Profiting from Environmental Economic Regulations: The Mediating Role of Innovation Capabilities

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Abstract--**Literature is concerned on whether environmental economic regulations hamper or incentivize firm performance, aside from their objectives of pollutant reductions. This paper adds to the discussion the inclusion of the effects of innovation capabilities on performance when a firm confronts environmental economic regulations, which impose limits to the products, processes or services, which are pollutant intensive.**

It is proposed here that in the presence of the innovative capabilities, the firm has the capacity to assimilate and respond to the environmental economic regulation, increasing its performance, and thus the notion of regulations boosting firm performance through such innovativeness dimension. On the other hand, in the absence of the innovative capability, the firm does not have the capacity to either assimilate or respond to the environmental economic regulation, being hampered by it, thus the notion of regulations decreasing firm performance.

This study uses the Kyoto Protocol Clean Development Mechanism (CDM) projects as the strategic response of firms to changes in regulation, using the UNEP Risoe Centre's CDM projects database. 1,497 CDM projects were analyzed using econometric analysis, finding quantitative support to the effects of innovation capabilities on the performance of firms confronting environmental economic regulations.

I. INTRODUCTION

There is an ongoing debate on whether environmental economic regulations fulfill their objective of reducing harmful practices on society, without imposing negative effects on firms. Some researchers and practitioners provide evidence in favor of environmental economic regulations fulfilling their goal while increasing firm performance ([1],[2],[3]). However, there are other groups that provide evidence against environmental economic regulations as performance drivers ([4],[5]). This paper takes on this debate and tries to clarify it by providing evidence of the relationship between environmental economic regulations and firm performance.

It is proposed here that the reason for these "mixed results" is the exclusion of the innovation dimension on the analysis of firm responses to these regulations. These signals from the environment come in the form of technological change as environmental economic regulations impose limits to the products, processes or services that are pollutant intensive, or provide pollutant reduction technologies. Therefore the capacity that firms must possess in order to respond to these signals from the environment must be technology related. This study states that the innovative capability allows firms to respond to these signals from the environment, by adopting new technologies that can improve their performance, in comparison to firms that adopt older technologies.

Scholars such as [6] have addressed the innovative capabilities from a resource-based perspective, and then by including the effect of the constantly changing environment ([7],[8]), innovation is addressed through the dynamic capabilities perspective. To address environmental economic regulations this paper will reach out to Clena Development mechanism part of the Kyoto Protocol. The clean development mechanism (CDM) is targeted at firms located in countries that are members of the Kyoto protocol but have no reduction commitments ([9]). The clean development mechanism provides firms with pollutant reduction technologies that allow them to transform their pollutants into less harmful emissions, these technologies differ in their degree of innovativeness, and each project chooses which technology it will be implementing. Therefore in the presence of an environmental economic regulation, if the firm possesses an innovative capability it will achieve a positive performance, thus the positive effect of environmental economic regulations on firms. However if there were not to have an innovative capability, the firm will not be able to respond to the economic regulation, thus giving place to the traditional perception that economic regulations hamper firm performance ([1]).

Here the innovative capability is operationalized as innovativeness. This study uses the UNEP Risoe Centre's CDM projects database, which is the repository of al CDM-related data. 1,497 CDM were left available after several data validation tests were performed. OLS analysis is used to test the effect of innovativeness on firm performance. Additionally control variables are included to account for possible exogenous determinants of firm performance.

Quantitative support is provided to the positive effects of innovativeness on firm performance in CDM projects. Therefore under an environment set by environmental economic regulations, CDM projects where the levels of innovativeness are higher tend to have a better firm performance, compared to other CDM projects with lower levels of innovativeness. Finally some limitations to this research and further research lines are presented.

II. THEORETICAL APPROACH

A. Environmental Economic Regulation

Environmental economic regulations (EER) refer to all practices aimed at reducing pollutants, enforced by economic means ([10]). These practices differ from recycling, low-

carbon intensity practices, and renewable energies, as these latter practices are aimed at directly reducing pollutant emission, while environmental economic regulations are practices that enforce the use of practices aimed at indirectly reducing pollutant emissions ([11]). Economic regulations enforce practices that fall under what [12] termed environmental technology, which includes hardware (equipment, instrumentation, and manufacturing process) and operating methods (recycling and production design) that can both create market demand and lower costs while preventing pollution. Therefore environmental economic regulations or EER can be regarded as practices that incentivize the reduction of pollutant emissions, while environmental regulations can be regarded as the practices that reduce pollutant emissions. The purpose of making this distinction is to separate what pertains to the area of engineering, to what pertains to the area of business.

