreign market is hence seen as a learning process (Ojala and Tyrväinen, 2006), and one fundamental underlying assumption is that the firms are well established in their domestic market before venturing into new markets abroad (Bell *et al*., 2003).

[3] For more information, please consult Table 1.1.

Many authors consider that these traditional theoretical frameworks fail to explain the internationalization process of born-globals and INVs. For example, Dimitratos and Plakoyiannaki (2003) contend that international risk-averse firms can be perceived as those that follow the process model/incremental model of expansion. As risk-prone firms that choose to go abroad from inception, born-globals' behaviour can not be explained in light of this theoretical framework. Moreover, as stressed by Wright and Dana (2003), the SMEs lack the resources for a gradual and stage progression. Thus, the referred theoretical framework might not be totally adjusted to explain the internationalization behaviour of this type of firms. Even further, the existence of possible jumps in the internationalization process – 'leapfrogging of stages' – that characterizes the rapid expansion of born-globals (Gilroy *et al.*, 2008) fails to be correctly addressed by this theoretical model.

Notwithstanding the abovementioned reservations in respect to this theoretical construct, some authors have applied it to the born-global phenomenon. One case in point is Hashai and Almor's (2004) study of knowledge-intensive born-globals in Israel, whose internationalization behaviour is explained in light of this evolutionary stage theory.

It should also be noted that, rather than individually, these theoretical frameworks have been used in combination to explain the international operations of young entrepreneurial firms, as can be attested in Table 1.1. This is in tandem with Rialp *et al.* (2005), who assert that the use of a single framework is a somewhat l approach, and a holistic and comprehensive understanding of the IE phenomenon is more likely to emerge with the combined use of multiple theoretical constructs.

1.4 Foreign Entry Modes

A company seeking to perform a business function outside its domestic market must choose the most adequate entry mode or institutional arrangement for the foreign market where it intends to build a presence. The entrant faces a wide range of choices, which greatly differ in terms of their advantages and drawbacks (Anderson and Gatignon, 1986). Companies need to select the most effective modes of entry, as they have different payback periods, which potentially influence the firm's performance (Zahra and Hayton, 2008). In addition to this, and as we will analyze in Chapter 2, entry modes can significantly influence the extent to which technologies are transferred across national borders.

There is no consensus in the literature in regard to the relationship between entry modes (Li and Quian, 2008). However, it seems to exist two main distinct views: (i) categorization of entry modes according to the control degree of the entrant (e.g. Anderson and Gatignon, 1986); and (ii) splitting of entry modes into two categories: equity or non-equity (e.g. Pan and Tse, 1996). The first perspective considers 'control' as the most relevant determinant of risk and return and, as such, arranges foreign entry modes in a continuum of increasing levels of control. The second perspective classifies modes of entry into two categories: contracts and equity.

According to Mitgwe (2006), the entry mode of export-only or single-stage is the most preferred modality of foreign market engagement among many international entrepreneurial firms. In the vision of Lu and Beamish (2001), to a large extent, this is due to the fact that these companies neither have the resources nor the financial capabilities needed to engage in foreign direct investment (FDI). Exporting enables SMEs to quickly access foreign markets, with little capital investment requirements, but with the opportunity of obtaining valuable international experience. Exporting can be direct, meaning without intermediaries, or indirect, which involves some sort of cooperation with an external partner.

Along with exporting, FDI is one of the most frequent modes of internationalization adopted by SMEs (Lu and Beamish, 2001). Acs and Terjesen (2005) define FDI as the location, outside of the home country, of a firm's activities such as the manufacture, assembly, distribution, sales or R&D. According to Lu and Beamish (2001), FDI holds two potential benefits when compared with the exporting option: (1) it minimizes transaction-related risks by internalizing functions within the firm; and (2) it enables the firm to leverage several location based-advantages such as, for example, a competitively priced labour force. Notwithstanding these potential benefits, FDI also holds some potential drawbacks. For instance, it requires a greater level of commitment in foreign markets than exporting, and it is much less flexible in coping with investment hazards in the host country, such as changing political conditions (Lu and Beamish, 2001).

New ventures tend to have fewer exports and invest less in outward FDI than large and established firms (Acs and Terjesen, 2005). This is due to a set of barriers or liabilities which, according to Lu and Beamish (2006), can be summarized as: (i) the liability of foreignness, due to the lack of local knowledge in foreign countries, which can lead to disadvantages in competing with local firms; (ii) the liability of newness, which pertains to difficulties in obtaining financing, staffing, securing relationships with suppliers and buyers and attracting local customers; and (iii) the liability of smallness, implying limited resources and capabilities.

Taking into consideration these liabilities, partnering with other firms by means of various forms of collaborative arrangements is becoming an imperative for SMEs which envisage to successfully internationalize (Wright and Dana, 2003). Indeed, inter-firm cooperation has become an essential component on the pursuit of global competitive advantage (Parkhe, 1993), and only very few firms can afford to develop all technologies they need on their own, or market their products globally, without the assistance of partners (Dussauge and Garrette, 1998).

It is against this backdrop that the intermediated mode of international expansion should be considered. The idea underlying this entry mode is that large MNCs serve as conduits for the international expansion of INVs (Acs and Terjesen, 2005). It stems on the existence of a symbiotic relationship between new ventures and large companies. This symbiotic relationship has its roots on two key elements: property rights and barriers to entry.

Property rights protect innovators' ability to reap benefits from their innovations. Within the context of a MNC, an innovator has limited personal property rights to protect his/her own invention, as it would actually be owned by the firm. Due to this, independent inventors working outside the constraints of large corporations are more prone to pursue radical innovations, making the new ventures that they might create as better vehicles for innovation than MNCs (Acs and Terjesen, 2005).

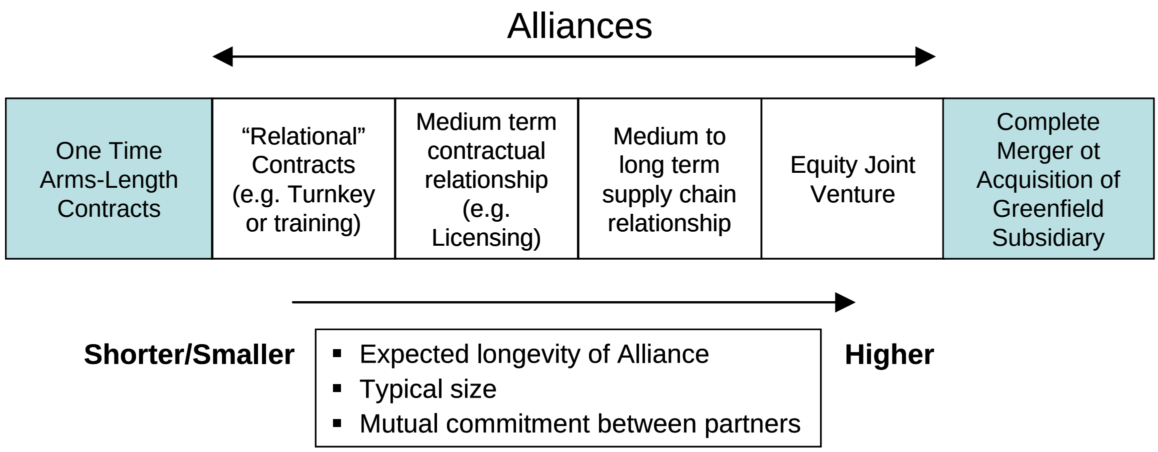
However, due to the liabilities of newness, smallness and foreignness, the new venture faces barriers to entry that, very often, hamper its innovation(s) to be harnessed. As large MNCs are not crippled by these liabilities, they can act as catalysts or facilitators, allowing new ventures to expand internationally by proxy (Acs and Terjesen, 2005). That is, MNCs serve as intermediators to the expansion of new ventures' innovation(s), allowing them to limit their liabilities of newness, smallness, and foreignness.

MNCs can benefit with such type of 'arrangement' in several ways. For example, an INV can be the supplier of an innovative sub-element of an MNC's offering. In alternative, an INV can be a reseller of an MNC's product through a new distribution channel, such as the internet. An INV can also provide a complementary solution to the existing offering of an MNC (Vapola *et al.*, 2008). In short, the intermediated entry mode should create a win-win situation, whereupon the large corporation acquires a comparative advantage it could not have developed internally, and the small one obtains market access (Spence *et al*., 2008).

It should be underscored that two drawbacks can be pointed out to this mode of foreign expansion (Acs and Terjesen, 2005). Firstly, there can be transaction difficulties in the process: as innovations are information-based, their transaction may entail agency problems. Secondly, MNCs may have bargaining power over new innovative firms, which may lead MNCs to extract monopoly rents from the partnership.

This intermediated or 'indirect' mode of entry is, in essence, a form of alliance between firms. As defined by Vapola *et al.* (2008), an alliance is any governance structure that manages an incomplete contract between separate firms and in which each partner has limited control. The term alliances encompasses several governance modalities and, according to Contractor and Lorange (2002), an alliance is any inter-firm cooperation that falls between the extremes of discrete, short-term contracts and the complete merger of two or more organizations (see Figure 1.1 below). Therefore, under this concept all types of cooperative arrangement, from 'relational contracting' modes to equity joint-ventures, are included.

Figure 1.1 – Typology of Alliances



Source: Adapted from Contractor and Lorange (2002: 487).

It should nonetheless be noted that some authors point out that there is some confusion about the meaning of concepts such as collaborative/cooperative agreements, and strategic alliances, with these terms often being used as synonyms (e.g. Narula and Hagedoorn, 1999; Eiriz, 2001). For instance, Narula and Hagedoorn (1999) contend that cooperative agreements include all inter-firm collaborative activity, while strategic alliances represent a subset of inter-firm cooperation. We come back to the concept of strategic alliances forward in this section.

Alliances can assume a multitude of shapes. For example, alliances can be classified as horizontal or vertical (Spence *et al.*, 2008). Horizontal alliances are cooperative relationships which transform competitors into allies; vertical networks are cooperative relationships which occur throughout the value chain between upstream and downstream partners. Alliances can also be split into ‘endogamic’ and ‘exogamic’. An endogamic alliance is established among firms in the same industry, while an exogamic alliance is established among companies that do not operate in the same industry (Spence *et al.*, 2008).

Alliances can also be classified according to the intensity of the relationship between the partners. For example, alliances such as training or turnkey operations are usually temporary and entail short-term relationships. Nevertheless, for example, supply chain alliances can often be intense and involve a long-term commitment between the partners engaged (Contractor and Lorange, 2002). In Figure 1.1 we schematically illustrate the alliance typologies we have just described.

As we can observe from Figure 1.1 presented above, the typology of alliances is presented along a continuum of increasing control, commitment and risk (Li and Qian, 2008), from the lowest degree in the left side (e.g. training operations), to the highest degree in the right side (e.g. equity joint venture).

Taking into consideration this considerable array of alliance options, we finish this section by briefly reviewing two alliance types: equity joint ventures and strategic alliances.

A joint venture (JV) can be defined as an entity that is created when two or more firms pool a portion of their resources in order to create a separate jointly owned organization (Lu and Beamish, 2006). Pooling partner resources is frequently cited as one of the chief advantages of JVs, enabling companies to do together what they could not do alone (Pearce and Hatfield, 2002).

Lu and Beamish (2006) contend that the international JV is a frequent mode of entry in the internationalization of SMEs. Mainela and Puhakka (2008) assert that, organizing a JV which is international in scope can be seen as a specific form of international entrepreneurship. Among other factors, and according to these authors, an international JV can be defined as a new venture if its competitors consider it a new market entrant and if it is considered as a new source of supply by its potential customers.

JVs are a frequent form of alliance arrangement in ‘clean technology’ industries. For example, in the solar business oil giant BP has established a JV with the Indian group Tata for the manufacturing of solar photovoltaic panels (Greentechmedia, 2009). In the hydrogen fuel cell industry, Ballard Power Systems (a pioneer in fuel cell development) has established JVs with car manufacturers Daimler-Chrysler and Ford (Perrot, 2009). And in the wind power business, most companies that have submitted applications to the development of offshore wind farms under the UK ‘Round 3’ programme have done so after establishing JV arrangements with other partner companies (Newenergyfocus, 2009).

Strategic alliances refer to inter-firm cooperative agreements which are intended to affect the long-term product-market positioning of, at least, one of the partners involved (Narula and Hagedoorn, 1999). Parkhe (1991: 301) defines global strategic alliances as «inter-firm cooperative arrangements, involving cross-border flows and linkages that utilize resources and/or governance structures from autonomous organizations headquartered in two or more countries, for the joint accomplishment of individual goals linked to the corporate mission of each sponsoring firm».

According to Chen and Chen (2003), a resource-based view seems particularly adequate to examine strategic alliances, because companies essentially use alliances to access valuable resources they do not own. This can be extended to a knowledge-based view, as alliances can contribute to the enhancing of organizational learning and to the knowledge transfer among firms (Sarkar *et al.*, 2001).

1.5 Conclusion

Several theoretical constructs have been applied by IE researchers to explain the behaviour and entry mode of international entrepreneurial firms. While many authors consider that the classic stage model of internationalization fails to conveniently describe the *modus operandi* of the IE type of firm, frameworks such as the transaction cost theory, the resource-based view, the networks theory and the knowledge-based view, have been applied to explain such phenomenon. However, it should be noted that, rather than individually, these theories have been used in combination to provide a more eclectic and comprehensive understanding of IE issues.

Entrepreneurship is a key driver of economic growth, and policy makers worldwide have been designing national policies to stimulate the entrepreneurial initiative. The challenge of reducing the carbon intensity of the world's economies will open a vast array of business opportunities to all kinds of private sector stakeholders engaged in the 'low-carbon' sector. Given the GHG reduction needs of developing countries and the fact that most clean technologies are located in the developed world, it is expected that the exploitation of most of these opportunities will imply that prospective entrepreneurs cross national borders.

There is a wide range of foreign entry modes that can be taken into consideration. FDI and exporting are amongst the most frequent modes of entry adopted by firms. In the case of born-globals/INVs, and due to their 'liabilities' of newness, foreignness and smallness, an intermediated or indirect mode of international expansion (under which large MNCs serve as intermediators, by providing access to new foreign markets by proxy) has been an increasingly recurrent internationalization option.

From the perspective of born-globals/INVs, the entrance into a new foreign market can also be pursued by means of alliances. Alliances can assume a multitude of shapes too, varying from vertical to horizontal, from endogamic to exogamic, and from low to high levels of commitment and control by the parties involved. Alliances offer benefits, but they also pose challenges. One of it its most salient benefits, the transfer of knowledge from one party to another, can be a critical issue and, in a worst case scenario, it can seriously jeopardize the survival of an alliance arrangement. In the case of those international entrepreneurs whose main source of competitive advantage lies in the innovative features of their products, the establishment of a partnership with a player that may take possession of these features can be a difficult trade-off.

The transfer of foreign technologies to the host economy is one of the potential benefits that national governments may expect from international entrepreneurs. Due to the importance of technology transfer towards the mitigation of climate change, we propose to examine these issues in the next chapter.

Chapter 2 – International Technology Transfer

2.1 Introduction

Technology transfer is a key element for economic development across all levels of industry, and is a fundamental mechanism for fostering technological change and economic growth (Radosevic, 1999; Morrissey and Almonacid, 2005).

In the scope of the current study, the importance of technology transfer is associated with the international community's efforts to curb human-induced climate change. In fact, it is now recognized that one of the key ways through which the emissions of anthropogenic greenhouse gases (GHGs) – the main cause of climate change – can be reduced is through the development and deployment of 'low carbon' technologies. However, most of these technologies are owned by private firms in developed countries, and its transfer to the developing world – whose countries are amongst the greatest emitters of GHGs – is crucial to the successful mitigation of climate change (Ockwell *et al.*, 2008).

Taking into account the above considerations, the main goals of this chapter are: (i) to analyze some of the central concepts related to the topic of technology transfer; (ii) to make an assessment of the most relevant mechanisms to transfer technologies across borders; and (iii) to examine some key issues associated with this process. The chapter provides the theoretical basis for the empirical study presented in Part II of this work, and is also quintessential for the analysis of the technology transfer mechanisms of ESTs undertaken in Chapter 3.

Following this introduction, the second section of this chapter provides a background for the study of technology transfer. Drawing on a knowledge-based view, we shed light on the fact that contemporary societies deem knowledge as a fundamental source of competitive advantage to the firm. The third section is fully dedicated to the examination of key notions pertaining to the subject of technology transfer. The section will revolve around the definitions of technology transfer, with a special emphasis on the focal topic of this chapter: international technology transfer (ITT).

The fourth section has the main objective of briefly describing the most relevant ITT mechanisms found in the literature, since there are numerous channels through which technology can be transferred across international borders. The purpose of the fifth section is to analyze some key issues associated with the topic of ITT. They include the absorptive capacity of recipient organizations, the need of technological capacity building in host countries, and the importance of national governments in creating the enabling environment for the adoption and diffusion of foreign technologies. These issues are particularly important in the scope of this work, and will serve us as guidelines for the framework we present in the empirical study. Finally, in the sixth section, conclusions are presented.

2.2 Background

In a knowledge-intensive economy, the ability to create and apply new knowledge is one of the main sources of competitive advantage to the firm (Kogut and Zander, 1993; Borg, 2001; Martín-de-Castro *et al.*, 2008). The stock of knowledge is considered vital to the success of companies, at a micro level, and to the reinforcement of the competitive performance of nations, at an aggregate level. Moreover, to a large extent, the differences between developed and developing nations can be explained by the unequal access to knowledge stocks and technological development (Castellaci and Archibugi, 2008).

As pointed out in the previous chapter, companies are social communities that serve as mechanisms for the generation and transformation of knowledge into economically rewarded products (Kogut and Zander, 1993). Nonetheless, according to Escribano *et al.* (2009), firms are gradually abandoning the idea that knowledge creation is, in its essence, an internal process. The boundaries between internal and external stocks of knowledge are becoming blurred, and several studies have claimed that knowledge creation results from the interplay between the firm and the external environment (Drejer and Jørgensen, 2005). This goes hand in hand with Dangelico *et al.* (2008)'s assertion that new technological knowledge results from the collection of information and knowledge owned by a variety of parties, which is subsequently combined with internal processes of creating knowledge.

Many authors (e.g. Kogut and Zander, 1993; Escribano *et al.*, 2009) have observed that knowledge is inherently different from traditional inputs of production, such as labour and capital. This is essentially due to the fact that knowledge has the property of being a public good, as it can be easily reproduced and quickly transferred with minimum marginal costs (Oviatt and McDougall, 1994). As knowledge is easy to transfer and hard to protect, the firm that is responsible for its creation faces difficulties in obtaining a fair return for its use. Another relevant characteristic of knowledge as an asset pertains to the fact that it can be classified into two categories: explicit and implicit. Explicit knowledge is associated with knowledge about a particular concept or phenomenon which can be codifiable or explainable. By contrast, implicit knowledge is tacit and non-codifiable, and is characterized by understanding and acquired through experience. While explicit knowledge can be quickly transferred across organizational contexts, tacit knowledge is more difficult to transfer (Duanmu and Fai, 2007).

The importance of knowledge as a fundamental asset in contemporary economies gave rise to the need of protecting intellectual property. The World Intellectual Property Organization (WIPO) defines intellectual property (IP) as «creations of the human mind, such as inventions, literary and artistic works, and symbols, names, images, and designs used in commerce» (WIPO, 2009:1). IP pertains to ideas, information and knowledge, and whereas the word intellectual refers to creative output, property underscores the fact that human creations can be viewed as a tradable commodity (ISIS, 2004).

The importance of protecting IP dates back to the nineteen century and, according to Borg (2001), there are two main motivations for this. First, the inventors' entitlement to reap the benefits from his/her own creative efforts. And second, the need to ensure fair economic incentives in order to spur and motivate innovation, meaning that if companies are unable to protect their innovations, they will not be willing to invest in the necessary R&D for producing future innovations.

Intellectual Property Rights (IPR) can be defined as specific legal rights that protect the owners of IP (WIPO, 2009), that is, they are government-protected rights granted to an inventor that exclude others from using the technology or product in question. The main fields of IP protection are: (i) patents for invention; (ii) trademarks; (iii) geographical indications of sources; (iv) industrial designs; and (v) copyrights (WIPO, 2004). According to WIPO (2004), while the first four fields of protection belong to the category of industrial property, the category related to copyrights is different in itself.

