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THE INFLUENCE OF ECO-INNOVATION SUPPLY CHAIN PRACTICES ON BUSINESS ECO-EFFICIENCY

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Abstract

This paper aims to study the influence of eco-innovation practices on eco-efficiency of business, which embraces environmental and economic performance. Four hypotheses are drawn up based on the existing literature in green supply chain and considering the business innovation. A survey questionnaire was used to collect data on a sample of USA and Portuguese innovative organizations. Multivariate statistics and Partial Least Squares (PLS) path modelling techniques were used to test the proposed hypothesis. The statistical analysis allows to conclude that there are differences between the eco-innovation practices deployed by organizations belonging to different sectors and with different sizes. Also, it was found that the level of implementation of the different eco-innovation practices by organizations influence the eco-efficiency of businesses.

Keywords: Eco-innovation, eco-efficiency, economic performance, environmental performance.

1. INTRODUCTION

The increased pressure from community and environmentally conscious consumers has lead to rigorous environmental regulations, forcing manufacturers to integrate environmental concerns into their management practices (Paulraj 2009; Rao & Holt 2005). Beyond the immediate economic concerns, businesses must address environmental and social issues to be more sustainable (Pagell & Wu 2009). To face these challenges, organizations should develop and implement innovative practices that support the minimization of the environmental negative impacts, while concurrently increasing business operational and financial performance.

Most managers have realised that taking the lead in ecological behaviour could bring important benefits (Elsayed & Paton 2005). Creating better performing products with less environmental impact is an important competitive strategy for firms (Picazo-Tadeo & Prior 2009; Porter & Linde 1995;). Therefore, the assessment of business eco-efficiency emerges as a practice with great potential to provide policy decision-makers and firm managers with relevant information as a sound basis for strategic decision-making. Eco-efficiency enables the business direction to reach a proper level of sustainable development and a way to international long-term competitiveness (Cagno, Micheli, & Trucco, 2012).

The World Business Council for Sustainable Development (WBCSD) (2000) considers that organizations can use the following elements to increase their eco-efficiency: reduce material and energy intensity; reduce dispersion of toxic substances; enhance recyclables; maximise use of renewables; extend product durability; and increase service intensity. These elements are related to green or environmental management practices. Examples of innovative green practices are found in Holliday, Hollidsy, Schmidheiny, & Watts (2002). The examples illustrate that the implementation of green practices has moved from the organization focus, e.g. using clean processes, to a supply chain focus reaching the upstream level, e.g. developing recyclable materials with suppliers, and also the downstream level, e.g. promoting package return.

Zhu, Sarkis, & Lai (2012) define green supply chain management (GSCM) as an organizational technological innovation that integrates the environmental concerns into the organizational supply chain activities. In the literature there are several studies that have analysed the impact of green approaches but on supply chain and business performance (Azevedo, Carvalho, & Cruz-Machado, 2011; Green Jr, Zelbst, Meacham, & Bhadauria, 2012; Zhu, Sarkis, & Geng, 2005; Zhu, Sarkis, & Lai, 2007). Zhu & Sarkis (2004) investigated the relationships between internal environmental management, external GSCM, investment recovery, and eco-design, and the impact of these practices on environmental performance and economic performance. Their results show a positive relationship between green supply chain practices and environmental performance but also the absence of a significant relationship with economic outcomes. Rao & Holt (2005) considered five latent constructs (namely, greening the inbound function, greening production, greening the outbound function, competitiveness, and economic performance) and concluded that greening the supply chain actually leads to increased competitiveness and better economic performance. However, such studies do not consider the effect of each innovative green practices individually, nor do they consider the connections between individual practices and eco-efficiency measures. Moreover, according to Zhu, Sarkis, Lai, & Geng (2008) organizational size is a critical characteristic in the adoption of innovative GSCM practices. There is also a lack of research on the relationship between eco-innovative practices and business performance.

The purpose of this paper is to investigate the influence of eco-innovation practices on the eco-efficiency of businesses. To attain this objective the following two questions will be addressed:

- Are there differences between the eco-innovation practices deployed by organizations belonging to different sectors and with different sizes?
- Does the level of implementation of the different eco-innovation practices by organizations influence the eco-efficiency of businesses?

Multivariate statistics and Partial Least Squares (PLS) path modelling techniques were used to answer to the research questions.

To address the above questions, this paper is organized as follows. First, it reviews the relevant literature on eco-innovation practices in supply chain management. Next, a set of performance measures to assess the business eco-efficiency are proposed. Also, four hypotheses about the relationships between eco-innovation and business performance are proposed as the respective rationale. Next, in section 3 an empirical analysis is presented. First, the research methodology is described, survey study details are presented, and the sample is characterized. Then, the results of the multivariate statistical analysis and the partial least squares are presented. The main findings about the influence of size and industrial sector on the implementation level of eco-innovation practices and also the effects of eco-innovation practices on the business eco-efficiency are presented and discussed. Finally, conclusions with some suggestions for further research are provided.

2. LITERATURE REVIEW AND HYPOTHESES

2.1. Eco-innovation practices in supply chain management

The green management approach is recognized as contributing to a cost reduction by using resources, such as water, energy and raw materials, more efficiently (E. Walker, Redmond, & Giles, 2010). In addition, there is evidence that the deployment of environmental friendly practices promotes innovation in business (Zhu et al., 2012) .

The definitions of innovation found in the literature differ depending on the context and scope of the analysis. For example West & Farr (1992) define innovation as: "The intentional introduction and application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, organization or wider society". Following, Hamel (2006) describes innovation more broadly as "a marked departure from traditional management principles processes and practices or a departure from customary organizational forms that significantly alters the way the work of management is performed."

If the emphasis is on sustainable development, the innovation concept loses its neutrality; it is then focused on the reduction of environmental burdens (Rennings, 2000) becoming eco-innovation. Eco-innovation is "the innovation that reflects the emphasis on a reduction of environmental impact, whether such an effect is intended or not and includes innovation in products, processes, marketing methods and organisational methods, and also includes innovation in social and institutional structures" (OECD, 2009, p.16).

According to Beise & Rennings (2003) eco-innovations may be developed with or without the explicit aim of reducing environmental harm. They also may be motivated by the usual business goals such as reducing costs or enhancing product quality. Grubb and Ulph (2002) stated that less innovative firms may adopt eco-innovation as a means to reduce production costs and comply with the minimum environmental standards, while more innovative firms may adopt eco-innovation in order to enter new markets. In an Organisation for Economic Co-operation and Development (OECD report about sustainable manufacturing (OECD, 2009), eco-innovations practices can be found in different contexts such as: improving energy efficiency of automobiles, sustainable plants, energy-saving types, self-service bicycle sharing system, alternative iron-making processes, advanced high-strength steel for automobiles, energy efficiency in data centres, energy-saving controller for air conditioning water pumps, enhancing recycling of electronic appliances, and managed print services. For this study, the research considered the definition of eco-innovation adopted by Kemp & Foxon (2007): "Eco-innovation is the production, application or exploitation of a good, service, production process, organisational structure, or management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resources use".

