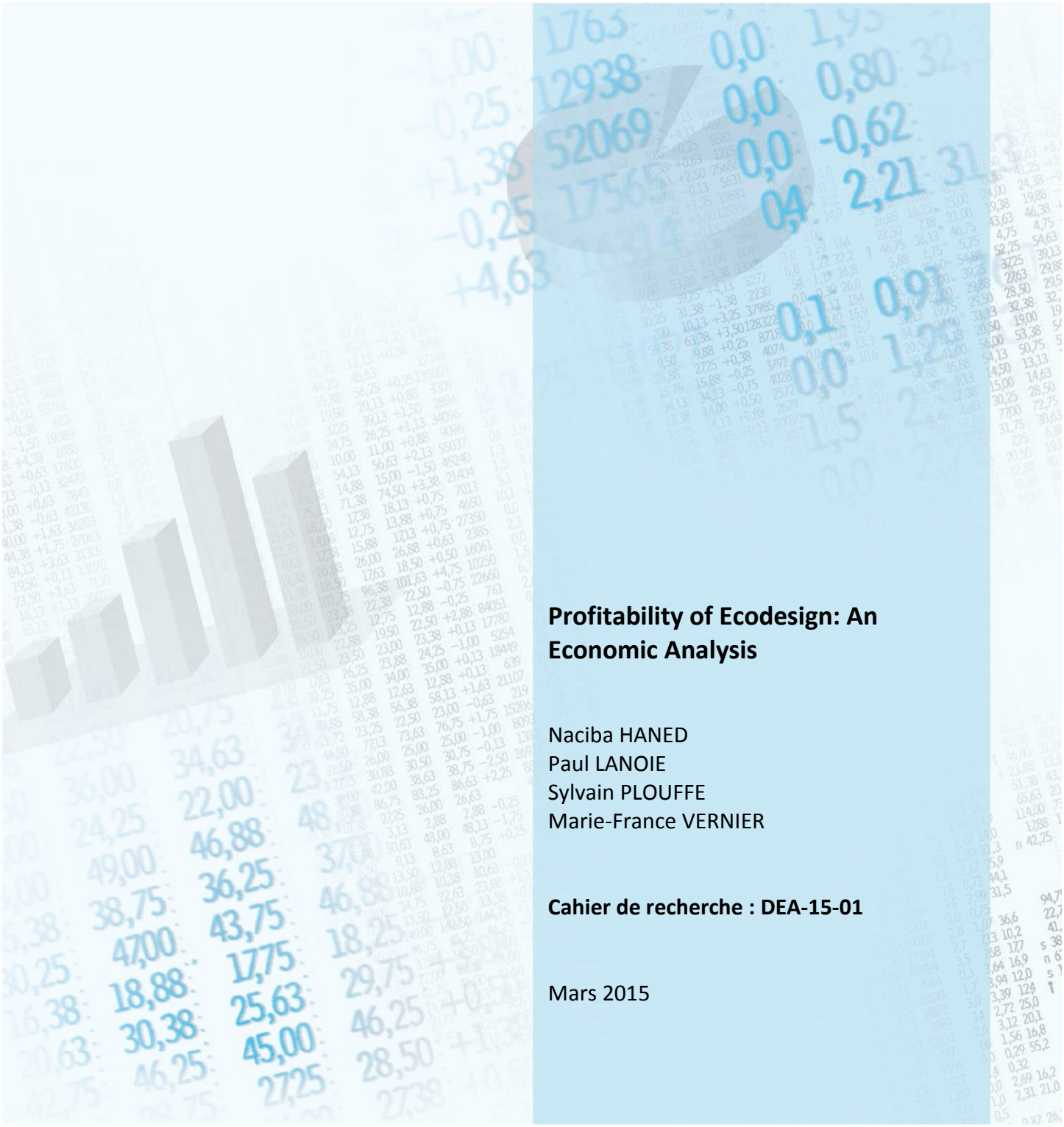
HEC MONTRÉAL
Département
d'économie appliquée



Profitability of Ecodesign: An Economic Analysis

Naciba HANED
Paul LANOIE
Sylvain PLOUFFE
Marie-France VERNIER

Cahier de recherche : DEA-15-01

Mars 2015

Département d'économie appliquée
HEC Montréal
3000 chemin de la Côte-Sainte-Catherine
Montréal (Québec) H3T 2A7
Canada
http://www.hec.ca/iea
iea.info@hec.ca

ISSN : 0825-8643

Profitability of Ecodesign: An Economic Analysis [1]

Naciba HANED, Université Catholique de Lyon

nhaned@univ-catholyon.fr

Paul LANOIE, HEC Montréal

paul.lanoie@hec.ca

Sylvain PLOUFFE, Faculté d'Aménagement, Université de Montréal

sylvain.plouffe@umontreal.ca

Marie-France VERNIER, ESDES, Université Catholique de Lyon

mfvernier@univ-catholyon.fr

[1] The authors thank the *Institut de développement de produits (IDP)* from Québec and the *Pôle Éco-conception et Management du Cycle de Vie* from France for initiating this research and for their continuous support. The financial support of the following organisations is also acknowledged: Ministère des finances et de l'économie du Québec, Industrie Canada, ADEME, CETIM, Conseil général Loire en Rhône-Alpes, and CCI St-Étienne Montbrison. The authors also thank Abderezak Ghenai, Camille Ouellette and Philippe Lemay for very valuable research assistance.

Abstract

In this paper, we examine two research questions: 1) Is it profitable for companies to adopt ecodesign practices? and 2) Why is ecodesign more profitable for one company than another ? With these questions in mind, we perform statistical analysis on new a survey data gathered by means of a questionnaire filled by 119 firms. With the descriptive data, we are able to draw up a profile of the typical ecodesign company and learn more about the profitability of the ecodesign approach. We also run robust regression analyses to identify the factors that determine the degree of profitability of ecodesign. With respect to the first research question, we find that, for 45% of the responding companies, ecodesign has a positive effect on the bottom line, in absolute terms, while the effect was neutral for 51 %. For a large portion of responding companies, the ecodesign approach also has positive, non-financial impacts. Regarding the second research question, it appears that some variables representing the intensity of the ecodesign approach are associated with greater profitability, like the number of product life cycle stages the company takes into consideration in its ecodesign approach, or the use of a formal methodological tool. Some indicators of the overall quality of company management are also associated with greater profitability, like the fact that a company received outside recognition of the quality of its management.

Key words: ecodesign, life-cycle, profitability, product innovation.

Résumé

Cette étude est consacrée à deux questions de recherche: 1) Est-ce rentable pour les entreprises de faire de l'écoconception? et 2) Pourquoi l'écoconception est-elle plus rentable dans une entreprise que dans une autre ? Pour y répondre, nous proposons une analyse statistique à partir de données provenant d'une nouvelle enquête à laquelle 119 entreprises ont répondu. Avec les statistiques descriptives, nous pouvons faire ressortir le profil type des entreprises qui font de l'écoconception et en apprendre davantage sur la rentabilité de cette activité. À partir d'analyses de régression, nous pouvons identifier les déterminants de la rentabilité de l'écoconception. En ce qui concerne la première question de recherche, nous trouvons que, pour 45% des entreprises qui ont répondu à notre questionnaire, l'écoconception a eu un impact positif sur les profits, en termes absolus, alors que l'impact a été neutre

pour 51 % d'entre elles. Pour une très grande proportion des entreprises, l'écoconception a également eu des retombées positives non financières. Pour ce qui est de la deuxième question, nous trouvons que certaines variables capturant "l'intensité" de la démarche d'écoconception, comme le nombre d'étapes du cycle de vie prises en considération ou l'utilisation d'une méthodologie formelle, sont associées avec une plus grande rentabilité. De plus, certains indicateurs de la qualité générale de la gestion de l'entreprise, comme le fait d'avoir obtenu une reconnaissance extérieure, sont également positivement correlées à la rentabilité.