Copyrights is a legal term describing the rights given to creators for their literary and artistic works. Copyright law protects the owner of the rights in artistic works against those who copy them, that is, those who take and use the form in which the original work was expressed by the author (WIPO, 2004). In the scope of this work, however, our interest goes to those fields of IP protection that fall within the category of industrial property[4].

Patents for invention, or simply patents, are the most widespread means of protecting the rights of inventors. Simply defined, a patent is the right granted to an inventor by a state, which allows the inventor to exclude anyone else from commercially exploiting his invention for a limited period of time (20 years in general). By receiving this exclusive right, the inventor must disclose the patented invention to the public. However, not all inventions are patentable, and laws generally require that an invention fulfils a set of conditions, namely: (i) industrial applicability; (ii) novelty; (iii) inventive step; and (iv) the invention must fall within the scope of patentable subjects defined by the national law (WIPO, 2004).

A trademark is a sign, or a combination of signs, which distinguishes the goods or services of one enterprise from those provided by another company. The owner of a registered trademark has an exclusive right in regard to his mark, enabling him to prevent unauthorized third parties from using it (WIPO, 2004).

A geographical indication is a sign used on products that have a specific geographical origin and possesses qualities that are due to that place of origin (WIPO, 2004). The industrial design refers

[4] As we will see in the fifth section of the current chapter, the concepts related to industrial property are especially important in technology transfer issues, namely in respect to licensing agreements.

to the right granted in many countries to protect the original, ornamental and non-functional characteristics of a product that results from design activity. The basic premise of this IP protection type is the need to stimulate the design element of production (WIPO, 2004).

The first efforts to ensure the protection of industrial property date back to the Paris Convention of 1883, where the first international treaties on IPR were agreed. Other initiatives soon ensued, but it was only in 1967 that a significant milestone would be achieved in this domain, with the creation of the WIPO. Notwithstanding its goals of protecting and promoting IP, WIPO's dispute resolution mechanisms and enforcement capabilities are considered weak. In order to address these issues, in 1994 the Trade-Related Aspects of Intellectual Property Rights (TRIPs) agreement was adopted (Magic, 2003).

The TRIPs agreement defines minimum standards for the protection of copyright, trademarks, patents and contracts, requiring a twenty year protection period for all inventions, products, and processes, in every area of technology. The TRIPs was established as an agreement under the World Trade Organization (WTO), and any nation willing to join WTO must comply with the standards defined in the TRIPs. Due to this fact, dispute resolution mechanisms are considerably stronger than those of the WIPO (Magic, 2003).

The TRIPs agreement acknowledges that the transfer and dissemination of technology is a fundamental objective of the IPR system (Maskus, 2004). Technology transfer is, as we know, the focus of this chapter, and in the next sections we proceed to examine this subject more attentively.

2.3 Towards a Definition of Technology Transfer

Until the early 1980s, the majority of research on technology transfer was focused on cross-national technology transfer, mainly the transfer of technologies from developed countries to less developed countries (Bozeman, 2000). The beginning of the 1980s represented a shift on the research agenda, and since then significant attention has been placed on domestic technology transfer issues, such as, for example, the technology transfer from universities to the private sector. However, the concept has been applied to a wide range of contexts, namely the technology transfers involving industrial companies, multinational companies and research organizations (Åberg, 2006).

According to Zhao and Reisman (1992), technology transfer can be defined in many different ways, varying according to the discipline of research. It then comes to no surprise the abundance of technology transfer definitions that can be found in the literature. In Table 2.1 we provide a summary of some of the most generalist definitions that have been proposed.

Table 2.1 – Definitions of Technology Transfer

Authors	Definition of Technology Transfer
Bar-Zakay (1971)	When scientific or technological information generated and/or used in one context is re-evaluated and/or implemented in a different context.
Seaton and Cordey-Hayes (1993)	The process of promoting technical innovation through the transfer of ideas, knowledge, devices and artefacts from leading edge companies, R&D organizations and academic research to more general and effective application in industry and commerce.
Parker and Zilberman (1993)	Any process by which basic understanding, information, and innovations move from a university, an institute, or a government laboratory to individuals or firms in the private and quasi-private sectors.
Niosi *et al.* (1995)	The assignment of a given technology (either protected through patents or not) from one economic agent to another.
Maskus (2004)	Any process by which one party gains access to a second party's information and successfully learns and absorbs it into his production function.
Autio *et al.* (2004)	Intentional, goal-oriented interaction between two or more persons or social units, during which technological knowledge and or artefacts are exchanged, and during which the sum total of technological knowledge possessed by the parties stays stable or increases.

Source: Own elaboration.

From the definitions presented above, we can conclude that, inherent to them all, is the idea that something is moved from a certain context or institutional setting to another, implying the crossing of some kind of boundary from a provider to a recipient entity. The product that is transferred – technology – is a notion that deserves some attention.

Eveland (1986) defines technology as information that is put into use in order to accomplish some task. By the same token, Audretsch *et al.* (2002) define technology as the application of new knowledge learned through science in order to address some practical problem. There is wide consensus in the literature that technology is not just about hardware, that is, the physical product that is transferred. Depending on the context, technology may pertain to scientific knowledge or technology, know-how and skills, as well as hardware and systems (Åberg, 2006). Kumar *et al.* (1999) have identified two main components of technology: (i) a physical component, which relates to items such as equipment, techniques and processes; and (ii) an informational component, which pertains to know-how in management, production, skilled labour and functional areas.

As the content of the technologies transferred can vary significantly, Bell (1987) proposes a typology to classify them. According to this author, technology flows can be classified into three categories: (i) capital goods and technological services, such as the purchase of machinery and equipment; (ii) skills and know-how for operation and maintenance; and (iii) knowledge, expertise and experience for the generation and management of technological change. While technological flow (i) leads to improvements in the production capacity, flow (ii) contributes to the enhancement of the technological capability at the basic, routine level, and flow (iii) enables the firm to generate dynamic technical and organizational change. This distinction is particularly important, because the characteristics of the technology determine the costs and mode of transfer (Kogut and Zander, 1993).

Drawing on the notions of explicit and implicit knowledge we referred to in section 2.2, technology can also be explicit or implicit. Whereas technology that can be codified into formulas, patent applications and the like can be deemed as explicit, non-codified technology – non-codified in the sense it requires some degree of implicit know-how from the personnel handling it – can be regarded as implicit technology (Maskus, 2004). This distinction should be taken into account, as the level of tacit knowledge embedded in a certain technology may prevent its effective transfer from the transferor to the recipient entity (Stern, 2007).

Technology transfer might more appropriately be thought of as a communication process between two parties whereupon messages flow in two ways, both from the providing entity and from the receptor organization (Rogers, 2002; Andersen *et al.*, 2007). In light of this view, the receptors are not necessarily passive entities in the process. Information is expected to flow in both directions, in an interactive way, and the transfer does not stop with the receptor organization becoming aware of the technological innovation. Rather, the process is expected to continue, as the receptor organization engages in a permanent communication relationship over time with the providing organization.

In the context of this study, our focus is on international technology transfer (ITT) issues. According to Maskus (2004), ITT can be defined as a comprehensive term covering a set of mechanisms for shifting information across borders and its effective diffusion into the host economies. In short and at its most basic level, ITT can be understood as the reception and utilization by one country of the technology developed in another (Graham, 1982).

Technology transfer can also be considered as a broad set of processes covering the flows of know-how, experience and equipment aimed at mitigating and adapting to climate change amongst different stakeholders such as governments, private companies, NGOs and research institutions (IPCC, 2001). This definition also includes the concept of technology diffusion, which refers to the extent to which a technology is utilized, meaning the amount of people or entities which have adopted the technology. This goes hand in hand with the notion of technology spillovers, which can be defined as information absorbed into competition, so that the benefits of the technology transfer do not accrue only to the technology owner (Maskus, 2004).

The majority of definitions of technology transfer found in the literature, including those we have examined above, do not take into consideration the possible modes of transfer (Radosevic, 1999). However, there are numerous dimensions that can be used to classify technology transfers modes.

One relevant dimension of analysis pertains to the maturity of the technology that is transferred. The movement of an established technology from one entity to another is usually known as a horizontal transfer. In contrast, vertical transfers are those technologies that are transferred directly from the R&D stage to the commercialisation phase (Ockwell *et al.*, 2008; Andersen *et al*., 2007).

Another relevant modality is related to the institutional path through which technology transfers flow. The IPCC (2001) identifies three technology transfer pathways: (i) government-driven; (ii) private-driven; and (iii) community-driven pathways. Government-driven pathways are technology transfers initiated by governments to fulfill specific policy goals. Private sector-driven pathways essentially involve transfers between commercially oriented private-owned organizations; and community-driven pathways are those transfers involving community organizations with a high degree of collective decision-making.

Technology transfers do not necessarily occur through market interactions. As such, another modality of transfer stems on the market vs. non-market dichotomy. The non-market alternative involves the acquisition of technology without the consent of the provider, such as through imitation, internet research or industrial espionage (Maskus, 2004; Andersen *et al.*, 2007).

In alternative to the above, Marvasti (1998) has suggested two different categories of technology transfer: those that occur by means of arm's length market transactions or through internalized transactions within a firm. One more alternative is proposed by Amesse and Cohendet (2001), whose distinction stems on the following groupings: (i) contractual arrangements; and (ii) relational arrangements (for example, alliances).

An additional dimension of analysis pertains to the type of stakeholders involved in the technology transfer process. These can include (but are not restricted to) governments, private companies, international institutions, research organizations, NGOs and individual consumers (Andersen *et al.*, 2007; IEA, 2001). The study of the stakeholders that take part in the process is very important, as the actions and interactions between them determine the direction and rate of technology transfer.

We can conclude from the above on the complexity of technology transfer flows. In effect, to capture all these dimensions into a comprehensive model or analytical framework is a difficult task and, indeed, few authors have endeavored to undertake such challenge. One exception is worth of note – Reisman (2005) – who proposed a taxonomy to classify technology transfer modalities, with the goal of providing a broad understanding of the conceptual depth of this topic. This taxonomy combines four main dimensions of the technology transfer process: (i) stakeholders involved; (ii) transaction characteristics; (iii) motivations for parties to participate in technology transfer; and (iv) disciplines and professions. The same author concludes that technology transfers can be characterized by 173 attributes, which, in combination, make up a large array of technology transfer possibilities.

We have shown in the above paragraphs that there are several dimensions associated with the modes of technology transfer, which emphasize different aspects of the transfer process. In spite of this, most researchers and practitioners have placed their attention on the examination of the mechanisms or ‘channels’ that lead to the transfer of technologies (Radosevic, 1999). Due to this, the next section is totally focused on this subject.

2.4 Mechanisms of International Technology Transfer: a Taxonomy

Drawing mainly from Maskus (2004)’s categorization, which stems on a market vs. non-market dichotomy, in the following paragraphs we briefly go through the most recurrent ITT mechanisms found in the literature. We start with those that can be considered ITT market mechanisms, and then we turn to those that can be considered non-market ones. We finalize with other mechanisms that do not necessarily fall into any of these categories.

The first ITT mechanism pertains to the trade of goods and services across borders. In fact, exports carry some potential for the transmission of technological information, not the least because they can be studied for design characteristics and reverse engineering (Maskus, 2004). As Radosevic (1999) puts it, we can consider technology transfer as some unknown percentage of the value of imported goods in a transaction.

FDI is another noteworthy mechanism of ITT. In principle, companies that invest abroad are expected, in some way, to transfer some form of technological information to the subsidiaries located in the recipient country (Maskus, 2004). FDI can be seen as a mode of technology transfer between affiliated firms, being a mechanism that usually involves large resource commitments and provides a high degree of control over the technology that is transferred (Vishwasrao, 2007; Radosevic, 1999).

A third market-based ITT mechanism is technology licensing. Licensing consists in the permission by the owner of a patented invention to another person or legal entity to perform, in a certain country and for the duration of the patent rights, one or more of the acts which are covered by the rights to the patented invention in that country (WIPO, 2004). Licensing contracts can vary in several ways, which may affect the degree of control that the licenser can retain over the technology, as well as the profits that he can obtain from the licensee (Vishwasrao, 2007). Variables include, for example, the imposition of restrictions on the markets where the licensee may commercialize the technology, or the charging of a one-time fee or the extraction of profits by means of a royalty (Vishwasrao, 2007).

Franchising can be defined as a contract-based organizational structure for entering in new markets which, in general, involves two parties: (i) a franchisor firm that compromises to transfer a business concept that it has developed; and (ii) a franchisee, which will implement this business concept in a non-domestic market, in the case the franchising is international in scope (Teegen, 2000). Franchising is a type of license agreement between parties, under which there is a transfer of rights and some form of know-how between the franchisor and the franchisee (Welsh, 2007; WIPO, 2004). This process of transfer can assume various guises, namely, in the form of direct franchising, area development franchising or master franchising (Teegen, 2000).

There are other noteworthy commercial means of ITT that WIPO (2004) considers, namely: assignments; know-how contracts; consultancy arrangements; and turn-key projects. An assignment consists in the sale by the owner of all his exclusive rights in a patented innovation, and the corresponding purchase of those rights by another entity. Simply put, a know-how contract consists in including a set of provisions concerning know-how in a document that is separate from the license contract. Through these provisions, the supplier of know-how compromises to communicate this know-how to another party. In the context of ITT, a consultancy arrangement pertains to the provision of advice and rendering of other services concerning the planning for, and the actual acquisition of, a given technology that is required by entities located in other countries that do not possess that technology. Finally, a turn-key contract arrangement is one in which a party designs and installs a system and transfers it to another party who will then operate it (WIPO, 2004).

In regard to non-market mechanisms, a spin-off can be defined as a new company that is formed by individuals who were former employees of a parent organization, with a technology which is transferred from the parent organization. In short, spin-offs represent the transfer of a technological innovation to a new entrepreneurial firm that is formed around that technological innovation (Rogers *et al.*, 2001). Spin-offs can be classified depending on the type of organization they originate. The two main sources of new technology-based firms are higher-education institutes (university spin-offs) and well-established private companies (corporate spin-offs) (Pérez and Sanchez, 2003).

Another non-market mechanism for ITT that is worth mentioning is imitation. Imitation is the process by which rival firms learn the technological secrets of another firms' products or services (Maskus, 2004). Imitation can be carried out by means of product inspections or reverse engineering, for example.

An alternative means of acquiring technological information without compensation is to study public available information about those technologies. By reading patent applications, rival firms can obtain knowledge about the underlying technologies, which may enable them to develop alternative technologies that do not infringe the rights of the original applicants (Maskus, 2004). Publications can also be seen as means of technology transfer. This is essentially the case of articles published in academic journals, but most often these articles are written for fellow scientists rather than for potential users of a research based technology. As such, they can not be deemed, in general, as an effective means of technology transfer (Rogers *et al.*, 2001).

Other ITT mechanisms can be found in the literature that do not necessarily fall into the market vs. non-market dichotomy. One case in point are the so-called “Cooperative Research and Development Agreements” (CRADAs), which are an example of collaborative arrangements established between an R&D organization and a receptor organization for the transfer of technology (Rogers, 2002). As defined by this author, CRADAs pertain to the transfer of technologies from federal R&D laboratories in the US to private companies.

Another means of ITT is to move people who have the technology into receptor organizations. This can either be observed in a market or non-market situation. For example, this situation can happen when the personnel that have the knowledge of a certain technology leave the firm and join a rival firm based on that knowledge. In this case, the technology is transferred without any compensation to the original owner (Rogers, 2002).

Also worth mentioning is the transfer of technology by means of person-to-person interaction, such as meetings or conferences, whereby some type of technological information can be exchanged. This kind of interpersonal interaction is emphasized by Harmon *et al.* (1997), who contend that transfers occur mainly through relationships between inventors and contacts in receptor organizations, even prior to the official transfer taking place.

We finish this section by summarizing in Table 2.2 the most relevant of these mechanisms, providing a brief description and outlining their strengths and weaknesses, both from the perspective of the transferor and the recipient of the technology.

Table 2.2 – International Technology Transfer Mechanisms

Transfer Mechanism	Brief Description	Strengths and Weaknesses
Foreign Direct Investment (FDI)	An investment abroad, where the company being invested in is controlled by the foreign corporation.	- FDI provides a high degree of control over the technology which is transferred; - Due to the above, FDI is more appropriate to the transfer of recent, complex and costly technology; - FDI often raises awareness among local companies of the new technological possibilities brought by the foreign firm; - FDI creates a situation whereby foreign firms fight with local companies for high-skilled personnel.
Joint Venture (JV)	An entity that is created when two or more firms pool a portion of their resources and create a separate jointly owned organization.	- Compared to other mechanisms, JVs are likely to lead to effective technology transfers, as the technology owner has an incentive to ensure that the underlying tacit knowledge is effectively transferred; - Under the JV, the technology receptor has access to the technology and know-how, as well as capital and market access; - Allows the spread of costs and risks, as well as different parties to learn news skills from each other.
International Trade	The exchange of services and goods across international borders.	- All exports carry some potential for the transfer of technological information, and as such they can be studied for design characteristics and reverse engineering; - The transfer of technological inputs to be incorporated into production processes can improve production processes, thereby accelerating technological change in the host country; - The acquisition of technology does not assure its effective transfer; - Technology transfer that is limited to capital goods can hardly lead to the development of technological capabilities.
Licensing	Contractual agreement granting permission to another party to use intellectual property under specific conditions.	- Low risk method for technology owners to obtain additional returns from their investments in R&D; - Licensors keep significant control over the dissemination, use, and protection of proprietary rights; - The technology licensed may experiment some sort of inefficiencies if there are no representatives in the host country providing warranty or maintenance services; - Licensing is a preferable strategy for companies which do not have sufficient resources to enter in a foreign country by means of FDI; - The benefits of licensing largely depend on the latter’s ability to negotiate the conditions of the agreement; - Licensing may be more appropriate for less complex technologies.

Franchising	A contractual-based arrangement involving a franchisor and a franchisee, whereupon the former compromises to transfer a business concept and some knowledge to the latter.	- Low risk method for technology owners to enter into a new market; - Franchisors keep significant control over the dissemination, use, and protection of proprietary rights; - Long-term commitment for the commercialization of the underlying business concept, both from the part of the franchisor and the franchisee.
Assignment Contract	Sale, by the owner of, all his exclusive rights in a patented innovation to another.	- Technology suppliers do not retain any significant control over the use of the technology that is transferred; - From the part of the technology supplier, it is the most appropriate means of technology transfer if he finds it impractical to impose restrictions on the use of the technology.
Consultancy Arrangements	Provision of advice and services by specialized professionals in a certain area of activity.	- Consultancy arrangements usually do not entail the responsibility of the consultant for the results; - They do not provide means to a continuous involvement of the technology supplier so that upgrades to the technology transferred can be more easily facilitated to the recipient; - It does not include measures to provide resources that may be needed for further growth of the recipient firm.
Turnkey Projects	A party designs and installs a system and transfers it to another party who will then operate it.	- It can be advantageous in the case of large projects that require sophisticated planning and coordination skills - Turnkey projects are often ill adapted to local conditions; - They do not provide means to a continuous involvement of the technology supplier so that advances in the technology transferred can be more easily facilitated to the recipient.
Mobility of Personnel	Movement of people who have the technology to receptor organizations.	- The transfer of specialized personnel, even if for just a limited period of time, is likely to enhance the effectiveness of the technology transfer.
Spin-Off	A new company that is established by individuals who were former employees of a parent organization, using a technology that is transferred from the parent organization.	- The parent organization may, in some cases, support the spin-off firm, either with the provision of physical assets or financial resources; - Problems with the transfer of IPR from the parent organization to the new company may arise.

Source: Own elaboration.

2.5 Key Issues on International Technology Transfer

There is some tendency to think about ITT as relatively simple and straightforward task. Far from it, the process of ITT is often quite complex, and its success and effectiveness depend on a set of key factors. We propose to briefly review them in the remainder of this chapter, but we first start by shedding light on what we mean by technology transfer effectiveness.

Technology transfer effectiveness is the degree to which the information embedded in the technology moves from one individual or organization to another one (Rogers, 2002). For authors such as Niosi *et al.* (1995) this means that the imported technology has to be effectively assimilated and mastered by the receptor organization. In the context of an engineering company, for example, this means that the transferee is able to independently conduct the activity it was supposed to have learned from the transferor.