There are several eco-innovations typologies suggested in the literature. Kemp (1997) and Frondel, Horbach, & Rennings (2007) suggested a typology with a more technological perspective. They considered the following eco-innovations: (1) *End-of-Pipeline Pollution Control Technologies* - which consists of applying end-of-pipeline solutions in order to treat, handle, measure or dispose emissions and wastes from production (DEFRA - Department for Environment, Food, and Rural Affairs, 2006). Examples of end-of-pipeline technologies include effluent treatment plant and exhaust air scrubbing systems; (2) *Integrated Cleaner Production Technologies* - refers to new or modified production facilities, which are more efficient than previous technologies, and contribute to pollution reduction. Examples of integrated technologies include improved housekeeping, which refers to improvements in management practices, monitoring, and maintenance; changes to process technologies, changes to products with the use of new technologies, which reduces the consumption of resources, waste and emissions; and changes to inputs by substituting toxic materials with environmentally friendly alternatives; and (3) *Environmental Research and Development (R&D)* - The main aim of environmental R&D is to improve products and processes by providing solutions for cleaner production and consumption.

Adopting a different perspective, Cheng & Shiu (2012) considered the following eco-innovation typology : (1) *Organizational Eco-Innovation* - which includes activities arising from the setting up of the different forms of organization and management in different functions of the organization. It includes eco-training programs, eco-product design programs, the introduction of eco-learning techniques, the creation of management teams to deal with eco-issues, and eco-management systems; (2) *Process Eco-Innovation* - refers to the introduction of manufacturing processes that lead to reduced environmental impact. Eco-process implementation involves the improvement of existing production processes or the addition of new processes to reduce environmental impact; and (3) *Product Eco-Innovation* - refers to environmental improvements of existing eco-products or the development of new eco-products. Eco-product implementation focuses mainly on a product's lifecycle in order to reduce environmental impact. This last typology was used in this study to define eco-innovation practices.

Often eco-innovation is used as shorthand for environmental innovation (EIAG - Environmental Innovations Advisory Group, 2006; Rennings, 2000). Vachon & Klassen, 2008) stressed that environmental management has evolved from the internal company focus to a supply chain perspective. Supply chain management increase business effectiveness, enhancing competitiveness, customer service and profitability and is also crucial to influence the business environmental impact. According to Zhu et al. (2012) GSCM is a proactive environmental management practice, which can contribute to a reduction of pollution and an improvement in organizational environmental performance. They also defend that GSCM may be helpful for improving operational performance and minimizing wastes through better coordination and cooperation with suppliers and customers. Thus, the operational improvements may occur throughout a supply chain. Environmental innovation overall, and GSCM in particular, are considered innovative concepts mainly in developing countries, where the focus is on economic growth and organizational environmental improvements (Liu, Mol, & Chen, 2005). Therefore, GSCM can be considered an eco-innovation concept and its practices as eco-innovation practices.

GSCM practices are considered to be any action which is performed across the supply chain (inward to the focal organization and involving relationships with partners upstream and downstream) to eliminate or reduce any kind of negative environmental impact; these practices could be related to the supply process, the product itself, the delivery process or advanced actions involving some kind of innovation (Azevedo et al., 2011). According to Hoek (1999) the green supply chain is much more than just reverse logistics, it embraces different activities from raw material acquisition, storage and packing to the distribution, reducing the sources of waste and resources consumption Also, Hervani, Helms, & Sarkis (2005) considered the GSCM as the following equation: GSCM = Green Purchasing+ Green Manufacturing/Material Management + Green Distribution /Marketing + Reverse logistics. Different studies , e.g. Zhu & Sarkis (2004); Walker, Di Sisto, & McBain (2008) and Vachon (2007), have defined GSCM from different perspectives implying that its definition can be redefined for particular industries, goals, and properties.

Some of the eco-innovation practices in the supply chain found in the literature are summarized in Table 1.

Table 1 - Eco-innovation practices in the supply chain

Upstream	Focal company	Downstream
Environmental collaboration with suppliers (1), (3), (4), (5), (7), (8)	Cross-functional cooperation for environmental improvements (2), (4), (7)	Cooperation with customers for cleaner production (4), (7)
Environmental monitoring of suppliers (3), (4), (5), (8), (10)	Environmentally friendly raw materials (2), (6), (8)	Customers return original packaging or pallet systems (6), (8)
Green procurement (8), (9)	Green design (3), (4), (9)	Environmental collaboration with customer (4), (5), (8)
Communicate with suppliers environmental and/or ethical criteria for goods and services (3), (4), (8)	ISO 14001 certification (2), 3), (4), (5), (7), (8)	Reverse logistics (1), (2), (3), (4), (5), (9)
Encourage suppliers to take back packaging (2), (8)	Recycle workplace materials (6), (8)	Environmentally friendly packaging (2), (7), (9)
Work with product designers and suppliers to reduce and eliminate product environmental impacts (1), (3), (8)	Reduce energy consumption (2), (6), (8), (10)	Cooperation with customer for green-design (4), (7)
Note: (1) Lippmann (1999); (2) Rao & Holt (2005); (3) Hu & Hsu (2006); (4) Zhu et al. (2007); (5) Vachon (2007); (6) Gonzalez, Sarkis & Adenso-Diaz)2008); (7) Zhu, Sarkis & Lai (2008); (8) Holt & Ghobadian (2009); (9) Routroy (2009); (10) Paulraj (2009).		

2.2. Eco-efficiency and Business Performance

There is a vast amount of literature on performance measurement frameworks and systems. Many of them provide insights into supply chain performance measurement, especially in the following topics: study of appropriate supplier evaluation systems (Carr & Pearson, 1999; Haq & Kannan, 2006; Kannan, Haq, Sasikumar, & Arunachalam, 2008); the effects of various factors on supply chain performance (Beamon & Chen, 2001; Aramyan et al., 2009; Lee, Kwon, & Severance, 2007) metrics appropriated to manage the four functions plan, source, make/assemble (Gunasekaran, Patel, & Tirtiroglu, 2001); current practice and future requirements in supply chain performance measurement (Gunasekaran & Kobu, 2007; Thakkar, Kanda, & Deshmukh, 2009; Gopal & Thakkar, 2012).

The relationship between GSCM practices and business performance has been explored from environmental (Zhu et al., 2005; Handfield, Walton, Sroufe, & Melnyk, 2002; Chan, He, Chan, & Wang, 2012; Azevedo, Carvalho, Duarte, & Cruz-Machado, 2012), economic (Zhu et al., 2005; Rao & Holt, 2005; Azevedo et al., 2012) and operational contexts (Zhu et al., 2005; Vachon, 2007; Hajmohammad, Vachon, Klassen, &

Gavronski, 2012). Recently the eco-efficiency has also appeared as a strategic performance measure to evaluate the environmental behaviour of business (Kim, 2011; Guenster, Bauer, Derwall, & Koedijk, 2011).

Eco-efficiency is increasingly becoming a key requirement for success in business. The notion of economic-ecological efficiency, commonly known as eco-efficiency, emerged in the 1990s as a practical approach to the more encompassing concept of sustainability (Schaltegger & Burritt, 2000). Eco-efficiency is a reduction of resource intensity and minimization of environmental impacts of production and products/services together with value creation by a continuous incremental improvement (Dias-Sardinha, Reijnders, & Antunes, 2002). Eco-efficiency is seen both as a concept and as a tool where the basic idea is to produce more with less impact on nature (Schaltegger & Burritt, 2000). One of the most quoted definition of eco-efficiency is from World Business Council for Sustainable Development (WBSD, 2000) that defines eco-efficiency as "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity'. By being eco-efficient, goods and services can be produced with less energy and fewer raw materials, resulting in less waste, less pollution and less cost" Environmental Protection Agency (EPA) (2000).