Mots clés: écoconception, cycle de vie, rentabilité, innovation de produits.

Introduction

The widespread globalization of goods and services is prompting companies in industrialized nations to adopt innovation and creativity strategies to ensure their growth. There is also the collective desire to engage in sustainable development, as evidenced by the various multilateral agreements. Ecodesign, therefore, can be seen as a response to this situation, combining creativity, innovation and environmental responsibility.

But adopting environmentally responsible strategies still elicits scepticism from industry, whose leaders question its cost-effectiveness. There are only a limited number of studies on the economic return of an ecodesign approach and this probably inhibits action from industry leaders. There is also a shortage of information on how to implement a successful ecodesign approach that would enable corporations to make relevant strategic choices.

To fill this gap in the literature, this paper addresses two research questions: 1) Is it profitable for companies to adopt ecodesign practices? and 2) Why is ecodesign more profitable for one company than another ? Or, in other words, what are the factors which differentiate firms in terms of profitability amongst those implementing ecodesign? To our knowledge, only few studies have looked at the profitability of ecodesign, and those studies had small non-representative samples (e.g. Plouffe et al. 2011, Tischner and Nickel 2003, Johansson et al. 2001). Furthermore, no existing studies have examined the determinants of the profitability of ecodesign. Businesses interested in implementing ecodesign are certainly looking for the "best practices".

We perform statistical analysis on new survey data gathered by means of a questionnaire filled by 119 firms: 49 in France, 26 in other European Union countries, and 44 in Quebec. To our knowledge, this survey data constitute the largest database available on ecodesign and related profitability. With the descriptive data, we are able to draw up a profile of the typical ecodesign company and learn more about the profitability of the ecodesign approach. Furthermore, we have enough observations to investigate, through a regression analysis, the determinants of that profitability. In order to do so, we

formulate our main working hypotheses are as follows: the more intense the ecodesign approach and the better the overall management of the company, the more profitable ecodesign will be. We also control for certain inherent characteristics of the companies surveyed, such as their size, or the industry in which they operate.

In particular, we find that, for 45% of the responding companies, ecodesign has a positive effect on the bottom line, in absolute terms, while the effect was neutral for 51 %. From a social standpoint, ecodesign is a thus win-win solution, as it generates environmental benefits for all, without any negative impact on profitability. For a large portion of responding companies, the ecodesign approach also has positive, non-financial impacts, like improved reputation and recognition.

From our statistical analysis, following our hypotheses, we observe that some variables capturing the intensity of the ecodesign approach are associated with greater profitability, like the number of product life cycle stages the company takes into consideration in its ecodesign approach, or the use of a formal methodological tool. Some indicators of the overall quality of company management are also associated with greater profitability, like the fact that a company received outside recognition of the quality of its management.

The remainder of the article is organised as follows: the second section summarizes studies previously published on the subject; the third one provides details on the methodology used and the econometric model; the study results are presented in Section 4, in two parts: first a descriptive examination of the sample, followed by a more in-depth analysis of the econometric results. In the conclusion, we discuss our findings and their main implications for companies and policymakers.

2. Literature review

Taking the environment into account in product design goes back more than 30 years, when it was closely linked to the first oil crisis. Growing collective awareness of the degradation of natural resources, along with increasingly stringent environmental regulations, undoubtedly fostered the

development and marketing of ecodesigned products. Added to this is the formalization of the processes and methods of development of ecodesigned products (OECD, 2005).

Since the 1980s, different expressions were used to account for the integration of environmental considerations in product design: “Green design”, “Ecological Design”, “Sustainable Design”, etc.. Today, nearly all processes and approaches related to this integration are grouped under the term ecodesign (Karlsson and Luttropp, 2006; Braungart et al., 2007). The most common approach used for ecodesign is life-cycle analysis - LCA (ISO, 2002). It involves taking simultaneously into account the environmental impacts in the selection of raw materials, the manufacturing process, the storage and transportation phase, usage, and final disposal.

Many publications, often government-generated, underscore the benefits of ecodesign. In these “Standard-setting” documents, the cost-effectiveness of ecodesign is always mentioned (ADEME 1999, WBCSD 2000, Environment Australia 2001, ISO 2002, Business for Social Responsibility-BSR 2003). The potential spinoffs of ecodesign practices can be grouped in three categories:

First, cost reductions can be achieved in various ways such as: the use of recycled materials, which can cost less, better use of raw materials (Platchek et al., 2008, Borchardt et al, 2010), improved logistics, less packaging and energy savings. Usually, these reductions are the result of the optimization of one or several aspects of the life-cycle of the product.

Second, ecodesigned products provide greater satisfaction to consumers, who are increasingly sensitive to environmental issues. Furthermore, a growing number of public and private companies are using environmental performance as a criterion for selecting their suppliers. Ecodesigned products therefore enable firms to qualify as potential suppliers. In many cases, ecodesign, while reducing a product’s environmental impact, can lead to its simplification and to a longer life-cycle, thus helping it to stand out from the competition. In addition, it can be easier to build customer loyalty when ecodesign leads a firm to sell a service rather than a product, since a long-term relationship is established for replacement of the product. At the same time, some ecodesigned products can generate

economic benefits for the buyers, such as lower energy consumption, and can therefore contribute to their loyalty (Aoe, 2007).

Third, ecodesign practices generate non-economic benefits for the organization. Ecodesign allows the firm to play a proactive role with respect to regulations, to adapt to them and remain competitive in countries where the authorities require producers to take back their products at the end of their useful life (extended responsibility). Ecodesign can also enhance the firm's image and improve relationships with various stakeholders: financial community, environmental groups, neighbouring communities, and so on. In proposing a new way of developing products or services, ecodesign can foster greater creativity or enhance innovation capability. In converging more closely with employees' values, ecodesign can increase the motivation of the work force.

Empirical studies on ecodesign are usually case studies that hint at a number of economic benefits stemming from these experiences. In van Hemel (1997), Dutch cases are described in the context of a government initiative to promote ecodesign in SMEs; Masera (1999) looks at the ecodesign of a chair in Mexico; Mathieux et al (2001) describe several cases in the electronic products industry in Europe, so do Gheorge and Ishii (2008); and Tischner and Nickel (2003) present a case in the printing industry. All these studies point to positive elements in terms of profitability, either through an increase in revenues or a decrease in costs.

Johansson et al (2001) conduct a more systematic study on the economic benefits of ecodesign on 11 companies in the electric and electronic sectors. Their results also indicate positive results for the companies, both at the economic and non-economic level. Such results are compatible with a growing trend in the literature showing that it is possible to reconcile the firms' environmental and financial performances (e.g. Ambec and Lanoie, 2008).

Plouffe et al. (2011) conduct an exploratory study of 30 ecodesign experiences (15 in France, 15 in Quebec) using semi-structured interviews. In 24 cases, firms increased their profits with ecodesigned products. In three cases, profits were equivalent and in the three remaining cases, it was not obvious

that the increased revenues compensated for the reduction of the profit margin. Furthermore, French companies were found to be more profitable than the Quebec cases; a possible explanation for this result is that French companies had a more systemic approach and therefore managed to make cost savings at several stages in the product life-cycle. Looking at the most successful cases (those with the highest profit margin), the authors also conclude that the most important aspects to consider when getting involved in an ecodesign project were to focus on increased functionality of the product and to seek environmental and economic improvement on as many life-cycle stages as possible.

Kanakaki (2013) provide a similar analysis with 21 cases of ecodesign in Greece. In particular, she finds that, in 19 out of 21 cases, there is a positive impact on firm's profits; in one case, the impact is neutral, and it is negative in the last one.