Bozeman (2000) considers that the effectiveness of a technology transfer process can pertain to several aspects, which include its impacts in the marketplace, the people involved in the transfer, and the influence in the political arena. Accordingly, he proposes a model to evaluate the technology transfer effectiveness based on a set of assessment criteria. For example, in his model the criterion ‘market impact’ assesses whether the technology transferred had an impact on the firms sales or profitability, while the criterion ‘scientific and technical human capital’ assesses whether the technology transfer activity led to an increment in the capacity to perform and use research within the importing firm (Bozeman, 2000). An alternative model was developed by Rogers *et al.* (2001), who evaluate technology transfer effectiveness by scoring a set of six interrelated criteria. However, this framework can only be applied to university-private sector technology transfers.

Notwithstanding the differences in approach, these authors are unanimous in recognizing the importance of the ‘absorptive capacity’ of the recipient organization to the effective transfer of technologies. The absorptive capacity can be defined as the ability of an organizational entity to recognize the value of new external information, assimilate it, and apply it to commercial ends (Cohen and Levinthel, 1990). In effect, technology transfer is not achieved until the recipient understands and is able to use the technology and, as such, the absorptive capacity of the recipient is a fundamental condition to the effective transfer of foreign technologies (Andersen *et al.*, 2007).

The absorptive capacity of an organization should be seen in the wider perspective of ‘capacity building’ in the host country. Capacity building is pivotal to the successful integration of technologies in the recipient country, and pertains to the strengthening of its technological infrastructure, as well as its human and institutional capabilities (IEA, 2001). The development of the domestic capacities to absorb and master the received knowledge, and potentially innovate from it, is of key importance in technology transfer, most in particular if the objects of transfer are ‘low-carbon’ technologies. For example, when waste and water treatment technologies are acquired by municipalities, case studies show that the provision of adequate training and technical assistance to enhance local capacity are essential to an effective technology transfer (Less and McMillan, 2005).

Due to the fact that countries’ capacities are very different, capacity building must be adapted to local circumstances. Consequently, given the unique characteristics of each country, any generic approach to the transfer of technologies is likely to fail (Andersen *et al.*, 2007). As such, the assessment of the technology needs of a country, whereupon the sectors that would benefit from the import of certain technologies are identified, should be the first step of any technology transfer initiative. By means of a technology needs assessment (TNA) programme, a country can set-up a plan to deploy the technologies it needs the most, which will increase the likelihood that these technologies are effectively transferred and spillover into the local economy (IEA, 2001; Stern, 2007).

By creating the policies and regulations that shape the environment in which technology transfers occur, national governments play a determinant role in the effectiveness of the technology transfer process. Their relevance should be emphasized in regard to the following aspects: (i) national systems of innovation; (ii) political framework; (iii) economic framework; and (iv) institutional framework.

The national systems of innovation are the network of institutions that influence the rate and direction of technological development within a certain country. They influence the innovation processes at the national level, and result from the complex web of relationships that exist among the stakeholders, which can include private companies, research institutions, local governments and universities. The better these organizational entities are established and interconnected, the quicker and easier will be the flow of knowledge between them. As such, by setting up adequate national policies, governments play a key role in stimulating the well-functioning of national systems of innovation, which will lead to the enhancement of the host country’s absorptive capacity and the dissemination of knowledge into the relevant economic sectors (Andersen *et al.*, 2007).

A stable political framework is also important for the transfer of technologies. In effect, the existence of instability and/or corruption problems in a recipient country is likely to discourage the entrance of foreign companies into that country and therefore reduce the likelihood of technology transfers (IEA, 2001).

The economic framework of the host country should also be taken into consideration. National governments play a relevant role in regard to the existence of trade barriers, taxes and/or subsidies that may hinder the adoption of new technologies and stimulate its transfer from developed countries. In the energy sector, for example, the existence of subsidies to fossil fuel power generation is a barrier to the deployment of new and clean technologies.

Finally, the lack of a solid institutional framework in the host country is also likely to thwart the transfer of technologies. Studies found in the literature are unanimous in recognizing that the existence of well designed regulations and the ability to enforce their adoption is likely to speed up the transfer and diffusion of technologies. Most in particular, the existence of effective mechanisms of legal protection is of key importance to private sector enterprises, essentially in respect to the protection of IPR.

The protection of IPR is, indeed, one of the most salient aspects in the discussion of technology transfer issues. In one perspective, there is some evidence in the literature that concerns over competition issues and the protection of IPR may lead companies to prefer the transfer of older technologies instead of new ones (Stern, 2007; Wei, 1995). According to the visions expressed in Andersen *et al.* (2007) and Copenhagen Economics (2009), IPR can sometimes encourage and other times hinder the transfer of technologies.

On the one hand, the existence of strong IPR in the national legal framework makes it more attractive for companies which are considering establishing in a certain country. As we have seen in Chapter 1, this is an issue of special relevance to small entrepreneurial companies whose main competitive advantage lies on the innovative features of the technologies they own. On the other hand, the protection of IPR may entail higher costs to the adoption of new technologies, which may slow down their ITT movements and consequently the subsequent adoption in recipient countries (Andersen *et al.*, 2007).

Another key issue in technology transfer pertains to the lack of financial resources of recipient countries (including the respective firms) to acquire the technologies identified as necessary to their economic growth. This is particularly relevant in the scope of ‘environmentally sound technologies’ to be transferred into developing countries (de Coninck *et al.*, 2008). As such, and as we will see in Chapter 3, most of the mechanisms identified to the transfer of these technologies involve a financial component.

2.6 Conclusion

In a knowledge-based economy, the central source of competitive advantage to the firm is knowledge. However, the creation of knowledge is a costly undertaking, and its outcome can often be freely used by other parties. Due to this, in a knowledge-intensive economy there is the need to protect and promote intellectual property. We have seen that there are several means of protecting intellectual property, such as patents for inventions, trademarks, geographical indication of sources, industrial designs and copyrights. We have also mentioned the importance of the TRIPs agreement as a means of enforcing the protection of IPR among members of the WTO.

Technology transfer is a topic of study that has been addressed through the lenses of several disciplines, such as ITT or the transfers between higher-education institutions and the private sector. The word ‘transfer’ suggests the movement of something between organizational boundaries, whereas ‘technology’ is a multidimensional concept, which may refer to equipment, explicit and/or implicit knowledge.

The transfer of technologies is a complex process and can be analyzed in light of a set of different dimensions. They include the institutional framework whereupon the transfer occurs, the maturity of the technology and the type of stakeholders involved. Frameworks that aggregate all these dimensions are few and far between, and most practitioners have focused their attention on the channels of communication, or mechanisms, through which technology transfer occurs.

We have seen that there are numerous channels of transferring technology across borders, such as FDI, licensing agreements or spin-offs. All have their advantages and disadvantages, both from the perspective of the transferors and recipients of technology. In respect to the various mechanisms of ITT, it should be underscored that JVs are one of the most likely means of leading to effective technology transfers, as the technology owner has an incentive to ensure that the underlying tacit knowledge is effectively transferred.

International technology transfer issues have been one of the topics increasingly addressed within the framework of technology transfer. In order to be sustainable and effective, ITT must take place as part of a wider process of technological capacity building in recipient countries. Policy makers can take a number of measures in order to promote a suitable investment climate for enabling a successful transfer of technologies to host countries, especially, towards the establishment of credible regulatory frameworks and the strengthening of IPR. Issues pertaining to IPR are considerably valuated by international entrepreneurs, who derive their competitive advantage from the characteristics of the technologies they own. Furthermore, the existence of strong IPR protection may seriously hinder the transfer of technologies into recipient economies. As such, IPR is a core topic in the scope of technology transfer discussions, most in particular in the area of climate change issues.

Chapter 3 – Climate Change and Technology Transfer: the role of the CDM

3.1 Introduction

Climate change is one of the most critical challenges the humanity currently faces. The warming of the planet due to the emission of anthropogenic greenhouse gases (GHGs) is now considered unequivocal (IPCC, 2007), and international collective action is required to address this challenge (World Bank, 2008, Stern, 2007).

This chapter aims to: (i) present an overview of some of the most relevant issues regarding the challenge of climate change; (ii) provide insights on a mechanism specifically designed to curb GHG emissions: the CDM; and (iii) make an assessment of the most relevant mechanisms that lead to the transfer of ESTs to the developing world.

The second section provides the necessary background for understanding the issues related to climate change. Several aspects are reviewed, such as the human responses to climate change and the importance of international collective action, the Kyoto Protocol and its flexible mechanisms, the importance of the public and the private sectors' engagement to address climate change, and the transfer of ESTs to developing countries.

The third section of this chapter is entirely focused on the Clean Development Mechanism (CDM). Set-up in the wake of the Kyoto Protocol in 1997, the CDM is a market-based tool aimed at reducing the emission of greenhouse gases in developing countries. We start this section by providing the essential background information on CDM, such as the CDM project cycle, the concepts of 'additionality' and 'baseline' (UNFCCC, 1997; UNFCCC, 2001), and the distinction between bilateral and unilateral projects. We then highlight the CDM's importance as an opportunity to international entrepreneurs and as a mechanism to transfer technologies from developed to developing countries. We finalize this section by briefly reviewing the main criticisms so far pointed out to the CDM in its current form of operation, as well as some of the proposals found in the literature to reform it.

In the fourth section we make an assessment of the main mechanisms for the transfer of ESTs. According to our analysis, these mechanisms can be split into two main groups: those that fall within the United Nations Framework Convention on Climate Change (UNFCCC); and the others that fall outside its jurisdiction. The fifth section of this chapter concludes and sets the ground for the issues that we will analyse in the scope of the empirical study.

3.2 Background

Over the last three decades, there has been an increasing concern within the international community to tackle climate change. The first noteworthy event was the World Climate Conference of 1979, which called the attention for the increasing quantities of CO_2 being emitted into the atmosphere (Stern, 2007). In 1988, the United Nations Environmental Programme (UNEP) and the World Meteorological Organization (WMO) jointly created the Intergovernmental Panel on Climate Change (IPCC), whose main propose is to assess the latest scientific, technical and socio-economic literature produced on climate change, in order to assist governments in their policy decisions (IPCC, 2009).

In 1992, at the Earth Summit Conference held in Rio de Janeiro, concerns over climate change led over 150 nations to sign the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC sets out the global framework for action with the goal of stabilizing GHGs concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the Earth's climate system. The Convention entered into force in March 1994, and has achieved near universal ratification to date.

The UNFCCC established the Conference of the Parties (COP), the supreme body for decision-making and implementation of the Convention, which is convened on an annual basis. The most significant meeting on climate change so far was the Third Conference of the Parties (COP-3), which was held in Kyoto in December 1997. The outcome of this conference was the agreement on the first international treaty binding the so called 'Annex-I countries' (which include 27 'industrialized nations' and 12 'economies in transition', and which are the source of most past and current GHG emissions) to reduce GHG emissions: the Kyoto Protocol. Now ratified by almost every country in the world, the treaty entered into force in February 2005.

Other milestones have been achieved during the last three decades in the fight against climate change by the international community. In Table 3.1 below we present a summary of these milestones.

Table 3.1 – Milestones in international efforts to curb climate change in the period 1979-2007

Year	Major milestones in international efforts to curb climate change
1979	• The first World Climate Conference highlights concerns on the increasing amount of CO_2 emissions into the atmosphere (Desonie, 2008).
1988	• UNEP and the WMO establish the IPCC (WRI, 2009).
1990	• The IPCC issues the 1st Assessment Report, confirming that anthropogenic

	GHGs emissions are likely to cause global warming (Desonie, 2008).
1992	• The UNFCCC is established at the Earth Summit in Rio de Janeiro (WRI, 2009).
1994	• The UNFCCC enters into force (WRI, 2009).
1995	• The IPCC issues the 2nd Assessment Report, confirming that climate change is a real problem and that human systems were its primary cause (WRI, 2009).
1997	• Adoption of the Kyoto Protocol at COP-3 (WRI, 2009).
2001	• Signature of the Marrakesh Accords, which set detailed rules for the implementation of the Kyoto Protocol (WRI, 2009).
2005	• The Kyoto Protocol enters into force in February 2005, after Russia's ratification in the end of 2004 (WRI, 2009).
2007	• The IPCC issues the 4th Assessment Report, concluding that global warming is 'unequivocal' and is being caused by human activities with 90% certainty (IPCC, 2007). • At the UNFCCC conference in Bali, world nations agree to negotiate a climate agreement to succeed the Kyoto Protocol (Desonie, 2008).

Source: Own elaboration.

The Kyoto Protocol determines that Annex-I countries reduce their combined GHG emissions (excluding the GHGs controlled by the Montreal Protocol[5]) by an average of 5.2% below 1990 levels, in the period 2008-2012 (which is called the 'first commitment period'). However, within Annex-I countries, differentiated reduction targets exist. For example, the EU is required to reduce its emissions 8% below 1990 levels, which correspond to a reduction of 340 million tons of CO_2-eq emitted (James and Fusaro, 2006). The Protocol does not require developing countries to reduce GHG emissions, but obliges every party to prepare national inventories of GHG emissions and develop national climate change policy programmes.

The Protocol does not stipulate how emission reductions should be taken. However, it proposes three flexible market-based mechanisms that allow Annex-I countries to meet their reduction commitments: (i) Emissions Trading Schemes (ETS); (ii) Joint Implementation (JI); and (iii) Clean Development Mechanism (CDM).

[5] The Montreal Protocol is an international treaty designed to protect the ozone layer by phasing out the production of chemicals that destroy the ozone layer. In addition to destroying the ozone layer, these ozone depletion gases are also GHGs, with a global warming potential thousands of times superior to CO_2 (Andersen *et al.*, 2007).

Emissions trading is a market-based approach designed to reduce the levels of a gas or substance that is emitted. The mechanism first sets an overall cap, that is, the maximum amount of emissions allowed for a certain period. Then the authorizations to emit, that is, the 'allowances' are distributed to the affected sources. The total number of allowances corresponds to the limit set by the cap. This mechanism is also known as 'cap-and-trade' (James and Fusaro, 2006).

Joint implementation (JI) is a mechanism under the Kyoto Protocol that allows industrialized countries to meet part of their required GHG emission reductions by paying for projects that reduce emissions in economies in transition. By the same token, the Clean Development Mechanism (CDM) is a tool that allows industrialized countries to meet their reduction targets by investing in a project in a developing country.

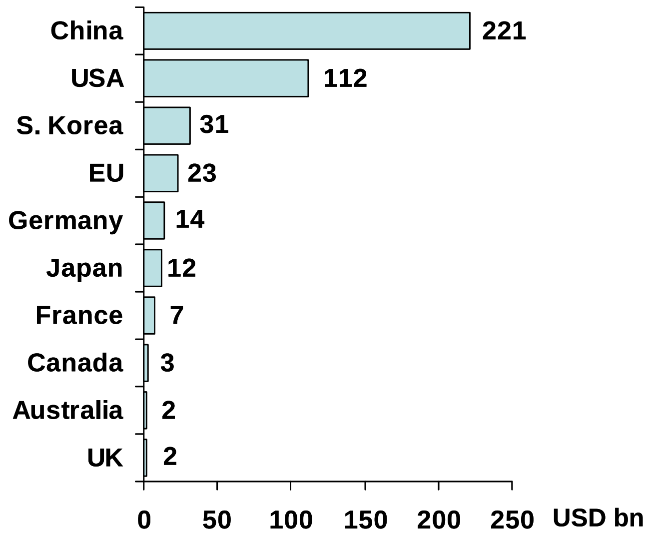
JI and CDM are project-based mechanisms, meaning that they are linked to projects that reduce GHG emissions. JI and CDM projects both generate 'carbon credits', which are an acknowledgment of the achievement of reduction in emissions of GHG with the activities of a certain project (James and Fusaro, 2006). While the carbon credits generated by a JI project are called ERUs (Emission Reduction Units), those generated by a CDM project are called CERs (Certified Emission Reductions).

Several carbon markets exist, but the European Union Emissions Trading Scheme (EU ETS) is the largest company-level trading system that was created under the framework of the Kyoto Protocol (Labatt and White, 2007). The scheme sets an overall limit on emissions from power generators and heavy industry, which account for around 40% of the total GHG emissions in the EU (The Economist Intelligence Unit, 2009).

The Kyoto Protocol has been criticized on several aspects. First of all on the grounds that there are countries which are not bound by its provisions, the most notorious case being the United States, the only Annex-I country that has not ratified the Protocol. Another source of criticism lies in the fact that developing countries do not have any quantitative obligations in terms of GHG reductions. For example, although China's emissions are amongst the highest in the world, this country is exempted from any reductions because it is considered a developing nation.

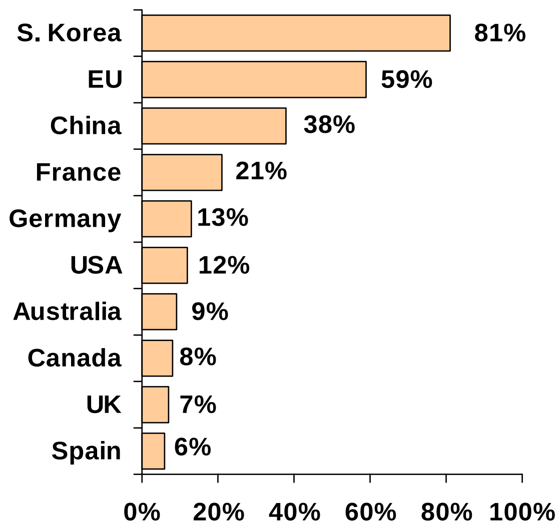
A third issue of criticism concerns the time horizons set under the Protocol (Stern, 2007). In effect, it does not provide any guidance linking the first commitment period to an overall target or long-term agenda for GHG emission reductions. A fourth aspect pertains to the weakness of international law in enforcing obligations between nations. The Kyoto Protocol contains specific sanctions to enforce the compliance by nations but these sanctions are only enforceable if a government chooses to remain within the framework of the Protocol. Other recurrent sources of critique pertain to the *modus operandi* of its flexible mechanisms, namely the CDM, but we will return to these issues in section 3.3. Notwithstanding the economic downturn that world economies undergo following the 2008 credit crisis, climate change issues continue high on the agenda of many governments. A report elaborated by the Hong Kong and Shanghai Banking Corporation (HSBC, 2009) found that governments worldwide have placed more than USD 430 billion in fiscal stimulus to key climate change industries, thus regarding low-carbon growth as a key lever for economic recovery. By observing Figures 3.1 and 3.2 presented below we conclude that policy makers are now regarding climate change as an opportunity rather than a threat to economic growth.

Figure 3.1 – Green stimulus, regional ranking (USD billion)



Source: HSBC, 2009.

Figure 3.2 – Green stimulus, regional ranking, as a percentage of total stimulus



Source: HSBC, 2009.

As climate change shares the characteristics of an environmental externality (Dean and McMullen, 2007; Stern, 2007), public policy is of paramount importance to correct this market failure. In fact, as GHG emissions generated in the production of a product are not normally included in the price of the product, neither the enterprises nor consumers have the incentives to reduce emissions on their own (Popp, 2008; Stern, 2007).

The IPCC (2007) highlighted the need for three fundamental policy instruments in order to decarbonise world economies: carbon pricing; traditional regulation (through mandates and subsidies); and innovation policy. These instruments are used for different motivations. Firstly, carbon pricing is used to internalize the external costs of climate change. Secondly, traditional regulation is used to correct market failures and consumer behaviour. And thirdly, innovation policy is used to provide incentives to the development of expensive, but promising new technologies.

According to a report elaborated by the Deutsche Bank (2008), the regulatory tools previously outlined are major drivers of investment opportunities in climate change. There are a number of measures that governments can take in order to create a suitable investment environment for the investment in solutions that address climate change issues, either serving mitigation or adaptation purposes. These include, for example, the assignment of subsidies to renewable energy generation, taxes on fossil-fuels and the enforcement of environmental standards (Moore and Wüstenhagen, 2004).

For addressing climate change, in the Deutsche Bank (2008)'s report are proposed four categories of solutions: (i) clean energy; (ii) environmental resource management; (iii) energy and material efficiency; and (iv) environmental services. Throughout this study we will use the designation 'environmentally sound technologies' (ESTs) to encompass the three first groups of solutions (see Table 3.2 below).

Table 3.2 – Universe of solutions that address climate change issues

Categories	Sub-categories
1. Clean Energy	• Power Generation (e.g. renewable energy technologies; clean coal technologies); • Cleantech Infrastructure; • Power Storage Technologies; • Biofuels.
2. Environmental Resource Management	• Water (e.g. desalination / purification; wastewater treatment); • Agriculture (e.g. irrigation innovation, clean pesticides, seeds); • Waste management (e.g. recycling, energy from waste).
3. Energy & Material Efficiency	• Advanced Materials (e.g. advanced coatings, lightweight substitutes); • Building Efficiency (e.g. insulation, micro-generation); • Power Grid Efficiency (e.g. storage, smart-metering).
4. Environmental Services	• Environmental Protection (e.g. land conservation, sea defenses, forestry);

	• Business Services (e.g. insurance, consultancy/advisory, intellectual property, microfinance, 'green' focused banking).