There are several reasons why it is important to measure the business eco-efficiency. Such reasons can be tracking and documenting performance, identifying cost savings and benefits, identifying and prioritizing opportunities for improvements (Holliday, Hollidsy, Schmidheiny, & Watts, 2002). Further, it can act as a management instrument to merge financial and environmental management accounting information given managers insights on how to move to a better business performance (Burritt & Saka, 2006). In addition it can be used as an instrument for sustainability analysis expressing the trade-offs between the economy and the environment results of business (Huppes & Ishikawa, 2009). Also it supports an framework for the collection of environmental information as energy consumption, emissions, material consumption, toxicity potential, and potential risk (Saling et al., 2002).

Measures of eco-efficiency are used at different scales, both temporal and spatial (Huppes & Ishikawa 2009). Also it can be related to product or organization performance. For example, according to Chen, Lai, & Wen (2006) the performance of eco product innovation is considered, from the ISO14031 standards as the performance in product innovation that is related to energy-saving, waste recycling and toxicity. For the eco-efficiency concept to become reality in organisations, the Canada´s National Round Table on the Environment and the Economy (NRTEE) (2001) claims that organizations must measure and monitor their performance in order to set targets for eco-efficiency indicators. Eco-efficiency indicators measure the enterprise's efficiency in the consumption of resources with reference to the ability to produce economic value.

There are several terminologies for the eco-efficiency concept (Huppes & Ishikawa, 2005). One ratio suggested in the literature to translate the eco-efficiency is the following Müller & Sturm (2001): Eco-efficiency = Environmental performance / Economic performance. In this ratio, the organization environmental performance is considered as the impact caused by its activities during a specific period and the economic performance is the financial value produced by the same activities during a specific period. Therefore, managers can increase eco-efficiency by decreasing environmental impact while increasing the economic performance. As such, the eco-efficiency improvements are reached through better environmental and economic performance (Preuss, 2005). In this study economic and environmental measures are used to analyze the extend to which the eco-innovative practices deployed by the research organizations contribute to improve business eco-efficiency. The economic performance measures used in this study are: environmental costs, material cost, total cost of products, sales volume and cash flow. The environmental measures deployed are: business waste and energy consumption.

2.3 Research variables and hypotheses

In this paper the eco-innovation practices discussed in previous section are operationalized using eight item measures to represent manifestations of the construct. In addition, the economic and environmental performance of businesses is evaluated using, respectively, five and two measurement items. Table 2 contains the variables measures and their respective definition.

Table 2 - Variables definition

Latent variables	Measures	Definition
Eco-innovation practices (EIP)	Environmental collaboration with suppliers (EIP1)	Interaction between organizations and its suppliers for joint environmental planning and shared environmental know-how or knowledge (Vachon & Klassen, 2008). It may represent environmental programs which may include technological and organizational development projects with suppliers (Sarkis, 2003).
	Environmental collaboration with customers (EIP2)	It comprises of a set of environmental activities engaged by organizations and their customers to develop a mutual understanding of the responsibilities regarding environmental performance, to reduce the environmental impact of their activities, to resolve environmental-related problems and to reduce the environmental impact of their product (Vachon & Klassen, 2006).
	Green purchasing (EIP3)	It consists of the selection and acquisition of products and services that minimize negative environmental impacts over their life cycle of manufacturing, transportation, use and recycling or disposal.
	Reverse logistics (EIP4)	It represents the "process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or proper disposal" (Rogers & Tibben-Lembke, 2001).
	Eco-product design programs (EIP5)	It is related to programs that incorporate product's environmentally preferable attributes such as recyclability, disassembly, maintainability, refurbishability and reusability (Ashley, 1993).
	Environmental management systems (EMS) (EIP6)	It is the part of the overall management system that includes organizational practices, procedures, processes and resources for developing, implementing, achieving, reviewing, and maintaining the organization environmental policy (US EPA, 2009).
	Innovation production process (EIP7)	It includes the activities starting from idea generation and ending with the innovation commercialization. Bernstein & Singh (2006) and Roper, Du, & Love (2008) pointed out that idea generation is identified as the initial stage in the IPP where individuals in the organizations gather information from both internal and external sources. It contributes to processes becoming more efficient through a decrease on raw materials, energy, and business waste.
	Development of new eco-products (EIP8)	It consists in developing and launching to the market green products that enable energy savings, waste recycling, and toxicity reduction (Lai, Cheng, & Tang, 2010).
Economic performance (ECP)	Total cost of products (ECP1)	It represents the sum of all fixed and variable costs associated with the production of the final product (Degraeve, Labro, & Roodhooft, 2005)
	Environmental	CE, 453/2001 defines environmental costs as "those

	costs (ECP2)	costs to prevent, reduce or recover damages that the entity has caused or is likely to cause on the environment as a result of its activities".
	Material cost (ECP3)	It represents the cost of all materials purchased or obtained from other sources, e.g. raw materials, process materials, pre- or semi-manufactured goods and parts (WBSD, 2000).
	Sales volume (ECP4)	It represents the quantity or number of goods sold or services sold in the normal operations of a company in a specified period.
	Cash flow (ECP5)	It consists of cash received or expended as a result of the company's internal business activities.
Environmental performance (ENVP)	Energy consumption (ENVP1)	It is the total sum of energy consumed. In other words, it equals energy purchases minus energy sold to others for their use (WBSD, 2000).
	Business waste (ENVP2)	It represents the wastes that come from the business activities of companies. Examples of metrics to evaluate this measure: total flow quantity of scrap (Tsay & Hung, 2009), or percentage of materials remanufactured (Hervani et al., 2005).

As previously stated, eco-innovation practices usually generate benefits in terms of business economic and environmental performance. The business eco-efficiency concept embraces the synergies that eco-innovation practices generate in terms of economic and environmental performance. However, contextual factors such as firm size and industry sector can affect this relationship. Using this information and current literature, objective of this study is defined by two research questions and some hypotheses are formulated.

The first question arises from the analysis of the literature review:

> Q_1: Are there differences between the eco-innovation practices deployed by organizations belonging to different sectors and with different sizes?

According to Zhu, Sarkis, Cordeiro, & Lai (2008) the effect of organizations size on environmental strategy may be due to resource-based aspects such as the greater capacity or slack characteristics of larger organizations that support commitment with voluntary environmental strategies, or because large organizations are subject to higher pressure by external stakeholders to comply with environmental regulations and to become more environmental friendly. Moreover, Min & Galle (2001) found that large organizations are more likely to put pressure on their suppliers to comply with environmental regulation than the small dimension organizations; this can be explained due to their greater bargaining power. However, according to these authors there is no significant difference between the importance that small and large organizations give to green initiatives such as the supplier's advances in developing green products and packages. Zhu, Sarkis, Cordeiro, et al. (2008) concluded that an organizations size has a statistically significant relationship with the adoption of GSCM practices.

According to Cohen & Klepper (1996) the percentage of total R&D dedicated to different types of innovative activities differ greatly across industries; for example in the petroleum refining industry three-quarter of total R&D is dedicated to process innovation, where as less than one-quarter of pharmaceutical R&D is dedicated to process innovation. Therefore it is expected that industry type is a relevant variable to understand the level of implementation of eco-innovation practices in organizations. Zhu & Sarkis (2004) also found significant differences among GSCM practices adoption in the automobile, power generation, and electrical and electronic industries. In the present study, the variable "organization size" is operationalized by the number of employees; three categories of organizations size were considered, small organizations (less than 50 employees), medium (between 50 and 250 employees), and large (more than 250 employees), according to the organizational criteria put forward by the European Commission (2005). The variable "sector" is determined by industry classification taxonomy proposed by the Industry Classification Benchmark (http://www.icbenchmark.com/).

