Paper 100. The Function and the Equation of Sustainability. A dissemination of a new advancement in the evolution of sustainable development.

Mauricio V. Umaña[1], Juan J. Gibaja[2] and Elena Ochoa[3]

Deusto Business School, University of Deusto, San Sebastian, Spain.

[1]*vlady642000@gmail.com,* [2] *jjgibaja@deusto.es,* [3]*elena.ochoa@deusto.es*

This study offers an empirical test and extension of Hart´s theory "Natural-Resource-Based-View (NRBV) of the Firm" and the contribution of the sustainability strategy in the triple bottom line consistent with economic, environmental and social sustainability. The proposed model is based on the combination of the NRBV plus the time of adoption of Strategic CSR practices as independent variables and, the Octagon Model as a dependent variable permits testing the Octagon Model, which represents an index of sustainability in developing countries like the sustainable performance of the companies. The empirical study has been carried out on 106 enterprises in El Salvador, a Central American country where the literature review offers the Octagon Model and NRBV in the context of some Latin American countries. The conclusion of this paper could be carefully generalized, first of all, as "Education for Sustainable Development" at universities in South America and consequently, to the developing world. This article intends to offer three main academic contributions. Firstly, it provides considerable insight, from the empirical evidence for quantitative prototypes of the general model, of a firm's contribution to sustainability. This offers a new quantitative model for the evolution of sustainable development thinking in young engineers and future managers in large and multi-national companies, supporting the empirical research and application in universities' curricula to narrow down the research gap, since most authors have focused only on qualitative approaches. Secondly, it offers a new advance in the evolution of sustainable development literature: The Function of Sustainability. Thirdly, it offers a seminal work based on empirical data and quantitative models with regression analysis, some 18 years after the publication of "A Natural-Resource-Based View of the Firm" (Hart, 1995). The argument in the original work has become stronger, having been confirmed by empirical data that explains how the dynamic capabilities of the firm working simultaneously can solve many concerns for developing countries in the interconnected relations with people-profit-planet. Ultimately, it is an advancement for engineering education and a radical departure from education with the concept of The Equation of Sustainability. Future research can be motivated to explore important practical implications by applying this regression model in the context of developed economies.

Keywords: sustainability, strategic CSR, pollution prevention, product stewardship, clean technology, base of the pyramid.

1 Introduction

This article provides an empirical study of the proposed model in the Ph.D. research "Sustainability as a result of Strategic CSR: The case of El Salvador", which is based in part on the general theory developed by Hart (1995) and has demonstrated not only its expansion, but especially its description of how the firm can help sustainability, 18 years after its introduction. The case is El Salvador, a country with conditions representative of the developing world, due to its industrialization, influence and dominance of the Anglo-American model of the corporation and, in the year 2013, a country in which, for every 3 adults, 1 lives in United States of America denoting an influence of the Anglo-American economy in the developing world. It is visible that the effect of growth and innovation for long term capitalism (Porter & Kramer, 2011) may be true for a corporate model that integrates sustainability into business strategy if we remember that the 100 largest economies in the world are corporations, not nations (Werbach, 2009).

2 Concepts and Evolution of CSR

Discussions on the importance of CSR have gone on for more than 80 years (Ballantine 1932, Berle 1931). This analysis suggests differences in the evolution of CSR since Corporate Philanthropy, Voluntary CSR, Responsive CSR and Strategic CSR.

2.1 Corporate Philanthropy

At this stage, this is a voluntary non-binding component of the company and consists of a voluntary contribution of private resources for public purposes (Lester Salamon, 1992). Philanthropy is by definition voluntary; therefore it has received much criticism for its fuzzy efforts, disconnected from the strategy (Porter & Kramer, 2002). There have been enemies of CSR (Friedman, 1970), as well as advocates of CSR such as (Samuelson, 1971). Wang, Choi & Li (2008) conclude that the relationship between corporate philanthropy and financial performance is best captured by an inverted U-shape. From this analysis, we propose that Corporate Philanthropy is a stage of CSR disconnected of the corporate strategy. Based on this, we hypothesize that the contribution to sustainability is best captured by an inverted U-shape and that the sustainability performance is low at this stage.

2.2 Voluntary CSR

Corporate Philanthropy in literature evolves into Voluntary CSR, which reflects a continued commitment of business to behave ethically and contribute to the economic development of their employees and families, as well as community and society in general (Holme & Watts, 2000; Hediger, 2010). Jamali & Mirshak (2007) have highlighted the strategy of these issues in developing economies and the lack of empirical studies on CSR, which unfortunately has been only a voluntary process. From this analysis, we propose that Voluntary CSR is a second stage of CSR disconnected from business strategy. Based on this, we hypothesize that the contribution to sustainability is best captured by an U-inverted form at this stage and that sustainability performance is average in the industrial sector and declines over time if the firm does not advance to the stage Responsive CSR.