B. The Kyoto Protocol and the Clean Development Mechanism.

This research will use as the operationalization of an environmental economic regulation the Clean Development Mechanism (CDM), which is part of an international agreement for reducing greenhouse gas (GHG) emissions: the Kyoto protocol. The Kyoto Protocol is a voluntary agreement for countries to reduce their GHG emissions that involves the use of environmental investment strategies to reduce GHG emissions at the country and firm level. Under this Protocol there are three mechanisms that can help to achieve this emissions reduction: emissions trading (ET), joint implementation (JI) for Annex I countries, and the clean development mechanism (CDM) for non-Annex I ones. The ET mechanisms work at the country level, while the JI and CDM work at the firm and project level and are very similar to each other ([13]). These mechanisms yield carbon credits, which can be used for trading and to obtain investment for the host project. Specifically, they are called assigned amount units (AAU, for the ET), emissions reductions units (ERU, for the JI), and certified emissions reductions (CER, for the CDM) ([9]).

The CDM provides the means for a firm located in a member country of the so called annex I list of the Kyoto Protocol (countries who have reduction commitments), that needs to meet its GHG reduction commitment to buy certified emissions reductions from a non-annex I country firm (countries that can engage in CDM projects but do not have reduction commitments) by investing in environmentally sustainable projects that yield CER'S ([9]). The JI provides the means for a firm located in a member country of the so called Annex I list, that needs to meet its GHG reduction commitment to buy emission reduction units from another Annex I firm. The projects can bring benefits to the host firm, such as revenues ([14],[15]), newer technology ([16]), and issue carbon bonds to the buyer to fulfill its environmental commitments.

It has been proven that both the JI and CDM projects can bring benefits to firms such as economic rents ([14],[15]) and inward technology transfers ([16]). This is the main driver for increasing the inward flows of technology and knowledge in CDM and JI projects ([16]). Additionally a source for CDM capacity is if the firm has previous experience in foreign direct investment (FDI) inflow deals, this is because the CDM works as a source for financial resources as it grants loans to the owner firms, which is somewhat similar to FDI ([17]).

On the relationship between environmental economic regulations and firm performance, [18] found that GHG reductions cause firms to increase their financial performance. In a similar manner [19] found that firms participating on The Chicago Climate Exchange obtained a better financial performance compared to non-participant firms. In the opposite direction, [20] found that stringent water regulations have a negative effect on firm's profitability, as a tighter regulation tend to increase cost for firms. However, later ([21]) found that the Clean Water Act Regulation (a type of EER) has a positive effect both in the short and long run on firm financial performance. This later change on the slope of the effect of EER on firm performance they ascribe to firms having the opportunity to respond in an innovative way to the regulations (for the case of the long run). These reasons provide evidence on the claim of this research that the innovative capability is sometimes necessary for firms to assimilate and respond to EER, and that its presence can turn a potential negative effect of EER on firm performance into a positive effect.

This research is concerned with the performance of a CDM project, therefore a measure of performance must be provided. The UNEP Risoe Centre is the repository for all data regarding CDM projects. It contains a database with all the information regarding each approved project. This database is called the CDM Pipeline. Along all these data there are two particular variables that can serve as a proxy for performance. First there is the efficiency rate of a project which is the ratio from the expected number of CER's that a project should yield, and the real number of CER's that a project yields. This number provides a real-empirical assessment of the performance of a project, and its capacity to fully utilize the methodology of selection. Secondly the revenues of the project reflect the monetary gains or losses. Although this number does not appear directly in the data base, it can be calculated from the number of CER's obtained in each project times the monetary value of the CER at the time of issuance, minus the investment of the project, which is also in the data base.