In order to address this question, two hypotheses relating the level of implementation of eco-innovation practices with the sector and size of organizations are formulated:

> $H_{1.1}$: There are differences in the level of implementation of eco-innovation practices according to the sector of organizations.
>
> $H_{1.2}$: There are differences in the level of implementation of eco-innovation practices according to the size of organizations.

These two hypotheses provide detail on the main characteristics of the organizations that deploy eco-innovation practices in terms of sectors and sizes. It is important also to analyse the influence that the deployment of these practices has on the eco-efficiency of businesses. Organizations that undertake eco-innovations practices will be able to reduce their production costs and/or enter into expanding markets for eco-products (Kesidou & Demirel, 2012). Moreover, eco-innovations can be less successful on the market than other innovations (Halila & Rundquist, 2011). They are also economically important at the level of individual organization since consumers are willing to pay extra for a product that is less harmful ecologically (Essoussi & Linton, 2010). To explore the influence of the construct eco-innovation practices has on economic and environmental performance, the following research question is formulated:

> Q_2: Does the level of implementation of eco-innovation practices by organizations influence the eco-efficiency of businesses?

The practices focused on this research attempt to contemplate not only internal organization eco-innovation practices but also the ones which transcend the organizations' boundaries involving suppliers and customers. Collaboration in supply chains is important in terms of innovation as partners realize the various benefits of innovation, such as higher quality, lower costs, more timely deliveries, efficient operations and more effective coordination of activities (Soosay, Hyland, & Ferrer, 2008). Collaborative activities with organizations' suppliers and customers can be translated not only into improved environmental performance, but also into quality, material and product costs (Hart, 1997; Porter & van der Linde, 1995; Lorenzoni and Lipparini, 1999).

Some advanced environmental management practices, such as design for the environment, life-cycle analysis, and reverse logistics, require the collaboration from different stakeholders in the supply chain (Vachon Stephan, Klassen, & Johnson, 2001). Moreover, Zsidisin & Siferd (2001) defend that environmental management has evolved to include boundary-spanning activities such as green purchasing, reverse logistics and product stewardship. Environmental collaboration improves the ability to coordinate operations and workflow in different supply chain tiers (Azevedo et al., 2011). Therefore, it contributes to the reduction of business waste, environmental cost, and total cost.

One of the most effective ways to tackle environmental problems is to focus on waste prevention and control from the source through green purchasing (Min & Gale, 2001). According to these authors, green purchasing cannot be totally successful without the systematic reduction of upstream waste sources associated with purchased materials/parts and their packaging. Although the purchase of green materials represents a cost, it can create economic value such as reduced environmental cost while improving the organization resource conservation. Adopting green purchasing practices avoids business waste and reduces environmental costs (Tsoulfas & Pappis, 2006).

According to Johnson & Leenders (1997), reverse logistics aids the organizations process by supporting the products and the recovery of waste for the main purpose of recycling, remanufacturing, resale, reuse, or disposal.. Absence of after-market support as well as rework, remanufacturing and recycling operations could damage brand and therefore corporate image in emerging markets (Richey, Tokman, Wright, & Harvey, 2005). Rogers & Tibben-Lembke (2001) argues that value can be obtained from managing the reverse flow cost-effectively and it can create a competitive advantage for business. Also supports the reduction of uncontrolled waste disposal which can irreparably damage natural resources and other industries over time. In order to enhance customer equity, firms invest enormous amounts of resources to build customer loyalty and improve customer satisfaction. Reverse logistics helps this strategic cause by providing customer and business partners the ability to take back a defective or unwanted product quickly and receive credit in a timely fashion (Rogers & Tibben-Lembe, 1999). Consequently customer satisfaction is positively correlated with the performance of organizations in terms of sales volume (Wiele, Boselie, & Hesselink, 2002).

Eco-product design programs allow introducing modifications early in the product design process of a product (Billatos and Basaly, 1997; DeMendonca and Baxter, 2001). Therefore, this practice contributes to a decrease in costs and business waste.

The implementation of environmental management systems is seen as critical organisational capability in environmental management (Wagner, 2007; Horbach, 2008).

Currently, there are several EMS standards to which a company can certify. These standards include ISO 14001 Eco-Management and Audit Scheme in Europe, and BS7750 in the UK (González et al., 2008). Introduced in 1996, ISO 14001 is the most widely accepted EMS certification. It is not easy to identify economic profitability in the short term, because an EMS is often connected with costs related to the time and expertise needed for the implementation of such a management system, however in the long term it is possible to identify some advantages, such as savings in energy use, waste recycling and the possibility to compete in new markets where environmental aspects are of great importance (Halila, 2007).

According to the literature review, the two hypotheses relating the eco-innovation practices to the environmental and economic performance are the formulated as:

> $H_{2.1}$: There is a positive relationship between the eco-innovation practices and the economic performance of organizations.
>
> $H_{2.2}$: There is a positive relationship between the eco-innovation practices and the environmental performance of organizations.

3. EMPIRICAL ANALYSIS

3.1. Measurement item and instrument

The data for the study was collected via a survey questionnaire that was divided into three sections. The first section captures the main characteristics of each company participant. The second section captures the level of implementation of eco-innovation practices by the research companies and the third section captures the economic and environmental performance during the last five years. The eco-innovation practices and performance measures used in this study were identified from the literature review (Table 2).

The survey instrument was pre-tested for content validity by asking four experienced researchers to review the questionnaire for ambiguity, clarity and appropriateness of measures used to form each latent variable. Moreover, the survey instrument was also mailed to four management executives affiliated with innovative manufacturing companies which reviewed the questionnaire for structure, readability, ambiguity and completeness. According to the feedback, the instrument was improved. This pre-test process yielded a survey instrument with high content validity. Also the Cronbach's alpha was used to measure its reliability (George & Mallery, 2006). Cronbach's alpha for the survey instrument is 0.829 (Appendix A), which indicates a high level of internal consistency for our scale with this specific sample. Then, the last version of the survey was distributed to the target respondents (Appendix B).

3.2. Sample

The target populations for the study were innovative organizations located in Portugal and USA. The sampling method was opportunistic since the researchers are from these two countries. The Portuguese organizations were identified using two contact lists: i) the organizations associated with COTEC Portugal which is a business association with the mission of promoting the competitiveness of organizations; it counts on the support of its associated companies and all agents of the National Innovation System (http://www.cotecportugal.pt/); and ii) the organizations supported by COMPETE Management Authority, which is an entity responsible for managing and executing the Operational Competitiveness Programme, in particular, to supporting productive investment in innovation, entrepreneurship, technology research and development, and the use of immaterial competitiveness factors (http://www.pofc.qren.pt/). The American companies belong to a database of the "World's Most Innovative Companies" published by Forbes (http://www.forbes.com/special-features/innovative-companies-list.html).

The research sample was collected from 557 Portuguese and 73 American innovative companies. A total of 32 responses were obtained during the five week period following the distribution of the questionnaires. An effective return rate of approximately 5% was obtained. Besides the small size of the sample, it is above the minimal requirements for the application of the statistical methods used in this research, which is 30 responses (Chin, 1998).