2.3 Responsive CSR

Voluntary CSR evolves into Responsive CSR, reflecting a reaction of the firm as a corporate act and the consequences in their shareholders (Freeman, 1984). Porter & Kramer (2006) define this stage as "good citizenship and mitigate damage arising from the activities of the company in the value chain". Based on this, we hypothesize that the contribution to sustainability is best captured by an inverted U-shape at this stage and that sustainability performance is good compared to the previous two steps and declines over time if the firm does not advance to the stage of Strategic CSR.

2.4 Strategic CSR

Strategic CSR represents an integrated business strategy in all activities of the value chain of the firm, looking at every business decision, to simultaneously contribute to maximizing long-term value for shareholders and benefits for society and the environment. Many authors have reflected on the competitive advantage of CSR (Drucker, 1984; McWilliams & Siegel, 2001). One of the first works based on the NRBV of the firm is Hart (1995), where the corporate social performance can constitute a source of competitive advantage and one of the pioneering empirical studies is Russo & Fouts (1997). McElhaney (2009) provides an excellent definition of Strategic CSR, which is "A Business Strategy that is integrated with strategic business objectives and core competencies of the firm, and, from the beginning, is designed to create business value and positive social change, and is integrated into the business culture and day-to-day operations". Finally, McWilliams, Siegel & Wright (2006) have described the theory of Hart (1995-2011) as allowing the company from CSR to strategically contribute to a sustainable competitive advantage. We propose that, in the final stage, the firm can contribute at the highest level of sustainability and we hypothesize this contribution with an exponential growth.

3   Contribution to the sustainability based on NRBV as Strategic CSR theory

It is found that Hart's theory, which was first published as NRBV has become known at management level as "The Sustainable Value Portfolio" of the firm. These strategic capabilities are each explained below.

3.1 Pollution Prevention (Pc)

This strategy raises the Total Quality Environmental Management (TQEM). It has been analyzed that the pollution reduction can be achieved by two primary means: a) control of emissions and effluents or b) the prevention of emissions or effluents (Willig, 1994).

3.2 Product Stewardship (Ps)

The second strategy integrates two key concepts: Design for the Environment (DfE) and Stakeholder Engagement. Also, to enhance quality and speed, many firms had already coordinated the design to manufacturing in the early 80s and the 90s taking into account the "voice of the customer" during the product development process (Takeuchi & Nonnaka, 1986; Clark & Fujimoto, 1991). It would be impossible to achieve this without a sustainable supply chain of the company.

3.3 Clean Technology (Ct)

The field of corporate sustainable development strategy has been separated into two distinct areas: Clean Technology and Base of the Pyramid (Hart, 1997, 2007; Prahalad and Hart, 2002). Using clean technologies what is looked for is to reduce the consumption of energy and materials that meet human needs without depleting the planet's resources (Meurig Thomas & Raja, 2005). Thus sustainable development strategy has two differences: first, it seeks only to reduce environmental damage, and beyond that, seeks to produce in a way that can be maintained indefinitely in the future. Secondly, it involves approaches to social and economic concerns. Clean technology strategies are then the ways in which firms build new skills and position themselves for competitive advantage as their industries evolve (Hart & Dowell, 2011).

3.4 Base of the Pyramid (BdP)

For Hart & Dowell (2011), there is an emerging literature that has developed around what has come to be known as the Base of the Pyramid (BoP), by Hart (2005, 2010); Prahalad (2005); Prahalad and Hammond (2002) and Prahalad & Hart (2002). BoP has also attracted increasing attention from corporations (Immelt, Govindarajan, & Trimble, 2009). The challenges associated with BoP (lack of formal institutions, poor infrastructure, low levels of education), seem to force companies to develop entirely new capabilities if they want to develop successful business models to serve the poor (Hart, 2007).