C. Innovative Capability

This research adopts the dynamic capability perspective when approaching the innovative capability, as they explain how firms integrate, build, and reconfigure internal and external competencies to address changing environments ([22],[23],[24]). Innovative capability is the firm's ability to

develop new products or services, through innovative behaviors and processes ([25]). This capability uses innovation as a means to make changes to or adopt technology, services or processes. This implies that when a firm uses dynamic capabilities in the form of innovative capability, it uses it to respond to changes in the environment or imposed by regulations. Innovative capability refers to the use of existing resources and capabilities to overcome barriers in the environment such as new products by competitors, decaying technologies, or direct regulations aimed at their products, process or technologies. With these arguments by [23] and [24] is how the innovative capability used in this research is placed under the resource-based-dynamic-capabilities approach, that is, the technology is the resource that suffers changes in the form of innovation in response to changes in the environment.

Some scholars have identified the innovation capability as the most important determinant of firm performance ([26],[27]). There are many studies that have identified the innovative capability as a dynamic capability ([28],[29],[30],[25]). [31] studied how product innovation leads to organizational renewal over time, and this could be considered to be a dynamic capability. [32] identified the innovative capability as a type of dynamic capabilities. They found that substantial investments in innovative capability are the primary engine for wealth creation, rather than the control of physical assets.

[33] stress that the innovative capability of firms is important to provide and sustain its competitive advantage, and in the implementation of its entire strategy. [34] mentions that innovative capability is dynamic in the way that it involves interaction between a firm's internal knowledge and signals from the exterior. [35] state that the innovative capability of a firm is highly contingent upon the level and the types of resources and other competences that the firm possesses. This argument made by [35] follows the logic used in this research to choose the resource-based approach to innovative capability used in the dynamic capabilities approach.

[23] disaggregates dynamic capabilities the capacity to sense and shape opportunities and threats, the capacity to seize opportunities, and the capacity to maintain competitiveness through enhancing, combining, protecting, and reconfiguring the firm's tangible and intangible assets. It is of particular interest for this research the capacity to sense opportunities and threats, as well as the capacity to enhance and reconfigure firm's assets, because these capabilities are, in the words of [23], the "micro-foundations" enclosed in the innovative capability, as the innovative capability is the capability to sense and respond to signals from the environment aimed at the technology level.

The definition that best fits the purposes of this research is the one provided by [36] that defines innovative capability as applying appropriate process technologies to produce new products, develop and adopt new technologies, and respond to unexpected opportunities. This research expands the definition of [36] by including the "unexpected opportunities" as the external pressures supplied by the environmental economic regulations. Rather than just considering the creation of new products as the sole or emerging function of innovative capabilities, an emphasis is made on the definition by [36] on the adoption of new technologies, services and process that reduce the pollution intensity of a firm, which is what allow firms to assimilate and respond to the signals from the environment.

With the previous arguments, innovativeness is used in this research as the operationalization of innovative capability at the variable level. Innovativeness relates to a firm's capability to engage in innovations ([37]), and reflects a firm's tendency to engage in and support new ideas, novelty, experimentation and creative processes that may result in new products, services, or technological processes ([38]). In the review of the CDM, each of the projects uses an approved methodology, and these methodologies differ from one another in their degree of innovativeness. By degree of innovativeness it is referred to how innovative a CDM approved methodology is, and therefore the innovative capability of a project, will be regarded by the position of the methodology, in the CDM approved methodologies ranking.

In this research, projects in which a firm engages, are considered as a proxy of how innovative a firm is. In order to measure how innovative a project is *vis a vis* other projects, we base this research on the type of technology of each project. For each project it can be chosen from 197 different technologies, information is available for these projects on the version of the project (the more versions on a project, the more changing it is, thus more innovative) and on the potential for HFC´s abatement (the more HFC´s it can reduce from a given source the more advanced and sophisticated the technology is, thus more innovative) with this information an index is composed which is used to rank the projects from the most innovative to the least innovative. Therefore, if a project uses a highly innovative project, it is considered here that in order to undergo with such project it must possesses high innovative capabilities. Information is available on which type of technology each of the observations on the sample use, therefore, being able to establish a value for innovative capability of each observation.