The research organizations are from Portugal (78.1%) and USA (21.9%). Most of them are large organizations (56.3%) since they have more than 250 employees and more than 37% spend between 1.5% and 3% of the total costs in R&D (Appendix C). From all the surveyed organizations more than 59% also had patents registered. The sample covers organizations belonging to the following eleven industry sectors according to the industry classification taxonomy - Industry Classification Benchmark (http://www.icbenchmark.com/): Forestry & Paper, General Industrials, Industrial Metals & Mining, Chemicals, Electronic & Electrical Equipment, Automobiles & Parts, Industrial Engineering, Support Services, Construction & Materials, Industrial Transportation, and Software & Computer Services.

In order to answer to the two research questions, a multivariate statistical analysis and partial least squares path modeling were performed using the SPSS version 11.0 and the

"Smart PLS" respectively.

3.3. Eco-innovation practices by industrial sectors and sizes

The first research question and its two hypotheses intend to analyze if organizations belonging to different sectors ($H_{1.1}$) and with different sizes ($H_{1.2}$) have different levels of implementation of eco-innovation practices. Prior to the one-way ANOVA the normality of the data was analyzed by using the Kolmogorov-Smirnov test and the homogeneity of variance by the Levene test (Hair, Black, Babin, & Anderson, 2009). The significance of the Kolmogorov-Smirnov test and the Levene test were smaller than 0.05 in all tests (Appendix D). This result implies that the normality of the data can not be assumed. Consequently, the use of the one-way ANOVA is inappropriate (Hair et al., 2009). Therefore, the Kruskal-Wallis test was used to compare different samples and to calculate whether there is a statistically significant difference between the ratings of sample attributes. This test does not assume normality in the data; therefore, it can be used when this assumption is not verified.

Therefore, to test hypotheses $H_{1.1}$ and $H_{1.2}$ the non-parametric Kruskal-Wallis test was used. The results from the Kruskal-Wallis test are provided in Tables 3 and 4.

Table 3 - Kruskal-Wallis test for $H_{1.1}$

Eco-innovation practices	Chi-Square	Asymp. Sig.
Environmental collaboration with suppliers	11.985	0.000*
Environmental collaboration with customers	13.704	0.035*
Green purchasing	12.313	.0054**
Reverse logistics	11.705	0.036*
Eco-product design programs	17.351	0.002*
Environmental management systems (EMS)	20.036	0.055**
Innovation production process	18.610	0.064**
Development of new eco-products	17.510	0.061**
* Significant for a significant level of 5% ** Significant for a significant level of 10%		

As shown in Table 3, the results of the Kruskal-Wallis test indicate that there are significant differences between the levels of implementation of eco-innovation practices based on the industrial sector of the research organizations. This result is illustrated in Table 4. Table 4 shows the industrial sector with higher level of implementation of eco-innovation practices is the Automobiles & Parts sector. In this sector only green purchasing (EIP3) presents low levels of implementation. Therefore, this sector can be considered as the most eco-innovative. It is followed by the Industrial Metals & Mining and the Support Services sectors, which presented considerable levels of implementation of an extended set of eco-innovation practices. The two sectors less eco-innovative are Chemicals and the Industrial Engineering. Another important conclusion is that the eco-innovation practice with higher levels of implementation in almost all industrial sectors is the Eco-product design program (EIP5).

Table 4 - The eco-innovation practices implementation level by industrial sector

Industrial sectors / **Eco-innovation practices**	Environmental collaboration with suppliers (EIP1)	Environmental collaboration with customers (EIP2)	Green purchasing (EIP3)	Reverse logistics (EIP4)	Eco-product design programs (EIP5)	Environmental management systems (EMS) (EIP6)	Innovation production process (EIP7)	Development of new eco-products (EIP8)
Forestry & Paper	2,50	4,50	3,50	3,50	4,00	4,50	3,50	3,50
General Industrials	4,00	3,00	4,00	2,00	5,00	4,00	2,00	2,00
Industrial Metals & Mining	4,00	4,00	3,00	4,00	4,00	4,50	3,50	3,50
Chemicals	2,60	3,20	3,40	2,40	2,00	3,60	2,60	2,60
Electronic & Electrical Equipment	3,40	3,20	3,00	3,20	4,00	3,60	2,80	2,80
Automobiles & Parts	4,75	4,25	2,75	4,00	5,00	4,50	4,50	4,50
Industrial Engineering	2,60	2,40	3,00	3,00	3,40	3,60	3,00	3,00
Support Services	5,00	4,00	3,00	3,00	5,00	3,00	5,00	5,00
Construction & Materials	3,50	3,50	3,00	3,00	4,50	3,00	4,00	4,00
Industrial Transportation	3,00	3,00	5,00	3,00	4,00	3,00	3,00	3,00
Software & Computer Services	3,75	2,75	4,00	3,50	2,25	4,50	3,00	3,00

Note: The values represent the mean answers with regard to the level of implementation of eco-innovation practices on a 5 point Likert scale, were 1 means "not implemented" and 5 "fully implemented".

This result is supported by the literature review since, according to Zhu & Sarkis (2004), there are differences between the GSCM practices considered in this study as eco-innovation practices deployed by companies belonging to different industrial sectors. According to these results, hypothesis H1.1 is supported by the research sample.

With regard to the second hypothesis ($H_{1.2}$) formulated in order to answer to the first research question, the same procedure was followed and the Kruskal-Wallis test performed (Table 5).

Table 5 - Kruskal-Wallis test for $H_{1.2}$

Eco-innovation practices	**Chi-Square**	**Asymp. Sig.**
Environmental collaboration with suppliers	28,653	0.008*
Environmental collaboration with customers	21,506	0.021**
Green purchasing	23,484	0.000*
Reverse logistics	22,810	0.012**
Eco-product design programs	24.203	0.003*
Environmental management systems (EMS)	5.277	0.071**
Innovation production process	22.532	0.021**
Development of new eco-products	21.312	0.003*
* Significant for a significant level of 5% ** Significant for a significant level of 10%		

Based on the results provided in Table 5, the organization dimension influences the level of implementation of eco-innovation practices, since the differences are statistically significant. This can also be seen in the Table 6. According to Table 6, large organizations present higher levels of implementation of eco-innovation practices and small organizations present lower levels. That is, large organizations are more eco-innovative.

Table 6 - Eco-innovation practices implementation level by organizations' size

Organization size / **Eco-innovation practices**	Small < 50 employees	Medium 50 - 250 employees	Large > 250 employees
Environmental collaboration with suppliers (EIP1)	3,17	3,38	3,50
Environmental collaboration with customers (EIP2)	2,50	3,38	4,76
Green purchasing (EIP3)	3,00	3,25	4,28
Reverse logistics (EIP4)	2,50	3,25	3,22
Eco-product design programs (EIP5)	3,00	3,25	4,22
Environmental management systems (EMS) (EIP6)	2,33	3,38	5,00
Innovation production process (EIP7)	3,83	3,50	4,06
Development of new eco-products (EIP8)	2,83	3,50	3,28
Note: The values represent the mean answers with regard to the level of implementation of eco-innovation practices on a five point Likert scale, were 1 means "not implemented" and 5 "fully implemented".			