Finally, it is worthwhile to mention the study of Molenbroek et al. (2012) which investigates the economic benefits of the European Union (EU) Ecodesign Directive. This Directive aims at reducing the environmental impact of a number of products (domestic appliances, commercial and industrial equipment, etc.) sold in the EU, with emphasis on their energy consumption. They find that an appropriate implementation of the Directive would yield savings of up to 600 TWh of electricity and 600 TWh of heat in 2020, equivalent to 17 % and 10 % of the EU total electricity and heat consumption, respectively. This would generate net savings for European consumers and businesses of € 90 billion per year (1% of EU's current GDP).

3. Methodology and measurement

Sample construction

Since data on environmental management are not collected systematically by any statistical nor business organization, as other researchers on related topics (e.g.,Henriques and Sadorsky, 1996, or Johnstone and Labonne, 2009), we had to collect data with our own survey. Hence, we base our empirical research on an original sample of 119 firms that have answered to the survey we conducted

in 2013: 49 in France, 26 in other European Union countries, and 44 in Quebec. Our targeted population is composed of companies that have experience in ecodesign[2].

It is not possible to compare the sample with the populational distribution because there is no statistical record indicating exactly the size of this population and its composition, so we have to use the most reliable information in the circumstances. Three professional organizations were involved with us in designing and producing this study: *Institut de Développement de Produits* (*IDP*[3]) for Quebec, the *Pôle National Éco-conception et Management du Cycle de Vie* (*POLE*[4]) for France, and the *European Network of Ecodesign Centres* (ENEC) for the rest of Europe, so we use primarily the information that they gave us.

In Quebec, *IDP* is committed to the promotion of the best practices in product innovation, and it offers different tools to train companies in ecodesign. We had access to the list of companies (around 100) involved in its training activities. Monitoring by *IDP* members and project researchers has helped to identify some 60 additional companies. We also had access to a list of around 30 suppliers of a major home hardware store that has developed an extensive range of ecodesigned products. So altogether, we identified around 200 Quebec firms involved in ecodesign; we contacted all of them and obtained 44 completed surveys.

Concerning French enterprises, the *POLE* provided us with its database (500 companies). It contains its 150 company members, 100 companies which asked for subsidies to implement an ecodesign approach to the Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME[5]), 80 company

[2] Another option would have been to have a group of firms doing ecodesign and a control group of firms producing identical products and services in a traditional way. Rapidly, we rejected this option. The sample would not have been random and, in a world of differentiated products, it would have been extremely difficult to find firms producing strictly comparable products. In our sample though, we had 42 firms which mentioned that they were producing ecodesigned products and similar products designed in a traditional way, so that comparing profitability of both types of products could be easier for them. χ^2 tests showed that results reported in Tables 1 and 2 below were not statistically different between the whole sample and the sample of these 42 firms.
[3] Institute for Products Development.
[4] National Centre for Ecodesign and Life Cycle Management
[5] Agency for Environment and the Control of Energy

members of the Centre technique des industries mécaniques (CETIM[6]), and 170 other companies working on ecodesign in France.

For the other European companies, 42 were identified with the help of IHOBE (Basque Ecodesign Center, Spain), OVAM (Flanders, Belgium), EFA (Effizienz-Agentur NRW, North Rhine-Westphalia, Germany), and EcoDesign Centre (Wales, United Kingdom). The final European subsample (outside France) is composed of 16 firms for Spain, 9 for Belgium and 1 firm in Wales.

Overall, more than 750 companies were contacted for a final sample of 119 firms (response rate of 16%). For all countries, company respondents (either a top manager, an environmental manager, a product manager, an R&D specialist, or an accountant) could complete the questionnaire online, or we could fill in with them over the phone

The questionnaire consists of 48 questions[7], the majority of which are multiple choice and are divided into four sections: 1) the "general characteristics of firms"; 2) the "history of ecodesign in the company"; 3) the "description of an ecodesigned product representative of the company (on sale for at least a year)"; and 4) the "profitability of this representative ecodesigned product".

Definition and measurement of variables

To answer the first central question of this study on the profitability of ecodesign, we will rely mainly on the descriptive statistics from Section 4) of the questionnaire. For the second central question (What makes ecodesign more profitable in one company than another?), we seek to identify the explanatory factors (independent variables) responsible for this profitability (dependent variable). The econometric model we use is the following:

$$PROFITABILITY_i = F\ (INTENSITY_{i,}\ QUALITY_i,\ X_i,\ \mu_i)$$

[6] Technical Center for the Mechanical Engineering sector.
[7] The questionnaire is available upon request.

where PROFITABILITY$_i$ is a measure of the profitability of ecodesign in company i; INTENSITY$_i$ is a vector of independent variables representing the intensity, scope, or scale of the ecodesign approach; QUALITY$_i$ is a vector of independent variables representing the "overall" quality of the company's management; X_i is a vector of control variables; and μ_i is an error term representing unobservable variations.

In other words, the model we test is meant to explain the magnitude of profitability associated with the eco-design practices of a sample of 119 firms, while controlling for the firms' characteristics. We use an ordered Probit model that we estimate by using a maximum likelihood estimation (Greene, 2003)[8].

In this case, we apply an extension of binary estimates, such as the latent variable models y * (which measures profitability of eco-design) is observed for all j observations that are mutually exclusive for each individual i:

$\sum_{j=0}^{m+1} P(y=j)=1 \forall i$; the probability associated with each response being:

$P(y_i = j) = F(X, \beta)\ i = 1,\ldots,n;\ j = 0,\ldots,m_i$; the conditionnal probabilities are given by :

$$P(y_i = m) = P(\mu_m < y_i^* \leq \mu_{m+1}) = 1 - F\left(\frac{\mu_m - Xi\beta}{\sigma}\right).$$

Our working hypotheses are as follows: the more intense the ecodesign approach and the better the overall management of the company, the more profitable ecodesign will be. We also control for certain inherent characteristics of the companies surveyed, such as their size or the industry in which they operate.

In order to verify these hypotheses, we construct three categories of independent variables. With respect to the first category (INTENSITY), we postulate that the more systematically ecodesign is done; the easier it is to identify opportunities to make it profitable. This hypothesis is based on previous literature (e.g. Plouffe et al. 2011), and on discussions with experts on these issues. For the

[8] This specific method is used because the assumptions of continuity and normality are no longer verified to minimize the variance more particularly in this case because the dependent variable is discrete.

second category (QUALITY), our rationale is that, all other things being equal, the better the quality of management, the greater the profitability (Porter and van der Linde 1995). The third category consists of control variables representing company size, industry, location, clientele, etc. They allow us to determine, for instance, whether ecodesign is more profitable when a company caters to consumers (B2C) or other businesses (B2B), whether there are economies of scale associated with company size, or whether factors specific to certain industries have an impact on profitability.

Profitability

In the last part of the questionnaire, we asked several questions on firms' profitability and we retain one measure that is whether ecodesign has helped increase the company's profits, in absolute terms. From these answers, we create a variable (PROF[9]) ordered from 1 to 3 that is intended to measure the intensity of the contribution of ecodesign to the increase in company profits. This variable equals 1 if there is a decrease or an important decrease in profits, a value of 2 if the impact on profits is neutral, and 3 if there is an increase or an important increase in profits[10]. This indicator is used because, in many cases, the economic success of ecodesign and more generally environmentally oriented measures are most importantly influenced by costs and income (Schaltegger and Synnestvedt, 2002).

Intensity of ecodesign practices

With respect to the impact of the intensity of ecodesign practices on profitability, we use 13 variables to capture eight dimensions of the intensity of the ecodesign approach. For each dimension, our expectations or hypotheses regarding the results are set out below.

Ecodesign experience (EXP1, EXP2 and EXP3[11]). A learning curve applies to the ecodesign approach (Lindahl, 2001); generally, the farther along on the curve, the more intense and the more profitable the approach should be (Jackson, 1998). On the other hand, those new to ecodesign can make significant

[9] The definition of all variables is provided in Table 4.