Source: Adapted from Deutsche Bank (2008).

A fundamental aspect of public policy intervention in the global fight against climate change pertains to technology transfer issues. In effect, the transfer of ESTs to the developing world has been a clear mandate under the UNFCCC, and this is enshrined in Article 4, paragraph 5 of the Convention, where it is established that: «The developed country Parties and other developed Parties included in Annex II shall 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, to enable them to implement the provisions of the Convention» (UNFCCC, 2009c).

Developing countries rely on the support of developed countries to the transfer of ESTs due to three reasons. First, they are more dependent on climate sensitive sectors (such as agriculture and forestry). Second, they lack the resources and/or infrastructure to respond to the consequences of climate change. Third, these countries have to deal with social challenges such as poverty reduction and may be reluctant to adopt policies that could limit their economic growth. As many climate friendly technologies already exist in developed countries to address the climate change and GHG emissions problems (Pascala and Socolow, 2004), its transfer to developing countries will enable them to leapfrog some stages in the technology development process (Stern, 2007; Popp, 2008).

According to a study elaborated by Less and McMillan (2005), there are no significant differences between the transfer of ESTs and the transfer of other technologies. However, they highlight one striking difference: EST transfers are significantly more reliant on regulation and public policy than 'traditional' technology transfers. It should also be noted that transfers of ESTs are likely to be both horizontal and vertical, as many of these technologies go directly from the development stage to commercialization within the new country context (Ockwell *et al.*, 2008; Stern, 2007).

Private sector companies are amongst the most relevant stakeholders in the process of technology transfer, as they own the vast majority of technology and technical innovations. Due to their fundamental role in the transfer of ESTs, by creating the policies and regulations that shape the environment in which technology transfers occur, the role of governments is of the utmost importance (Ockwell *et al.*, 2008; Andersen *et al.*, 2007). As observed in Chapter 2, if technology transfer is to be effective in the long-term, the process will have to take part of the process of technological change and capacity building in the recipient country.

3.3 The Clean Development Mechanism

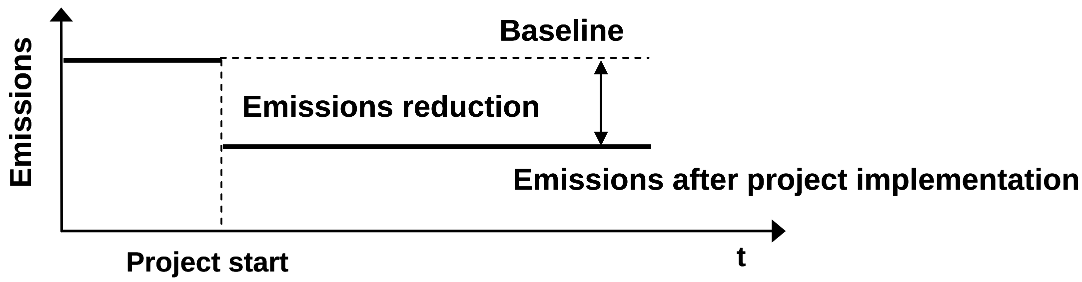
The Clean Development Mechanism (CDM) is one of the three flexible mechanisms under the Kyoto Protocol. The CDM has two main purposes: to allow Annex-I countries to invest in projects that reduce emissions in developing countries to offset a part of their domestic obligations; and to assist non- Annex-I countries in achieving sustainable development. Considered one of the most innovative tools brought up by the Kyoto Protocol (Dechezleprêtre *et al.*, 2008), the CDM stems on the premise that the reduction of GHG emissions in less-developed countries may be cheaper than in Annex-I countries. Certified Emission Reductions (CERs) are the CDM's currency, and they are the measure of the quantity of GHG emissions that has been avoided ('offset') by CDM projects.

Notwithstanding the fact that the CDM does not have an explicit technology transfer mandate, one of the sustainable development benefits (the so called 'development dividend') that CDM projects should bring is the use of technologies and know-how that are not available in the host countries (de Conick *et al.*, 2008; Doranova *et al.*, 2009; Seres, 2007).

The COP-7 held in Marrakech in 2001 was quintessential to establish the rules that govern the CDM. Among the most debated of these rules are the concepts of 'additionality' and 'baseline'.

In what concerns the first concept, a CDM project is considered 'additional' if the anthropogenic emissions of GHGs are reduced below those that would have occurred in the absence of the project. References need to be made in relation to a 'business-as-usual' scenario – the 'baseline', the second concept – which represents the GHG emissions that would occur in the absence of the proposed CDM project. If the emissions of the planned CDM project activity fall below those of the appropriate baseline, the project can be considered additional (see Figure 3.3 for an illustration of the concept).

Figure 3.3 – Illustration of the principle of 'baseline'

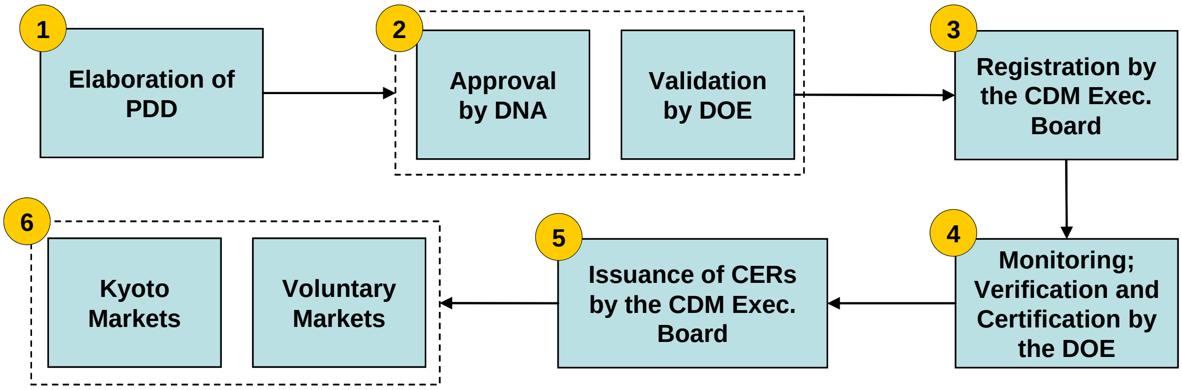


Source: Adapted from Lütken and Michaelowa (2008).

To utilize any of the Kyoto mechanisms, a country must comply with some requirements. For a non-Annex-I country there are two requirements: they must have ratified the Kyoto Protocol, and they have to designate a national authority (DNA) to be in charge of regulating CDM activities. In order to use CERs for it compliance commitments, Annex-I countries must meet other requirements, which include to have a national registry of GHG emissions and an updated inventory of the GHG past emissions.

There are various stages and studies that project developers are required to undertake in order to develop a CDM project. The main steps are illustrated in Figure 3.4 below, and consist of the following: (i) preparation of a project design document (PDD); (ii) validation process and approval by the host country DNA; (iii) registration; (iv) monitoring, verification and certification; (v) CER issuance; and (vi) CER transfer (World Bank, 2004; Lauser, 2005; Yamin 2005).

Figure 3.4 – The Development Cycle of a CDM Project



Source: Own elaboration.

After developing a project idea, a CDM project developer has to submit information about its project using a specific template, which is the 'project design document' (PDD). Among other things, the PDD requires a description about the CDM project, a methodology for determining the baseline and the additionality of the project. The submission of the PDD is necessary for starting the validation process.

The validation is the process whereupon a project activity is evaluated by an independent designated operational entity (DOE). During this phase, the DOE reviews the PDD and any supporting documentation and assesses whether the proposed activity conforms to certain requirements (Yamin, 2005; World Bank 2004). Moreover, the Designated National Authority (DNA) of each host country must provide a written approval to confirm that the project activity assists the country in achieving sustainable development.

Registration is the formal acceptance by the CDM Executive Board (EB) – the body in charge of supervising CDM at multilateral level – of a CDM project proposal. This phase is essentially to ensure that all CDM projects are scrutinised by an international entity.

After being registered, a CDM project is eligible to generate CERs. In order to determine the emission reductions, a monitoring plan to scrutinize the operation of the project must be in place. Verification pertains to the periodic review to be undertaken by an independent entity – the DOE – to confirm that the registered CDM project is *de facto* generating carbon credits. And finally, the certification process consists in the written document elaborated by the DOE that, during a specified time period, confirms that a project activity achieved the claimed reductions in GHG emissions.

The following stage consists in the issuance of the CERs that pertain to the specific project activity. In this phase, the CDM EB instructs the CDM Registry Administrator to issue a certain number of CERs, who will then be forwarded to the accounts of the project participants. The CDM Registry plays a purely technical role in this process.

Once the CERs are forwarded to the appropriate accounts, they can be used to assist Annex-I country to fulfil their commitments under the Kyoto Protocol. In parallel to the 'Kyoto market', a voluntary market for the sale of CERs has also emerged. This is mainly composed of entities such as governments, companies or individuals who buy these carbon credits for other reasons than regulatory compliance (Taiyab, 2005).

There are three main approaches to develop a CDM project: (i) bilateral; (ii) unilateral; and (iii) multilateral. A bilateral approach is observed when an Annex-I country or its legal entities invest in projects in partnership with a non-Annex-I country (Yamin, 2005). Unilateral projects are those where there is no foreign investment and the project is developed entirely in the host country (Wilder, 2005). A multilateral approach is where an international financial institution or intermediary puts together a portfolio of CDM activities on behalf of others (Yamin, 2005).

As a further extension to this classification, Laseur (2005) distinguishes four project organization categories in regard to the involvement of local entities in the CDM project development: (i) hosting only (non-host country nationals propose and develop the CDM project, with the role of the hosting country limited to passive facilitation); (ii) hosting and proposing (host countries initiate the project and then invite foreign citizens to develop it); (iii) bi or multilateral CDM project development (host and non-host country nationals mutually cooperate to develop a project throughout the entire CDM project cycle); and (iv) unilateral CDM project development (host countries develop the project independently).

One key aspect of CDM is that it is intended to stimulate private sector investments in climate-friendly projects, because at its core is the generation of credits (CERs) that have market value and can be sold for a profit (Yamin, 2005; Stern, 2007).

If we exclude unilateral project types from our analysis, CDM projects can be considered a form of international entrepreneurship. In effect, the CDM laid out an institutional framework that enables and stimulates firms that own some type of 'climate-friendly technology' to proactively seek new markets for their technologies and, in complement, to benefit from the extra revenues provided by the sale of CERs. By installing in a certain country a technological solution that leads to the reduction of GHGs, entrepreneurs are moving innovations across borders, bringing change to where it is needed, and being expected to contribute to local sustainable development goals.

We have observed in the previous section the importance of the private sector in the transfer of ESTs to developing countries. Although the transfer of technologies is not an explicit goal of the CDM (indeed, the CDM was not originally designed with this purpose), these projects are expected to contribute to technology transfer by financing GHG reduction activities that use technologies not available in host countries. For instance, in one section of the PDD project developers are required to include a description of how ESTs are to be transferred to the host country parties. Furthermore, some host countries require that some sort of technology transfer occurs for the CDM project to be approved by the respective DNA (Seres, 2007). China, India and Brazil are examples of such countries. It therefore sounds reasonable to expect technology transfer to occur through CDM projects.

According to van der Gaast *et al.* (2009), it remains to be seen how important is CDM's contribution to the transfer of ESTs to developing countries. However, we can find in the literature some studies that have analyzed technology transfer issues within the CDM. Most of them use statistical data available from CDM projects in order to analyse these issues. In the majority of these studies, this info is collected from the analysis of PDDs.

Haites *et al.* (2006) concluded that technology transfers occur in one third of the projects analyzed (860), accounting for two-thirds of the CERs generated. Analyzing the 2293 projects existent in the CDM pipeline as of September 2007, Seres (2007) found technology transfer to be very heterogeneous across project types, varying in terms of reliance on imported technology, knowledge and equipment flows, and the countries where the technology came from. He concludes that technology transfer is more common in larger projects, and also on those that count with some sort of foreign participation (that is, bilateral and multilateral projects).

Although using a smaller data set, in their empirical study on CDM and technology transfer Dechezleprêtre *et al.* (2008) achieve conclusions similar to those of Seres (2007), namely that transfer likeliness increases with the size of the projects. In addition to this, Dechezleprêtre *et al.* (2008) conclude that the probability of transfer is 50% higher when a CDM project is developed by a subsidiary of an Annex-I country. The study also confirms that the technological capabilities (see Chapter 2) of the host country strongly influence the likelihood of technology transfers, but only in the energy and chemical industry sectors. In the case of agriculture, the authors conclude that technological capabilities reduce the likelihood of accomplishing an effective technology transfer.

Other studies in the literature about energy entrepreneurship and technology transfer are worth mentioning. Doranova *et al.* (2009) investigated the sources of technology transfer in CDM projects, and found that in more than half of the projects reviewed, the whole package of technology was deployed in the host country. They also point out to the existence of South-to-South technology transfers in CDM project activities.

Adopting a different approach, which is based on the main factors that characterise technology transfer and interviews with experts, Schneider *et al.* (2008)'s study corroborates some of the conclusions of the other studies. They observe that the transfer of technology occurs both in terms of equipment and know-how in CDM projects, although they vary considerably depending on technology type, geography and project size.

The study performed by the ENTTRANS (2008) consortium is also noteworthy because it proposes an approach to support host country DNAs in building the capacity to assess which CDM projects could contribute to the countries' low-carbon sustainable development needs and priorities.

There is wide consensus in the literature that a set of reforms are needed to improve the CDM in its current form (see, for example, Lütken and Michaelowa, 2008; Carbon Trust, 2009). Some authors (e.g. Haya, 2007; FOE, 2008) consider the CDM system so flawed that they propose a complete restructuring or even the outright replacement of this mechanism for other alternatives.

In the scope of the possible improvements to be introduced, one of the initiatives currently being embraced is the so-called 'programmatic' CDM, which provides carbon credits to clusters of activities or broad policy reforms rather than on a project-to-project basis (Wara and Victor, 2008). By the same token, Stern (2007) suggests that a more standardized approach to the selection of eligible technologies – 'technology CDM' – and relevant baselines could be adopted in the CDM framework. For addressing the problem of CER overestimation, Haya (2007) recommends that validators (that is, DOEs) should be assigned randomly to each project and contracted directly by the UNFCCC instead of the project developer. The same author calls for the application of environmental and social standards to safeguard the environmental integrity and sustainable development benefits of CDM projects.

3.4 Technology Transfer Mechanisms to address Climate Change

The transfer of environmentally sound technologies (ESTs) is one of the tenets of the UNFCCC and the Kyoto Protocol. In addition to the CDM, we can identify a set of other specific instruments which are designed and/or can contribute to the transfer of ESTs. They are presented in Table 3.3 below and we have split them into two main groups: those within the UNFCCC, and those outside its jurisdiction. We briefly characterize the most relevant of them in the remainder of this section.

Table 3.3 – Mechanisms for the transfer of environmentally sound technologies

1. Mechanisms Under the UNFCCC	
Kyoto Protocol Flexibility Mechanisms	• Clean Development Mechanism (CDM); • Joint Implementation.
Mechanisms not included in the scope of the Kyoto Protocol	• Expert Group on Climate Change (EGCC); • Technology Information Clearing House (TT: Clear); • Global Environmental Facility (GEF); • Adaptation Fund.
2. Mechanisms Outside the UNFCCC	
Bilateral Mechanisms	• Official Development Assistance (ODA); • Export Credit Agencies.
Multilateral Mechanisms	• Multilateral development banks; • Regional development banks.
Private Sector Mechanisms	• Foreign Direct Investment (FDI); • Joint-Ventures (JVs); • International Trade; • Licensing; • Projects channelled though voluntary carbon markets; • Clean Technology and Carbon Funds; • Philanthropic sources.
Others Mechanisms	• International and national technology R&D and programmes of technology transfer; • Cross-sector partnerships.

Source: Adapted from UNFCCC (2009a).

The Global Environmental Facility (GEF) is as an independent financial organization that provides grants to developing countries for projects that address environmental issues and promote sustainable development in local communities. The GEF is also the designated financial mechanism for a number of multilateral environmental agreements, which include the UNFCCC and the Montreal Protocol (GEF, 2009).

Bilateral sources of technology transfer are those which are established under the provisions of a treaty, memorandum of understanding or other agreement, usually between two sovereign nations (IEA, 2005). Within this category we identify two main mechanisms: ODA and export credit agencies.

Official Development Assistance (ODA) consists on loans, grants and technical assistance that governments of developed countries provide to developing countries (World Bank, 2009). Many industrialized countries are providers of some sort of ODA but, in this context, ODA pertains to the finance and support of technology transfers to developing countries.

The export credit agencies (ECAs) are international financial agencies that provide loans, guarantees and insurance to domestic businesses that are trying to establish a presence in emerging markets (Andersen *et al.*, 2007). Most ECAs do not have an environmental or sustainable development mandate; however there are some notable exceptions, examples including Australia's EFIC, Canada's EDC and Japan's JBIC (Less and McMillan, 2005).

Regarding multilateral mechanisms, they pertain to international financial institutions that can be involved in the transfer of ESTs, either by providing financing, technical assistance to national governments in setting appropriate policies, or working with the private sector on low-carbon investments (Stern, 2007). The term 'multilateral development banks' typically refers to the World Bank Group and its agencies, while 'region development banks' refers to the following financial entities: (i) the African Development Bank; (ii) the Asian Development Bank; (iii) the European Bank for Reconstruction and Development; and (iv) the Inter-American Development Bank Group (Andersen *et al.*, 2007).

In respect to private sector-driven technology transfer mechanisms, we have already analyzed some of them in section 2.4, and they include FDI, JVs, international trade and licensing.

Carbon markets can be split into two main categories: regulatory and voluntary markets. Voluntary markets allow entities that do not have mandatory GHG emission reductions to buy carbon credits at cheaper prices in order to reduce their carbon footprint. Due to the fact that voluntary markets do not operate under an emissions cap, all credits purchased are project-based transactions (Bayton *et al.*, 2007). Most of these projects do not follow a particular standard, and therefore are usually cheaper than CDM projects, as they avoid the bureaucratic procedures and costs associated with the CDM project-cycle. According to Taiyab (2005), compared with the CDM, voluntary markets have potentially more scope to channel investments in small sized projects that bring sustainable development benefits to host countries and promote technology transfer.

Other mechanisms not encompassed in any of the aforementioned categories include a set of formal programmes to promote R&D and technology cooperation and dissemination. These programmes vary in nature and scope, but they share the common goal of promoting the sharing of knowledge and the transfer of ESTs. Examples of this kind of programmes include IEA's Networks of Expertise in Energy Technology (NEET), the Asia Pacific Partnership on Clean Development & Climate, and the Global Bio-Energy Partnership (GBEP).

In total, we have identified 19 mechanisms to the transfer of ESTs. Given the considerable differences that exist among these mechanisms, we consider the need for setting-up a framework that enables a comparative analysis. This is most pertinent due to the limitations found in the literature about the performance assessment of CDM projects in comparison with other alternative mechanisms.

3.5 Conclusion

Climate change is now considered unequivocal, and international collective action towards mitigation and adaptation to climate change is already underway. At multilateral level, the establishment of the UNFCCC and the ratification of the Kyoto Protocol were some of the greatest milestones achieved to date. The Kyoto Protocol is the only legally-binding treaty committing industrialized countries to reduce their emissions of GHGs. Among its innovations was the setting up of a flexible mechanism, the CDM, which allows industrialized nations to comply with their commitments by investing in GHG reduction projects in developing countries.

The UNFCCC expects the transfer of ‘environmentally sound technologies’ to play a key role in the reduction of GHG emissions in the developing world. In this regard, the role of the public and private sectors will be determinant. Governments have the role of designing the right policies and creating the ‘enabling environment’ to promote the effective transfer of technologies, including the protection of IPR and capacity building. The private sector, as the owner of most technologies and technical resources, also has to be engaged so that the relevant technologies are transferred.