4 The General Model of Contribution to Sustainability based on NRBV of the firm

The research model classifies companies into 4 stages of development of its Social Responsibility: Philanthropy, Voluntary CSR, Responsive CSR and Strategic CSR, respectively. Each one of these stages is associated with a level of Contribution to Sustainability from Philanthropy (Low Contribution), to Voluntary CSR (Average Contribution), to Responsive CSR (Good Contribution) and Strategic CSR (High Contribution). These changes are seen in figure 1 with respect to the X axis (the time of adoption of CSR practices).
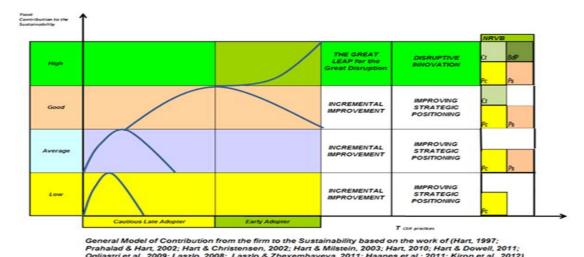

General Model of Contribution from the firm to the Sustainability based on the work of (Hart, 1997; Prahalad & Hart, 2002; Hart & Christensen, 2002; Hart & Milstein, 2003; Hart, 2010; Hart & Dowell, 2011; Ogliastri et al., 2009; Laszlo, 2008; Laszlo & Zhexembayeva, 2011; Haanes et al.; 2011; Kiron et al., 2012)

Figure 1. The General Model of Contribution to the Sustainability

5   Methodology

For this study we used a quantitative methodology to address the research question. While empirical research on CSR is mainly of a quantitative nature in the USA and of a qualitative nature in Europe (McIntyre *et al.*, 2009), taking this into consideration (Hart, 1997) explained that the USA cannot be an example of sustainability for the planet.

The type of knowledge that we are concerned with, is what stage of CSR the firm contributes better to sustainability, which adheres to a constructionist research approach (Silverman, 2004) and qualitative asseveration (Moon, 2007). The focus has been to discover a model that better describes the contribution to the sustainability of the firm.

5.1 Selecting the companies

This article is based on our study of the Ph.D. research "Sustainability as a result of Strategic CSR. The case of El Salvador", that was carried out in 106 companies from El Salvador, a Central American country. The enterprises, the list of which is confidential, represent the 2 most stable sectors (Industry and Services) in the economy and the size of the enterprises are Big Domestic and Multi-national companies based on more than 100 employees, and Medium-sized companies with 51 to 100 employees and Small companies with 11 to 50 employees. The type of company ranges from financial activities services to a multinational industrial manufacturer. All companies are based in El Salvador, most of them operate internationally or are Salvadorian subsidiaries of an international parent-company. For the stage of Corporate Philanthropy, we include 19 Small and Medium-sized Enterprises (SMEs).

The companies were brought together in the pilot plan (for 2 months in 2011), where three different managers per company took part in specific parts of the instruments, based on their qualifications and skills on the topic. We have selected the same kinds of company for our study, for three reasons. Firstly, in 2012, the Chambers of Commerce and Associations were involved in a networking strategy (for 1 month), and the collecting of data (3 months). Moreover, the company management regarded the selected participants as key players in their CSR and Sustainability efforts. For these reasons, the participating managers were able to provide data on the CSR and Sustainability process of their company. Secondly, this methodology permits the study of the 2 steadiest sectors in the economy and the same way of dealing with the relationship between CSR and Sustainability. Thirdly, because of the previous cooperation in the pilot plan a feeling of trust and support was already established by the 5 clusters of Chambers of Commerce and Associations, and in exchange for conservation of confidentiality, companies were willing to provide extensive information, including confidential data. We collected and analyzed empirical data about the relationship between CSR and Sustainability over a period that covers 3 months (August to October 2012).

5.2 Collecting data

The method of collecting data was "one stage cluster sampling", including document analysis and interviews. The individual interview of each manager in enterprises was face to face, transcribed and analyzed by using "one stage cluster sampling", ordering, coding and grouping to form categories (Levy & Lemeshov, 1999; Thompson, 1990). For some authors like (Thompson, 1990) the applications of Cluster Sampling do not compromise the quality of the data in comparison with a simple random sampling. The data collection was split into three phases. First of all, with a pilot plan of research to discover errors of methodology and the

possibility of getting the data. Secondly, with a network for all Chambers of Commerce and Associations. In the third phase, we executed a within-case analysis by company based on the instruments for all the companies. The models of research are based on the Octagon model for INCAE Business School in Costa Rica (Ogliastri *et al*., 2009), as an index of contribution to sustainability, and with the NRBV of the firm from Hart (1995; 2011), as a Strategic CSR model. These models permit the classification of the companies in 4 stages based on the literature of the companies. Where possible, we reviewed texts and material published by themselves (from 2009 to 2012) only to verify what they expressed in the interviews. All the information was summarized on a data sheet. For each company, a summary data sheet with the 83 categories of the instruments was constructed.