For firm performance, initially we proposed two ways for measuring performance, first the data base provided an efficiency rate measure for each of the projects. This measure was composed from the expected vs. the real HFC´s mitigation, providing the information as percentage. This measure was discarded because all of the models where it was included were not statistically significant. The other measures for performance are the revenues of the project. Information is available on the initial investment in all of the observed projects, as well on the gains from the sale of the CER (certified emission reductions – the carbon bonds used for trading inside the Kyoto Protocol). Thus here we propose that the revenues obtained for each project are a reflection of

how good they were at reducing HFC´s at the lower cost, via their innovative capability.

III. HYPOTHESIS: CLARIFYING THE HAMPERING OR ENHANCING EFFECT OF REGULATION

What is proposed here is that the innovative capability involved in a CDM project determines, by mediation, the performance of such project. Above, the construct of innovative capability was brought to the variable level and regarded as the innovativeness of the CDM project. The construct of performance is regarded as the CDM project performance at the level of alternative variables.

A. Development of the Hypothesis

Innovative capability is operationalized into innovativeness in terms of variables, which in turn are defined as a firm's capability to engage in innovations ([37]), and reflects a firm's tendency to engage in and support new ideas, novelty, experimentation and creative processes that may result in new products, services, or technological processes ([38]). Performance is operationalized into CDM project performance also in term of alternative variables. [39] analyzed the effects of the innovative capabilities on performance in pharmaceutical and biotechnological R&D organizations. They found that the innovative capability is a minor contributor to firm performance, in the long term. [40] found that the innovative capability has a significant effect on performance among high technology start-ups. It is proposed here that at higher levels of innovativeness, a firm possesses greater capacity to engage in CDM projects, that is, the firm is more capable of making use of its innovative capability. This gives place to hypothesis 1 as follows: *An increase in the innovativeness of the CDM technology involved in a project will increase the CDM own project performance.*

IV. DESIGN METHODOLOGY AND APPROACH

The population to whom this research is addressed is all firms that engage in CDM mechanism projects. Taking part in CDM projects imply several things, first it means that the firm is from one of the non-annex I countries in the Kyoto protocol, second, it implies that the firm is being subject to environmental economic regulations, and therefore it receives a signal from the environment in the form of new GHG emission reduction technologies.

A. Database and Sample

The sample was obtained from the UNEP Risoe Centre. The database holds 11,992 CDM projects. These projects can be registered, rejected/withdrawn, under review, or in validation. Out of them this research used the registered ones. Rejected/withdrawn projects are of no use since they were never started, as well as projects at validation or under review. There were 2,177 projects at validation in the data base of all cases; 2,997 projects were rejected/ withdrawn between years 2005 and 2012, and 159 projects are at the review stage which, for practical purposes, is similar to "at validation" since projects have not been started. Therefore for the analysis there are 6,659 registered projects useful for this research. Given the fact that the database has many missing values regarding the measurement of performance, the final number of observations was reduced to1,640.

B. Dependent Variable

The dependent variable of this research is CDM project performance; is measured as the ratio of the investment of the project over the revenues obtained from the sale of the CER's. This measure is better to reflect aspects such as the investment in the project, the institutional capacity, investment climate and economic activity. The higher its value, the better is performance in strategic way. The success rate was considered as an alternative dependent variable, as described above. Upon initial statistical tests, this alternative variable did not behave statistically significant in any of the alternative models, due to its bounded limits and not clear truncation. Therefore, the analysis concentrated on the variable Revenues generated by the CDM projects.

C. Independent Variable

The independent variable of this study is innovativeness which will be operationalized as how innovative a project is in terms of the complexity of the methodology it implements. CDM projects can only use approved methodologies for reducing emissions. There are 259 approved and consolidated methodologies in the CDM registries. These methodologies are ranked according to their innovativeness, relying on two aspects, their potential for GHG reductions and the number of improvements each methodology has gone through. From such 259 methodologies, 62 were not present on the CDM projects of the sample. Therefore the methodology ranking for the analysis is assessed from 1 to 197. Some projects involve a mixture of different methodologies because of the difficulties of assigning an innovative rank value to these methodologies. When such indetermination occurred, it implied that there was a lacking of value on the innovativeness variable. So 234 projects were left out to clean the sample, where an innovativeness rank was clearly measured, according to the number of projects used. To assess how innovative each methodology is, I use a rank from the least innovative to the most innovative methodology that is dependent on the institutional soundness. The characteristics selected for this sorting are the version of the methodology that is currently used, its abatement potential, and the years since its appearance to the market (the latter reflects the innovation cycle, although in somewhat non exponential form). The innovativeness, and therefore innovative capability of a project, will be operationalized as the position of the methodology, in the CDM approved methodologies ranking. The ranking is available upon request.