Relevant to note in the context of this work is the fact that the CDM is a form of international entrepreneurship and a mechanism for the transfer of ESTs. On the one hand, the CDM was specifically designed to encourage companies in industrialized countries to invest in GHG reduction projects in developing countries. On the other, and although it was not its initial purpose, the CDM is also expected to lead foreign investors to bring their ‘climate-friendly’ technologies to projects located in the developing world. Therefore, the CDM is a stimulus to the entrepreneurial behaviour of companies and individuals engaged in the ‘low-carbon’ sector, as well as a means of encouraging the transfer of technologies.

Recent studies confirm that CDM projects can, indeed, lead to the transfer of technologies to developing countries. However, we have also identified other mechanisms that may be used, in alternative or in complement, to the transfer of ESTs. It is against this background that arises the need for a benchmarking tool as we propose in Chapter 4.

Part II – Empirical Study

Chapter 4 – Methodology

4.1 Introduction

In Chapter 3, we have seen that CDM projects can lead to the transfer of technologies to developing countries. We have also identified a set of other mechanisms that may be used, in complement or in alternative to the CDM, to the transfer of ESTs. Given this fact, it is adequate to develop a benchmarking approach which allows the comparison of the CDM with these other international technology transfer mechanisms, not the least because the absence of such type of tool is a caveat found in the literature.

Against this background, the goal of this chapter is threefold. First, to shed some light on the foundation of a benchmarking process by presenting an overview of the main goals of a benchmarking approach and the modalities or typologies of benchmarking. Second, given the fact that IE is the main theoretical background supporting this work, our aim here is to elaborate a brief literature review on qualitative research methods in entrepreneurship. In this sense, two different approaches are reviewed, and they are the grounded theory and sampling in entrepreneurial settings. In the methodological approach we propose these qualitative methods are taken into consideration in the scope of a benchmarking approach[6].

Third, we set-up a benchmarking approach in order to evaluate international technology transfer mechanisms applied to ESTs. This includes the areas that correspond to the focus of our analysis, the identification of Key Performance Indicators (KPIs), its characterization, and the way this tool can be applied in operational terms. In this section we also suggest classification levels that can be adopted by the project proponent in the application of this operational tool.

These three goals are addressed in sections 4.2, 4.3 and 4.4 respectively. In section 4.5, conclusions are provided.

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[6] As it can be observed in the case studies presented in Chapter 5.

4.2 The Benchmarking Process

In a broad sense, benchmarking is a process of comparing in order to learn how to improve. The basic motivation to perform a benchmarking study is the willingness to advance one's current practices and competitive edge (Watson, 2007).

One crucial aspect of a benchmarking approach is the notion of benchmark, which is the reference or target for performing comparative analyses (Peters, 2006). Another fundamental concept is that of 'best-practice', which can be understood as the best in class or the industry leader in the area under assessment (Kraft, 1997).

In the view of Watson (2007), benchmarking encompasses three major goals. First, to measure performance. Second, to identify the causes for achieving a certain level of performance by a determined organization or process. And third, to extract the practices that may be transferred to other organizations with the goal of improving the performance on a specific area. Garlick and Pryor (2004) also observe that benchmarking is a tool focused on the organization's learning process, envisioning the continuous improvement of prevailing practices and results.

As pointed out by Raposo *et al.* (2006), the various definitions of benchmarking found in the literature incorporate the following characteristics: comparative evaluation; potential application to any type of economic activity, industry or organization; focus on the best practices; systematic learning process; and continuous improvement.

A benchmarking approach can be applied to a vast array of contexts, and in the Table 4.1 presented below we review the main modalities or typologies of benchmarking according to the type of analysis they pertain to.

Table 4.1 – Benchmarking Modalities

Benchmarking modality	Description
Strategic benchmarking	• A benchmarking study that aims to improve the overall performance of an organization, by examining its strategy in the long term; • It focuses on critical business areas, which might have to change so that competitive advantages are achieved; • This type of benchmarking may be difficult to implement and the benefits are likely to take a long time to materialize.
Process or operational benchmarking	• It is focused on improving specific critical processes and/or operations; • It is expected to provide improvements in the productivity of specific activities, by increasing the effectiveness and the efficiency

	of business operations; • Benefits from such type of benchmarking can be obtained both in the short and in the long term.
Performance or competitive benchmarking	• It aims to determine which type of organization performs best according to a set of indicators.
Generic benchmarking	• It is a benchmarking study made against organizations from different business/industrial sectors; • Such type of benchmarking may lead to innovation and radical improvements in the organization.
Internal benchmarking	• A benchmarking study whereupon an organization learns from sister companies, subsidiaries or divisions that take part om the same group or company; • Usually, performance information is compared for the same process or business function.
External benchmarking	• Benchmarking study performed against outside organizations which are considered to be the best in class; • This type of benchmarking may take a long time to be elaborated, not only to obtain the necessary data and information, but also to address comparability purposes.

Source: Own elaboration, adapted from Watson (2007) and Peters (2006).

According to Raposo *et al.* (2006) and Silva *et al.* (2008), the benchmarking approach adopted by an organization depends on its promoter. Notwithstanding this fact, it should be mentioned one of the most prominent benchmarking methodologies that can be found in the literature, which was proposed by Robert Camp on his seminal study from 1989 (Camp, 1989). Based on this author, a benchmarking approach should be compromised of the following 12 steps: (i) selection of the subject for the benchmarking analysis; (ii) definition of the process; (iii) identification of potential partners; (iv) identification of data sources; (v) collection of data and selection of partners; (vi) determination of the gap; (vii) establishment of process differences; (viii) targeting of future performance; (ix) communication; (x) goal adjustment; (xi) implementation; and (xii) review.

Simplified or modified versions of this approach are common in the literature about benchmarking practices. An example is the one proposed by the consultancy company Bain & Company (2009), which consists on the following stages: (i) selection of a product, service or process to benchmark; (ii) identification of key performance metrics; (iii) selection of companies or internal areas to perform the benchmark; (iv) collection of data on performance and practices; (v) analysis of data and identification of opportunities for improvement; and (vi) adaptation and implementation of best practices, setting reasonable goals and ensuring companywide acceptance.

As we will see in section 4.4, we will follow our own approach in the design of the benchmarking tool we propose. However, insights were drawn from the methodologies proposed by Camp (1989), Raposo *et al.* (2006), Silva *et al.* (2008), and Bain & Company (2009).

4.3 Qualitative Research Methods in Entrepreneurship

From the set of methodologies proposed by Neergaard and Ulhøi (2007) on their Handbook of Qualitative Research Methods in Entrepreneurship, we briefly review the grounded theory research and the sampling process in entrepreneurial settings. This is particularly useful for the study performed in Chapter 5 regarding the CDM experience in China.

Grounded theory can be defined as a research methodology originating from social sciences, which generates theory in the process of systematically collecting and analyzing data during the research process (Glaser and Strauss, 1967; Mäkelä and Turcan, 2007). Grounded theory is an inductive methodology, that is, instead of starting with hypothesis formulation, the research process starts by defining the research question and then proceeds to data collection (GTI, 2009; Mäkelä and Turcan, 2007).

This research methodology was developed by two sociologists during the 1960s: Anselm Strauss and Barney Glaser. Of noteworthy importance is their book from 1967, “The Discovery of Grounded theory: Strategies for Qualitative Research”, which was the first publication to present in a thorough way how to develop grounded theory. Since the publication of the book, the two authors have disagreed on how to perform this theoretical approach, which resulted in the arousal of two distinct paradigms, the Glaserian and the Straussian. One noteworthy difference is that, for Glaser, the grounded theory is not a qualitative research method only, as all kind of data could potentially be incorporated into the research (Glaser, 1992).

Mills *et al.* (2006) contend that grounded theory can be seen as a ‘methodological spiral’ that began with Glaser and Strauss (1967)’ work and which continues to evolve. According to Mäkelä and Turcan (2007), the grounded theory research process can be divided into three main stages: (i) research design; (ii) data collection; and (iii) data analysis.

The first stage encompasses the definition of the research problem. Moreover, the specification of some preliminary constructs before evolving to the next phase of the process should also be undertaken. As an additional caveat, the authors call the attention for the fact that this stage should be prepared in order to maximize the quality of the research undertaken.

The second phase pertains to the collection of data which, in grounded theory, should be similar to other qualitative research activities. It should be noted that all known techniques for collecting empirical material can potentially be used in this type of research.

The third phase attempts to conceptualize, reduce, elaborate and relate the data collected in order to make up a novel theory. According to Strauss and Corbin (1998), this stage can be split into three sub-stages. The first sub-stage, ‘open coding’, consists on finding and naming categories, as well as discerning their properties and dimensions. In the second sub-stage, ‘axial coding’, the researcher endeavors to relate categories to their subcategories by coding around main category levels. And in the third sub-stage, ‘selective coding’, the researcher is expected to refine these categories and integrate them into a coherent theory.

Regarding this research method, Eisenhardt (1989) noted both strengths and weaknesses. The increased likelihood of a novel theory being produced and the fact that the new theory is empirically valid should be underscored as strengths. The likelihood of the empirical evidence generating an overly complex theory should be noted among its weaknesses.

There are several motivations to adopt the grounded theory as a research method. For example, when the research area is relatively recent, or in situations where there is scarce empirical validation of the existing perspectives on the subject. In addition to this, some practitioners contend that theory grounded in data is more likely to depict reality than constructs built from articulating insights derived from prior literature, experience and/or common sense (Mäkelä and Turcan, 2007).

The second methodology we propose to briefly review is associated with sampling in entrepreneurial settings. Neergaard (2007) advocates that an adequate sampling strategy is crucial for achieving a high quality research project. In this context, several difficulties concerning sampling in entrepreneurship research must be surpassed, namely: (i) the identification of a population; (ii) the size of the population; and (iii) the access to a proprietary data set for extracting the necessary information for analysis.

Based on a literature review, Neergaard (2007) provides an overview of 20 different sampling strategies and below we briefly outline those that have been taken into consideration when applying our benchmarking approach in Chapter 5.

The strategies selected are the following: (i) extreme/deviant; (ii) typical; and (iii) critical. While the first strategy highlights the unusual features of the phenomenon to be studied, the second strategy aims to describe what is normal or average. For its turn, the third strategy consists on picking up a case considered critical, in order to challenge a prevalent idea or an existing theory.

Two additional issues are critical in what concerns sampling in qualitative research. On the one hand, the optimum sample size is a matter of judgment by the researcher, and should be adequate to the purpose of the study. On the other hand, a caveat should be made in regard to the generalization of a sample as representative of a larger universe. As such, it is important that the sample extracted correctly describes the broad phenomenon that is being targeted.

4.4 Benchmarking Approach: a Proposal

The current benchmarking approach encompasses four steps. The first corresponds to the identification of the process to be targeted in the benchmarking approach. In the present study, the focus of analysis is the CDM, in regard to which we aim to analyze how well does it perform as an international technology transfer mechanism for ESTs – our central research question.

The second step corresponds to the identification of alternative mechanisms in respect to which the CDM could be studied and compared. This was already performed in section 3.4, where we have elaborated a taxonomy of the most relevant mechanisms for the international transfer of ESTs.

The third step embraces the identification of the main areas to perform the benchmarking approach. From the insights provided in the previous literature review (mainly Chapters 2 and 3), we came up with four focus areas which, in our view, are quintessential in the scope of international transfers of ESTs. The referred focus areas are: capacity building; investment and operational costs; enabling environment; and sustainable development.

The first area is related to capacity building, which consists on the strengthening of the host economy's technological infrastructure, including its human and institutional capabilities (IEA, 2001). According to many authors and studies (e.g. Wei, 1995; Radosevic, 1999), the capacity to master the received technology and innovate on that knowledge is a critical aspect on the process of technology transfer. Due to this fact, it is important to evaluate the extent to which the mechanism of technology transfer contributes to the enhancement of the host country's technological capacity.

The second area of analysis concerns to the financial flows associated with investment and operational costs of the mechanism under evaluation. As previously observed in section 3.2, many developing countries lack the financial resources needed to reduce the carbon intensity of their economies. As such, the propensity of the mechanism to financially contribute to the implementation of ESTs in the host economy is an issue that needs to be addressed. In line with the insights derived from section 3.4, mechanisms that have a financial component include, for example, the CDM, FDI and JVs. Examples of mechanisms deprived of such component are the

UNFCCC's Technology Information Clearing House and the IEA's Networks of Expertise in Energy Technology.

The third area pertains to the enabling environment of the host economy. This aspect has to do with the policies, regulations and institutions that exist in the country and that may influence the effectiveness of the technology transfer process. For example, the protection of IPR is a key issue that is usually analyzed by the private sector before taking the final decision of entry into a foreign market. There are several mechanisms that can exert some influence in shaping the enabling environment of the host economy. Examples include projects implemented in the scope of the Global Environmental Facility (GEF, 2009) and programmes implemented by the World Bank.

The fourth area is related to the extent the technology transfer mechanism contributes to sustainable development goals in the host economy, an aspect which is key in the case of ESTs (de Conick *et al.*, 2008; and Doranova *et al.*, 2009). For example, one of the reasons CDM projects related to the reduction of hydrofluorocarbons were strongly criticized has been due to their limited contribution to local communities' sustainable development needs.

After defining the key focus areas, the fourth step of our methodology consists in the definition of key performance indicators (KPIs) for each of the referred areas. Both the evaluation areas and the respective KPIs are presented in Table 4.2 below.

Table 4.2 – Focus areas and key performance indicators for the benchmarking analysis

Focus areas	Key performance indicators (KPIs)	Description
1. Capacity Building	1.1 Type of technology transferred (QUALI)	The indicator assesses whether the technologies transferred are in the form of equipment, explicit or tacit knowledge. The higher the amount of tacit knowledge transferred, the higher will be the likelihood of technology capacity enhancement.
	1.2 Maturity of the technology transferred (QUALI)	The indicator assesses whether the technologies transferred are vertical or horizontal. Vertical technology transfers are more likely to contribute to the build-up of local technological capacities than horizontal transfers.
	1.3 Transfer of complementary non-technological capabilities (QUALI)	The indicator evaluates if non-technological capabilities are involved in the scope of the transfer, such as managerial, marketing and organizational capabilities. If this is the case, the capacity enhancement of the host country will be higher.
	1.4 Knowledge spillovers into the host economy (QUALI)	The indicator evaluates the extent to which technologies transferred through the mechanism under consideration are likely to spillover among the host economy.
2. Investment and operational	2.1 Total annual investment (QUANTI)	The indicator measures the total amount of financial flows in ESTs into the host economy using the mechanism.

costs	2.2 International technology transfer costs (QUANTI)	The indicator measures the costs entailed by the host economy (i.e. through the host firm) by using the international technology transfer mechanism.
3. Enabling Environment	3.1 Stakeholders involved (QUALI)	The indicator assesses the type of stakeholders involved in the host economy in the international technology transfer process. In the case of governmental stakeholders being involved, it is likely that the mechanism can contribute to the improvement of the regulatory framework of the host economy.
	3.2 IPR protection (QUALI)	The indicator assesses the degree to which the mechanism contributes to the enhancement of IPR protection in the host economy.
4. Sustainable Development	4.1 Economic benefits to local communities (QUALI)	The indicator assesses the economic benefits accrued to local communities as a consequence of the technology transfer, by using the mechanism under consideration.
	4.2 Social benefits to local communities (QUALI)	The indicator assesses the social benefits accrued to local communities as a consequence of the technology transfer, by using the mechanism under consideration.
	4.3 Environmental benefits to local communities (QUALI)	The indicator assesses the environmental benefits accrued to local communities as a consequence of the technology transferred using the mechanism under consideration.

Source: Own elaboration.

Legend: Quantitative indicator (QUANTI); and Qualitative indicator (QUALI).

In our benchmarking approach, as we can see from Table 4.2 presented above, we propose a mix between qualitative and quantitative KPIs, although only focus area 2 (investment and operational costs) is to be evaluated with the support of quantitative indicators. In regard to its classification, and drawing on the approach designed by Raposo *et al.* (2006) on their 'Benchmarking Manual for Universities', we propose that the scale should range from level 1 (lowest performance) to level 5 (highest performance).

Based on these areas and the respective KPIs, we can now design a benchmarking scoreboard, which is presented in Table 4.4. In regard to the tool presented, two remarks deserve to be stressed. First, this tool was designed to evaluate the international technology transfer mechanisms both from the perspective of the host economy and the investor. In the case it is the host economy which is performing an evaluation, KPIs 2.1, 2.2 and 3.2 should not be considered in the assessment, as these are areas that concern exclusively the investor. Conversely, KPIs 3.1, 4.1, 4.2 and 4.3 pertain to areas that are usually not of the concern of investors. However, in the case the company in question has corporate social responsibility (CSR) commitments or considers the contribution to sustainable development goals in the host economy as relevant, then KPIs 4.1, 4.2 and 4.3 should be taken into consideration in the analysis.

Taking as reference Table 4.4, the second remark is related to the performance level column, which is constituted by two sub-columns. One pertains to the actual measurement for that KPI, while the other corresponds to the target or best practice classification. The difference between these values should be calculated and noted in the column titled 'Deviation'. If the deviation is negative, this means that the mechanism is performing below the best practice or the envisioned target. Conversely, if the deviation is positive, the mechanism is scoring above the best practice or the envisioned target. Finally, in the last column, correction measures should be indicated, depending on the score obtained.

This benchmarking tool was designed to evaluate international technology transfer mechanisms on a case-to-case basis. This is due to the fact that, for example, CDM projects in certain countries vary widely in terms of their contribution to international technology transfer. Because of this, we recommend that individual projects are evaluated under this framework, unless they can be clustered into a set of case studies sharing common characteristics. In Chapter 5 we provide an illustration of how this tool works by applying it to the CDM (and non-CDM) reality in China.

It should also be underscored that this framework was designed to be used in a flexible way by its proponents, that is, it should be adapted in order to fit each one's particular needs. For example, instead of being used to reflect the perspectives of both the investor and the host economy, the scorecard can be simplified with these two perspectives being merged. For practical reasons we adopt such simplification in the benchmarking approach presented in Chapter 5.

Last but not least, it is necessary to define the classification levels in respect to which the case studies are to be evaluated. In Table 4.3, we provide an indication of these for each KPI. It should be noted, nonetheless, that these classification levels should be adapted and revised by the performance evaluator when implementing this operative tool for his/her own needs.

Table 4.3 – Classification levels for the each KPI in the benchmarking scorecard

Key performance indicators (KPIs)	**Classification Levels**
1.1 Type of technology transferred	▪ **Level 1** – Any type of technology transfer occurs. ▪ **Level 3** – Technology transfer occurs in the form of explicit knowledge. ▪ **Level 5** – Technology transfer occurs in the form of implicit knowledge.
1.2 Maturity of the technology transferred	▪ **Level 1** – Any type of technology transfer occurs. ▪ **Level 3** – Horizontal technology transfer occurs with the project. ▪ **Level 5** – Vertical technology transfer occurs with the project.
1.3 Transfer of complementary non-technological capabilities	▪ **Level 1** – Any transfers of non-technological capabilities are reported to occur with the project. ▪ **Level 3** – Medium intensity of non-technological capabilities transferred with the project activity. ▪ **Level 5** – High intensity of non-technological capabilities transferred with the project activity.

1.4 Knowledge spillovers into the host economy	▪ **Level 1** – No knowledge spillovers into the host economy occur with the project. ▪ **Level 3** – Medium intensity of knowledge spillovers into the host economy occur with the project. ▪ **Level 5** – High intensity of knowledge spillovers into the host economy occur with the project.
2.1 Total annual investment	Indicative investment costs, 2006 figures (IEA, 2008):[7] ▪ **Onshore wind power**: 1244 USD/kW – 1707 USD/kW ▪ **Combustion of biomass for heat purposes**: 23 USD/kWth ▪ **Small-hydro power generation**: 1244 USD/kW ▪ **Solar thermal plants (using troughs)**: 4 USD/W – 9 USD/W.
2.2 International technology transfer costs	Impossible to define indicative classification levels, as it is extremely dependent on a case-to-case basis.
3.1 Stakeholders involved	▪ **Level 1** – No involvement of stakeholders either at municipal/regional or governmental levels. ▪ **Level 3** – Involvement of stakeholders at municipal and/or regional level in the project. ▪ **Level 5** – Involvement of governmental level stakeholders in the project.
3.2 IPR protection	▪ **Level 1** – No contribution of the project to the enhancement of IPR protection levels in the host country. ▪ **Level 3** – Moderate contribution of the project to the enhancement of IPR protection levels in the host country. ▪ **Level 5** – High contribution of the project to the enhancement of IPR protection levels in the host country.
4.1 Economic benefits to local communities	▪ **Level 1** – No economic benefits accrued to local populations with the implementation of the project. ▪ **Level 3** – Moderate economic benefits accrued to local populations with the implementation of the project. ▪ **Level 5** – High economic benefits accrued to local populations with the implementation of the project.
4.2 Social benefits to local communities	▪ **Level 1** – No social benefits accrued to local populations with the implementation of the project. ▪ **Level 3** – Moderate social benefits accrued to local populations with the implementation of the project. ▪ **Level 5** – High social benefits accrued to local populations with the implementation of the project.
4.3 Environmental benefits to local communities	▪ **Level 1** – No environmental benefits accrued to local populations with the implementation of the project. ▪ **Level 3** – Moderate environmental benefits accrued to local populations with the implementation of the project. ▪ **Level 5** – High environmental benefits accrued to local populations with the implementation of the project.