[10] To answer this question, the respondents were given three examples of situations which could have led to an increase in the absolute level of profits, a neutral impact or a decrease. Then, they were asked: "Choose the item that best describe the impact the ecodesigned product had on the firm's profits: 1) the product led to an important increase in profits; 2) the product led to an increase in profits; 3) the product had a neutral impact on profits; 4) the product led to reduction in profits; or 5) the product led to a large reduction in profits.

[11] EXP1 an EXP2 are used in all models except for model 2 where we add the binary variable EXP3.

gains ("low-hanging fruit") in a short space of time (Plouffe et al. 2011). To measure experience, we use alternatively two quantitative variables (EXP1 and EXP2) that measure the years of experience and the number of projects with ecodesign; and a binary variable (EXP3) that equals 1 for firms that have already undertaken ecodesign projects they had completed in the last three years.

Motivation to undertake the ecodesign approach. In the questionnaire, we list the main reasons that might prompt a company to undertake an ecodesign approach. From this, we construct three ordered variables that measure the commitment of upper management (respectively MOTDIR; MOTREG, and MOTMRK). The question of the determinants of ecodesign practices has been largely discussed in the literature which suggests that impetus from senior management is crucial to the success of any organizational change (see Doonan et al., 2005). We therefore postulate that companies where motivation of that kind is fully in evidence probably have more encouragement to succeed with their ecodesign approach and make it profitable (MOTDIR). After reviewing the data, we decided to add two more variables related to motivation: MOTREG for the anticipation of new regulations and MOTMRK for the search of new markets as the motivation for undertaking an ecodesign approach. These two major types of motivation should be related to profitability.[12]

Environmental certification. We add a binary variable to indicate whether the developed product meets a standard, a regulation, or some type of environmental labeling (CERT[13]). A product awarded an environmental certification is a sign of a systematic approach and a mark of quality for customers. These two elements should have a positive impact on profitability (see Kok and Kahn, 2012). However, obtaining environmental certification can be a long and expensive process, as suggested in Berneman et al. (2009). On a purely theoretical level, it is thus impossible to predict whether the certification will have a positive or negative impact on the profitability of the ecodesign approach. We need statistical analysis to answer that question.

[12] MOTDIR; MOTREG, and MOTMRK are used in all models except for model 3 where we add the ordered binary variable MOTIV. This variable takes the value of 1 if one of these three motivations is mentioned by the respondent; 2 if two of these three motivations are mentioned and 3 if all three are mentioned.

[13] The variable is given a value of 1 if the developed product met a standard, a regulation, or some type of environmental labeling; if not, it is assigned a value of 0.

Life cycle stages. To measure the number of stages taken into consideration in the product life cycle (raw material, production, storage, transportation, end of life, etc.), we add an ordered variable (CYCLE). The higher the number of stages, the higher the probability the ecodesign approach will be profitable[14] as suggested by the Standard ISO 14062[15].

Methodology We add a binary variable to take into consideration whether there is a formal methodological tool supported by a standardization or international institution (like life-cycle analysis, a protocol related to a specific environmental label, etc.) used in the ecodesign approach (METHOD[16]). The more a company's ecodesign approach is systematic and formally organized, the more profitable it should be.

Integration of ecodesign into the different functions within a company. We use an ordered variable (INTEG) to state which of the company's functions (senior management, R&D, marketing, production, etc.) are involved in the ecodesign approach. We postulate that the more the ecodesign approach is integrated into the different functions[17], then the easier collaboration would be, the more synergy there would be, and the more profitable the approach would be (see Doonan et al., 2005).

Outside support received. If the company receives support for its approach from an outside organization, it probably contributes to its profitability, especially if the expertise is not available within the company. We add a binary variable (SUP) whether the company received financial or other support from public or professional organizations for its ecodesign approach[18]. A positive answer is deemed to increase the likelihood of profitability.

Environmental communication. All other things being equal, companies that emphasize the environmental benefits of their ecodesigned products in their communications (ads, articles, etc.)

---

[14] The variable is given a value from 1 to 7 depending on the number of life cycle stages taken into consideration.
[15] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=33020
[16] The variable is given a value of 1 if a methodological tool was used in the ecodesign approach; otherwise, 0.
[17] The variable is assigned a value from 1 to 6 depending on the number of functions involved.
[18] The variable is given a value of 1 if the company received support; otherwise, 0.

should have more success in reaching customers aware of sustainability issues and therefore in increasing their profits. We use a binary variable (COM) to indicate whether the companies promote the environmental qualities of their products in their marketing campaigns. Companies that do so should be more profitable than those that do not[19].

Quality of company management

All other things being equal, better-managed companies should be better able to take advantage of ecodesign to boost their profits. We use four variables to capture this dimension.

Innovation. Innovation is one of the keys to business success (see Bogliacino and Pianta, 2013). Changes in R&D spending can serve as an indicator of innovation. We add an ordered variable (RD) linked to trend in companies R&D expenditures over the last three years[20].

Product quality. In the same vein, innovation can lead to improvements that make the product more attractive to buyers and contribute to its profitability. This is suggested by Berneman et al. (2009); the more a company adds functional qualities to its product, the more profitable the ecodesign approach appears to be. We use an ordered variable (FUNC)[21] to measure the functional advantages for the user of the ecodesigned product when compared with a conventional product (more economical to use, easier to maintain, lighter, more ergonomic, etc.).

Outside recognition. The opinion of an independent third-party organization can be a good way to assess the quality of a company's management. We add a binary variable (RECOG) whether the company received certification or an award in the last three years in recognition of the quality of its management or products, or not[22].

[19] The variable is assigned a value of 1 if the companies promote the environmental qualities of their products in their marketing campaigns; otherwise, 0.
[20] The variable is given a value from 1 to 6 depending on R&D growth over the past three years.
[21] The variable is given a value from 1 to 7 depending on the number of functional advantages identified.
[22] The variable is assigned a value of 1 if the company received a certification or an award; otherwise 0.

Commitment to sustainable development. There is growing acceptance that taking a path towards sustainable development can improve a company's performance (Porter and van der Linde, 1995; Ambec and Lanoie 2008). We add an ordered variable (COMIT) to rate the senior management's level of commitment to sustainable development[23].

Control variables

Here, thirteen variables were used capturing five different dimensions.

Size. The size of a company can have various impacts on its profitability. On the one hand, larger companies may be able to leverage advantages that help make the ecodesign process more profitable. For example, if their product range is broader, they may be able to benefit from economies of scale by simultaneously applying the same ecodesign innovations to several products. Furthermore, larger companies usually find it easier to obtain financial capital and to attract a more diversified workforce, which facilitate the integration of ecodesign practices, etc. On the other hand, smaller companies can be more flexible and consequently better able to seize profitable business opportunities. On a theoretical level, it is therefore impossible to predict whether a company's size will have a positive or negative impact on ecodesign profitability. Statistical analysis is needed to answer that question. We measure company size (DSIZE1, DSIZE2, DSIZE3 and DSIZE4) by the number of employees[24]. We also add an ordered variable (SIZEO) according to four size classes.

Industry. Characteristics specific to a given industry can influence the profitability of ecodesign. For example, if an industry is less competitive as a result of a high concentration of companies, then it is possible that, all other things being equal, each innovation developed in the industry will be more profitable. Based on our review of the sample, we decided to divide the companies into three industry categories: manufacturing, trade and services, and other. Three binary (two-state) variables are

[23] The variable is given a value from 1 to 5 depending on the level of commitment.
[24] We create four size categories and assign them values from 1 to 4 (1: 0 to 10 employees [DSIZE1]; 2: 11 to 50 [DSIZE2]; 3: 51 to 250 [DSIZE3]; 4: 251 or more [DSIZE4]). SIZEO is an ordered variable for these four size classes.

created: DMAN for manufactured activities, DTRA for trade and services and DOTHER for firms in the agricultural or construction industries[25].