3.4. The influence of eco-innovation practices on business eco-efficiency

In order to answer the second research question, the partial least square path modeling statistics was used to test the two associated research hypothesis ($H_{2.1}$ and $H_{2.2}$). PLS was chosen because it allows researchers to simultaneously examine theory and measures. This modeling technique is considered superior to more traditional techniques (e.g., multidimensional scaling, factor analysis) since it: i) allows the explicit inclusion of measurement error, ii) has the ability to incorporate abstract and unobservable constructs (Fornell & Bookstein, 1982) iii)) makes assumptions, constructs, and hypothesized relationships in a theory explicit; iv) adds a degree of precision to a theory, since it requires a clear definition of constructs, operationalizations, and functional relationships (Bagozzi, 1980); and v) is deployed in real world applications and when models are complex (Wynne W Chin & Peter, 1999; Hulland, 1999) as it is the case in this research.

In the application of PLS three sets of methodological components are considered relevant (Wynne W Chin & Peter, 1999): i) assessing the reliability and validity of measures; ii) assessing the convergent validity of the measures associated with individual latent variables; and iii) assessment of the structural model.

3.4.1. Assessing the reliability and validity of measures

A reflective measurement model, as it is the case, usually is analyzed and interpreted sequentially in two stages: i) the assessment of the reliability and validity of the measurement model; and ii) the assessment of the structural model. This sequence ensures that the researcher has reliable and valid measures of latent variables. Figure 1 contains the measurement model, which specifies the three latent variables ("eco-innovation practices", "economic performance" and "environmental performance"), respective measures (according to Table 1 notation) and error values (*e*) that reflect the proportion of variance accounted for in the observed variables.

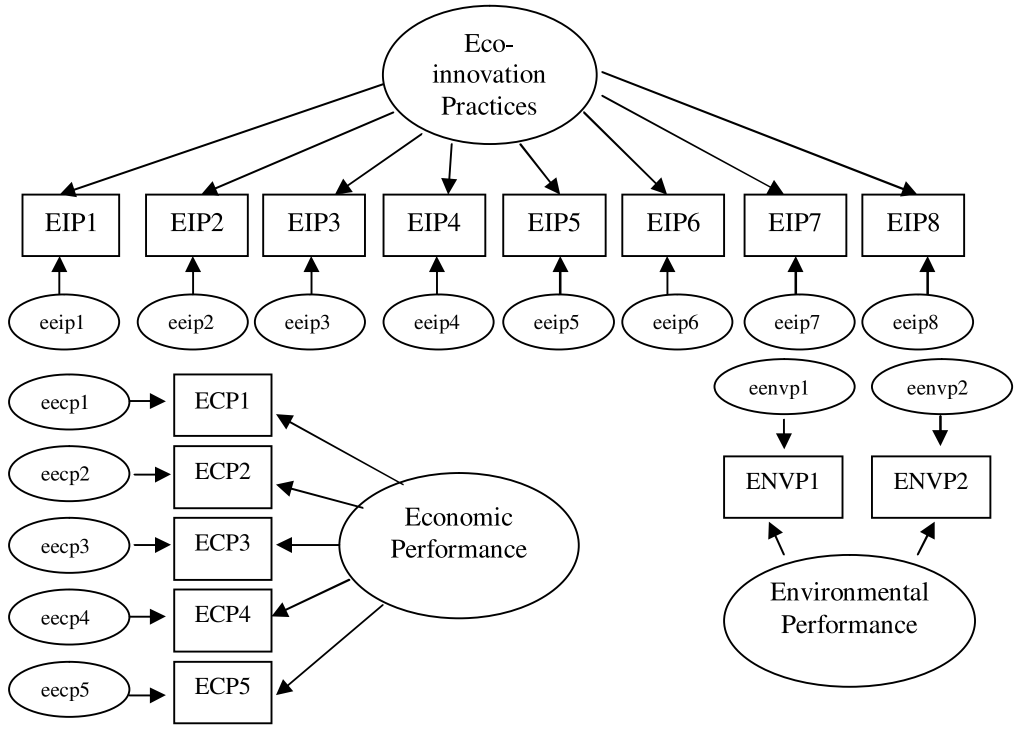

Figure 1 - Measurement model

Table 7 presents the loadings and cross loadings of the reflective measures used to translate the latent variables. The loadings represent the correlation coefficient between the latent variable and their respective measures and the cross loading represents the correlation coefficient between each latent variable and the measures belonging to the other latent variables (Wynne W Chin & Peter, 1999).

Almost all of the loadings are higher than the recommended level of 0.7 (Carmines & Zeller, 1979; Barclay, Higgins, & Thompson, 1995) which indicates adequate individual item reliability (i.e. there is more shared variance between the construct and its measures than error variance). However, the loadings associated with the measures sales volume (ECP4) and cash flow (ECP5) are quite smaller than the reference value.

Table 7 - Loadings and cross loadings of measures

Measures	Loadings	Cross-loadings		
		Eco-Innovation Practices	**Economic Performance**	**Environmental Performance**
Environmental collaboration with suppliers (EIP1)	0.7939 (0.8169)	0.7939 (0.8169)	0.3458 (0.3003)	0.4332 (0.4361)
Environmental collaboration with customers (EIP2)	0.7184 (0.7203)	0.7184 (0.7203)	0.1362 (0.2683)	0.0597 (0.2773)
Green purchasing (EIP3)	0.7763 (0.7802)	0.7763 (0.7802)	0.3614 (0.3335)	0.2357 (0.2385)
Reverse logistics (EIP4)	0.7190 (0.7230)	0.7190 (0.7230)	0.0309 (-0.0707)	0.1947 (0.0861)
Eco-product design programs (EIP5)	0.8201 (0.8321)	0.8201 (0.8321)	0.5234 (0.4523)	0.1236 (0.1121)
Environmental management systems (EMS) (EIP6)	0.7504 (0.7714)	0.7504 (0.7714)	0.2504 (0.1399)	0.1095 (0.1293)
Innovation production process (EIP7)	0.7192 (0.7321)	0.7192 (0.7321)	0.0519) (0.0526)	0.2575 (0.2617)
Development of new eco-products (EIP8)	0.7987 (0.8035)	0.7987 (0.8035)	0.3892 (0.3581)	0.1534 (0.1584)
Total cost of products (ECP1)	0.7170 (0.7834)	0.1413 (0.1481)	0.7170 (0.7834)	0.2042 (0.2027)
Environmental costs (ECP2)	0.9081 (0.9178)	0.4574 (0.4793)	0.9081 (0.9178)	0.2169 (0.2165)
Material cost (ECP3)	0.8321 0.8367)	0.3215 (0.2778)	0.8321 (0.8367)	0.0409 (0.0405)
Sales volume (ECP4)	-0.0689	0.1471	-0.0689	-.0889
Cash flow (ECP5)	-0.1138	-0.1506	-0.1138	-0.1738
Energy consumption (ENVP1)	0.8551 (0.8730)	0.4974 (0.4650)	0.2193 (0.2889)	0.8551 (0.8730)
Business waste (ENVP2)	0.8279 (0.9362)	0.2917 (0.2011)	0.3436 (0.2207)	0.8279 (0.9362)

Note: The numbers in parenthesis represent the loadings and cross loadings after the ECP and ECP5 measures were excluded.

According to (Hulland, 1999) measures with loadings of less than 0.4 should be dropped from the analysis since they will add very little explanatory power to the model. Following this suggestion, the two measures (ECP4 and ECP5) were excluded from the analysis and the reliability and validity of the other measures were assessed again (values shown in parenthesis in Table 7). As can be seen in Table 7, after the two measures were excluded, almost all of the measures of the loadings and cross loadings values were improved which reflects an improvement in the reliability and validity of measures.