Source: Own elaboration.

Two final remarks should be made. First, the case studies can be selected using one of the sampling strategies proposed by Neergaard (2007). And second, this benchmarking approach might be used as a tool to analyze data in the scope of a grounded theory research project.

[7] The indication of investment figures for these technologies will be justified afterwards in Chapter 5, which presents the case studies related to the CDM's reality in China.

Table 4.4 – Key performance indicators to evaluate mechanisms to transfer ESTs

Focus areas	Key performance indicator	Perspective		Performance level (Investor) (scale: 1 to 5)		Performance level (Host economy) (scale: 1 to 5)		Deviation: A-B (+/-)		Corrective measures / Improvement Opportunities
		Investor	**Host economy**	**Real (A)**	**Est. (B)**	**Real (A)**	**Est. (B)**	**Investor**	**Host economy**	
1. Capacity building	1.1 Type of technology transferred (QUALI)	**X**	**X**							
	1.2 Maturity of the technology transferred (QUALI)	**X**	**X**							
	1.3 Transfer of complementary non-technological capabilities (QUALI)	**X**	**X**							
	1.4 Knowledge spillovers into the host economy (QUALI)	**X**	**X**							
2. Investment and operational costs	2.1 Total annual investment (QUANTI)	**X**				**N/A**	**N/A**		**N/A**	
	2.2 International technology transfer costs (QUANTI)	**X**				**N/A**	**N/A**		**N/A**	
3. Enabling environment	3.1 Stakeholders involved (QUALI)		**X**	**N/A**	**N/A**			**N/A**		
	3.2 IPR protection (QUALI)	**X**				**N/A**	**N/A**		**N/A**	
4. Sustainable development	4.1 Economic benefits to local communities (QUALI)		**X**	**N/A**	**N/A**					
	4.2 Social benefits to local communities (QUALI)		**X**	**N/A**	**N/A**			**N/A**		
	4.3 Environmental benefits to local communities (QUALI)		**X**	**N/A**	**N/A**			**N/A**		

Source: Own elaboration. Legend: Quantitative indicator (QUANTI); Qualitative indicator (QUALI); and Non Applicable (N/A).

4.5 Conclusion

Benchmarking is the process of incessantly searching for the best methods or practices, and either adopting or adapting their good features in order to achieve excellence.

Benchmarking is a versatile tool and can be applied to several contexts. The most frequent areas or modalities of benchmarking include strategic, process, competitive, generic, internal and external benchmarking.

The process of conducting or performing a benchmarking study can encompass many stages, and the methodologies proposed by Camp (1989), Raposo *et al.* (2006), Silva *et al.* (2008) and Bain & Company (2009) provide valuable insights on how this process can be undertaken.

The benchmarking framework we have proposed in this chapter is aimed at assessing the performance of international technology transfer mechanisms of ESTs, with a particular emphasis on CDM projects. In order to do so, four main areas of focus have been identified – capacity building, investment and operational costs, enabling environment and sustainable development – and they pertain to key aspects upon which the successful transfer of ESTs should be examined. These areas are assessed by means of a set of key performance indicators and, to each of these KPIs, a target or best practice score should be identified so that comparative analyses can be performed. Moreover, this benchmarking approach was set-up so that it can incorporate the perspectives of both the host economy and the investor.

This benchmarking methodology was designed to be used on a case study basis, but it can also be applied to a set of studies illustrative of a broader reality if they share a set of common characteristics. For the selection of case studies, the sampling strategies proposed by Neergaard (2007) can provide useful guidelines. Moreover, we consider that the case studies selected and the conclusions drawn from a benchmarking study can also be used in the scope of a grounded theory research project.

The next chapter will provide a practical illustration of this benchmarking methodology applied to the recent Chinese experience with climate friendly technologies.

Chapter 5 – Case Studies: Benchmarking approach applied to the Chinese reality

5.1 Introduction

Now that we have a tool to evaluate the performance of mechanisms that lead to the transfer of ESTs, the main goal of this chapter is to empirically test our benchmarking proposal by using a set of selected case studies related to the Chinese reality.

Our empirical study is focused on China and this is due to three chief motivations. First, China has undertaken the US as the world's largest emitter of carbon dioxide (World Watch Institute, 2009). Second, Chinese policy makers have been increasingly aware of the unsustainable path that the country is undergoing, and have been directing their efforts in order to address this shortcoming. Measures include the implementation of an ambitious energy efficiency programme and the political willingness to promote the transfer of ESTs from developed countries into China (EU - China CDM Facilitation Project, 2009). And third, China is one of the countries with the highest number of CDM projects implemented so far (Schneider *et al.*, 2008, UNFCCC, 2009b).

In the second section of this chapter, we examine how different are these projects in terms of the results delivered for technology transfer purposes and conclude if it is possible to cluster them as adequate representatives of the wider CDM phenomenon in China. For this purpose we first propose the criteria used for selecting the case studies, a procedure which also includes a brief overview of the legal and regulatory framework shaping the development of CDM projects in China. Then we provide a brief description of the cases selected and the research method used for this purpose. And finally, the benchmarking scorecard proposed in Chapter 4 is used to characterize and evaluate each of these cases.

In the third section we consider alternative technology transfer mechanisms of ESTs other than the CDM. For this purpose, and in a similar vein to section two, here we select four case studies that illustrate non-CDM technology transfer mechanisms. We analyze them in light of our benchmarking tool with the main goal of assessing, under a comparative basis, their performance as mechanisms for the transfer of ESTs. The findings are then compared with those of the CDM case studies.

The fourth section presents a synthesis of the findings from sections two and three, and the main goal here is to draw conclusions from the contrasting experiences of CDM and non-CDM case-studies. Lastly, the fourth section concludes and provides implications from the benchmarking analysis.

5.2 Benchmarking analysis of CDM projects

China was a relatively latecomer in regard to its CDM policy, defining a first draft in 2004 and adopting a final version of it as late as November 2005 (Lütken and Michaelowa, 2008). The Chinese CDM set-up has some noteworthy features, some of them without parallel in many other CDM host countries. In this regard, two essential aspects should be underscored. First, the obligation of all Chinese CDM projects to have a minimum of 51% Chinese ownership stake. And second, the existence of a minimum purchase price for the CERs generated by the project activity (IGES, 2009). This is to protect project owners from price dictations imposed by foreign buyers of CERs (Schroeder, 2009).

In addition to this, other aspects specific to the Chinese CDM regulatory framework should be mentioned. For instance, in article 4 of the “Measures for Operation and Management of CDM Projects in China” (the law defining China’s internal CDM policy) priority areas for developing CDM projects are defined, and they are the following: (i) energy efficiency improvement; (ii) development and utilization of new and renewable energies; and (iii) methane recovery and utilization. In article 10, it is stipulated that CDM project activities should promote the transfer of ESTs to China. In article 16, the role played by the Designated National Authority is assigned to the National Development and Reform Commission (NDRC). And finally, according to article 24 the Chinese government is entitled to a certain percentage (by means of a levy) of the CERs generated by the project activity (CCChina, 2009). In the case it is a priority area or a forestation project, the government’s levy is just 2%. In the case of HFC and N_2O projects, the levy charged is 65% and 30%, respectively.

As it can be easily assessed in the paragraphs below, it is necessary to be aware of the fundamentals of China’s CDM framework in order to select the case studies for our analysis. For this purpose, we have significantly drawn from Neergaard (2007)’s guidelines for sampling procedures in entrepreneurial settings, which were previously outlined in section 4.3.

Based on Neergaard (2007)’s recommendations, a crucial step is to choose an adequate sampling strategy in order to select relevant case studies. As the main aim of our analysis in this section is to assess whether a set of CDM projects in China share a set of common characteristics, the strategy pursued is to look for “typical” cases, that is, cases that illustrate what is normal or average. Four criteria were adopted in the selection process of the case studies: (1) small-scale projects, in accordance with the CDM rules; (2) projects already registered by the CDM Executive Board; (3) projects in the sector of renewable energies; and (4) projects where some sort of foreign participation can be identified.

In regard to criterion 1, and according to our literature review in the scope of Chapter 1, in general, small international entrepreneurs do not possess the resources of larger companies, that is, they usually face a ‘liability of smallness’ when building a presence in a new foreign market. Reminding the reader that international entrepreneurship is one of the founding theories of the present dissertation, we consider that this kind of players are more likely to take part in small-scale CDM project activities as a modality of foreign entry into China. According to the CDM Rulebook, small-scale projects are those that fall into either one of the following categories: (i) they pertain to renewable energy projects with a maximum output capacity of 15 MW; (ii) they are energy efficiency improvement projects leading to the reduction of energy consumption up to 60 GWh per year; and (iii) they are projects leading to the reduction of GHG emissions up to 60.000 ton of CO_2 equivalent per year (CDM Rulebook, 2009). Project developers applying for small-scale CDM projects can benefit with this by, for example, using simplified baseline methodologies and contracting the same DOE to undertake validation, verification and certification activities.

The second criterion pertains to the selection of projects already registered by the CDM Executive Board. As we have seen in section 3.3, the CDM project cycle encompasses a set of steps and, before a certain project activity can be physically implemented, it has to be approved or registered by the CDM Executive Board. Due to this fact, we consider it more likely that a certain project will be *de facto* implemented and lead to the transfer of some sort of environmentally sound technology after it has been registered, and this aspect was taken into consideration in the selection of our case studies.

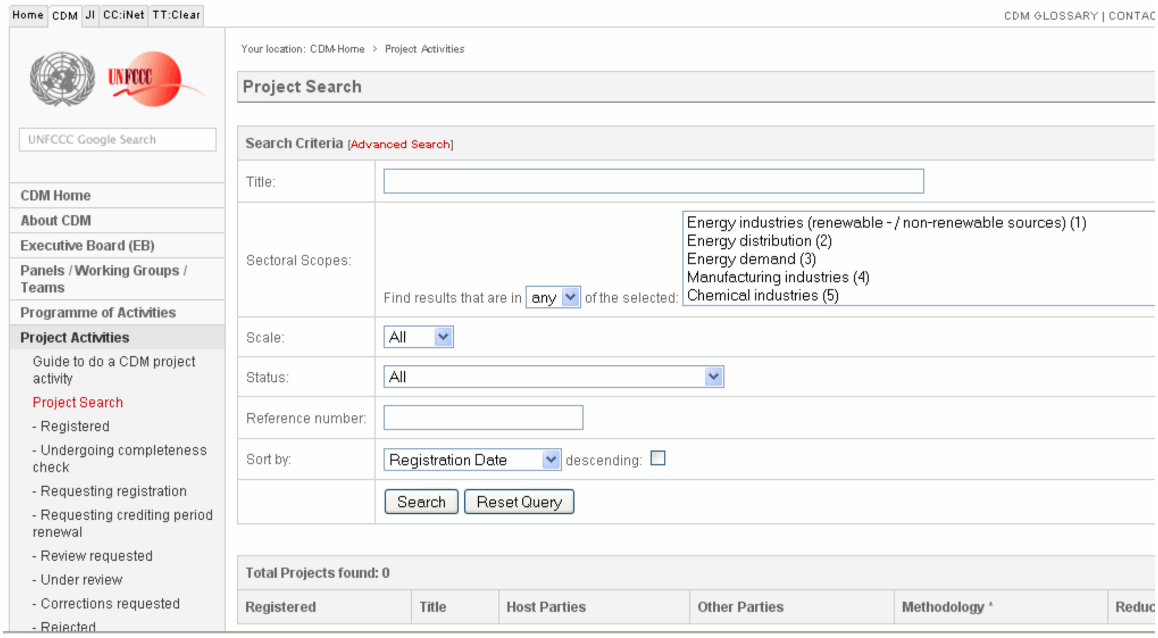
The third criterion pertains to the choice of projects in the area of renewable energies. This is due to the fact that, as we have seen above, this is one of the priority areas of CDM project development defined by public policy makers in China.

The fourth criterion has to do with the existence of some sort of foreign involvement in the selected CDM project activity, a piece of information which is indicated in the PDD of the project. Only the projects where there is some sort of foreign participation have been considered eligible to be included in our sample of case studies.

Adding to these criteria, and for the purpose of our analysis, we have also taken into consideration three complementary aspects for the case study selection: (i) mode of entry into the Chinese market by the foreign participant; (ii) share of FDI in the CDM project; and (iii) type of technology transfer contract established between the foreign and domestic parties involved in the project. Although the access to such data was not considered as criterion for project selection, we considered it relevant to have it in order to better perform the benchmarking approach. However, for the CDM projects selected below, most of this information was not possible to obtain due to confidentiality issues.

The research for projects was undertaken using the Project Search database available from the CDM official website. The layout of this research engine is presented below in figure 5.1.

Figure 5.1 –The research engine on CDM projects available from the official CDM website



Source: UNFCCC CDM, 2009e.

For the purpose of our investigation, this database was extensively researched for the period of one week (from the 10th to the 17th May 2009) using the following filters: the sectoral scope selected was “Energy Industries (renewable-/non-renewable sources)”; the scale of the project selected was “Small”; the status of the project selected was “Registered”; and the results were sorted out by “Host Country”, in order to better identify the projects located in China. All other fields were left blank.

According to Neergaard (2007), an aspect to take into consideration in such type of research is the dimension of the sample to be extracted. In line with this author, who considers this issue a matter of personal judgment, in our approach we deemed it adequate to extract a sample of four CDM projects as case studies because they correspond to some of the most widespread renewable energy technologies worldwide, that is: wind energy, hydro power, biomass and solar energy (REN21, 2008). As previously noted, one of our goals is to assess whether these projects share a set of common characteristics, which will allow us to decide if it is acceptable to generalize the sample as representative of a larger universe of CDM projects in China (within the renewable energy category). The other goal – the main one – is to assess the contribution of these projects to the international transfer of ESTs into China.

From the set of results obtained from the database using these filters, the selected projects are displayed in Table 5.1 below. For each of them we provide the correspondent title, reference number within the CDM database, underlying renewable energy technology and brief description of the project activity.

Table 5.1 – Selected CDM projects

Title and Project Number	Technology Used	Description
Changling Wind Power Project (Project #0771)	Wind Power	The project proposes to install and operate a wind farm in the Jilin Province (China). The project consists of 11 Gamesa G58 wind turbines of 850 kW nominal capacity, for a total installed capacity of 9.35 MW.
China Shangbao Small Hydropower Project (Project #1376)	Small Hydro	Located in the Hunan Province (China), the project is a run-of–river power production facility with a power generation capacity of 14.1 MW.
Hubei Eco-Farming Biogas Project Phase I (Project #2221)	Biomass	The project proposes to build and put into operation in rural communities located in the province of Hubei a set of biogas digesters utilizing pig manure as energy source. The biogas produced will be used as thermal energy to replace the coal currently used to meet the households' daily energy needs for domestic use.
Federal Intertrade Pengyang Solar Cooker Project (Project #2307)	Solar Power	Located in the dry region of Ningxia in Northwestern China, the project proposes to install 17.000 solar cookers for poor rural households. The project will enable the rural residents to substitute coal for renewable solar energy for their domestic heating needs.

Source: Own elaboration, with data collected from UNFCCC CDM (2009a, 2009b, 2009c and 2009d).

In addition to the information provided in the previous Table 5.1, it is noteworthy to mention that in none of these case studies has the respective project company received the direct financing of a non-Chinese entity. They are unilateral projects (Michaelowa, 2007) in the sense that a Chinese entity develops, implements and finances the project on its own, with all equity originating from the host country. As the purchasers of the CERs generated by the respective project activity, the participation of foreign stakeholders is hence significantly reduced. In Table 5.2 below we provide an overview of the capital structure of the firms participating in these projects, as well as the foreign entities involved with them.

Table 5.2 – Selected CDM projects – Capital Structure and Foreign Involvement

Project	Capital Structure	Foreign Involvement
Changling Wind Power Project	▪ 40% Equity (provided by the project owner, Jilin Wind Power Stockholding Co. Ltd). ▪ 60% Debt.	▪ Climate Change Capital Carbon Fund, from the UK, is participating in the project as the sole authorized buyer of the CERs generated by the project.
China Shangbao Small Hydropower Project	▪ 30% Equity (provided by the project owner, Guangdong	▪ Carbon Asset Management Sweden AB is participating in the project as the sole

	Shaoneng Group Co. Ltd). ▪ 70% Debt (to be provided by a local bank).	authorized buyer of the CERs generated by the project.
Hubei Eco-Farming Biogas Project Phase I	▪ Farmers involved in the projects (66.17%). ▪ World Bank loan (16.85%). ▪ Government subsidies (16.54%).	▪ The International Bank for Reconstruction and Development participates in the project as trustee of the Community Development Carbon Fund.
Federal Intertrade Pengyang Solar Cooker Project	▪ 100% Equity (provided by the project owner, Ningxia Federal Intertrade Company).	▪ The CERs generated by the project are to be purchased by the Government of the Netherlands, through Swiss Re Global Markets Limited.

Source: Own elaboration, with data collected from UNFCCC CDM (2009a, 2009b, 2009c and 2009d).

The data used to evaluate these projects were collected from the official CDM database, with the main document of analysis being the PDD. This is in line with other studies evaluating the transfer of ESTs from CDM projects, which have only based on the analysis of the PDD to assess the project's contribution to technology transfer (see for example Dechezleprêtre *et al.*, 2008).

For the purpose of our analysis we have used a simplified version of the benchmarking scorecard presented in Chapter 4. In this respect, it should be noted that we have merged the perspectives of both the investor and the host economy into a single one, and that we have omitted the "Corrective Measures" column. Instead of this last item, we provide an overall assessment of the case studies in the end of this section. In addition to this, and due to the fact that this is still an exploratory study without par in the literature, we did not have and/or assign any benchmark target to the case studies under analysis, a procedure which is in tandem with the recommendations found in Raposo *et al.* (2006). Due to this, the column "Deviation" was also omitted from our original benchmarking scorecard. Last but not least, we have also included the *rationale* for the KPI's classification for each case study.

The benchmarking assessment for each of these four case studies is presented in Tables A.1, A.2, A.3 and A.4 of the Appendix. Due to the dimensions of these tables, they are presented in the Attachments section, which follows the Bibliography.

From our assessment, we can conclude that the only project where some sort of international technology transfer occurs is the Changling Wind Power Project. However, it should be noted that its contribution to technology transfer is somewhat indirect, in the sense it is using a foreign owned technology which is locally manufactured. In the three other projects, the technology used is domestically available and there is no need for foreign-owned and/or foreign-produced technology. Such findings should not constitute a surprise, as the Chinese regulatory framework requires that renewable energy technologies used in domestic installations are produced with a 70% locally-sourced content (Schroeder, 2009).

In the KPIs assessing the contribution of the project to capacity building, the wind power case study is the one that best ranks among the case studies analyzed. Not only does it contribute to the transfer of an international technology in terms of explicit knowledge (although indirectly), but it also provides specific training to the local staff involved in the project. Furthermore, some sort of knowledge spillovers are expected into the local economy by raising awareness among Chinese manufacturers about the specific features of the wind turbine used in the project, which is specially designed for low mean wind speeds.

A common characteristic among the four case studies applied to CDM projects is their scant contribution to the improvement of the host economies' enabling environment. This can be explained, to a large extent, by the generalized lack of involvement of participants at either municipal or governmental level in the development of these projects. It should be noted nonetheless that the Hubei Biogas and the Solar Cooker projects are expected to make some contribution (although modest) to the improvement of the local enabling environment, due to their close collaboration with municipal energy agencies during their implementation and operation phases.