Clientele. All other things being equal, companies doing business with other companies are more likely to turn a profit on their ecodesign activities than companies catering to the general public. Company purchasing professionals seem more aware and better equipped than consumers to appreciate ecodesign-related innovations, as suggested by Plouffe et al. (2011). We use an ordered variable (B2B) according to the type of users of the company's products[26].

Buyer awareness. Similarly, all other things being equal, if the product targets buyers who are more sensitive to environmental issues, then they should be willing to pay more for the product, and company profitability for the product should be higher. We add an ordered variable according to the buyer awareness (AWARN)[27].

Origin. All other things being equal, ecodesign may be more profitable in one geographic area than another for a variety of reasons, such as stricter government regulations that require calls for tenders to include environmental performance assessments in their selection criteria, or greater public awareness of environmental issues[28].

4. Empirical results

Ecodesign Profitability

To answer our first research question, we present our raw data on ecodesign profitability and firm performance. Three questions were asked to measure the impact of the ecodesigned product on

[25] The variable DMAN is set to 1 for manufacturing companies, and otherwise to 0. The variable DTRA is set to 1 for companies in the trade and services industries, and otherwise to 0. The variable DOTHER is the one excluded by default.
[26] The variable is given a value of 0 if the type of users is B2C, a value of 1 if it is B2B, and a value of 2 if it is B2B and B2C.
[27] The variable is assigned a value from 1 to 3 depending on the buyer awareness assessment (1: not aware; 2: average awareness; and 3: strong awareness).
[28] Three binary (two-state) variables are created. The variable FR is set to 1 for French companies, and otherwise to 0. The variable QC is assigned values in the same fashion. The variable EU (European Union) is the one excluded by default.

profitability and performance (the regression results will be based on the first one). Regardless of the indicator chosen, the impact was positive or neutral in most cases.

First, Table 1 shows the impact of ecodesigned products on firms'profitability, in absolute terms. We find that, for 45% of the responding companies, ecodesign has a positive effect on the bottom line, while the effect was neutral for 51 %, and negative for only 4 %. Thus, 96 % of the respondents said that the impact of ecodesigned products on company profits, in absolute terms, was positive or neutral (France 98%, the European Union 96%, and Quebec 93%). A positive impact was more common in the European Union (64%) and Quebec (51%) than in France (29%).

Table 1. Impact of ecodesigned products on profits (in absolute terms)

116 out of 119 companies answered this question

	France	*Quebec*	*European Union*	*Total*
	(%)	(%)	(%)	(%)
Important increase	0	5	20	6
Increase	29	46	44	39
No effect	69	42	32	51
Decline	2	7	4	4
Important decline	0	0	0	0
Total	100	100	100	100

In Table 2, we present how the profit margin of ecodesigned products compares to that of conventional products. In 30% of cases, the profit margin of ecodesigned products is higher than that of conventionally developed products, and similar in 55 % of the cases.

Table 2. Change in profit margin (compared with conventional design)

114 out of 119 companies answered this question

	France	*Quebec*	*European Union*	*Total*
	(%)	(%)	(%)	(%)
Much higher	2	9	0	4
Higher	19	28	38	26
Similar	75	32	54	55
Lower	4	26	8	13
Much lower	0	5	0	2
Total	100	100	100	100

Regarding these differences in profit margin, the answers from the responding companies were significantly heterogeneous across regions. While the margin was similar or positive in 96% of the cases in France, the corresponding percentage was only 69% in Quebec.

Third, when asked about the benefits of ecodesign other than financial (Table 3), a large portion of companies mentioned "improved recognition and reputation" (average of 86% across the three areas). "Greater employee motivation or pride" was considered to be another major benefit of ecodesign (41 %), followed by "Better customer relations" (36 %) and "Greater capacity to develop new products" (32 %).

Table 3. Other positive impacts of ecodesign approach

117 out of 119 companies answered this question

Respondents could select multiple choices

	France	*Quebec*	*European Union*	*Total*
	(%)	(%)	(%)	(%)
Improved recognition and reputation	92	84	81	86
Greater employee motivation or pride	21	53	58	41
Better customer relations	33	47	23	36
Greater capacity to develop new products	29	33	35	32
Easier to recruit staff	4	23	19	15

Improved relations with funding agencies, regulatory authorities, or NGOs	8	12	19	12
Better interdepartmental cooperation	17	2	19	12
Other	4	9	4	6

Overall, our results indicate that companies can improve their environmental impact without suffering any adverse effects on their profits, in absolute terms, or on their profit margin, while enjoying non-financial benefits. This confirms results of previous studies (Plouffe et al., 2011, Johansson et al., 2001), but with a much more extensive and representative sample.

Table 4 presents the summary statistics for the variables described in Section 3. These variables are used in our regression analysis to answer our second research question: Why is ecodesign more profitable for one company than another? These statistics also allow us to obtain a "profile" of the firms undertaking ecodesign. It is noteworthy that these firms are mainly in the manufacturing sector (62 %), that they are relatively small (81 % have less than 250 employees and 53 % have less than 50 employees), and active in R&D (2.19 on a scale of 3). Furthermore, the main motivation to implement ecodesign is the impulse from the senior management, who is highly committed toward sustainable development.

Regarding how ecodesign is done within these companies, a number of features are worth mentioning: half of the firms are involved in a certification process; on average, four stages of the life cycle are taken into account; more than 75 % rely on a formal methodological tool; on average, three administrative units are involved in the ecodesign process; around half of the firms received outside support, and almost all of them (91%) communicate on the environmental quality of their product.

Table 4. Summary statistics of variables

	Definition	Observations	Mean	Std	Min	Max
Dependent variable						
PROF	Ordered variable for the intensity of the contribution of ecodesign to the increase in company profits	119	2.42	0.57	1	3
Explanatory variables : intensity of ecodesign						
EXP1	Quantitative variable for ecodesign experience (number of years)	103	7.07	6.91	1	37
EXP2	Quantitative variable for ecodesign experience (number of projects)	95	11.55	23.98	0	150
EXP3	Binary variable: equals 1 for firms having an ecodesign experience	117	0.47	0.50	0	1
MOTDIR	Ordered variable for the importance of senior management impetus (from 0 to 3)	115	2.33	1.17	0	3
MOTREG	Ordered variable for the importance of regulation, actual or anticipated (from 0 to 3)	115	0.53	0.91	0	3
MOTMRK	Ordered variable for the importance of demand and supply incitation (from 0 to 3)	115	1	0.96	0	3
MOTIV	Ordered variable for the three first motivation factors (from 0 to 3)	119	2.26	1.19	0	3
CERT	Binary variable: equals 1 for firms that are committed in an environmental certification procedure	111	0.48	0.5	0	1
CYCLE	Ordered variable for number of life cycle stages used (from 1 to 7)	119	3.7	1.62	1	7
METHOD	Binary variable : equals 1 for firms that used a methodological tool	116	0.76	0.43	0	1
INTEG	Ordered variable for the number of functions involved (from 1 to 6)	119	3.14	1.3	1	6
SUP	Binary variable : equals 1 for firms that received support from external organizations	117	0.56	0.49	0	1
COM	Binary variable : equals 1 for firms that highlight environmental quality in communications	117	0.91	0.28	0	1
Explanatory variables : quality of management						
RD	Ordered variable for change in R&D investments (from 0 to 3)	116	2.19	0.89	0	3
FUNC	Ordered variable for functional qualities of the product (from 0 to 5)	119	1.97	1.19	1	6
RECOG	Binary variable : equals 1 for firms that received a certification or award for quality of management	112	0.52	0.51	0	1
COMIT	Ordered variable for the level of senior's management commitment to sustainable development (from 1 to 4)	115	3.4	0.71	1	4
Control variables						
DSIZE1	Binary variable : equals 1 for firms with 0 to 10 employees	119	0.27	0.45	0	1
DSIZE2	Binary variable : equals 1 for firms with 11 to 50 employees	119	0.26	0.44	0	1