The information of the data sheet in the pilot plan in 2011 was used as a starting point and base of correction for the second phase of the data collection during 2012. In 2012, the collecting was a series of structured interviews utilizing the questionnaires of the Octagon model and NRBV instruments, with participants (an average of 3 per company) from each enterprise. The interviews were guided by a protocol that focused only on the guidelines and instruments. One point of focus was the place of managers in the organizational structure. As part of the interviews, the information about CSR and Sustainability documents or reports from document analysis was checked and further developed during the conversations. This procedure allowed for the improvement of the internal validity of data.

In the third phase, data has been presented and discussed with some specific participants like HSBC, IBERPLASTIC & GEA. Others companies did not allow the mention of the names of the enterprises, but J & B Radiators, from Sacramento, California, USA, has been a volunteer enterprise for the exploration of future lines of research in the developed economy. In general, the process of the field investigation has been the following: idea, literature review, hypothesis and variables, instrument of measure, evaluation of the instrument, collecting data, analyzing data & elaboration of the results report (Hernández *et al*., 2007).

5.3 Analyzing data

Based on the conceptual framework we proposed a model of "general contribution to the sustainability for the firm". We used variable-oriented strategies, based on the guiding concepts of our conceptual framework, and the concepts split up into several variables. We used the set of variables to write up each case report with a similar set up. Then we used matrices & tables to analyze each stage of contribution to the sustainability of the firm, and started by a check-list analysis and display in a meta-matrix. That information has been condensed, to make graphical comparison possible.

To present the empirical data in the next section, we have split up the condensed meta-matrix into 4 small tables for explicative variables and explained the results in written text. Firstly, we classify the index of contribution to sustainability to describe the four stages of the literature of CSR. Next, we analyze the differences by stage in a graphical way and for OLS "Ordinary Least Squares" to discover a model for each stage. Finally, we analyze the patterns of the model of the function of sustainability and based on that we propose an equation of the model.

6   Results of Empirical Research.

The most important purpose of this article is to analyze in what stage of CSR the firm contributes better to sustainability. In this exploratory study, the results of gathering information were computed with software R. All the results are based on the 106 companies and presented in Table 1.

6.1 Results about Philantrophy

In 14 companies the stage was Philanthropy. The hypothesis about the inverted U-shape of the contribution to sustainability in this stage was rejected. The behaviour was a line increasing for the time of adoption of CSR practices, probably because of the composition of the database in this stage with Small and Medium-sized Enterprises, and these companies trying to advance to the next stage. Moreover, the best fitted model with the function evaluating itself resulted in an adjusted R-squared of 0.8986, and with a p-value of 1.58e-07, considering an explanatory capability of the model in 89.86% of the contribution to sustainability   and simultaneously taking into account the complexity of the model.

6.2 Results about Voluntary CSR

In 33 companies the stage was Voluntary CSR. The hypothesis about the inverted U-shape of the contribution to sustainability in this stage was accepted. The composition of the database in this stage was Big Domestic and Multinational Enterprises, and the behaviour of these companies is trying to advance to the next stage. Moreover, the best fitted model with the function evaluating   resulted in   , with an Adjusted R-squared of 0.5208, and with a p-value of 1.29e-06, considering an explanatory capability of the model in 52.08% of the contribution to sustainability   and simultaneously taking into account the complexity of the model. In this case the hypothesis about the function is not supported by the database but can reflect, in this kind of economy, that the discourse of CSR and sustainability has not advanced to the strategic level in most of the firms, because after this analysis we have 44% of the total data only contributing to sustainability with the strategic capability of Pollution Prevention.

6.3 Results about Responsive CSR

In 44 companies the stage was Responsive CSR. The hypothesis about the inverted U-shape of the contribution to sustainability in this stage was accepted. The composition of the database in this stage was Big Domestic and Multinational Enterprises, and the behaviour of these companies is trying to advance to the last stage, Strategic CSR, but a decrease in the performance of sustainability is possible even in this stage. Moreover, the best fitted model with the function evaluating   resulted in   , with an Adjusted R-squared of 0.2278, and with p-values of Pc = 0.02369 y Ct = 0.00395, considering an explanatory capability of the model in 22.78% of the contribution to the sustainability (and simultaneously taking into account the complexity of the model. In this case the hypothesis about the function is not supported by the database but can reflect, in this kind of economy, that the discourse of CSR and sustainability has advanced to the strategic level in most of the firms, but many of them need to improve the strategic capability of Product Stewardship even though they are in this stage. After this analysis we have 85.84% of the total data, contributing to sustainability with the strategic capabilities of Pollution Prevention and Clean Technology.