D. Control Variables

In this case it is assessed the effect of environmental economic regulations and institutional environment over innovation, and the data that is used to aggregate at the innovation level, therefore this research uses the most commonly used control variables for addressing this level of analysis. Control variables that are common for this kind of studies are measures or proxies for industry type, business taxes, general market conditions, and mostly market size. Therefore the proposed control variables are: the *size of the economy* which will be operationalized as the gross domestic product per capita. The information for GDP per capita is obtained from the World Bank for the year (latest date, i.e. 2007) since it was the year with more information about the GDP of the countries, and will be referred as *GDPPC*. Another control variable is the foreign direct investment which will account for the size of the economy where the project is located, and will be measured in USD, and will be referred as FDIINF. Finally another control variable worth of including is the geographic area which can account for the potential of placing large scale projects in a host country. This variable will be measured as the number of square kilometers that a host country possesses in which the CDM project is carried, and it will be referred as AREASQKM. FDI inflows of countries were obtained from the World Bank Indicators consulted on April 16, 2013. Data on the GDP/capita in US dollars was obtained from the World Bank Indicators consulted on April 16, 2013. For the data on the GDP per capita, information for South Korea, Cuba, and Iran was not available, thus leaving 23 projects out of the analysis. Data was gathered on both variables for each of the countries. From 256 countries and regions on this database, 145 were excluded from the analysis in order to use 111. There were no missing values to report for the FDI inflows, however 5 observations had negative values for their FDI inflows thus being discarded when applying logarithms to partially control for heteroskedasticity problems in the first modeling exercise. Finally for the data on the land of each country, there were not any missing values to report. Therefore the final number of observations on this data base was 1,497. However both AREASQKM and FDIINF were highly correlated with the independent variable, therefore they were left out from the analysis.

E. Econometric Analysis

Model 1 directly tests l_GDPPC with the dependent variable, the model has a relatively bad goodness of fit with a value for R^2 of 0.0657. l_GDPPC variable was statistically significant at 99%, and a value of 0.5787. Model 2 integrates the main independent variable l_INNOV to the analysis. The value for R^2 significantly increases in this model compared with the previous two, to a value of 0.2729. l_GDPPC is still significant, however its value now is 0.3463. l_INNOV is significant with a p-value lower than 0.01 and a value of 0.7644, meaning that when innovativeness is included in the model its explaining of the CDM project performance considerably increases, while being statistically significant, close to proportionately (models in logs give the parameters elasticity meanings).

TABLE 1. DEPENDENT, INDEPENDENT, AND CONTROL VARIABLES

Code	Construct	Variable	Operationalization	Abbreviation
Dependent Variable	Performance	CDM project performance	- No. of CER's Issued by Price of the CER (6 euro) Minus Project Investment	REV6
Independent	Innovative Capability	CDM Project Innovativeness	Rank of the Methodology Used in the CDM Project	INNOV
Control Variable	Economic activity of host country	FDI Inflows	FDI Inflows in Millions of USD	FDIINF
Control Variable	Size of the Economy	Gross domestic product per Capita	Millions of USD over Population	GDPPC
Control Variable	Geography of the Host Country	Geographical Area of the Host Country	Area in square KM	AREASQKM

TABLE 2. LN REVENUES AS DEPENDENT VARIABLE (OLS)

	Model 1 Control Variables	**Model 2 Independent Variable**
Intercept	1.7879***	1.2801
l_GDPPC	0.5787***	0.3463***
l_INNOV		0.7644***
R^2 Adjusted	0.0657	0.2729
F	84.66c	68.51
P-Value	<0.00	<0.00
Observations	1469	1469
Method	HC-OLS	HC-OLS

* p < .10 ** p < .05 *** p < 0.01

V. RESULTS AND DISCUSSION

When using l_REV6 as the dependent variable hypothesis 1 is confirmed. Therefore, the innovative capability is a reliable predictor of the CDM project performance. This finding holds constant for all the tested models when tested in isolation, and with control variables. These results match the findings of [1] who also demonstrate that innovativeness is a reliable predictor of performance.