DSIZE3	Binary variable : equals 1 for firms with 51 to 250 employees	119	0.28	0.45	0	1
DSIZE4	Binary variable : equals 1 for firms with more than 250 employees (reference variable)	119	0.19	0.39	0	1
SIZEO	Ordered variable for four size classes (from 1 to 4)	119	2.39	1.08	1	4
DMAN	Binary variable : equals 1 for firms in manufacturing	119	0.62	0.48	0	1
DTRA	Binary variable : equals 1 for firms in trade and services	119	0.23	0.42	0	1
DOTHER	Binary variable : equals 1 for firms in agricultural or construction industries (reference variable)	119	0.15	0.36	0	1
B2B	Ordered variable for main users (from 0 to 2)	118	0.94	0.77	0	2
AWARN	Ordered for final buyers' awareness (from 1 to 3)	118	2.24	0.48	1	3
FR	Binary variable : equals 1 for French firms	119	0.41	0.49	0	1
QC	Binary variable : equals 1 for Quebec firms	119	0.37	0.48	0	1
EU	Binary variable : equals 1 for European firms (reference variable)	119	0.22	0.41	0	1

Results of the regression analysis and discussion

The results of the regressions are presented in Table 5. To check the robustness of results, we have estimated four models in which we use alternative explanatory variables for experience, motivations to implement eco-design products, and size. Due to missing values to certain questions of our survey, there are 80 firms for which we have access to the complete set of informations necessary to conduct our regressions. The regression results are reliable and robust, that is, the explanatory power of the model is strong enough to allow us to deduce the initial statistical interpretations about the relationships we want to test. Model 1 (benchmark model) explains 29% of the studied phenomenon. In model 2, we consider a different way to measure the experience with ecodesign. In model 3, a different set of motivations is analyzed, while in model 4 we measure the size of the company in a different manner. The explanatory power of the regression is similar across the different models.

A first set of explanatory variables measuring the intensity of eco-design practices —motivation from regulatory purposes, life cycle stages and methodological tools (respectively **MOTREG, CYCLE and METHOD**)—have a significant and positive impact on profit growth, while the variable used to measure the impact of external support (**SUP**) on an ecodesign initiative is significant and negative.

More specifically, environmental regulation enhances firm's positive impact of the ecodesign process on profitability, probably because firms with this type of motivation tend be ready to adapt faster to new legislation requirements, or tend to be more proactive in general (Canon de Francia et al., 2007). The variables **CYCLE** and **METHOD** - which represent respectively the number of product life cycle stages taken into consideration in the ecodesign process and the use of a formal methodological tool- have a significant and positive coefficient, so it is the case with the marginal effects (Table 6). This result indicates that the greater the number of stages considered in the process, the higher the probability that ecodesign will be profitable. Similarly, the use of a methodological tool seems to have a significant positive impact on the dependent variable. These results, in line with the empirical literature on the subject, show that the more global, structured, and systematic the ecodesign approach, the higher the probability that economic performance will improve (Zailani et al., 2012).

However, the negative impact of support on a positive profit evolution is probably related to the sunk costs generated by the organizational changes firms are constrained to in this particular case, especially in the case of a technical support/aid (Berneman et al., 2009). Another reason for this somewhat surprising result could be that "external support" is a proxy for the "lack of internal experience on ecodesign", suggesting that a critical mass should be reached in terms of expertise to make ecodesign profitable. This result is corroborated by marginal effects showing that such a support enhances the propensity of having a bad profit experience (Table 6).

A second set of explanatory variables was used to measure the overall quality of the management of the firms in the sample. The variable that measures the quality of company management— based on certifications or awards received (**RECOG**)—of the product has a significant and positive impact on the evolution of profits (in two out of four models). This suggests that outside recognition helps companies to achieve better market penetration for their ecodesigned products. This also confirms the trends observed in the literature on the subject that asserts the importance of company management for environmental friendly practices to be economically rewarding (Ameer and Othman, 2012).

The comparison of the coefficients of variables shows that methodological tools and external recognition for the quality of management have a highest impact on profits compared to the other significant factors (Table 6).

Of the 13 control variables, **DSIZE3**, representing medium sized companies, and **QC**, for Quebec companies, are negative and significant. Consequently, the smaller a company in our sample, the greater the impact of the ecodesigned product on the variation in profitability. This observation suggests, among other things, that small businesses, being more dynamic and flexible than larger ones, are better able to seize ecodesign-related business opportunities (see also Berneman et al., 2009).

In addition, being a Quebec company involved in ecodesign has a significant negative impact on variation in profitability when compared with the other two geographic areas. Based on the descriptive analysis of the data collected for this study, it would appear that at least three factors can explain this finding: (1) Quebec-based companies use proportionately fewer formal methodological tools than companies in France or the rest of the EU; (2) the overall quality of their management, as reflected by outside recognition in the form of certification and awards, would appear to be lower; and (3) they have more experience in ecodesign, suggesting that the best business opportunities for profiting from ecodesign may have already been seized.

Table 5. Results of the ordered Probit regression (dependent variable: PROF)

	Model 1	Model 2	Model 3	Model 4
Explanatory variables : intensity of ecodesign				
EXP1	0.03 (0.0289)	0.02 (0.0295)	0.03 (0.0286)	0.02 (0.0267)
EXP2	0.002 (0.0074)	-0.0001 (0.007)	0.002 (0.0069)	0.003 (0.007)
EXP3	/	0.54 (0.3923)	/	/
MOTDIR	-0.01 (0.2033)	0.05 (0.196)	/	0.04 (0.1837)
MOTREG	**0.4** **(0.2051)**	**0.4** **(0.2109)**	**/**	**0.4** **(0.203)**
MOTMRK	0.04 (0.2164)	0.11 (0.2259)	/	
MOTIV	/	/	-0.04 (0.1294)	/
CERT	0.008 (0.3853)	0.07 (0.3839)	0.05 (0.3811)	-0.06 (0.368)
CYCLE	**0.2** **(0.112)**	**0.2** **(0.1152)**	**0.2** **(0.1096)**	**0.2** **(0.1085)**
METHOD	**0.9** **(0.398)**	**0.9** **(0.4014)**	**0.8** **(0.3885)**	**0.9*** **(0.3886)**
INTEG	-0.003 (0.131)	-0.02 (0.1342)	0.04 (0.126)	0.002 (0.1273)
SUP	**-0.8** **(0.43)**	**-0.7*** **(0.4415)**	**-0.8** **(0.3849)**	**-0.8** **(0.4122)**
COM	-0.70 (0.6422)	-0.9 (0.6616)	-0.5 (0.5899)	-0.641 (0.6228)
Explanatory variables : quality of management				
RD	-0.013 (0.1915)	0.004 (0.194)	-0.02 (0.1819)	0.07 (0.1856)
FUNC	0.09 (0.1565)	0.09 (0.1598)	0.08 (0.1534)	0.1134 (0.1531)
RECOG	**0.7*** **(0.4298)**	0.6 (0.4366)	**0.7*** **(0.422)**	0.4 (0.3849)
COMIT	0.4 (0.2726)	0.4 (0.2814)	0.4 (0.2597)	0.3 (0.2639)
Control variables				
DSIZE1	-0.2 (0.6617)	-0.02 (0.679)	-0.2 (0.6076)	/
DSIZE2	-0.8 (0.656)	-.7032 (0.6644)	-0.9 (0.5984)	/
DSIZE3	**-0.9*** **(0.5756)**	-0.9 (0.5777)	**-1.03*** **(0.564)**	**/**
DSIZE4	REF.	REF.	REF.	/
SIZEO	/	/	/	0.04 (0.2075)
DMAN	-0.3 (0.5551)	-0.4336 (0.5561)	-0.4 (0.5594)	-0.3 (0.5376)
DTRA	0.03 (0.6513)	-0.02 (0.659)	-0.02 (0.6378)	0.0886 (0.6208)
DOTHER	REF.	REF.	REF.	REF.
B2B	0.12 (0.2323)	0.2 (0.2368)	0.06 (0.2338)	0.2597 (0.2176)