6.4 Results about Strategic CSR

In 15 companies the stage was Strategic CSR. The hypothesis about the form of the contribution to sustainability in this stage was rejected because we discover a lineal function in the database. The composition of the database in this stage was Big Domestic and Multinational Enterprises, and the behaviour of the companies is increasing the sustainable performance in a steady way in this stage of Strategic CSR. Moreover, the best fitted model with the function evaluating   resulted in   , with an Adjusted R-squared of 0.9815, and with p-values of Pc = 2.96e-05, Ps = 0.000744, Ct = 0.029853 and BdP = 0.111066, considering a very good explanatory capability of the model in 98.15% of the contribution to sustainability (and simultaneously taking into account the complexity of the model. In this case the hypothesis about the function is supported partially for database because BdP is slightly bigger than the level of confidence of 0.05, but we decided to incorporate to the model because we have been relatively close to demonstrating Hart's theory in this empirical study and for the strong explicative capability of the model. After this analysis we have 14.15% of the total data contributing to the sustainability with the strategic CSR capabilities of Pollution Prevention, Product Stewardship, Clean Technology and Base of the Pyramid.

Table 1. Results of Empirical Research

	Function evaluating	Best Model	Variables in Best Model	t value (Pr(>|t|))	Adjusted R-squared (p-value)
Philanthrophy	Y = f(Pc)	Y ~ Pc	Pc	10.78 (1.58e-07 ***)	0.8986 (1.58e-07)
Voluntary CSR	Y = f(Pc, Ps)	Y ~ Pc	Pc	5.982 (1.29e-06 ***)	0.5208 (1.293e-06)
Responsive CSR	Y = f(Pc, Ps, Ct)	Y ~ Pc + Ct	Pc	2.350 (0.02369 *)	0.2278 (0.001881)
			Ct	3.055 (0.00395 **)	
Strategic CSR	Y = f(Pc, Ps, Ct, BdP)	Y ~ Pc + Ps + Ct + BdP	Pc	7.190 (2.96e-05 ***)	0.9815 (2.391e-09)
			Ps	4.781 (0.000744 ***)	
			Ct	2.530 (0.029853 *)	
			BdP	1.748 (0.111066)	
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

7   Conclusions

The research question of this study focused on demonstrating in what stage of the evolution of CSR the firm contributes best to sustainability. We define Strategic CSR as the stage of the best level of contribution for this economy and we have demonstrated Hart´s theory empirically taking the form of what we named The Function of Sustainability. As Moon (2007) explained, the firms that have been most prepared to pursue short-term profitability are probably in the first 2 stages. On the other hand, the long-term profitability and success of the firms comes from the 4th stage. This study is a new dissemination of what happens when enterprises are investing simultaneously in all four strategic capabilities of the NRBV of the firm. Then, the

sustainability performance is increased. Moreover, this knowledge can be introduced in education for sustainable development in Central America and South America curricula for careers in Engineering and Business Administration because the 4 strategic capabilities have been studied separately in Universities' study plans and applied in business for society.

This article presented a first step in describing, analyzing and proposing for the very first time as a tribute to Professor Hart´s theory based on this Ph.D. research, the introduction of The Equation of Sustainability: . We would like to summarise the investigation, based on the previous finds. Firstly, it should be made clear that this is a seminal work and explorative study which suggests a function and equation, but that does not intend to reduce the concept of Sustainable Development to an equation of sustainability. Secondly, it should be made clear that the function and equation of sustainability are not intended to explain the topic of sustainability as a whole, which would be counter-productive, but they do intend to explain the contribution of the firm to sustainability, that is, the role that the firm should perform in order to achieve a more sustainable world.

One limitation of the study is the method used, which resembles an explanatory study. Therefore, the equations are not strong enough for theoretical generalisation. However, the importance of the educational theme is related to the skills needed in pollution prevention, product stewardship, clean technology and base of the pyramid applied simultaneously by engineers in the engineering industry. The principal contribution of this article to education in the evolution of sustainable development with regards to young engineers is to rethink the role and responsibility of the professional engineer by applying and studying Clean Technology at university. However, this in isolation is not enough. A change in the work at the centre of technology is necessary: the needs of the base of the economic pyramid, the management of products and the prevention of contamination. The need for simultaneousness in the work of all of the strategic capabilities becomes a competitive necessity. For this reason, leaders are increasingly recognising the relationships between and interdependences of economic, environmental and social aspects and the short, mid and long-term effects (Stormer F., 2003; Lozano R., 2011). Based on Boons and Ludeke-Freund (2013), the research on sustainable innovation has tended to neglect the way in which firms need to combine a value proposition.

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