The control variables used for this research was the GDP per capita of the host country (l_GDPPC). There were other two control variables: FDI inflows and area in square kilometers. However these two variables presented high multicollinearity with the independent variable, thus being selected-out from the analysis. L_GDPPC was statistically significant with p-values lower than 0.01 in all models were it was used, and with a greater weight over the dependent variable.

VI. CONTRIBUTIONS, LIMITS AND FUTURE RESEARCH

A. Contribution to Economic Environmental Regulations.

This research sheds some light on the effects that both internal and external determinants of performance have on firms placed under economic environmental regulations. It was shown how the innovativeness of a CDM project which is regarded as an internal determinant of performance, is a determinant of the total effect of the EER. It is shown here how project innovativeness increases the financial performance of such projects measured as revenues are increased.

B. Contributions to the Dynamic Capabilities Perspective

This study constitutes an application of the innovative capability as a part of the dynamic capabilities perspective which has been put forward by scholars such as [28], [29], [30], [25]. It is shown here that the innovative capability has a direct and positive effect over firm performance.

Also the innovative capability had an important role in this research since it is the means that allows for assessing the firms' response to technologically-driven signals from the environment, thus facilitating the adoption of such technology, and the increase of performance. In this case the EER imposes limits to the pollutant activities that firms can perform, thus acting at the technology level, and forcing firms to a situation of adapting or be selected-out.

Another contribution is that the data sets gathered for the empirical analysis allowed for measuring innovativeness, since it was possible to establish a ranking of how innovative a technology is.

C. Contributions to Practice

The implication for managers is that they can now be more aware of the characteristics that their firms must possess in order to cope with changing environments. Therefore managers of firms located in dynamic markets, with the dynamism being created by technological change originated by regulations, must make efforts to increase the innovative capability of their firms in order to have a response to these regulations in a value creating way.

Policy makers can now be more aware of the variables which induce change on markets and try to favor them in the crafting of regulations. They now know that in order to create regulations that fulfill their objective while protecting the economic activity, they must consider the innovative capabilities of the firms that could go under such regulation.

D. Limitations

The main limitation that this research encounters is the measurement of the dependent variable. This research measures performance as the revenues obtained from each CDM project, which is composed from the project investment and the sales of CER. This measurement is not the standard for research at the project level, however it was the only measurement available that was relevant in this research.

E. Directions for Future Research

This research can be considered a first approach to clarifying the issue of mixed results in the analysis of the effects of EER on firm performance. The first way in which this research could be expanded is by extrapolating the analysis other types of EER not just the CDM from the Kyoto protocol, such as the Regional Initiative of Green House Gases and other local and regional regulations. The objective of this will be to test if the findings of this research hold for other scenarios, thus being reproducible and replicable. By looking into other scenarios it could be possible to find new measures of performance that could provide a better fit with the other variables. The second way to expand this research could be with an in-depth case study in order to find other variables besides the innovative capability which could help solve the mixed results found in the analysis of EER and firm performance.

The hypothesis proposed in this research is merely an exploratory one. The core of this research is, based on this first hypothesis, to disaggregate the effect of the innovative capability over firm performance, by considering it as an intermediary between the institutional environment (the environmental regulation) and firm performance. Also we are trying to figure out the effect of different institutional environments, and by this it is referred to different countries and economic regions. Thus, further hypothesis might go similar to: Different institutional environments will determine the extent to which CDM project innovativeness increases CDM project performance, as a mediating variable.

The origin of this research is to establish that the institutional environment (institutional conditions of the host economy such as institutional capacity, social stability, property and intellectual rights, etc.) have an effect over firm performance, and that the innovative capability is the means

that allow a firm to respond to the signals from the institutional environment in a value creating way.

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