3.4.2. Assessing the convergent validity of the measures associated with individual latent variables

Beyond the individual measures reliability it is also important to assess the discriminant validity. The discriminant validity represents the extent to which measures of a given latent variable differ from measures of other latent variables in the same model. To assess discriminant validity, Fornell & Larcker (1981) suggests the use of average variance extracted (AVE). AVE captures the average variance shared between a latent variable and its measures. Table 8 provides the value of AVE for the latent variables.

Table 8 - Average Variance Extracted (AVE) for the latent variables

Latent variables	**AVE**
Eco-innovation Practices	0.4513
Economic Performance	0.7187
Environmental Performance	0.7983

This measure should be greater than the variance shared between the latent variable and other latent variables in the model (i.e. the squared correlation between two latent variables) (Barclay et al., 1995). For adequate discriminant validity, the diagonal elements in the correlation matrix should be significantly greater than the off-diagonal elements in the corresponding rows and columns (Barclay et al. 1995). AVE is generated automatically using the bootstrap technique by the PLS-Graph. Table 9 lists the correlation matrix for the latent variables.

Table 9 - Correlation matrix for the latent variables

	Eco-innovation practices	**Economic performance**	**Environmental performance**
Eco-innovation practices	**0.6718**		
Economic performance	0.4172	**0.8478**	
Environmental performance	03828	0.2762	**0.8935**

The diagonal elements in the latent variable (shown in bold) are the square root of the AVE. The off-diagonal elements are the correlation among the construct. In this study, the assessment of the discriminant validity does not reveal any problems because the AVE for each latent variable is larger than the correlation of that latent variable with all other latent variables in the model (i.e. the diagonal elements are greater than the corresponding off-diagonal elements).

3.4.2. Assessment of the structural model

The structural model indicates the causal relationships among latent variable in the model. It includes estimates of the path coefficients, which indicate the strengths of the hypothesized relationship (i.e. the relationship between the dependent and independent variables), and the R^2 value, which determine the predicting power of the model (i.e. the amount of variance explained by the independent variables). Together, the R^2 and the path coefficients (loadings and significance) indicate how well the data support the hypothesized model (Chin, 1998).

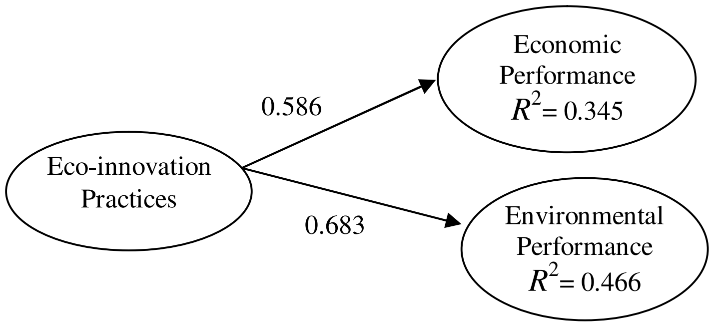

Figure 2 - Structural Model

Figure 2 shows the results of the test of the hypothesized structural model from the PLS-Graph output. As expected eco-innovation practices had significant influences on both economic performance (R^2= 0.586) and environmental performance (R^2 = 0.683). Also, the eco-innovation practices accounted for 34.5 percent of the variance in economic performance and 46.6 percent on environmental performance of businesses.

According to Chin (1998) the relationships between the latent variables are considered robust if they are associated with a structural coefficient higher than 0.2. The structural coefficients associated with the latent variable are 0.586 and 0.683. Therefore, the latent variables are considered robust in this study. This also makes it possible to conclude that the two suggested hypothesis $H_{2.1}$ and $H_{2.2}$ are supported by the data.

4. Conclusions

This paper investigates the influence of eco-innovation practices on eco-efficiency of businesses. A comprehensive review of the literature to date was performed in order to identify the eco-innovation practices and also the economic and environmental performance. A set of eco-innovation practices to organizations belonging to different industry sectors was proposed. To study the organizations eco-efficiency a set of economic and environmental performance measures was proposed. A survey was used to collect data to perform multivariate statistics and partial least squares path modelling technique to answer to the research questions.

Cohen & Klepper (1996) theorize that larger organizations have an advantage in R&D because of the larger output over which they can apply the results. Therefore, it was expected that an organizations size is an important variable to influence the implementation level of eco-innovation practices. The study results indicate that the implementation level of eco-innovation practices is different by industrial sectors ($H_{1.1}$) and by organizations' size ($H_{1.2}$). These results are supported by the works of Cohen & Klepper (1996) and Zhu & Sarkis (2004) which argue that the deployment of innovative and GSCM practices differ across industries and by organizations' size. According to Min & Galle (2001), the greater bargaining power of larger organizations can influence the implementation level of these kinds of practices not only by organizations but also by their suppliers. This makes possible to conclude that the first research question (Q_1) is answered affirmatively since their two hypotheses are supported..

In addition, the influence of eco-innovation practices on business eco-efficiency is supported by the data for both hypotheses ($H_{2.1}$ and $H_{2.2}$) based on the PLS analysis. This means that the eco-innovation practices influence both economic and environmental performance. However the greater influence is on environmental performance. These same results are consistent with the research of Min & Galle (2001), Tsoulfas & Pappis (2006) and Halila (2007).

Considering these results and the ratio of eco-efficiency proposed by Müller & Sturm (2001) in which Eco-efficiency = Environmental performance / Economic performance, it could be stated that eco-innovation practices contribute to improve the eco-efficiency of businesses since the numerator of the ratio is a highly influenced by the eco-innovation practices. For the second research question, it is possible to conclude that the implementation of the different eco-innovation practices will positively influence business eco-efficiency.

This study represents an important contribution in innovation, environmental, and eco-efficiency measurement areas. A set of eco-innovation practices at upstream, focal company, and downstream level of supply chain are proposed which provide insights to the kind of eco-practices deployed by innovative organizations. Also, to assess the eco-efficiency of business a set of economic and environmental performance measures are suggested. This study also highlights the importance for organizations to adopt eco-innovation practices as a way for improving not only their environmental but also their economic performance.

The research findings, however, are tempered by some shortcomings. First, the sample size is small making it difficult to generalize the results. Also, there should be a more homogenous distribution of samples between Portuguese and American organizations.

Moreover, there is an unbalanced distribution of research organizations by industrial sectors. The industrial sector most representative is Chemical which could lead to an unbiased analysis.

It is therefore necessary to conduct research related to replication, cross-industrial, and multi-national investigations in different industrial contexts in order to provide a generalization of these findings.

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APPENDIX A - *Cronbach's alpha*

Case Processing Summary

		N	%
Cases	Valid	32	100.0
	Excluded[a]	0	.0
	Total	32	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.829	.842	15

APPENDIX B - Questionnaire

This questionnaire aims to support research on the influence of eco-innovation practices on business performance. Eco-innovation consists of new or modified processes, techniques, practices, systems, and products to avoid or reduce environmental harms.
Your contribution is very important to the development of this study. We appreciate your collaboration in filling out the following questionnaire.

A - FIRM CHARACTERIZATION

A.1 Industry Sector / SIC: __________
A.2 Number of employees: _________
A.3 Primary product(s): ________________________________
A.4 Primary customer activity(s): ____________________________________
A.5 Your job title: ____
A.6 What are your job responsibilities? ____
A.7 Which is the percentage of the expenditures in research and development (R&D) in the total cost of the organization?