AWARN	0.44 (0.411)	0.3 (0.4077)	0.3225 (0.3934)	0.6 (0.3668)
FR	-0.2 (0.431)	-0.2 (0.5542)	-0.13 (0.5299)	-0.2 (0.5277)
QC	**-1.05** **(0.554)**	**-1.2** **(0.5702)**	**-1.2** **(0.5581)**	**-0.9*** **(0.5157)**
EU	REF.	REF.	REF.	REF.
Obs	80	80	80	80
Likelihood	-47.77	-46.81	-49.72	-49.47
Pseudo R2	0.2933	0.3076	0.2645	0.2682

Coefficient (Standard error)/ * significant at 10 %, ** significant at 5 %, *** significant at 1 %

Table 6. Marginal effects for model 1 (dependent variable: PROF)

	y= Pr(PROF=1)	**y= Pr(PROF=2)**	**y= Pr(PROF=3)**
Explanatory variables : intensity of ecodesign			
EXP1	-0.0006 (0.0075)	-0.01 (0.0109)	0.01 (0.0114)
EXP2	-0.00004 (0.0002)	-0.0007 (0.0028)	0.0007 (0.813)
MOTDIR	-0.001 (0.004)	-0.02 (0.0711)	0.0227 (0.0751)
MOTREG	-0.009 (0.008)	**-0.14**** **(0.0783)**	**0.16**** **(0.0807)**
MOTMRK	-0.001 (0.0047)	-0.02 (0.0803)	0.02 (0.0849)
CERT	-0.0002 (0.0082)	-0.003 (0.1414)	0.0032 (0.1495)
CYCLE	-0.0048 (0.0044)	**-0.082**** **(0.0422)**	**0.087**** **(0.0437)**
METHOD	-0.04 (0.0331)	**-0.31***** **(0.1244)**	**0.35***** **(0.1418)**
INTEG	0.0001 (0.0028)	0.001 (0.0486)	-0.001 (0.0514)
SUP	0.02 (0.0209)	**0.29**** **(0.1456)**	**-0.32**** **(0.1564)**
COM	0.009 (0.0085)	0.3 (0.1828)	-0.3 (0.1854)
Explanatory variables : quality of management			
RD	-0.0003 (0.0041)	-0.005 (0.0711)	0.005 (0.0752)
FUNC	-0.002 (0.0037)	-0.04 (0.0583)	0.04 (0.0615)
RECOG	-0.02 (0.0174)	**-0.26*** **(0.1489)**	**0.27*** **(0.1586)**
COMIT	-0.008 (0.0086)	-0.15 (0.1029)	0.15 (0.1073)
Control variables			
DSIZE1	0.005 (0.0178)	0.08 (0.2442)	-0.08 (0.2615)
DSIZE2	0.03 (0.0482)	0.29 (0.1968)	-0.32 (0.2362)
DSIZE3	0.04 (0.0424)	**0.33*** **(0.174)**	**-0.37*** **(0.2044)**

DSIZE4	REF.	REF.	REF.
DMAN	0.007 (0.0131)	0.13 (0.2019)	-0.14 (0.2133)
DTRA	-0.0007 (0.0135)	-0.0129 (0.2413)	
DOTHER	REF.	REF.	REF.
B2B	-0.003 (0.0053)	-0.05 (0.0865)	0.05 (0.0913)
AWARN	-0.008 (0.0104)	-0.14 (0.1502)	0.1439 (0.1579)
FR	0.004 (0.0142)	0.06 (0.2011)	-0.06 (0.2149)
QC	0.03 (0.0282)	**0.37** **(0.1749)**	**-0.39**** **(0.1907)**
EU	REF.	REF.	REF.
Obs	80	80	80

Coefficient (Standard error)/ * significant at 10 %, ** significant at 5 %, *** significant at 1 %

5. Conclusion

In this paper, we have examined two research questions: 1) Is it profitable for companies to adopt ecodesign practices? and 2) Why is ecodesign more profitable for one company than another ? With these questions in mind, we performed statistical analysis on data gathered in a new survey. The survey was conducted by means of a 48-item questionnaire, and data were collected from 119 firms: 49 in France, 26 in other European Union countries, and 44 in Quebec.

In the first, purely descriptive stage of our statistical analysis, we presented the highlights of the answers to the questionnaire regarding the profitability of the ecodesign approach. In the second stage of the study, we sought to identify the factors that determine the degree of profitability of ecodesign. Our working hypothesis was as follows: the more intense the ecodesign approach and the better the overall management of the company, the more profitable ecodesign will be. To test the hypothesis, we used an ordered Probit regression model where the phenomenon to be explained is a measure of ecodesign profitability, and the explanatory factors are the intensity of the ecodesign approach, the overall quality of company management, and certain intrinsic characteristics (control variables).

Our main findings could be described in the following way. Regarding our first research question, while environmental protection is generally considered to be incompatible with a company's profitability, this is not the case with ecodesign. For 45% of the responding companies, ecodesign has a positive effect on the bottom line, in absolute terms, while the effect was neutral for 51 %. From a social standpoint, ecodesign is a win-win solution, as it generates environmental benefits for all, without any negative impact on profitability. The profit margin of ecodesigned products compares well with that of conventionally developed products. In 30% of cases, the profit margin of ecodesigned products is higher than that of conventionally developed products, and similar in 55 % of the cases. The vast majority of responding companies said that the ecodesign approach also had positive non-financial impacts. The four most frequently cited positive impacts were improved recognition or reputation, greater employee motivation or pride, better customer relations, and greater

capacity to develop new products. These results confirm those of previous studies, but with a much more extensive and representative sample

Regarding our second research question, some variables representing the intensity of the ecodesign approach are associated with greater profitability. In particular, the higher the number of product life cycle stages the company takes into consideration in its ecodesign approach, the greater the profitability. Similarly, the more methodical the ecodesign process, such as applying a formal methodological tool, the higher the profitability. However, receiving support (financial or other) from outside is negatively associated with profitability. Regarding the overall quality of company management, one indicator (outside recognition) is associated with greater profitability. Finally, the smaller the company, the greater its chances of turning a profit on its ecodesign activities and, all things being equal, Quebec companies appear to have been less successful than companies elsewhere in making their ecodesign initiatives profitable.

Implications

These results have a number of implications, some of which are more relevant for business executives, others for policymakers who are in a position to promote ecodesign. First, ecodesign is a promising strategy for improving a company's profitability. But the positive impact is more than just financial—the ecodesign approach can become a competitive advantage. Ecodesign should be done methodically, using a formal methodological tool. Ecodesign should be done in a systematic manner and take several stages of the product life cycle into consideration. By winning an award or earning certification for the quality of its products or its management, a company can send a positive signal that helps to open up the market for ecodesigned products.

For policymakers, since the ecodesign approach is beneficial for the environment, but has no adverse effects on the economy, it is clearly worth promoting. A number of measures could be implemented to encourage its adoption: 1) Set up ecodesign awareness and training programs, or provide better support for existing programs; 2) adopt stricter environmental criteria for government procurement of goods and services, and 3) further develop extended producer responsibility programs.

Limitations

First, one could be concerned by our sample composed of self-reported data. For instance, one could think that the firms most likely to answer our survey are those that are most involved in and committed to ecodesign. Altogether, we are confident in the quality of the data for the following reasons: 1) many high quality analyses have been produced using self-reported data (e.g.,Henriques and Sadorsky, 1996, or Johnstone and Labonne, 2009); 2) in line with the previous point, for certain very pertinent issues, like the question of ecodesign and profitability, there is no other way to obtain data; 3) we trust the design of the questionnaire has to an extent prevented bias such as non-neutrality bias, complacency bias or strategy bias[29]; and 4) if respondents were mostly positively biased toward ecodesign, we would not find undesirable outcomes (like reduction in the profit margin) for a fairly large fraction of our respondents. Second, our study focused on short term impacts. As ecodesign has contributed to reputation building and recognition, more benefits could likely accrue in the long term. So, from this perspective, we could be understating the benefits.