In respect to the investment costs associated with the projects (KPI 2.1), if we take into consideration the indicative values presented in table 4.3, we can conclude that we have obtained distinct results. Starting with the Changling wind power case study, we conclude that the investment figures are within the indicative thresholds for onshore wind presented in table 4.3. The result is different in regard to the hydro power's capital expenditures, which are fairly above the indicative benchmark. In regard to the biogas and solar cooker projects, we face extreme situations. While in the former the investment figures are significantly above the benchmark (3125 USD/kWth against an indicative figure of 23 USD/kWth), in the latter we verify the opposite situation: an investment of 80 USD/kW against an indicative figure of 4000-9000 USD/kW.

For the biogas project this can be explained by the fact that the value indicated in table 4.3 for the combustion of biomass for heat purposes is based on large-scale production facilities. As this CDM project is quite different in scope and dimension, the indicative value we determined might not be the most adequate to assess the performance of the project in respect to this KPI. The same *rationale* applies to the solar-cooker project, although the conclusion is the opposite. In this case, the investment figures for solar thermal plants using troughs might not be an adequate technology benchmark for the solar-cooker technology applied in this CDM project.

In regard to the sustainable development indicators (KPIs 4.1, 4.2 and 4.3) the performance levels of the four CDM case studies are, in general, quite satisfactory. From these cases, the contribution of the Hubei biogas project to sustainable development should be underscored, most in particular for the high environmental benefits delivered to the local communities. On the other hand, the least significant in terms of sustainable development commitments is the hydro-power project, with a fairly limited contribution to the economic welfare of the local communities impacted by the project.

All in all, we can conclude that there are several points in common among the case studies related to CDM projects under analysis, by making use of the current benchmarking proposal. However, an obvious difference should be noted: while with the wind power project it is expected the international transfer of technologies (although indirectly) and significant contributions to capacity building, the other three projects do not reveal such characteristics. Due to this fact, we do not deem it correct to cluster these case studies together as representative of the wider CDM reality in China for renewable energy projects.

5.3 Benchmarking analysis of non-CDM case-studies

In Chapter 3 we have argued for the need of designing a tool to compare different technology transfer mechanisms for the transfer of ESTs. Indeed, the benchmarking framework we proposed in Chapter 4 is specifically aimed at performing such task, although it can also be used to benchmark CDM projects on a case-to-case basis, as we have seen in section 5.2.

One of the conclusions drawn from the section above is that it is difficult to extract a sample of CDM projects in China in the area of renewable energy that are representative of the global CDM phenomenon in China in respect to technology transfer issues. Due to this fact, conclusions about the CDM's contribution to technology transfer have to be drawn on a case-to-case basis (although, many small-hydro power projects using the CDM share significant similarities among themselves).

Taking this into consideration, in this section we propose to analyze four non-CDM projects leading to the transfer of ESTs within the renewable energy sector. For the selection of relevant case studies, we first checked Table 3.2 (where we present a taxonomy of the most relevant transfer mechanisms for ESTs) in order to identify alternative ITT mechanisms. From this set of options, we have undertaken extensive research in order to find an array of projects that could be placed on a comparable level with the CDM case studies analyzed in the previous section 5.2. Most specifically, the projects selected would have to be related to renewable energy technologies, have some sort of foreign involvement, and be implemented in China.

The first case study was chosen from the Global Environmental Facility (GEF) database, and this was due to three main reasons. Firstly, because the GEF has been acknowledged as one of the most relevant mechanisms for the international transfer of ESTs (see, for example, IPCC, 2001); secondly, China is the country in the world obtaining more support from the GEF (Heggelund *et al.*, 2005); and thirdly, the GEF has one of the few public-available repositories of information about climate-friendly projects.

The project selected is named “Passive Solar Heating for Rural Health Clinics in China”, and it is jointly implemented by the GEF and the World Bank. Its overarching goal is to improve the energy efficiency and environmental friendliness of health facilities located at township level. The project aims to demonstrate and promote energy efficient passive solar health clinic designs and to encourage the adoption of these designs in the construction of all new public buildings in rural China (GEF Online, 2009). In short, the chief objective of the project is to develop the Chinese domestic capacity to design and construct these energy-efficient passive solar buildings.

The project encompasses five main stages: (i) design and technical assistance, where an international passive solar consultant will work with local teams of architectural consultants; (ii) passive solar health clinic construction, whereupon the standard approaches developed in stage 1 will be implemented in 30 demonstration health clinics; (iii) monitoring and evaluation of the project; (iv) promotion and training, whereupon the experience gained with the project will be disseminated for the rapid adoption of the passive solar designs to other public buildings; and (v) capacity building for architects, engineers, officials and administrators, including workshops for preparing local trainers. Strictly speaking, passive solar design is not a renewable energy technology. Rather, it is an architectural design and a building technique which performs a similar function to renewable energy, in that it reduces the use of conventional fossil fuels.

The project is directly related to the World Bank Health VIII project, which is working in close cooperation with the Government of China with the goals of improving health service delivery and ensuring basic health services for the Chinese rural population. The project we analyze is to be implemented on three Chinese provinces – Qinghai, Gansu and Shanxi – and it should also be seen against GEF’s past experience of assistance to China in renewable energy development, which has been primarily focused on photovoltaic power and on utility level programs (GEF Online, 2009).

The three other case studies pertain to private sector technology transfer mechanisms (please check Table 3.2). Their identification and selection was based on extensive research in the following databases: the Energy Technology Data Exchange World Energy Base (ETDEWEB, 2009); RenewableEnergyWorld.com (2009); and EnergyCentral.com (2009).

The first of these private-sector led case studies depicts the investments of Vestas – a Danish-based company which is the world leader in wind power technology – in China. Vestas decided to move into China in year 2005, and the company currently has six factories in the country, a sales office in Beijing and a procurement office in Shanghai. In regard to its technological capabilities in China, Vestas’ overarching goal is to improve its Chinese sourcing capabilities, aiming at having turbines manufactured with 100 per cent Chinese-made components. Four years after starting its direct investment in China, the company now counts with a workforce of 1800 people there (Focus Communication, 2009; Vestas, 2009).

The second case study describes a licensing agreement established between an Australian and a Chinese company for the transfer of an environmentally friendly technology. The Australian firm is Wasabi Energy, which has a 70% ownership stake over Global Geothermal Ltd., the company which owns the technology to be licensed. The Chinese company is Shanghai Shenghe New Energy Resources Science and Technology Co. Ltd., and it is a developer of waste heat, geothermal and solar thermal power plants in China. The technology licensed is called “Kalina Cycle technology”, which is considered one of the most efficient methods of converting sub 200ºC heat into electricity. The owners of the technology have granted an exclusive license of 15 years for the utilization of this technology in the Chinese market. The technology will be used in a set of demonstration projects, which are expected to include waste heat power plants in a cement factory, a solar thermal power plant and a geothermal power plant (Wasabi, 2009).

The last case study is focused on the Chinese experience of Novozymes, a Danish company which is engaged in the production of enzymes for bio-fuel production. This company has been present in the Chinese market since the mid-1990s and, in addition to the main goal of increasing its sales and profitability in this market, Novozymes has also concentrated in R&D efforts in the country. In respect to the latter issue, Novozymes involvement can be split into three layers of activities: (i) R&D within its own facilities; (ii) collaboration with some Chinese research laboratories; and (iii) collaboration with local companies for the implementation of technologies originally developed by Novozymes. Technology transfers might occur through each of these layers of activities. It should be underscored that, at present, Novozymes has an exclusive agreement with a large Chinese company in the agriculture and food sector, COFCO, for the Chinese market of second generation biofuels. Under this agreement, COFCO has built a pilot plant in the province of Harbin, whereupon some of Novozymes’ staff is implementing the enzymes that are being developed in the company’s R&D center in Beijing. This agreement with COPCO also foresees the sharing of IPR owned by Novozymes under normal commercial conditions (Delman and Chen, 2008; Novozymes, 2009).

In Tables A.5, A.6, A.7 and A.8 of the Appendix, these non-CDM case studies are assessed using our benchmarking scorecard. For the sake of convenience, these tables are also presented in the attachments section.

Starting with the GEF project, the main benefits delivered are within the area of capacity building, an aspect which comes to no surprise, as this is one of the main goals envisioned by the project. If we compare the benefits expected with this project with the CDM case study on solar cookers, we can conclude that the differences are considerable in what concerns capacity building.

Another aspect to underscore about this project is the involvement of a multitude of stakeholders across all development stages, both at municipal and governmental level. In this case, the standard design is expected to be disseminated into other provinces and implemented in all new government-financed buildings throughout China. At a later stage, the enforcement by law of this standard design could be seen as the corollary of this project's influence in shaping the host country's enabling environment. The sustainable development benefits delivered by the project are also quite positive and they are in tandem with the outcomes expected with the CDM case studies.

The second case study – Vestas involvement in China – is an example of FDI as a technology transfer mechanism. From this case we can conclude on the moderate contribution of Vestas' presence in China to technology transfers into the host country, which can be summarized in terms of explicit knowledge (e.g. quality standards for component production by local suppliers) and knowledge spillovers into the domestic wind power industry. In this case, concerns over IPR have hindered Vestas to share more of its technological know-how with Chinese stakeholders, which is reflected on the company's decision of placing its R&D units in other countries.

The third case study, involving Wasabi Energy and a Chinese company, presents a typical licensing agreement leading to the international transfer of technologies which is established on a pure arm's length basis. Technology transfer does occur, but few complementary benefits accrue with the transfer process in the short run, namely in what concerns the sustainable development needs of local populations and the improvement of the host country enabling environment.

Arising as a somewhat contrasting experience with Vestas, the fourth case study illustrates how FDI can significantly contribute to the enhancement of a country's technological capacity. In the case of Novozymes, the decision of establishing a R&D unit in China was quintessential for this purpose, with technologies being transferred to and from the country due to the integration of this unit into Novozymes' global R&D system. In this context, other technology transfers might occur, namely in the scope of Novozymes collaboration with the Chinese company COFCO, although in this situation such transfers are expected to occur on pure commercial terms.

All in all, we can conclude on the different results delivered by these non-CDM case studies to the international transfer of ESTs. One common point should, however, be mentioned: their limited contribution to the improvement of IPR protection in the host country. In this respect, the conclusions achieved are in tandem with the four CDM case studies analyzed in the previous section.

5.4 Comparative Benchmarking: CDM Projects vs. non-CDM Case Studies

The goal of this section is to make a brief comparative analysis between the two types of projects analyzed in the previous sections 5.2. and 5.3, that is, CDM vs. non-CDM projects. We have seen that each category of projects may significantly differ within themselves, and this was the motivation why we did not deem it correct to cluster them into a set of projects sharing the same characteristics. Notwithstanding this finding, we seek to draw some conclusions on the main benefits in terms of technology transfer accrued by each category of project, as well as the potential impacts on the entrepreneurial dynamics of the host economy.

For addressing this aim, in Table 5.3 presented below, each case-study is characterized in respect to a set of aspects. They are the following: (i) mode of foreign entry, (ii) type of foreign participation; (iii) type of technology transfer; (iv) regulation barriers to ITT; (v) impacts on the entrepreneurial dynamics of the host country; and (vi) sustainable development benefits delivered to host economies. The same table provides a comparative summary of the findings related to the case studies presented in the two previous sections.

A common pattern revealed by the CDM case-studies is their unilateral dimension, meaning that the projects are fully financed by a Chinese entity and also that it is not verified any type of market entry into the Chinese market by the foreign participant in the project. The consequence is that there is a reduced scope for the international transfer of technologies into China through these projects, and only in the Changling wind power project it is expected some sort of technology transfer, although in an “indirect” way. The main constraints hindering a more effective transfer of international technologies and the stimulation of international entrepreneurs into China can be pointed out to the domestic CDM framework and the locally-sourced content requirements for installations utilizing ESTs in China.

Although the non-CDM case-studies analyzed are quite diverse among each other, we found that they are more likely to effectively contribute to the international transfer of technologies than the CDM projects. To a considerable extent this can be explained by the fact that they are not hindered by the constraints posed by the Chinese internal CDM framework. Furthermore, in the case of the GEF sponsored project, the involvement of several governmental stakeholders can be considered as an effective way of promoting efficacy at the level of the technology transfer process. However, the local content requirements and the poor enforcement of IPR protection in China (Levy, 2007), are significant barriers to more accomplished international technology transfers and inward FDI into China. Also of note is the impact of Vestas and Novozymes presence in China to the entrepreneurial dynamics of the host economy, with the former raising awareness among local suppliers for the benefits of wind power technology, and with the latter potentially contributing to the arousal of spin-offs from their R&D activities.

Table 5.3 – CDM vs Non-CDM case-studies: a comparative summary

Project	Mode of Foreign Entry	Type of Foreign Participation	Type of technology transferred	Regulation Barriers to ITT	Impacts on the host country entrepreneurial dynamic	Sustainable Development Benefits
Changling Wind Power Project	▪ No-foreign entry	▪ Off-take of the CERs generated by the project activity	▪ Explicit knowledge transferred (indirectly)	▪ Locally-sourced content requirement; ▪ CDM internal framework.	▪ Knowledge spillovers expected into the host economy.	▪ Moderate sustainable development benefits delivered.
China Shangbao Small Hydropower Project	▪ No-foreign entry	▪ Off-take of the CERs generated by the project activity	▪ No technologies transferred	▪ Locally-sourced content requirement; ▪ CDM internal framework.	▪ Undetermined.	▪ Low / moderate sustainable development benefits delivered.
Hubei Eco-Farming Biogas Project Phase I	▪ No-foreign entry	▪ Off-take of the CERs generated by the project activity	▪ No technologies transferred	▪ Locally-sourced content requirement; ▪ CDM internal framework.	▪ Undetermined.	▪ High sustainable development benefits delivered.
Federal Pengyang Solar Cooker Project	▪ No-foreign entry	▪ Off-take of the CERs generated by the project activity	▪ No technologies transferred	▪ Locally-sourced content requirement; ▪ CDM internal framework.	▪ Undetermined.	▪ High sustainable development benefits delivered.
Passive Solar Heating for Rural Health Clinics	▪ No-foreign entry	▪ Projects finance through an international fund (GEF) ▪ Foreign consultants contributing with know-how and experience	▪ Explicit and implicit knowledge transferred	▪ No regulation barriers reported, as the project involved many governmental stakeholders.	▪ Undetermined; however the impacts are not expected to be high, as the project is expected to improve an energy efficiency standard to be implemented in new buildings.	▪ High sustainable development benefits delivered.
Vestas Foreign Direct Investment in China	▪ FDI	▪ Wholly-owned subsidiaries and facilities in China	▪ Essentially, transfers in the form of explicit knowledge	▪ Locally-sourced content requirement; ▪ Low IPR protection in China.	▪ Strong knowledge spillovers into the host economy, raising awareness for wind power technology among local players (e.g. Sinovel and Goldwind) and, indirectly, stimulating their growth.	▪ High sustainable development benefits delivered.
Licensing agreement for technology transfer	▪ No-foreign entry	▪ Arm's length agreement for the transfer of a technology	▪ Essentially, transfers in terms of explicit knowledge	▪ Not reported.	▪ Undetermined.	▪ Low sustainable development benefits delivered.
Novozymes Foreign Direct Investment in China	▪ FDI	▪ Wholly-owned subsidiaries and facilities in China	▪ Transfers in the form of explicit knowledge, with scope for implicit knowledge transfers too	▪ Low IPR protection in China.	▪ Stimulation of Chinese R&D labs to develop new technological solutions; ▪ Potential arousal of spin-offs from Novozymes R&D activities in China.	▪ Low / moderate sustainable development benefits delivered.

Source: Own elaboration

5.5 Conclusion

This chapter aimed to apply the benchmarking methodology proposed in Chapter 4 to a set of case studies and conclude on their contribution to the international transfer of ESTs into China. We started with the analysis of four CDM case studies leading to the implementation of different renewable energy technologies in China. We concluded about the unevenness of these CDM projects in terms of their contribution to the international transfer of ESTs.

Despite the dimension of the sample extracted, which might be considered small given the incidence of CDM project development in China, it has uncovered to us that the contribution of CDM projects to technology transfer in China can be quite limited. This can be justified by the Chinese regulatory framework for CDM projects, which encourages the development of unilateral projects, that is, a situation upon which host country companies develop CDM projects on their own with limited or no foreign participation. Although not directly associated with the internal CDM framework, another aspect helps to explain our findings. This consists on the local content requirement of 70% for renewable energy equipment which, in conjunction with the poor IPR situation in China, hampers the technology transfer the CDM was supposed to deliver.

The benchmarking methodology was also applied to four non-CDM case-studies in order to contrast the CDM projects with experiences outside the CDM framework. In parallel with the CDM projects analyzed, we also obtained different results for these projects across the four benchmarking assessment areas. However, three remarks deserve to be highlighted. First, FDI can be an effective mechanism for the transfer of ESTs, as the Novozymes and Vestas experiences confirm. Second, this one drawn from the GEF project, the involvement of governmental and municipal stakeholders in the host country is likely to improve the country's technological capacity and the enhancement of the enabling environment. And third, private sector technology transfers are less likely to bring sustainable development benefits to local populations (at least in the short run), an aspect which is more salient if we compare such finding with our CDM case studies.

All in all, we conclude that international investments into China made outside the CDM framework are more likely to lead to the transfer of ESTs. As uncovered by our case-studies, the technology transfer benefits delivered by the CDM projects can be considered quite modest and, as such, China cannot rely on this mechanism in order to ensure its technological catch-up in climate friendly technologies. Moreover it should be underscored that the CDM, as a public policy mechanism designed to stimulate international entrepreneurs to bring their technologies into the developing world, is failing on its goal of attracting international entrepreneurs into China, as it is evident on the profusion of unilaterally-financed projects. Consequently, there is a more reduced scope for the international transfer of technologies. In this line of reasoning, if the transfer of ESTs is to be successfully achieved in China without changing the internal CDM framework, alternative mechanisms to the CDM will have to be encouraged and adopted.

Chapter 6 – Concluding remarks and implications

This study has been an attempt to conceptualize the CDM as an international technology transfer mechanism and as a public-policy tool designed to stimulate international entrepreneurs to bring innovations and technologies into developing countries.

The contribution of this dissertation to the literature on entrepreneurship is three-fold: (i) analysis of the CDM in the framework of International Entrepreneurship and Technology Transfer theories; (ii) proposal of a benchmarking scorecard for evaluating the performance of ITT mechanisms in climate friendly technologies; and (iii) evaluation of the contribution of small-scale CDM projects to the international transfer of technologies into China.

The central research question of this dissertation was to assess how does the CDM perform as an international transfer mechanism for environmentally sound technologies. To address this question, a benchmarking approach was designed and applied to the CDM reality in China. For a sample of case studies within renewable energy technologies in this country, we concluded on the limited contribution of CDM projects in terms of international technology transfers.

The benchmarking approach was also applied to a set of non-CDM case studies: one GEF/World Bank project, and three private-sector activities in China where some sort of technology transfer was involved. In all these case studies we concluded on the existence of technology transfers into China, although the contribution of the private-sector cases to the sustainable development needs of local populations was relatively limited, mainly if compared with the results delivered by the CDM projects analyzed.

In regard to the implications of this study to policy makers, it should be noted the inadequacy of the Chinese legal framework to stimulate the investment of small international entrepreneurs into China through the CDM. Most in particular, these players are likely to feel deterred with the obligation of relying on a Chinese partner for venture control, and may also feel discouraged with the prospects of paying a minimum purchase price for the CERs generated by the project. As such, if Chinese policy makers are willing to encourage foreign investment into China through CDM projects and, indirectly, stimulate the transfer of ESTs, they should consider reforming the internal CDM framework on these aspects. The same applies for the legal requirement of renewable energy equipment having to be sourced with at least 70% locally produced content, although this is not directly related to the CDM framework.

In terms of implications for managers and practitioners – that is, small international entrepreneurs considering investing in CDM projects in China – they should take into consideration the extent to which venture control is an important factor. If this is deemed as a critical issue, then other countries should be analyzed as alternatives for the project in question, specifically those with a relatively stable and predictable business environment, such as Brazil, Mexico or India.

Some limitations can be pointed out to this investigation, namely in respect to the benchmarking approach proposed. One aspect pertains to the difficulties in determining the benchmark targets or the best practices for the key performance indicators (KPIs) in order to evaluate selected case studies. This is most evident in the qualitative KPIs, whose determination is somewhat subjective, relying considerably on the project proponent's judgment. These difficulties are extensive to the quantitative KPIs as well, mainly when the case study under evaluation differs significantly from past or current experience. Due to these difficulties, we opted not to assign any benchmark targets to our empirical approach, but the results obtained can be used as such in further research to be developed in the emerging field on international energy entrepreneurship.