☐0% ☐0% - 1,5 ☐1,5 - 3% ☐3% - 4,5% ☐4,5% - 5,5% ☐ > 5,5%

A.8 Have your organization any patents registered? ☐ Yes. ☐ No. If yes, how many? _______
A.9 How do you define your firms' position in your supply chain?

4th tier supplier	3rd tier supplier	2nd tier supplier	1st tier supplier	**(1) Focal firm**	1st tier customer	2nd tier customer	Retailer	End-customer
○	○	○	○	x	○	○	○	○

Legend: (1) Focal firm - is the initiator of an International business transaction, they conceive, design, and produce the offerings [goods or services] intended for consumption.

B - GREEN AND ECO-INNOVATION PRACTICES

Please give your perception about the following items by placing an "X" in the appropriate square.
(1= Not at all, 2= Very little, 3 = Moderately, 4= Somewhat, 5 = To a Great Extent)

Practices	**1**	**2**	**3**	**4**	**5**
To what extent does your firm get involved in **environmental collaboration** practices with your **suppliers**? (Environmental collaboration with customers- consists of conducting joint planning to anticipate and resolve environmental-related problems - e.g. making joint decisions about ways to reduce the environmental impact of the product)	○	○	○	○	○
To what extent does your firm get involved in **environmental collaboration** practices with your **customers**? (Environmental collaboration with suppliers- represents the interaction between organizations and its suppliers pertaining to joint environmental planning and shared environmental know-how or knowledge)	○	○	○	○	○
To what extent does your firm engage in **green purchasing** practices with your supply chain partners? (Green purchasing - consists of the selection and acquisition of products and services that minimize negative environmental impacts over their life cycle of manufacturing, transportation, use and recycling or disposal.)	○	○	○	○	○
To what extent does your firm engage in **reverse logistics** practices with your partners? (Reverse logistics- is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal).	○	○	○	○	○
To what extent does your firm use **eco/green products design programs** to launch new green products? (Eco/green products design programs consists of programs that incorporate product's environmentally preferable attributes—including recyclability, disassembly, maintainability, refurbishability, and reusability)	○	○	○	○	○

To what extent does your firm use **Environmental Management Systems**? (eg. ISO 14001, Total Quality Environmental Management (TQEM))	○	○	○	○	○
To what extent does your firm engage in periodic **innovation of existing production processes**?	○	○	○	○	○
To what extent has your firm been engaged in the development of **new eco/green products** in the last 5 years? (New eco/green products consist of launching green products to the market that allow energy savings, waste recycling, and toxicity reduction)	○	○	○	○	○

C - PERFORMANCE MEASUREMENT

Please give your perception about the following items by placing an "X" in the appropriate square.
(1= Not at all, 2= Very little, 3 = Moderately, 4= Somewhat, 5 = To a Great Extent)

Performance Measures	**1**	**2**	**3**	**4**	**5**
To what extent did your firm reduce the **total cost of your product(s)** in the last 5 years? (Total cost of product represents the sum of all fixed and variable costs associated with the production, warehousing, and delivery of the final product)	○	○	○	○	○
To what extent did your firm reduce the **environmental cost** in the last 5 years? (Environmental costs are costs that serve to prevent, reduce, or recover damages that organizations caused or is likely to cause on the environment as a result of its activities)	○	○	○	○	○
To what extent did your firm reduce the **material cost** in the last 5 years? (Material cost represents the cost of all materials purchased or obtained from other sources - e.g. raw materials, process materials, pre- or semi-manufactured goods and parts)	○	○	○	○	○
To what extent did your firm reduce the **production cost** in the last 5 years? Production cost - represents all the costs associated directly with the production process)	○	○	○	○	○
To what extent did your firm improve the **sales volume** in the last 5 years? (Sales volume represents the quantity or number of goods or services sold in the normal operations of a company in a specified period)	○	○	○	○	○
To what extent did your firm improve the **cash flow** in the last 5 years? (Cash flow consists of cash received or expended as a result of the company's internal business activities)	○	○	○	○	○
To what extent did your firm reduce the **energy consumption** in the last 5 years? (Total sum of energy consumed equals energy purchases minus energy sold to others for their use)	○	○	○	○	○
To what extent did your firm reduce the **business waste** in the last 5 years? (Business wastage – e.g. total flow quantity of scrap or percentage of materials remanufactured)	○	○	○	○	○

APPENDIX C - *Sample Characteristics*

	Percent	Cumulative Percent
USA	21.9	21.9
Portugal	78.1	100.0
Total	100.0	

Size			
	Frequency	Percent	Cumulative Percent
Small (less than 50 employees)	6	18.8	18.8
Medium (employees between 250-50)	8	25.0	43.8
Large (more than 250 employees))	18	56.3	100.0
Total	32	100.0	

Industrial sectors		
	Frequency	**Percentage**
Forestry & Paper	1	3,1
General Industrials	2	6,3
Industrial Metals & Mining	3	9,4
Chemicals	7	21,9
Electronic & Electrical Equipment	3	9,4
Automobiles & Parts	3	9,4
Industrial Engineering	6	18,8
Support Services	1	3,1
Construction & Materials	1	3,1
Industrial Transportation	1	3,1
Software & Computer Services	4	12,5
Total	32	100

Expenditure R&D			
	Frequency	Percent	Cumulative Percent
0% - 1,5	5	16.1	16.1
1,5 - 3%	3	9.7	25.8
3% - 4,5%	12	38.7	64.5
1.5% - 3%	0	-	64.5
4,5% - 5,5%	4	12.9	77.4
> 5,5%	7	22.6	100.0
Missing	1		
Total	32	100.0	

Patents Register			
	Frequency	Percent	Cumulative Percent
No	11	34.4	36.7
Yes	19	59.4	100.0
Missing	2	6.3	
Total	32	100.0	

Patents Register			
Nº of patentes registered	Frequency	Valid Percent	Cumulative Percent
0	20	64.5	64.5
1	5	16.1	80.6
2	2	6.5	87.1
3	2	6.5	93.5
4	1	3.2	96.8
16	1	3.2	100.0
Total	31	100.0	

APPENDIX D - Normality and homogeneity of variance

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Country	.488	30	.000	.492	30	.000
Size	.350	30	.000	.720	30	.000
Expenditure R&D	.234	30	.000	.862	30	.001
Position in supply chain	.311	30	.000	.758	30	.000
Environmental collaboration with customers	.217	30	.001	.903	30	.010
Environmental collaboration with customers	.225	30	.000	.904	30	.011
Green purchasing	.249	30	.000	.902	30	.009
Reverse logistics	.183	30	.011	.912	30	.017
Eco-product design programs	.190	30	.007	.910	30	.015
Environmental management systems (EMS)	.232	30	.000	.837	30	.000
Innovation production process	.239	30	.000	.806	30	.000
Development of new eco-products	.183	30	.011	.915	30	.021
Total cost of products	.252	30	.000	.858	30	.001
Environmental costs	.192	30	.006	.910	30	.015
Material cost	.213	30	.001	.898	30	.008
Sales volume	.224	30	.001	.892	30	.005
Cash flow	.208	30	.002	.900	30	.009
Energy Consumption	.297	30	.000	.769	30	.000
Business waste	.270	30	.000	.829	30	.000
a. Lilliefors Significance Correction						