Finally, it could be very useful if data on environmental management practices, like ecodesign, could be collected more systematically through a statistical or a business organization like the World Business Council on Sustainable Development.

[29] More specifically, we trust that the main characteristics of the questionnaire were appropriate: the conditions in which the interviewee completes the questionnaire (not face-to-face), the way in which the questions are drafted (objectively and impartially), the information provided to the interviewee about the questionnaire's final objective (not commercial nor policy oriented, thus no incentive to cheat), the possibility of responding anonymously (firm identification was optional), and the confidentiality guarantee (a note was included in the questionnaire with an express reference to data protection).

REFERENCES

ADEME Agence de l'Environnement et de la Maîtrise de l'Énergie (1999). *Conception de produits et environnement: 90 exemples d'écoconception*. Paris: ADEME Éditions.

Ambec, S. & Lanoie, P. (2008) "Does it pay to be green ? A systematic overview". *Academy of Management Perspectives* 22 (4), 45-62.

Ameer, R. & Othman, R. (2012) "Sustainability practices and corporate financial performance: A study based on the top global corporations". *Journal of Business Ethics*, 108:61–79

Aoe, T. (2007). "Eco-efficiency and ecodesign in electrical and electronic products". *Journal of Cleaner Production* 15 (15), 1406-1414.

Berneman, C., Lanoie, P., Plouffe, S. & Vernier, M.F. 2009. *L'Écoconception: Quels retours économiques pour l'entreprise?* Discussion paper IEA-09-03, HEC Montréal, Canada.

Bogliacino, F & Pianta, M. (2013)."Profits, R&D and innovation – A model and a test," *Industrial and Corporate Change*, Vol. 22, No. 3, 649–678.

Borchardt, M., Wendt, M.H., Peirera, G.M. & Sellitto, M.A. (2011). "Redesign of a component based on ecodesign practices: Environmental impact and cost reduction achievements". *Journal of Cleaner Production* 19, 49-57.

Braungart, M., McDonough, W. & Bollinger A.T. (2007). "Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design". *Journal of Cleaner Production* 15 (13-14): 1337-1348.

BSR Business for Sustainable Responsibility (2003). *Green product design*. www.bsr.org /CSRResources/IssueBriefDetail.cfm?DocumentID=50105

Canon-de-Francia, J., Garces-Ayerbe, C. & Ramirez-Aleso, M., (2007). "Are more innovative firms less vulnerable to new environmental regulation?". *Environmental and Resource Economics* 36, 295–311.

Chassagnon, V. & Haned, N., 2013. « PME et innovations environnementales: une étude empirique sur données françaises », *Économie appliquée*, vol. 66, n°4, 117-139

Chassagnon, V. & Haned, N., 2014. "The relevance of innovation leadership for environmental benefits: A firm-level empirical analysis on French firms", *Technological Forecasting and Social Change*, In Press.

Doonan, J., Lanoie, P. & Laplante, B. (2005) "Determinants of environmental performance of Canadian pulp and paper plants: An assessment from inside the industry," *Ecological Economics*, Vol. 55, 73–84.

Environment Australia (2001). *Product innovation: The green advantage—An introduction to design for environment for Australian business*. www.environment.gov.au/settlements/industry/finance/publications/pubs/producersguide.pdf

Gheorghe, R. & Ishii, K. (2008). *"Eco-design value alignment-Keys to success"* Mimeo, Stanford School of Engineering and Stanford Graduate School of Business.

Greene, W. H. (2003) *Econometric Analysis* (fifth edition), Prentice Hall, 736-740.

Henriques, I., Sadorsky, P. (1996) The determinants of an environmentally responsive firm: An empirical approach *Journal of Environmental Economics and Management* 30 (3) May, 381–395.

ISO International Organization for Standardization (2002). *Environmental management- Integrating environmental aspects into product design and development.* ISO/TR14062 :2002(F). Geneva : ISO.

Jackson, D. (1998) *Technological Change, the Learning Curve and Profitability*, Edward Elgar Publishing, 240 p.

Johansson, G., Widheden J. & Bergendahl, C.G. (2001). *"Green is the colour of money – Commercial success stories from ecodesign"*. GreenPack Report 2001-02. Sweden: Nordic Industrial Fund.

Johnstone, N., Labonne, J. (2009) Why do manufacturing facilities introduce environmental management systems? Improving and/or signaling performance *Ecological Economics* 68 (15) January, 719–730

Karlsson, R. & Luttropp, C. (2006). "EcoDesign: what's happening ? An overview of the subject area of EcoDesign and of the papers in this special issue". *Journal of Cleaner Production* 14 (15-16), 1291-1298.

Kanakaki, A. 2013. *"The Eco approach: Impact on economic efficiency and business strategy"* Paper presented at The MacroTrend Conference, Paris.

Kok, N. & Kahn, M.E. (2012) *The value of green labels in the California housing market*, Mimeo, UCLA.

Le Pochat, S., Bertoluci, G. & Froelich, D. (2007). « Integrating ecodesign by conducting changes in SMEs". *Journal of Cleaner Production* 15 (7), 671-680.

Lindahl, M. (2001), "Environmental effect analysis – How does the method stand in relation to lessons learned from the use of other design for environment methods," Proceedings Ecodesign: Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Tokyo, Japan, 11–15 December, 864–869.

Masera, D. (1999). "Sustainable product development: A key factor for small enterprise development – the case of furniture production in the Purépecha region, Mexico". *The Journal of Sustainable Product Design*, 8, 28–39.

Mathieux, F., Rebitzer, G., Ferrendier, S., Simon, M. & Froelich, D. (2001). Ecodesign in the electronics industry: An analysis of the current practices based on case studies. *The Journal of Sustainable Product Design* 1(4), 233-245.

Molenbroek, E., Cuijpers, M. & Blok, K. (2012). *Economic benefits of the EU Ecodesign directive.* Ecofys –Sustainable Energy for Everyone. Netherlands.

Organization for Economic Co-operation and Development (2005), *Oslo Manual*. Paris, 3rd edition.

Platcheck, E.R., Schaeffer, L., Kindlein, W. & Cândido, L.H.A. (2008). "EcoDesign: case of a mini compressor re-design". *Journal of Cleaner Production* 16 (14),1526-1535.

Plouffe, S., Berneman, C., Lanoie, P. & Vernier, M.F. (2011). « Economic benefits tied to ecodesign», *Journal of Cleaner Production*, Vol. 19, no 6-7, April-May, 573-579.

Porter, M. & van der Linde, C. (1995) "Toward a new conception of the environment-competitiveness relationship.," *Journal of Economic Perspectives*, 9(4), 97–118.

Schaltegger S. & Synnestvedt T. (2002) "The link between green and economic success: environmental management as crucial trigger between environmental and economic performance*". Journal of Environmental Management*, 65, 339-346.

Tischner, U. & Nickel, R. (2003). "Eco-design in the printing industry – Life-cycle thinking: Implementation of Eco-design concepts and tools into the routine procedures of companies". *The Journal of Sustainable Product Design* 3 (1-2), 19–27.

van Hemel, C.G. (1997). "The IC EcoDesign Project: results and lessons from a Dutch initiative to implement eco-design in small and medium-sized companies". *The Journal of Sustainable Product Design*, 2, 7–18.

WBCSD World Business Council for Sustainable Development. (2000). *Eco-efficiency: Creating more value with less impact.* www.wbcsd.org/includes/getTarget.asp?type=d&id=ODkwMQ.

Zailani, S., Eltayeb, T. K., Hsu, C., & Tan, K. (2012). "The impact of external institutional drivers and internal strategy on environmental performance". *International Journal of Operations & Production Management*, 32(6), 721-745.