Another potential limitation stems on having the PDD as the major source of information for the benchmarking analysis. In fact, the data extracted from the PDD is *ex-ante* information, that is, it pertains to information prior to the project's *de facto* implementation. This is linked to another drawback and/or potential limitation in the practical application of this benchmarking scorecard, which is the difficulty in finding complementary public available information to support the analyses undertaken.

For future research, several guidelines are proposed. It would be interesting to analyze other climate friendly projects, most in particular CDM, in order to evaluate their contribution to the protection of IPR in the host country. Although this aspect was scrutinized in the Chinese case studies selected in the scope of this investigation, further applied research is needed in order to expand knowledge about the impact of energy entrepreneurship on the economic growth of the host economies, especially, in the context of emergent economies.

Also related to IPR, another avenue of research is to investigate to what extent IPR is a barrier to the transfer of environmentally sound technologies. Such research should take into account the role played by the individual – the entrepreneur – as a core agent of change in terms of entrepreneurial dynamics and international business, as well as to examine the relevance of such issues in CDM projects involving some sort of international technology transfer.

Finally, under a comparative and regional framework, examples of topics that deserve further research include the comparative analysis between the CDM realities of other countries, namely Brazil, India and Mexico, the study of the incidence of unilateral CDM in large-scale projects in China, and the analysis of the viability for creating an internal carbon market in China the outlook of a post-Kyoto architecture.

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Appendix

Table A.1 – Benchmarking Assessment for the Changling Wind Power Project

Key performance indicator	Performance level measured (1 to 5)	*Rationale*
1.1 Type of technology transferred	**3**	The project is expected to lead to the installation of 11 Gamesa G58 wind power turbines. Although this is not mentioned in the PDD, these turbines are manufactured in the Chinese facilities of Gamesa, a Spanish technology provider. That is, the technology is foreign-owned, but locally produced. This is in tandem with the Chinese regulatory framework, which requires that wind power plants have 70% of locally manufactured content. As such, we can consider that this project is indirectly contributing to the international transfer of technologies. Such technology is transferred into China in the form of explicit knowledge to Gamesa's production facilities.
1.2 Maturity of the technology transferred	**3**	Despite being a mature technology, this turbine design is still relatively new for China, as only one wind park in the country had been built using this equipment.
1.3 Transfer of complementary non-technological capabilities	**3**	This project is expected to significantly enhance local experience with the development and operation of wind power on a commercial scale, including other capabilities not necessarily related with the technology, such as the management of an intermittent source of energy (wind power) and electricity trading. In addition to this, a "package" of technology transfer activities is also included, such as training for operation and maintenance.
1.4 Knowledge spillovers into the host economy	**3**	The project uses a wind turbine specifically designed for a low mean wind speed. This technology is still a novelty in China, so in the case the project is successfully put into operation it is likely that, at least, there is a growing awareness among Chinese stakeholders about the benefits of deploying such technology. This may encourage local companies to develop models with the same capabilities and characteristics of the Gamesa G58 turbine.
2.1 Total investment	**1446 USD/kW**	▪ Total investment = 106.8 Million Chinese RMB ▪ Total capacity = 9.35 MW ▪ 1 Chinese RMB = 0.12661 USD (at 20 Oct. 2006, the date the PDD was submitted) ▪ Investment per kW installed = 1446 USD/kW
2.2 International technology transfer costs	**6.32 Million USD**	▪ Cost of acquiring the foreign equipment: 49.94 Million Chinese RMB, which equates to 6.32 Million USD (using the same conversion rate as indicated above).
3.1 Stakeholders involved	**1**	The local government was consulted in the 'stakeholders' comments' section of the PDD, however it was not involved at any stage of the project development.
3.2 IPR protection	**1**	No contribution of the project to the enhancement of IPR protection.

4.1 Economic benefits to local communities	**2**	Enhancement of the tourism potential of the locations near the wind farm.
4.2 Social benefits to local communities	**3**	Local employment creation during the construction and operation phases of the wind farm.
4.3 Environmental benefits to local communities	**3**	Reduction of local air pollution, by replacing coal with clean renewable energy generation.

Source: Own elaboration, with data collected from UNFCCC CDM (2009a); Windfair (2009). Source for the exchange rate: www.oanda.com.

Table A.2 – Benchmarking Assessment for the China Shangbao Small Hydropower Project

Key performance indicator	Performance level measured (1 to 5)	*Rationale*
1.1 Type of technology transferred	**1**	No technology is transferred from other countries in the scope of this project.
1.2 Maturity of the technology transferred	**1**	No technology is transferred from other countries in the scope of this project.
1.3 Transfer of complementary non-technological capabilities	**3**	The project owner is expected to provide specific training to a set of project participants in areas such as quality control, management rules and knowledge about CDM.
1.4 Knowledge spillovers into the host economy	**1**	No knowledge spillovers are expected with this project.
2.1 Total investment	**1840 USD/kW**	▪ Total investment = 196.13 Million Chinese RMB ▪ Total capacity = 14.1 MW ▪ 1 Chinese RMB = 0.13231 USD (at 28 Aug. 2007, the date the PDD was submitted) ▪ Investment per kW installed = 1840 USD/kW
2.2 International technology transfer costs	**N/A**	▪ N/A
3.1 Stakeholders involved	**1**	The local government was consulted in the 'stakeholders' comments' section of the PDD, and it showed entire support for this CDM project. However it was not involved at any stage of the project development.

3.2 IPR protection	**1**	No contribution of the project to the enhancement of IPR protection.
4.1 Economic benefits to local communities	**1**	Any significant economic benefits accrue to local communities with this project.
4.2 Social benefits to local communities	**3**	Local employment creation during the construction and operation phases of the power plant, reducing the amount of workers migrating to urban area in search for work. Improved reliability of electricity supply in the project area.
4.3 Environmental benefits to local communities	**3**	Reduction of local air pollution (not only CO_2, but also SO_2 and NO_x) by replacing coal with clean renewable energy generation.

Source: Own elaboration, with data collected from UNFCCC CDM (2009b). Source for the exchange rate: www.oanda.com.

Legend: N/A = Non-available.

Table A.3 – Benchmarking Assessment for the Hubei Eco-Farming Biogas Project Phase I.

Key performance indicator	**Performance level measured (1 to 5)**	***Rationale***
1.1 Type of technology transferred	**1**	No technology is transferred from other countries in the scope of this project.
1.2 Maturity of the technology transferred	**1**	No technology is transferred from other countries in the scope of this project.
1.3 Transfer of complementary non-technological capabilities	**3**	Establishment of Project Management Offices (PMO) at county level in order to monitor and ensure the well-functioning of the project according to certain standards.
1.4 Knowledge spillovers into the host economy	**1**	No knowledge spillovers into the host economy are expected with this project.
2.1 Total investment	**3125 USD/kWth**	▪ Total investment = 25 Million USD ▪ Thermal energy production capacity for the bundled project = 8 MWth ▪ Investment per kWth installed = 3125 USD/kWth
2.2 International technology transfer costs	**N/A**	▪ N/A
3.1 Stakeholders involved	**2**	The project company is working in close cooperation with the local government rural energy agencies in order to provide technical services to households, supervise and monitor the project.

3.2 IPR protection	**1**	No contribution of the project to the enhancement of IPR protection.
4.1 Economic benefits to local communities	**3**	The project will reduce expenditure needs for households in terms of energy consumption (i.e. coal).
4.2 Social benefits to local communities	**3**	Local employment creation during the installation, operation, and maintenance of biogas digesters.
4.3 Environmental benefits to local communities	**5**	The project will replace traditional coal stoves by installing biogas burners, significantly reducing indoor air pollution. In addition, it will improve manure management practices, reducing ground and surface water contamination.

Source: Own elaboration, with data collected from UNFCCC CDM (2009c).

Legend: N/A = Non-available.

Table A.4 – Benchmarking Assessment for the Federal Intertrade Pengyang Solar Cooker Project.

Key performance indicator	Performance level measured (1 to 5)	***Rationale***
1.1 Type of technology transferred	**1**	All equipments used in the project are domestically produced; therefore no technology is transferred from other countries in the scope of this project.
1.2 Maturity of the technology transferred	**1**	All equipments used in the project are domestically produced; therefore no technology is transferred from other countries in the scope of this project.
1.3 Transfer of complementary non-technological capabilities	**2**	The monitoring methodology foreseen in the PDD is expected to contribute with the transfer of some non-technological capabilities.
1.4 Knowledge spillovers into the host economy	**3**	The project is intended to serve as a model for future projects using the same concept. As the technology and experience acquired from the project are expected to be transferred to future projects, knowledge spillovers are expected into the host economy.
2.1 Total investment	**80 USD/kW**	▪ Total investment = 7.23 Million Chinese RMB ▪ Total capacity = 13.1 MW ▪ 1 Chinese RMB = 0.14631 USD (at 3 Mar. 2009, the date the PDD was submitted) ▪ Investment per kW installed = 80 USD/kW
2.2 International technology transfer costs	**N/A**	▪ N/A

3.1 Stakeholders involved	**3**	The project company is working in close cooperation with the local government rural energy agencies in order to successfully contribute to the implementation of the project.
3.2 IPR protection	**1**	No contribution of the project to the enhancement of IPR protection.
4.1 Economic benefits to local communities	**3**	The project will reduce expenditure needs for households in energy (i.e. coal).
4.2 Social benefits to local communities	**3**	Improving of living conditions of rural households.
4.3 Environmental benefits to local communities	**4**	The project will replace traditional coal stoves by installing solar cookers, significantly reducing indoor air pollution.

Source: Own elaboration, with data collected from UNFCCC CDM (2009d). Source for the exchange rate: www.oanda.com.

Legend: N/A = Non-available.

Table A.5 – Benchmarking Assessment for the Passive Solar Health Clinic Project in China

Key performance indicator	Performance level measured (1 to 5)	*Rationale*
1.1 Type of technology transferred	**4**	In the design and technical assistance stage of the project, an international passive solar consultant is expected to work with three local Chinese teams in order to develop a range of standard passive solar design prototypes for the provinces targeted in the project. To a large extent, explicit knowledge about the technology is expected to be transferred and, to a lesser extent, some degree of implicit knowledge is also expected to be transmitted in the process. Several computerized passive solar design tools are available to assist the design teams, one case in point being the US Department of Energy passive solar design tool "Energy 10".
1.2 Maturity of the technology transferred	**3**	The technology to be transferred is already existent in several Western countries, and it is at a mature stage of evolution. However, this technology will be adapted to the local needs and, for this purpose, a specific standard design will be developed by the working teams and customized to the characteristics of local health clinics.
1.3 Transfer of complementary non-technological capabilities	**2**	The process of knowledge transfer is only expected to target aspects directly associated with the technological component of the project. However, the methodologies in the monitoring and evaluation of the project, as well as the training procedures, are expected to deliver to the local teams involved some non-technological capabilities.

1.4 Knowledge spillovers into the host economy	**4**	The knowledge and experience gained with the project are expected to be documented and disseminated into other counties not initially covered by the programme. In addition, efforts will also be made to encourage the application of the technology to other public buildings (e.g., secondary schools, other institutional and community buildings).
2.1 Total investment	**1.58 Million USD**	This is a capacity building project, with a total investment of 1.58 Million USD. The expenses incurred with this project only pertain to the enhancement on in-country capacity and do not include the construction of the demonstration clinics.
2.2 International technology transfer costs	**0.55 Million USD**	Costs directly related with the international technology transfer process: 0.55 Million USD, which include personnel, training, equipment, travel and evaluation missions.
3.1 Stakeholders involved	**5**	Stakeholders involved include the Chinese Ministry of Health, the Chinese Foreign Loan Office; the China Ministry of Finance; provincial and county health bureaus; township health clinics' workers; and the local government.
3.2 IPR protection	**1**	No contribution of the project to the enhancement of IPR protection.
4.1 Economic benefits to local communities	**4**	Decreased need for expenses on coal, which is expensive due to the unavailability of this resource in local areas. Improvement of the energy efficiency of the township health clinics. The main implication is that more money will be available for patient care.
4.2 Social benefits to local communities	**3**	Improved health care facilities, with enhanced conditions for the treatment of diseases in local health clinics.
4.3 Environmental benefits to local communities	**4**	Reduction of indoor air pollution, by replacing the burning of coal by the heat produced from the solar panels in the new building designs. Reduction of CO_2 emissions, as well as other pollutants such as NO_x and SO_2.

Source: Own elaboration, with data collected from GEF Online (2009).

Legend: N/A = Non-available.

Table A.6 – Benchmarking Assessment for Vestas' FDI in China

Key performance indicator	Performance level measured (1 to 5)	*Rationale*
1.1 Type of technology transferred	**3**	In general, Vestas' presence in China has moderately led to technology transfers. Its strategy in the country has stemmed on developing its technologies elsewhere, but assigning to local suppliers the manufacture of the majority of turbine components. That is, while the technology is owned by the company and protected by IPR, Chinese companies contribute with labour and materials to the manufacture of components. Due to this fact, we consider Vestas' major contribution in terms of technology transfer to China consists on the transmission of some level of explicit knowledge essential for local suppliers and the assemblage of the components, such as quality control and performance standards (e.g. the implementation of programmes such as the 6-Sigma and LEAN production principles). This should also be seen in light of the Chinese regulatory framework, which requires all wind turbines installed in the country to be sourced with at least 70% of locally produced content.
1.2 Maturity of the technology transferred	**3**	The technologies transferred to China are at a mature stage. Indeed, Vestas has made the strategic decision of concentrating its R&D activities in other countries rather than China, namely Denmark, Singapore, India, the US and the UK.
1.3 Transfer of complementary non-technological capabilities	**3**	Vestas is committed to share its 30 years of experience and expertise in wind energy with China. This goes beyond the transfer of knowledge intrinsically related to its technologies, and includes counselling on issues such as grid integration, turbine sitting, and human resource development.
1.4 Knowledge spillovers into the host economy	**4**	Knowledge spillovers brought by Vestas' presence in China can be described as both direct and indirect. Direct in the sense that the placement of Vestas factories in China have stirred Chinese suppliers to deliver turbine components with the high quality standards required by Vestas. Moreover, it has been reported the migration of employees trained by Vestas to local competitors, increasing their competitive edge. Indirect spillovers are gained in the sense that the presence of the world's leading wind turbine manufacturer has raised domestic awareness on the need to develop wind turbine technology, stimulating the rise of Chinese manufacturers.
2.1 Total investment	**$363 Million USD**	Vestas has been increasing its investments in China during the last few years. In March 2009, the company announced it would invest another $90 million USD, with a total of $363 million USD invested so far.
2.2 International technology transfer costs	**N/A**	Not Possible to quantify.
3.1 Stakeholders involved	**2**	There has been some involvement with governmental and municipal stakeholders since Vestas' entrance in China as a foreign direct investor, but no direct participation of such stakeholders in project implementation and/or follow-up activities.
3.2 IPR protection	**1**	The case illustrated does not contribute to the enhancement of IPR protection in China.

4.1 Economic benefits to local communities	**5**	Direct economic benefits, resulting from the development of local companies that supply turbine components to Vestas' facilities.
4.2 Social benefits to local communities	**4**	Local employment generation in the communities where Vestas' facilities are placed, requiring a relatively high degree of professional qualification by the workforce employed.
4.3 Environmental benefits to local communities	**1**	Marginal environmental benefits accrued to the local communities where Vestas' facilities are installed.

Source: Own elaboration, with data collected from Focus Communication (2009); Enorth (2009); Vestas (2006, 2009); Lewis (2006, 2008).

Legend: N/A = Non-available.

Table A.7 – Benchmarking Assessment for the licensing of the Kalina Cycle Technology to Shanghai Shenghe New Energy Resources Science and Technology Co.

Key performance indicator	Performance level measured (1 to 5)	*Rationale*
1.1 Type of technology transferred	**3**	The technology transferred in the scope of this licensing agreement is, essentially, in terms of explicit knowledge. However, some sort of implicit technology is also expected to be transferred, as a six month training programme is foreseen in addition to the transfer of the technical details.
1.2 Maturity of the technology transferred	**3**	The technology transferred is at a mature stage, and it resulted from 18 years of R&D efforts.
1.3 Transfer of complementary non-technological capabilities	**1**	No non-technological capabilities are expected to be transferred under the licensing agreement established between the Chinese and Australian companies.
1.4 Knowledge spillovers into the host economy	**1**	The agreement for the licensing of the technology will not lead to any knowledge spillover into the host economy. However, at a later stage, when the technology is implemented in a set of demonstration projects, knowledge spillovers might occur.
2.1 Total investment	**-**	The technology will be used in four demonstration plants in China, and the total investment has not been quantified and/or disclosed yet.
2.2 International technology transfer costs	**2 Million USD**	The total amount paid by the Chinese company to obtain an exclusive license for the technology in its domestic market is 2 million USD. In addition to this, the owner of the technology will receive royalties based on the installed capacity of Kalina Cycle plants constructed in China for the life of the license (15 years).
3.1 Stakeholders involved	**1**	Any governmental or municipal stakeholders have been involved in the technology transfer process.

3.2 IPR protection	**1**	No contribution of the project to the enhancement of IPR protection.
4.1 Economic benefits to local communities	**1**	No immediate and/or direct economic benefits are delivered to local communities with the technology transfer process. That might occur at a later stage, when the technology is implemented in demonstration projects.
4.2 Social benefits to local communities	**1**	No immediate and/or direct social benefits are delivered to local communities with the technology transfer process. That might occur at a later stage, when the technology is implemented in demonstration projects.
4.3 Environmental benefits to local communities	**1**	No immediate and/or direct environmental benefits are delivered to local communities with the technology transfer process. That might occur at a later stage, when the technology is implemented in demonstration projects.

Source: Own elaboration, with data collected from Wasabi (2009) and ASX (2009).

Table A.8 – Benchmarking Assessment for the Novozymes investment in China

Key performance indicator	Performance level measured (1 to 5)	*Rationale*
1.1 Type of technology transferred	**5**	Novozymes possesses a R&D unit in Beijing, which counts with a team of 60 scientists. This R&D unit is integrated into the global Novozymes R&D system, and technology transfers might occur in both ways. Most of the technology should be in the form of explicit knowledge, but there is also wide scope for implicit knowledge transfers. In the scope of the Novozymes' collaboration with COFCO, the bulk of technology to be transferred is expected to be in terms of explicit knowledge, such transfer being regulated by an IPR sharing agreement. As Novozymes and COFCO are working together in this demonstration project, some degree of implicit knowledge can also be expected to be transferred.
1.2 Maturity of the technology transferred	**5**	Given the high level of interconnectedness between the Chinese R&D unit and the global Novozymes R&D system, it is expectable that vertical technology transfers might occur in the Chinese market. Vertical technology transfers are also expected to occur in the in the scope of the Novozymes' collaboration with COFCO. Indeed, enzymes developed in the Novozymes' Beijing R&D unit are being tested in the Harbin's COFCO facility, which is a demonstration plant. As such, it is reasonable to expect that technologies can be transferred directly from R&D to the commercialization stage.
1.3 Transfer of complementary non-technological capabilities	**1**	In general, non-technological capabilities are not expected to be transferred in the scope of Novzymes involvement in the Chinese market.

1.4 Knowledge spillovers into the host economy	**3**	There is some scope for knowledge spillovers into the local communities of researchers in the pilot project being developed in Harbin province, as Chinese scientists have been invited to study the technologies being implemented there.
2.1 Total investment	**-**	Data unavailable.
2.2 International technology transfer costs	**-**	Data unavailable.
3.1 Stakeholders involved	**1**	No municipal or governmental level stakeholders involved in the technology transfer process.
3.2 IPR protection	**1**	No contribution to the enhancement of IPR protection in the host country.
4.1 Economic benefits to local communities	**1**	No immediate and/or direct economic benefits are delivered to local communities with the technology transfer process. That might occur at a later stage, when the technology is implemented in a project-to-project basis.
4.2 Social benefits to local communities	**3**	Employment opportunities to high-qualified Chinese resources. Further benefits of this kind might occur at a later stage, when the technology is implemented in a project-to-project basis.
4.3 Environmental benefits to local communities	**1**	No immediate and/or direct environmental benefits are delivered to local communities with the technology transfer process. That might occur at a later stage, when the technology is implemented in a project-to-project basis.

Source: Own elaboration, with data collected from Delman and Chen (2008), Chinese Stock (2008) and Novozymes (2009)